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## DOCTORATE in BUSINESS ADMINISTRATION

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# ORGANIZATIONAL AMBIDEXTERITY FOR MEDIUM-SIZED FIRMS IN A CONTEXT OF GROWING UNCERTAINTY

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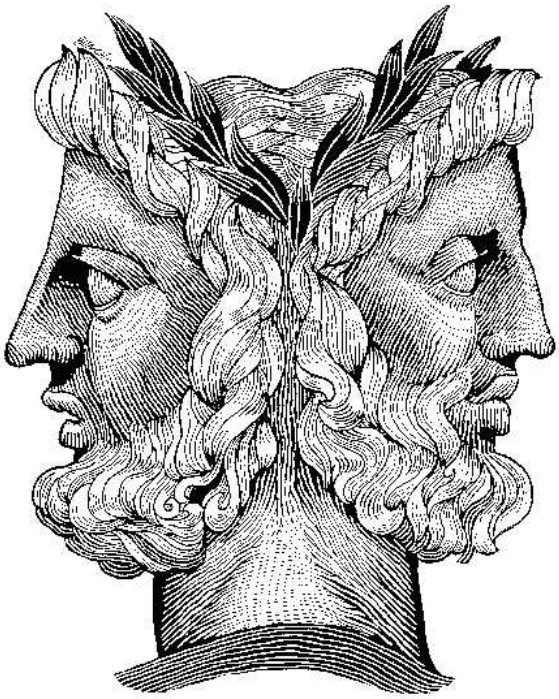
*“There is no more delicate matter to take in hand, nor more dangerous to conduct, nor more doubtful in its success, than to be a leader in the introduction of changes. For he who innovates will have for enemies all those who are well off under the old order of things, and only lukewarm supporters in those who might be better off under the new.”*

*The Prince,*
Niccolò Machiavelli



***Janus**,*
*God of Change and Time,*
*a face looking to the past,*
*a face looking into the future.*

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## Abstract

Managers are constantly exposed to the increasing complexity of our fast-paced, globalized, interconnected and hyper-competitive world. In such an increasingly unpredictable context, structuring an organization and designing a strategy that balances the needs for short-term profitability with long-term survival is becoming growingly difficult. Organizational ambidexterity has been proposed as a means of managing these contradictory objectives, but its effect on the longevity of organizations remains largely unproven. We discuss this issue by situating it in the academic literature and propose that business segments that are highly exposed to a very uncertain environment benefit from the application of an ambidextrous strategy according to a constantly evolving dynamic process superimposing different measures, varying in intensity; and from the regular modification of this mix in response to external stimuli and newly acquired internal capabilities. Hence the question pertaining to *how* to operate this, especially in medium-sized companies (SMEs) with constrained resources; a domain that has also been largely overlooked by management scholars so far.

Our analysis proceeds by a longitudinal single case study covering the 25 years of existence of a medium-sized company operating internationally in the field of industrial biotechnology. It relies on a mix of quantitative and qualitative methods with the aim to abductively search for explanations for the events observed so as to enrich the current view of the manner in which generative mechanisms are activated and underlying processes put to work in regards to contextual conditions.

In light of our findings, we argue that SMEs operating in turbulent environments with high technological content would benefit from combining a highly flexible organic-type of structure at the decision-making level with a more mechanistic structure at the execution level. We show that organizational ambidexterity can advantageously be achieved in medium-sized companies by nurturing a customer-centric effectual approach for projects belonging to short development cycles in combination with a strict stage-gate system resorting to a classical causal logic for projects imbedded in long development cycles. We also claim that the integration of effectual logic into business practices at the operational level creates an ongoing and affordable opportunity for the variation, selection and retention of new knowledge and capabilities that helps the company stay ambidextrous and makes it more robust in the face of environmental change. Overall, the integration of our observations, as diverse as they are varied, confirms that organizational ambidexterity is a rich, complex and multilayered concept that must be dynamically analyzed in the light of the company's available resources, especially when they are limited as for the majority of mid-sized firms; but also with regards to the surrounding environmental changes, especially when these are accelerating and becoming unpredictable.



## Keywords

Organizational ambidexterity, corporate strategy, change management, uncertainty, chaos, exploitation/exploration, causation/effectuation, fragility/antigragility.

## Résumé

Les managers sont constamment exposés à la complexité croissante de notre monde trépidant, globalisé, interconnecté et hyperconcurrentiel. Dans un tel contexte de moins en moins prévisible, structurer une organisation et concevoir une stratégie qui équilibre les besoins de rentabilité à court terme et la survie à long terme devient de plus en plus difficile. L'ambidextrie organisationnelle a été proposée comme moyen de gérer ces objectifs contradictoires mais son effet sur la longévité des organisations reste largement non-démontré. Nous discutons cette problématique en la situant dans la littérature académique et proposons que les métiers fortement exposés à un environnement très incertain bénéficient de la mise en pratique d'une stratégie ambidextre selon un processus évolutif et dynamique superposant différentes mesures, variables en intensité, à plusieurs niveaux de l'entreprise et par la modification régulière de ce mix en réponse aux stimuli extérieurs et aux capacités internes nouvellement acquises. Dès lors la question de savoir *comment* mettre ça en place, en particulier dans les moyennes entreprises (PME) ayant des ressources limitées, un domaine qui a été largement négligé par les chercheurs en gestion jusqu'à présent.

Notre analyse consiste en l'étude longitudinale d'un cas unique couvrant les 25 années d'existence d'une entreprise de taille moyenne opérant à l'international dans le domaine de la biotechnologie industrielle. Il s'appuie sur une combinaison de méthodes quantitative et qualitative dans le but de rechercher de manière abductive des explications pour les événements observés afin d'enrichir la vue actuelle de la manière dont les mécanismes générateurs sont activés et les processus sous-jacents mis en oeuvre en fonction des conditions contextuelles.

À la lumière de nos constatations, nous soutenons que les PME opérant dans des environnements turbulents avec un contenu technologique élevé bénéficieront de la combinaison d'une structure de type organique hautement flexible au niveau décisionnel avec une structure plus mécanistique au niveau de l'exécution. Nous montrons que l'ambidextrie organisationnelle peut être atteinte dans les entreprises de taille moyenne en favorisant une approche effectuelle axée sur le client pour les projets appartenant à des cycles de développement courts combinée à un strict système d'étapes qui recourt à une logique causale classique pour des projets intégrés dans les cycles de développement longs. Nous prétendons également que l'intégration de la logique effectuelle dans les pratiques commerciales au niveau opérationnel est de nature à créer une opportunité constante et peu coûteuse pour la variation, la sélection et la rétention de nouvelles connaissances et capacités qui aident l'entreprise à rester ambidextre et la rendent plus robuste face à un environnement changeant. Dans l'ensemble, l'intégration de nos observations, aussi diverses que variées, confirme que l'ambidextrie organisationnelle est un concept riche, complexe et multicouches qui doit être analysé dynamiquement à la lumière des ressources disponibles de l'entreprise, en particulier lorsque celles-ci sont limitées comme pour la majorité des entreprises de taille moyenne; mais aussi au vu des changements contextuels qui entourent l'entreprise, en particulier lorsque ceux-ci s'accélèrent et deviennent imprévisibles.



## Mots clés

Ambidextrie organisationnelle, stratégie d'entreprise, management du changement, incertitude, chaos, exploitation/exploration, causation/effectuation, fragilité/antigragilité.

# Acknowledgements

Conducting research work as part of a doctorate in parallel with a dense professional life, and avoiding interferences between both, requires a great deal of structure and compromise. In a way, such a dual adventure integrates in itself the principles of organizational ambidexterity, the central subject of this thesis, and offers perhaps a good means to grasp from the inside, on a daily basis, at the level of our personal small scale, the tensions that make ambidexterity so indispensable, so difficult to achieve in practice, but also so rewarding when properly managed.

As I come to the twilight of this thesis project, and before tomorrow presents itself with new challenges, I would like to thank all those who made this work possible.

First of all, I would like to thank my thesis supervisor, Professor Caroline Mothe, for the quality of her guidance, for her knowledge of the subject, for her availability, for her unfailing enthusiasm, and for our exciting conversations on the shores of Lake Geneva. I am also grateful to Professor Jean Moscarola for the excellent advice he gave me especially in terms of methodological approach for this work.

I also express my gratitude to the Business Science Institute and the Institut d'Administration des Entreprises of the University of Lyon III, and particularly to Professor Michel Kalika, Scientific Advisor of the former and professor at the second, for having created this Doctorate in Business Administration. Such a program allows managers to take a step back from their practice, reflect on the implications of their work at a broader level, and participate at their modest individual scale in knowledge creation and sharing. Moreover, the distance education character offered by the BSI makes it possible to combine this type of program with an active life, a formula without which I would never have been able to finish such a work.

Particular attention also goes to Professor Emeritus Robert Brasseur, my father-in-law and one of the brightest minds I have been offered to cross, for the support he gave me with a computer algorithm used in this dissertation, but far beyond that, for the affection that binds us and for our interminable discussions every summer.

And of course, my deepest appreciation and my greatest thanks go to my wife, Véronique, who supported me patiently all along this journey, taking much on her shoulders to relieve mine; to my children Kyllian, Kaylie, William and Jade, for their love; and to my mother without whom I would never have become what I am.

To all, thank you.

Ligne,

May 31st, 2017

# Introduction

*"It is not the strongest of the species that survive, nor the most intelligent, but the one that is most responsive to change"*

Charles Darwin

## Foreword

Some authors argued that research in strategy and organizations would be better served if it were more grounded in the phenomena and they suggested that the context of executive education offers an underused framework for faculty and doctoral students to develop relationships with practitioners (Tushman & O'Reilly, 2007). What closer relationship between researcher and practitioner than to have both in the same person? This is precisely the opportunity offered by an Executive Doctorate in Business Administration but the posture of manager-researcher is hard to hold because the manager must be operational, hands-on, close to the subject, in the heart of action; while the researcher must maintain a critical distance with the subject of his/her study to ensure neutrality and objectivity[1]. Moreover, this posture is not deprived of risks and bias: risk of circularity and risk of ignoring the principle of equifinality (Dumez, 2012), risk of narrative fallacy (Taleb, 2012), single-informant bias (Kumar, Stern, & Anderson, 1993), *ad hoc* hypothesis (Bamford, 1999) etc… Therefore, to be useful, research in the social sciences conducted by managers-researchers, even more perhaps than other types of studies, must combine relevance and methodological rigor (Stokes, 1997).

We believe that the subject of our dissertation and the research question that arose from it are relevant because they correspond to theoretical gaps identified in academic literature but also and foremost because they were inspired by our own experience as a business manager in various geographical and conjunctural contexts. As for the methodology, with a background of engineer we feel spontaneously more attracted by positivist or post-positivist approaches but management is about people[2] (social science) and reducing management's complexity to general and average patterns (normal distributions) leads to missing its local idiosyncratic dimension (sometimes located "in the tails") which is precisely what practitioners are confronted with. Consequently, as explained further in this dissertation, we have adopted a critical realist posture and a rigorous multi-method qualitative and quantitative study design which we hope will reveal useful to the matter in generating new knowledge of both academic relevance and pragmatic interest.

[1] Except for certain streams of research in social science and especially in management science such as action-research for instance.
[2] Hence the question to know if engineers make good managers… A question that falls far beyond the scope of this dissertation, tough.

## General context

> *« We need to learn to deal with a rain forest of individuals and firms and markets and societies, intermeshed and woven together with completely coherent yet vastly diverse local patterns that add up to a complex, interdependent ecology of human artifacts. We need to move away from the vision of the "market" as a monolithic construct that rides roughshod over vast farmlands of homogenous commodities, relentlessly separating the wheat from the chaff, and start researching "markets" as groups of individuals and communities developing a variety of gardens and parks based on their particular tastes in landscaping and architecture. Only then can we begin to explain why people of all types seem to build successful companies.»*
>
> (Sarasvathy, 2001, p.258)

### *A question of survival*

There has been a lot of debates about why do firms exist. Some see the purpose of companies' existence in profit generation while others believe growth should be the main target for managers. Academics approached this question from a transaction cost perspective (Coase, 1937), an agency cost perspective (Jensen & Meckling, 1976), a resource-based perspective (Penrose, 1959) or a knowledge-based perspective (Barney, 1991; Kogut & Zander, 1992). Birkinshaw and Gupta (2013) highlighted a slightly different but interesting viewpoint initially developed by Moran and Ghoshal (Ghoshal & Moran, 1996; Moran & Ghoshal, 1999) by which they argue that firms do things markets cannot. In substance, they claim that markets allocate resources to short-term best uses and firms then transform these resources into long-term outputs to create value. This is why, according to these authors, we need both markets and companies to sustain economic development. However, because corporations are built on the assumption of continuity (long-term operations) and markets are built on the assumption of discontinuity (short-term creation and destruction)(Foster & Kaplan, 2001b), the former are not able to change at the pace and scale of the latter. This lends further credence to McKelvey's contention (1999) that the environment changes more rapidly than organizations. The markets remove the weaker performers and, while some corporations thrive to survive for quite long periods of time, they don't have the ability to

perform as well or better than the markets and to earn average or above-average shareholders returns over the long run. Foster and Kaplan (2001b) for instance, using their research on the performance of more than 1,000 corporations in 15 industries over a 36-years period, show that the long-term survivors, these few companies that survived the "perennial gale of creative destruction" (Schumpeter, 1934), earned as a group a long-term return for their investors 20% lower than that of the overall market. They did not find any long-term survivor that had significant sustained outperformance. There were many new entrants that had stronger performance than that of their peers but the phase of exceptional performance always came to an end after a certain period of time. Hence the question: what should matter for managers and companies' stakeholders: short-term profits, growth or long-term survival?

## Profits

The idea that the only purpose of a firm is to make money for its shareholders is largely related to the Chicago School of Economics and its 1976 Nobel Prize-winning leader Milton Friedman who published a provocative article in the New York Times on September 13, 1970 titled "The Social Responsibility of Business is to Increase its Profits"(M. Friedman, 1970). Almost half a century later, there is a growing consensus that focusing on short-term shareholder value is certainly questionable for society but also leads to poor business results (Murray, 2013). Indeed, as recently showed in the US (Asker, Farre-mensa, & Ljungqvist, 2015), companies listed on the stock market invest only about 3.7 per cent of their total assets whereas privately-held companies invest about twice as much, this because executives at publicly traded companies are paid to generate higher share prices by hitting quarterly earnings targets, therefore reducing investments that will only impact profits at longer term. Even Jack Welch, the iconic former President and CEO of General Electric and true-believer of the shareholder value theory, mitigated the idea in an interview with the Financial Times in 2009 when he said that "Shareholder value is a result, not a strategy (…) Your main constituencies are your employees, your customers and your products (…) Managers and investors should not set share price increases as their overarching goal (…) Short-term profits should be allied with an increase in the long-term value of a company". In a similar way, de Geus (1997) observed that "corporations fail because the prevailing thinking and language of management are too narrowly based on the prevailing thinking and language of economics. (…)

Companies die because their managers focus on the economic activity of producing goods and services, and they forget that their organizations' true nature is that of a community of humans" (p.3). Collins and Porras (1994), drawing upon a six-year research project looking in depth at eighteen long-lasting companies in direct comparison to their top competitors came to conclude that "profitability is a necessary condition for existence and a means to more important ends, but it is not the end in itself" (p.55).

Therefore, while most research to date has highlighted revenue as the primary performance outcome (Gibson & Birkinshaw, 2004; He & Wong, 2004), an accent on this single trait alone provides an incomplete picture of the firm's overall success and a finer-grained view of firm performance is needed (Chakravarthy, 1986).

### Growth

The literature on organizational success implicitly regards growth as another adequate indicator of success.

Whetten (1980, p.577) noticed a bias in organizational theories in favor of growth with implied assumptions such as "there is a positive correlation between size and age", hence the greatest need of organizations as they mature would be to manage growth; "size is a desirable characteristic" as large size is supposed to enable organizations to function more efficiently owing to economies of scale and to help absorb environmental changes; and "size is an indicator of effectiveness" as it is common to assume that firms grow thanks to appropriate strategies and effective management. Whetten (1980) further remarked the intertwined relationship between growth and effectiveness in system theory that views organizations as "living entities" with growth becoming the preferred organizational states as "it denotes youth and vitality" (p.578).

Conversely, numerous old and large organizations have had to substantially reduce the size of their operations or redefine their outputs in order to maintain their level of effectiveness, and there are several examples of companies that have failed to respond to declining environmental conditions because their management was primarily preoccupied with growth (Starbuck, Greve, & Hedberg, 1978). Organizational growth may also induce negative or dysfunctional consequences as large

organizations are likely to become “too complex, too rigid, too impersonal, too inefficient, and too inaccessible to outsiders” (Whetten, 1987, p.341).

Additionally, Hanks *et al.* (1993) describe two apparently stable and sustainable disengagement configurations in their taxonomic life-cycle model by which enterprises appear to disengage from the growth process after establishing their viability at relatively modest size because owners consciously chose to keep their firms small as they believe that the negative effects of growth outweigh the positive outcomes, respectively the “life-style disengagement” (also described by Davidsson (1989)) and what McMahon (1998) called “capped-growth disengagement” (similar to Churchill & Lewis (1983) “success-disengagement”). Hanks *et al.* (1993) observed that these disengagements patterns can be justified for firms operating in small market niches for instance and McMahon (1998) asserted the disinclination of some entrepreneurs and managers to surrender control and/or be accountable to others.

Consequently, although growth is praised by many in mainstream business magazines and size is generally regarded as a positive indicator of success, there are situations in which decision makers may not want to seek to grow their business beyond a certain point or may even be forced to take actions to reduce the size of their operations in order to fulfil other goals.

## Survival

> *« Social scientists from different disciplines have different views on the importance of corporate longevity. Economists, who view companies as instruments for organizing economic transactions that cannot be performed with market mechanisms and/or for maximizing financial benefits for their owners, do not consider company longevity a goal per se. Sociologists, who view companies as institutions that inherently seek to survive study why and how they do so, primarily in terms of legitimacy as a determinant of longevity. Strategy scholars combine aspects of the economic and sociological perspectives by focusing on the determinants of a company’s economic performance and viewing this as a condition for its continued survival.»*
>
> (Burgelman, 2015, p.73)

Notwithstanding the evidence that generating profits is of paramount importance and that achieving growth may be seen as an equi-important driver in managing a company, companies also exist

because of their social impact. This stakeholders' perspective is evidenced, for instance, by the growing interest towards Corporate Social Responsibility (Lewis, Andriopoulos, & Smith, 2014). Contrary to traditional economic thinking, some investors do value the sustainability and long-term survival of their investments as much as, or sometimes even more than, the short-term returns they are generating (Collins & Porras, 1994; de Geus, 1997; Stadler, 2007; Stadler & Hinterhuber, 2005). A typical example of such a long-term investor/shareholder standpoint, as opposed to the one of speculators, short-sellers and some activist investors, comes with the family offices where "the family ownership brings the family values alive in a vision, which deeply cares for the next generation, not just for the next five years" (Schwass, 2013, p.9).

De Geus (1997) goes even further in his book "The Living Company: Habits for Survival in a Turbulent Business Environment" in which he summarizes 38 years of high-level management at Royal Dutch/Shell and the findings of an in-depth study of 27 corporations that had successfully weathered some fundamental changes in the world around them such that they still existed with their corporate identity intact. He asserts that providing financial returns, products or services, serving customers, making human life more comfortable, creating jobs and ensuring a stable economic platform for all the stakeholders of society, for important as these goals are, are all secondary. He states that, from the point of view of the organization itself, "like all organisms, the living company exists primarily for its own survival and improvement" (de Geus, 1997, p.11).

For the anecdote, let us remind that the word "business" was known in traditional Chinese as 生意, pronounced "Shēngyì", in which the first character - "Shēng" - stands for life, livelihood, and the second character - "yì" – means purpose, sense, intention, and significance but also desire or wish. Hence, as per the ancient Chinese, business can be assimilated to "the purpose of life" or "the desire of life" and the term "survive" has the same root: 生存, "Shēngcún", "to retain life".

Many researchers have attempted to better understand the organizational causes of success and failure (Fleck, 2009; Miles & Snow, 1992; Miller, 1993; Weitzel & Jonsson, 1989), archetypes of organizational success and failure have been proposed (Miller & Friesen, 1978; Miller & Friesen, 1977) and broad longitudinal studies on American (Foster & Kaplan, 2001b), European (Stadler, 2007) or international (Collins & Porras, 1994; de Geus, 1997) long-lasting companies have been published. In addition to several other attributes such as cohesion, identity and tolerance (de Geus, 1997), integrity and diversity (Fleck, 2009) or conservatism (de Geus, 1997; Stadler, 2007), all

these authors stress out the necessity for organizations to learn from and adapt to their surroundings, to explore new avenues and exploit existing competences, to enterprise and at the same time navigate a dynamic environment. Other authors (e.g. Gibson & Birkinshaw, 2004) have referred to adaptability (capacity to evolve rapidly) and alignment (capacity to work coherently).

This "ability of organizations to compete in mature technologies and markets where efficiency, control, and incremental improvement are prized and to also compete in new technologies and markets where flexibility, autonomy, and experimentation are needed"(O'reilly & Tushman, 2013, p. 324) is often referred to as "Organizational ambidexterity" in organizational scholarship.

In a seminal article published in 1991, March explains that "the basic problem confronting an organization is to engage in sufficient exploitation to ensure its current viability and, at the same time, devote enough energy to exploration to ensure its future viability" (March, 1991, p.105). The relationship between organizational ambidexterity and firm viability, i.e. firm survival, is straightforward. Pointing at some confusion or ambiguity about what precisely the term "organizational ambidexterity" refers to, O'reilly & Tushman (2013, p.330) insist that "the long-term *survival* of the firm is the sine qua non of organizational ambidexterity", and they add that "Ambidexterity is not simply about whether a firm can pursue efficiency and innovation or compete in multiple markets but about developing the capabilities necessary to compete in new markets and technologies that enable the firm to *survive* in the face of changed market conditions"(O'Reilly & Tushman, 2007, emphasis is ours).

In conclusion, long term survival appears to be of importance for organization's stakeholders and developing ambidextrous capabilities may be an efficient way to deal with apparently opposed short term and long term pressures. Our research aims precisely to add additional specificity and insights into this view in order to help substantiate it. Nonetheless, before going further, some clarity must be brought upon the very definition of survival or related terms such as longevity and sustainability, which is what is addressed in the next section.

### Survival, longevity or sustainability?

The term *sustainability* seems too broad in its first sense ("the ability to be maintained at a certain rate of level") and too narrowly linked to ecology in its more common meaning ("the ability to

preserve an ecological balance by avoiding depletion of natural resources"). This term will therefore not be used here.

The Oxford dictionary defines *longevity* as "long life, long existence or service". Similarly, *survival* is defined as "the state or fact of continuing to live or exist". Both terms therefore apply to our subject. They both appear for that reason in this dissertation, we use them indifferently in the following sections to improve the narrative flow and avoid too many repetitions. Doing so, we follow several scholars who use the two terms without nuance in their publications (Laplume, 2010; Weitzel & Jonsson, 1989) while others use only one of these terms but without elaborating on the meaning of the word chosen or on the reason of their choice (a.o. for "longevity": Burgelman & Grove, 2007; de Geus, 1997; Hannan & Freeman, 1984; Laplume & Dass, 2009; Malik & Hine, 2011; Piao, 2014; Stadler, 2007 ; for "survival": Blank, 2013; Boumgarden, Nickerson, & Zenger, 2012; Carmeli & Schaubroeck, 2008; Christensen, Suarez, & Utterback, 1998; Foss, 1998; Foster & Kaplan, 2001b; Junni, Sarala, Taras, & Tarba, 2013; Kogut & Zander, 1992; Lin, Yang, & Demirkan, 2007; March, 1991; Miller & Friesen, 1977; O'Reilly & Tushman, 2013; Stadler & Hinterhuber, 2005; Winter, 1964).

The Oxford dictionary adds to the definition of survival "typically in spite of an accident, ordeal, or difficult circumstances" which makes this term even more appropriate to our reference frame, i.e. the context of growing uncertainty in which organizations are evolving. Furthermore, the Darwinian idea of "survival of the fittest", meaning the continued existence of organisms that are best adapted to changes in their environment, applies perfectly to the underlying dimension of our questioning: how organizations can better adapt to environmental uncertainty. Yet, the purpose of our study is not to look at how companies can get prepared to, and deal with, unexpected punctual events of accidental nature, such as in high-reliability organizations theory (Weick & Sutcliffe, 2007) or in normal accidents theory (Perrow, 1984), but more to see how they can cope with evolutionary or revolutionary trends in a longer run. The word "*longevity*" contains already this long term dimension, but for the sake of clarity and to avoid any misunderstanding, instead of the term "*survival*" alone we use generally in this document the expression "*long term survival*".

## *A changing world*

> *"Historians may well look back on the first years of the 21st century as a decisive moment in human history. The different societies that make up the human family are today interconnected as never before."*
>
> Kofi Annan, UN secretary-general, 1997-2006

" Madness *is* afoot" (Peters, 1987, p.17, emphasis original). The world has always been changing but the pace of change is oviously increasing, and increasing fast. Globalisation is one of the core factors behind changing economic conditions. For Friedman (2005), the world that has entered a third phase of globalization is flattening which brings new opportunities to entrepreneurs but also increases risks such as, without limitations, trans-border competition and currency fluctuations. Despite protectionist movements in the United States and other nations, transactions that cross international borders are sharply on the rise. The very notion of frontiers disappears in the face of technological developments: not only the borders between countries, but also between markets, and even the boundaries of the companies themselves.

Indeed, the progression of technology – taken in a broad sense – is changing the economic landscape and hence the companies' environment. More than ever in history, "creative destruction" (Schumpeter, 1942) is accelerating exponentially: everyone is increasingly connected, high-speed computers and communications technology facilitate the development of global sourcing and allows outsourcing routine tasks, science makes disruptive progress in many field thanks to genetics and process intensification, etc.

Also often associated with periods of heightened uncertainty are periods of crisis and the resulting intense restructuring. Over the last years, the financial environment has changed as a result of recent crisis (especially the financial crisis of 2008). On the one hand, interest rates are kept at a very low level to prevent inflation to spur and to try kick-starting economic growth, but on the other hand, the financial authorities have tightened the regulatory framework for credit institutions

and investment firms (Basel III[3]) which hinders the access to capital for companies, especially the small ones, the more fragile and hence, maybe, the ones the more in need.

Another important change affecting companies lies in a profound mutation of their organization due to a shift of power from the management team (from the 1929 crisis till the 1980ies) to the shareholders (since the eighties). For instance, notions like Value-Based Management focussing more on ROCE (return on capital employed, a typical shareholder standpoint) than on ROS (return on sales, an enterprise perspective) spur companies to increase their capital turnover and outsource some of their competencies making them weaker in tough times.

In the modern world, the list of evolutions and revolutions triggering change at a global level is endless. Where this observation assumes its significance for companies, and especially for the managers called to lead them, is when one remark that systematic and unsystematic risks are related by the way economies manage changes in economic conditions (Haltiwanger, 2011): the variance of idiosyncratic shocks (i.e. at the microlevel of companies) is at least an order of magnitude larger than the variance of aggregate (systematic) shocks (i.e. at the macrolevel of markets or economies)(Cooper & Haltiwanger, 2006). In order words, a ripple across an economy can become a tsunami at the scale of a business.

That is why it is more essential than ever for companies to adopt the right organizational methods to take the waves when they arise and, more than simply preventing capsizing, be able to surf them at best and, even, be able to benefit from them.

[3] "Basel III: a global regulatory framework for more resilient banks and banking systems", Basel Committee on Banking Supervision, Bank for International Settlements, ISBN 92-9131-859-0, December 2010 (rev. June 2011).

## Uncertainty and unpredictability

> *"Man-made complex systems tend to develop cascades and runaway chains of reactions that decrease, even eliminate, predictability and cause outsized events. So the modern world may be increasing in technological knowledge, but, paradoxically, it is making things a lot more unpredictable."*[4]
>
> (Taleb, 2012, p.7)

De Meyer, Loch and Pich (2002) postulated four types of uncertainty sourrounding organizations which can be put in relation with the ones outlined by Courtney, Kirkland and Viguerie (1997). The former authors primarily look at the level of projects whereas the latter investigate more broadly the impact on corporate strategy.

| De Meyer *et al.* (2002) | Courtney *et al.* (1997) | How to deal with this situation? |
|---|---|---|
| **Variation**<br>Internal and external factors vary randomly but in a predictable range. | **A clear enough future**<br>Traditional strategic approach of laying out a vision of the future. | Simple forecasting precise enough to be captured in discounted cash-flow analysis and other classical tools. |
| **Foreseen uncertainties**<br>A few known factors are of influence in unpredictable ways. | **Alternate futures**<br>A few discrete outcomes define the future. | Decision trees, option valuation models, game theory, scenario planning. |
| **Unforeseen uncertainties**<br>Some major factors of influence cannot be predicted. | **A range of futures**<br>A range of possible outcomes but no natural scenarios. | This form of uncertainty requires businesses to work more flexibly, employ more novel strategic approaches abd work more closely with suppliers and customers. |
| **Chaos**<br>Unforeseen events completely invalidate any kind of planning or strategy. | **True ambiguity**<br>No basis to forecast the future. | Some tools can be used such as analogies, pattern recognition, and nonlinear dynamic models but with limited success. Organizational learning is key. Managers must be resilient, adaptable and creative. |

*Table 0.1: Four types of uncertainty as proposed by De Meyer (2002) et al. and Courtney et al.(1997).*

Whereas uncertainty can be equated with unpredictability (Özsomer, Calantone, & Di Benedetto, 1997), its perception is nevertheless relative. A context that is perceived as simple, static, and with

[4] *Paul Valéry went even further claiming a causal link between scientific or technological knowledge and unpredictability, he said :"Unpredictability in every field is the result of the conquest of the whole of the present world by scientific power" (cited in Schwartz, 1996).*

little uncertainty by one organization may be perceived as complex, dynamic, and with a high degree of uncertainty by another. Similarly, an event can come as a surprise for one organization while it is obvious an well anticipated by another. Therefore, if uncertainty is a fact, the perception of uncertainty is not an objective phenomenon (Taleb, 2007b). This said, Anderson and Tushman (2001) have shown in a longitudinal study of the Amercian cement industry convering 92 years and of the minicomputer industry over 24 years that uncertainty is the key environmental dimension associated with organizational mortality. The greater the uncertainty, the higher the failure rate. Their results indicate that organizations can better deal with complexity, economic conditions and environmental munificence than with uncertainty which they qualify as "a lethal characteristic of organizational environments" (opcit., p.675).

Of course, the type of activity in which organizations are involved defines their sensitivity to uncertainty. Indeed, some market segments are less exposed to volatility; activities in these segments are non-scalable in the sense that the returns generated are simply dependent on the labor or effort invested. An example comes with convenience food stores, fast-food restaurants or retail businesses. There is a relation between the size of a local population, the purchasing power of its members and the number of stores or fast-food restaurants that could survive and progress in this environment. Other sectors such as the ones with a high technology content, the pharmaceutical industry, the art industry, the movie industry, the internet industry etc… are much more exposed to volatility. In these industries, a single technological breakthrough or a blockbuster can propel a company to new heights never expected: they are scalable. The former follow normal (Gaussian) distribution of outcomes and are therefore not much impacted by surrounding volatility; the latter are much more exposed and they follow pareto-like power laws.

In a world such as ours, managers must understand the fundamentals that support the sector of activity in which they evolve in order to define the most appropriate type of organization. Indeed, uncertainty precludes rationalization, and some well-known management methods (Kroc's McDonaldization, Weber's bureaucracy, Taylor's scientific management, and Ford's assembly line)(Tsoukas, 2011) no longer apply to some industries evolving in fast changing, highly volatile, environments.

## The dangers of forecasting

> *"Organizations create plans to prepare for the inevitable, preempt the undesirable, and control the controllable. Rational as all this may sound, planning has its shortcomings. Because planners plan in stable, predictable contexts, they are lulled into thinking that the world will unfold in the expected manner."*
>
> (Weick & Sutcliffe, 2007, p.66)

The citation above summarizes what Mintzberg calls "the fallacy of predetermination" (Mintzberg, 1994, p.227). Beyond the fact that plannification assumes predetermination and contains a good level of prediction (which accuracy can be highly hypothetical), Weick tells us that planning can be dangerous[5]. It influences perception by reducing the number of things people notice (slight deviations from the expected course of events are smoothed over and quickly lose their salience); planning also undercuts organizational functioning by limiting the organization's view of its capabilities to those it has already (contingency plans preclude improvisation); and finally, forecasting naturally tends to push organizations to replicate pattern of activities that they know well and that have worked in the past (a kind of "success trap" to which we will return later in this work).

In any case, as pointed by Antoine de Saint-Exupéry: "Your task is not to foresee the future, but to enable it"[6].

[5] In fact, Popper presented the limits of searching for underlying patterns that allow future predictions, in short the limits of forecasting, much earlier than Weick and Mintzberg in "*The Poverty of Historicism*" published as a series of 3 papers in Economica 11 and 12 in 1944 and 1945 before being published as a book in 1957 (Murphy, 2009; Popper, 1957).

[6] In *The Wisdom of the Sands* (*Citadelle*) (1948).

## Uncertainty: an opportunity

> *"Violent and accelerating change, now commonplace, will become the grist of the opportunistic winner's mill. The losers will view such confusion as a "problem" to be "dealt" with."*
>
> (Peters, 1987, p.21)

Oscar Wilde once said that "To expect the unexpected shows a thoroughly modern intellect". He was living, already, in a fast changing world. During his lifetime, great inventions revolutionized life and business: the steam machine that would change transports, the internal combustion machine that would lead to modern cars, the telephone and the telegraph that would ring the bell of telecommunications, electricity and the light buld that would pave the way for everything from the television and the radio to the refrigerator and the curling iron, and many others. Philosophers tell us since long time already that it is useless to try to change the world, we should better enjoy it and take benefit from it as it is. It is part of Nietzsche's line of thought who proposed, with his "*Amor Fati*", not to try to change the world but to love it as it is, to want nothing but what is. For Nietzsche, the world is not a *Cosmos* well ordered, nor natural as for the Ancients, nor constructed by the will of men as for the Moderns. On the contrary, it is a *Chaos*, an irreducible plurality of forces that are constantly confronting each other (Ferry, 2006). And chaos should be seen as a chance: "Chaos is a state of endless variety that is creativity" (Stacey, 1994, p.55). Financial traders have understood that volatility brings value because it increases the likelihood of upsides whereas option pricing tools help them mitigate the risk of downsides. Similarly, volatility offers opportunities to managers by widening the realm of possibilities. Figure 0.1 illustrates this graphically.

Thefore, uncertainty leads to a much wider distribution of possible outcomes[7]; "injecting uncertainty into the system (…) causes an increase of both positive and negative surprises" (Taleb, 2012, p.438).

[7] In mathematical terms, injecting uncertainty changes the probability distribution from a normal (Gaussian) distribution to a Cauchy density function with heavier tails.

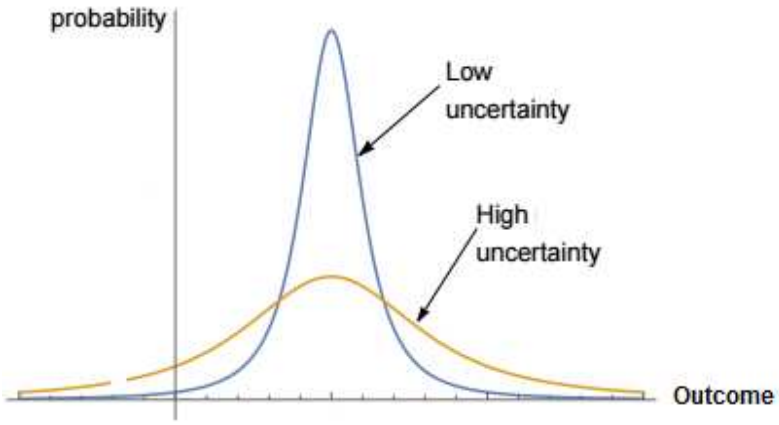



*Figure 0.1: Impact of an increase of uncertainty on probability distribution of possible outcomes* (reproduced from Taleb, 2012, p.438)

As the pace of technological, socioeconomic and regulatory change accelerates, survival depends increasingly on devising entrepreneurial responses to these unforeseen discontinuities (Meyer, Brooks, & Goes, 1990). Managers have to cope with this uncertainty and, instead of trying in vein to predict the unpredictable, they should devise strategies to navigate tough waters, survive stormy weathers, seize opportunities when they arise and, at the same time, protect their organizations against major threats. It is our belief that organizational ambidexterity might offer a frame for such strategies provided that the trade-offs at its core (that will be described further in this dissertation) be properly managed, especially in turbulent environments which volatility functions precisely as an amplifier of these trade-offs (Schmitt, Probst, & Tushman, 2010).

## Main goal of the research

> *"The greatest danger in times of turbulence is not the turbulence, it is to act with yesterday's logic."*
>
> Peter Drucker

As we have seen in the previous chapters, the purpose for a business is not necessarily and solely to grow and make profits, but also, simply, to survive. The world around us is however increasingly volatile, hence uncertain, and this uncertainty leads to unpredictability that makes many actors utterly unable to properly plan their future actions; and the very fact of trying to predict the future does not come without danger. So what can companies do to prepare for their future without forgetting their present activities?

This question emerged from our prior experience as manager and from new insights gathered during our literature survey. As manager, and especially as Managing Director of a sino-western joint venture during seven years, we have often been confronted with the difficulty of aligning short term and long term perspectives. Studying the academic literature on corporate success and failure, especially through an evolutionary lens, we found a relative consensus among authors about the necessity for long-lasting organizations to learn from and adapt to their surroundings, to explore new avenues and exploit existing competencies, to enterprise and at the same time navigate a dynamic environment. This led us naturally to research on organizational ambidexterity, and particularly on the still under-studied aspects of it pertaining to how it can be practically operated in medium-sized organizations often characterized by constrained resources.

Our study therefore intends to address the subject on the basis of a specific and fine-grained analysis answering the following question:

> *How can organizational ambidexterity be operated in medium-sized companies to dynamically adapt to unanticipated environmental changes and increase their survival chances?*

Whereas organizational ambidexterity has been studied through various theoretical lenses (e.g. organizational learning, organizational design, knowledge management, dynamic capabilities) almost exclusively with the help of cross-sectional research design neglecting the influence of time in the conceptualization (Simsek, Heavey, Veiga, & Souder, 2009), our study aims to contribute to the strategic management literature by identifying some new aspects of an evolutionary and dynamic perspective on strategy-making processes (Burgelman, 1991) and by drawing more explicit attention to the simultaneity of multiple layers of these processes within the organizations. The purpose is to investigate how an ambidextrous medium-sized organization highly exposed to a very dynamic environment adapts its exploration-exploitation balance, the crux of organizational ambidexterity, to the varying environmental conditions over time.

With this study, it is our intention to generate new knowledge of academic relevance and pragmatic interest.

## General structure of the thesis

This dissertation defends the thesis that medium-sized companies can implement organizational ambidexterity to dynamically adapt to unanticipated changes in their environment and thereby improve their chances of long-term survival. Our study, mostly of abductive explanatory nature, focuses particularly on finding explanations for the events observed so as to enrich the current view of the manner in which generative mechanisms are activated and underlying processes put to work with regards to contextual conditions.

To introduce the subject and come to our research question, we start by reminding that of importance for managers should not only be profit generation or growth but also, and maybe above all, long term survival. As obvious as it sounds, this dimension is often neglected in academic research whereas it takes on even more significance in the context of increasing uncertainty into which the modern world plunges us. But if this world becomes ever more unpredictable and threatening, it also offers more opportunities.

Then, the core of our work is articulated around three sections according to a rather classic architecture:

- The **first section** contains a **literature review** to identify the main theories and concepts. In this section, we present the origin of organizational ambidexterity and the main methods used to operationalize the construct. We elaborate on the different conceptualizations of the two dimensions that form the construct, i.e. exploration and exploitation, and we review the extant literature pertaining to their interactions with the different aspects of interest for our research question such as long term survival, environmental dynamism and particularly the case of medium-sized enterprises. We conclude this section by highlighting the theoretical gaps that we intend to address and by framing the scope of our study.
- The **second section** details the **design of our research** with respect to our epistemological posture (critical realism), research setting (industrial biotechnology), unit of analysis (the company Galactic) and research methodology (longitudinal case study). We also expose in detail the source of our data and the way they have been treated to feed our analysis.
- In the **third section**, we present and discuss our **results** and we put them into perspective with the intention to generalize what can be. To answer our research question, we have adopted a four-steps approach:
    - As **Step 1**, we look at **the company** (Chapter 3.1) **and its environment** (Chapter 3.2). On the basis of a narrative of the history of the company covering its 25 years of existence, we identify four main epochs characterized by different strategic intents and clear underlying dynamics. For the environment, we first investigate whether it is dynamic and then we confirm its unpredictable nature. We conclude this step by relating the evolution of the company to the major changes in its environment which suggests that it would benefit from a truly ambidextrous organization.
    - In **Step 2**, we **quantify organizational ambidexterity and its components** (exploration intensity and exploitation intensity), and we look at their evolution over time (Chapter 3.3). We also investigate further into different forms of ambidexterity (Chapter 3.4) from a perspective internal to the company (structural ambidexterity) as well as external to the company (network ambidexterity); and we measure which form matters the most and should be

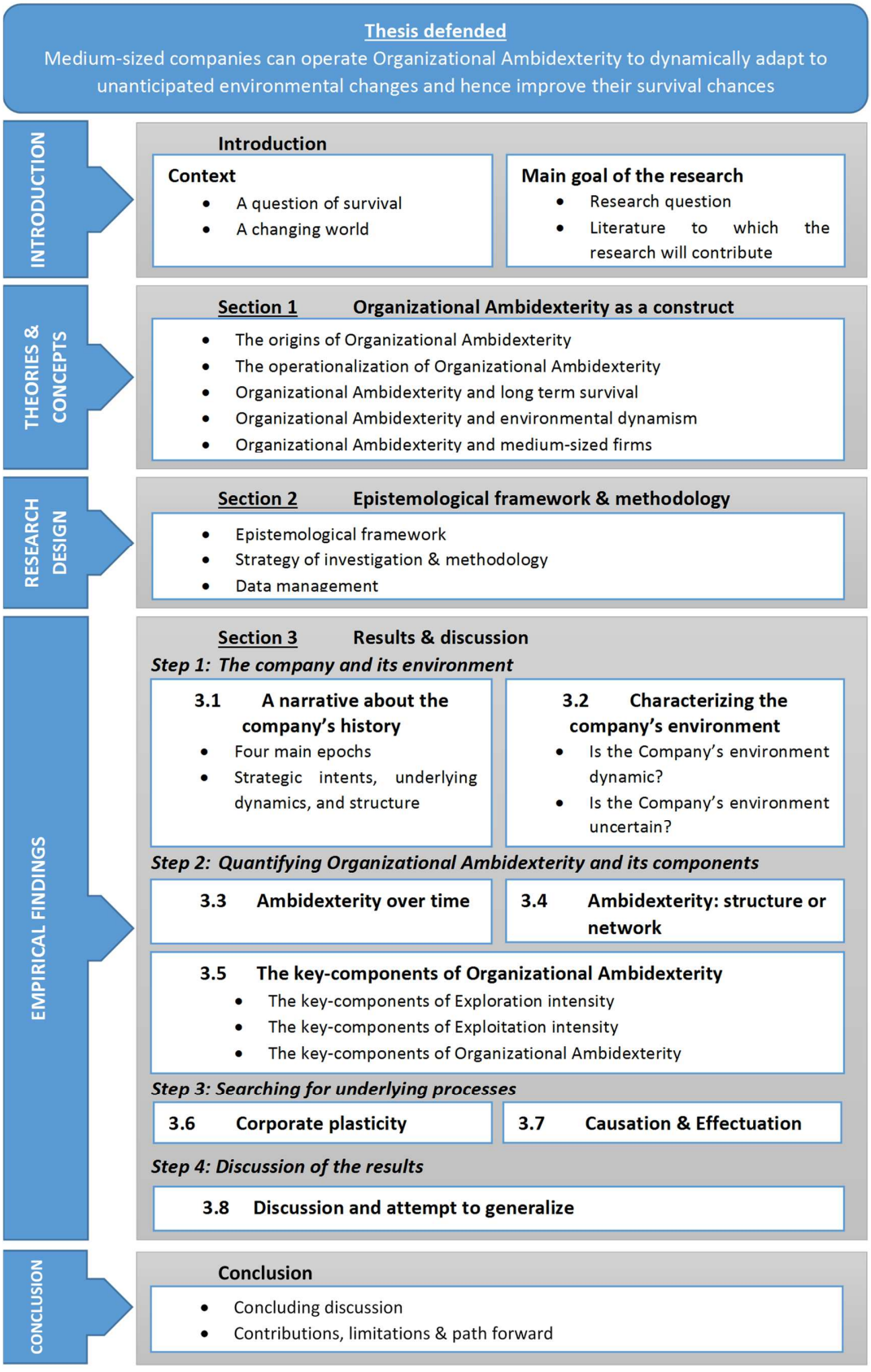
favoured by managers of medium-sized companies in case a trade-off becomes necessary because of constrained resources for instance. In addition, we condense our data in a few simple relationships so as to better let emerge the links between the key-components of organizational ambidexterity and to better measure their respective impacts on three principal indicators, i.e. exploration intensity, exploitation intensity and ambidexterity score. This part enables us to highlight the most relevant elements of an ambidextrous approach applied to SMEs in order to prioritize the actions to be eventually taken by the managers who wish to develop the present activities of their organizations without jeopardizing their chances to survive the long run.

- In **Step 3**, we **search for underlying processes** supporting organizational ambidexterity. We identify and discuss two of these processes. The first one consists to nurture corporate plasticity by combining an organic structure of management at the top of the company with a mechanistic type of organization at the execution level. The second process relies on the combination of a customer-centric effectual approach for projects belonging to short development cycles with a strict stage-gate system resorting to a classical causal logic for projects imbedded in long development cycles.
- Finally, in **Step 4**, we wrap up our results, we put them into perspective and we discuss their generalization to other fields of activity and other domains. We also try to identify what is symptomatic of medium-sized companies and what can be extended to other types of organizations.

Finally, we conclude by highlighting academic contributions, managerial recommendations, limitations, and avenues that remain open for future research.

Attached to our study are also various supporting documents among which an 87 page-long narration of the four main phases (epochs) in the company's development (Appendix II). We chose for this level of detail so as to reconstruct the company's history and identify the internal and external changes that have paved its evolution until now.

The general approach adopted is summarized in a diagram on the next page.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A question of survival
A changing world
Main goal of the research
Research question
Literature to which the research will contribute
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Organizational Ambidexterity and long term survival
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Epistemological framework
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Section 3 Results & discussion
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Is the Company's environment dynamic?
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Step 2: Quantifying Organizational Ambidexterity and its components
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3.5 The key-components of Organizational Ambidexterity
The key-components of Exploration intensity
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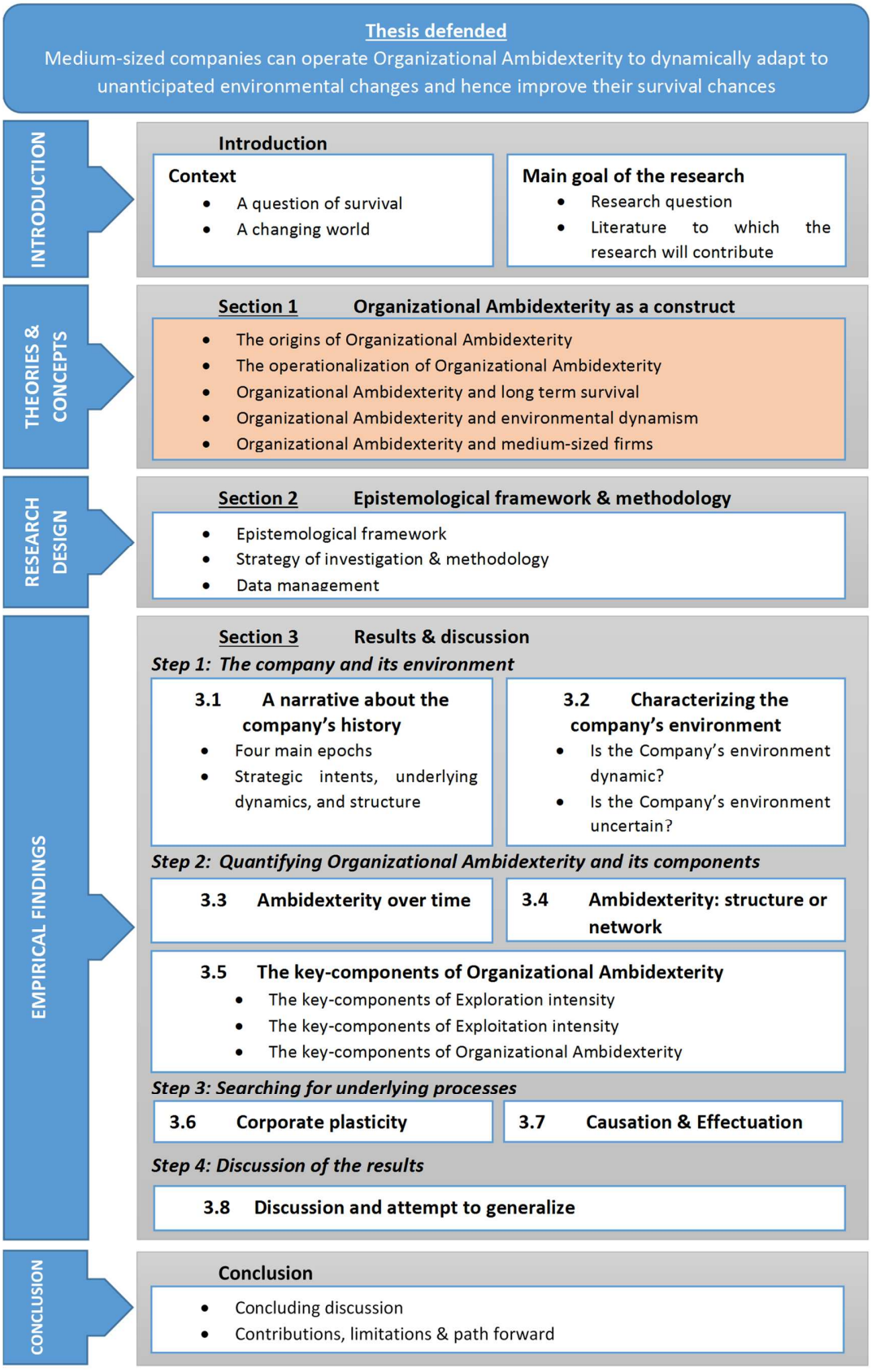
3.7 Causation & Effectuation
Step 4: Discussion of the results
3.8 Discussion and attempt to generalize
CONCLUSION
Conclusion
Concluding discussion
Contributions, limitations & path forward

# Section 1. Organizational ambidexterity as a construct

*"The test of a first-rate intelligence is the ability to hold two opposed ideas in the mind at the same time, and still retain the ability to function."*

F. Scott Fitzgerald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In this section[8], we aim to present the different facets of Organizational ambidexterity as a construct, the different streams that have evolved in researching this concept, as well as some of its peculiar conceptualizations. Setting the scene in this somewhat broad fashion will help us identify, in the qualitative part of our study, the ambidextrous patterns eventually implemented intentionally or unwittingly by the company under review in reaction to changes in its environment and to the ever growing uncertainty in which it operates. We then look at the various methods used to operationalize the construct and to measure its components: exploration and exploitation.

Next, after having reported about the different authors having voiced to bring the concept of organizational ambidexterity back to its fundaments, i.e. developing the capabilities necessary to enable the firms to survive in the face of changed market conditions (O'Reilly & Tushman, 2007), we identify theoretical gaps in the research on the subject matter and we determine avenues for our own research.

## 1.1. The origins of organizational ambidexterity as a construct

Despite its relative novelty, the concept of organizational ambidexterity rooted in March's framework of exploration and exploitation (March, 1991) has drawn substantial interest among scholars and several literature reviews as well as special issues and unplugged thematic series of articles have been published in prominent journals (Birkinshaw & Gupta, 2013; Lavie, Stettner, & Tushman, 2010; O'Reilly & Tushman, 2013; Raisch, Birkinshaw, Probst, & Tushman, 2009). We refer the interested reader to these sources, especially Lavie *et al.* (2010) for a comprehensive overview of the antecedents of exploration and exploitation within and across organizations.

As noted by Birkinshaw and Gupta (2013), organizational ambidexterity is an academic construction and practitioners never use the term which has in fact no intuitive meaning. Hence, they say, "a discussion of the underlying meaning of ambidexterity has to start from theory" (p. 290). Beyond the human trait allowing individuals to use both hands with equal dexterity, the

[8] A summary of this section has been published in French in *Revue Economique et Sociale* in its March 2016 issue under the title:"*Survie à Long Terme dans un Contexte d'Incertitude Croissante: L'Ambidextrie Opérationnelle est-elle la réponse?*" (see Appendix I).

ambidexterity metaphor refers to the ability exhibited by some organizations to exploit existing competencies and explore new opportunities with equal skillfulness.

### *1.1.1. The rise of ambidexterity research*

Research on ambidexterity as an organizational concept has seen a meteoric ascent over the last 10 years (Birkinshaw & Gupta, 2013), it is now viewed as an emerging research paradigm in organizational theory. As such, organizational ambidexterity has taken shape as "a theoretical framework of a scientific school or discipline within which theories, generalizations, and the methods to test them are formulated" (Raisch & Birkinshaw, 2008, p.396) and its genesis is well documented. The purpose of the next section is however not to analyze exhaustively each and every literature stream that has been reported on the subject (e.g., organizational learning, technological innovation, organizational adaptation, strategic management, organization design) but more to account for the main milestones along which the construct evolved and the leading conceptualizations through which organizational ambidexterity can be examined.

March and Simon (1958) posited that organizations can improve their performance by separating units making use of existing successes from those trying to identify new opportunities. Burns and Stalker (1961) argued that "mechanistic management systems" characterized by clear hierarchical relations and well defined responsibilities are more efficient in stable environment whereas less formal "organic systems" perform better in more turbulent conditions. Building on this insight, researchers came to agree that organizations' structures must be aligned with different strategies and environments (Tushman & O'Reilly, 2002). Thompson (1967) asserted that organizational potency relies on a trade-off between efficiency and flexibility that he characterized as a paradox of administration. He argued that efficiency in existing practices is needed for the organization to maintain its competitive advantage, whereas flexibility is necessary to prevent being trapped into obsolete routines and procedures, a situation often described as organizational inertia (Hannan & Freeman, 1984; Volberda, 1996), organizational simplicity (Miller, 1993) or cultural lock-in (Foster & Kaplan, 2001b). Duncan (1976) was the first to coin the term "Ambidextrous Organization" when he advocated for companies to put in place "dual structures" requiring different time perspectives and management capabilities to accommodate simultaneously the conflicting alignments needed for efficiency and innovation.

In 1991, March who had worked previously on bounded rationality (March, 1978) started to look at the duality between efficiency and flexibility from a learning perspective and noted that the main adaptive challenge companies are facing is the need to exploit existing assets and capabilities while, at the same time, they provide for sufficient exploration to adapt to changes in markets and technologies (March, 1991). Following the same knowledge-based view, Levinthal and March (1993) pointed out "the confusing experience and the complicated problem of balancing the competing goals of developing new knowledge (i.e., exploring) and exploiting current competencies in the face of dynamic tendencies to emphasize one or the other" (p.95). They concluded that organizations approach this problem of tradeoff between "exploitation of old certainties" and "exploration of new possibilities" through simplification and specialization which leads to different forms of "learning myopia" and biases. Two decades after Duncan, Tushman and O'Reilly (1996) picked up on the concept of "dual structures" and emphasized structural separation between activities aiming at managing evolutionary (incremental) change and revolutionary (discontinuous) change in simultaneous fashion. That was the emergence of what is now called ***structural*** or ***simultaneous ambidexterity***.

As an extension of their previous work on technological discontinuities, dominant designs (Anderson & Tushman, 1990) and punctuated equilibrium (Romanelli & Tushman, 1994; Tushman & Romanelli, 1985), Tushman and colleagues described an evolutionary pattern contrary to Darwinian evolution theory in which relatively long periods of incremental change are punctuated by short bursts of intense discontinuous change and they concluded with the need to align organizational strategy, structure and culture on the short-term but also to periodically destroy this alignment in order to adapt to environmental shifts in a sequential process (Tushman & O'Reilly, 1996). Time made its entry and gave birth to the concept of "***sequential ambidexterity***" (Geerts, Blindenbach-Driessen, & Gemmel, 2010), a notion again alluded by O'Reilly and Tushman in 2007 (p.192) and a term they later used explicitly (2013, p.327), whereas other authors refered to it more recently as "sequential alternation" (Birkinshaw, Zimmermann, & Raisch, 2016). In this vein, firms have been described to use "rhythmic switching" (Brown & Eisenhardt, 1997) or to "vacillate" (Boumgarden et al., 2012) back and forth between periods of exploration and periods of exploitation. The rationale behind this argument is that it is easier for firms to switch between different formal structures from time to time than to change their organizational culture. It's worth noting however that scholars are not unanimous towards the concept of sequential ambidexterity:

Gupta, Smith and Shalley (2006) for instance consider that ambidexterity refers to the *synchronous* pursuit of exploration and exploitation, whereas temporal differentiation, such as punctuated equilibrium, constitutes a radically different mechanism. They are joined in this viewpoint by Boumdarden, Nickerson and Zenger (2012) who consider that the static approach in which firms adopt ambidextrous organizational structures to balance exploration and exploitation, and the dynamic approach in which firms sequence structures that target either one or the other, are fundamentally distinct; the former being true organizational ambidexterity and the latter being defined as organizational vacillation. Still, both simultaneous and sequential ambidexterity (or punctuated equilibrium or vacillation) strive at resolving the exploration/exploitation dilemma through structural measures.

Then came the year 2004 which marked another turning point in the conceptualization of organizational ambidexterity with Gibson and Birkinshaw (Birkinshaw & Gibson, 2004; Gibson & Birkinshaw, 2004) when they parted from the existing corpus of structural ambidexterity to introduce the notion of ***contextual ambidexterity***, sometimes called "behavioral integration" (Birkinshaw et al., 2016). They argued that a context characterized by a combination of stretch, discipline, support and trust (the four attributes describing organizational context as per Ghoshal and Bartlett (1994)) allows individuals to use their own judgement as to how they divide their time between alignment-oriented and adaptation-oriented activities. Promoting ambidexterity in an organization is no longer only a question of deciding what organizational structure is the most appropriate but becomes also a reflection on how to initiate the right set of stimuli and pressures to motivate people to act in a certain way. It displaces the decision process from a centralized top management team to decentralized sub-units or even to the individual employees themselves. Kauppila (2010) and O'Reilly and Tushman (2013) objected however that, while contextual ambidexterity might well help within a given stable technological regime, it does not consider how to adjust to discontinuous and disruptive environmental changes or to conduct radical forms of exploration or exploitation.

### *1.1.2. New directions and peculiar conceptualizations*

Until the late 90$^{ies}$, most work on exploration and exploitation had focused essentially on the organization level. About at the same time as scholars started to research the impact of

ambidexterity at the sub-unit and individual levels with the contextual ambidexterity, articles about the inter-organizational level started to flourish. Alliance formation and partnerships can be seen as forms of exploration and exploitation (Park, Chen, & Gallager, 2002; Rothaermel & Deeds, 2004) in the sense that exploratory alliances provide opportunities to access new knowledge and investigate new market and technologies (Grant & Baden-Fuller, 2004) while exploitative alliances can be used to make the most of complementary resources and leverage existing competencies across organizational boundaries (Lin et al., 2007; Rothaermel & Deeds, 2004). We will refer to this type of ambidextrous approach hereinafter as ***network ambidexterity***, also sometimes called ***interorganizational ambidexterity*** (Kauppila, 2010).

More recently, scholars have started to investigate the importance of leadership characteristics in the management of contradictions and tradeoffs organizations are facing (De Clercq, Thongpapanl, & Dimov, 2014; Lubatkin, Simsek, Ling, & Veiga, 2006; Smith & Tushman, 2005; Tushman & O'Reilly, 2011; Tushman, Smith, & Binns, 2011; Vaccaro, Jansen, van den Bosch, & Volberda, 2012). Burgelman and Grove (2007, p.965, brackets added) asserted that "corporate longevity depends on matching cycles of autonomous [exploration] and induced [exploitation] strategy processes to different forms of strategic dynamics, and that the role of alert strategic leadership is to appropriately balance the induced and autonomous processes", with 'strategic leadership' defined as "how top management designs the strategy-making process" (p.967). Building on this insight, Laplume and Dass (2009) suggested the concept of ***adaptive ambidexterity***, which relates to a mixed form of simultaneous ambidexterity and sequential ambidexterity to dynamically adapt the balance of exploration and exploitation to organizational and contextual circumstances over time. More recently, Luger (2014) introduced the same concept under the term ***dynamic ambidexterity*** which he described as the firm's ability to align its exploration-exploitation balance over time with the environment's shifting demands, while constantly maintaining the two activities in order to capture their synergistic qualities. He explained that "while static ambidexterity is focused on operating at a given intermediate point on the exploration-exploitation continuum, dynamic ambidexterity enables the firm to adjust this point in response to changing environmental requirements" (p.33). Tushman *et al.*, in an article explicitly titled "The Ambidextrous CEO" (2011), contended that decisions about the firm's present and future must be made at the senior-executive level and they propose different approaches to holding the tensions at the top. This perspective highlights the role of senior teams in shaping competitive advantage over time

(O'Reilly & Tushman, 2007). Actually, the ability of senior managers to seize opportunities through integration and coordination of both existing and new assets to overcome inertia and path dependencies is at the core of ***dynamic capabilities***, defined as "the firm's ability to integrate, build, and reconfigure internal and external competencies to address rapidly changing environments" (Teece, Pisano, & Shuen, 1999, p.516). This ability of the firm to "synthetize and apply current and acquired knowledge" has also sometimes been referred to as "combinative capabilities" (Kogut & Zander, 1992, p.384) or "architectural competence" (Henderson & Cockburn, 1994). As stressed out by Raisch and his colleagues (2009), organizational ambidexterity implies therefore the managerial challenge not only to balance exploration and exploitation but also to integrate internal and external knowledge. Considering organizational ambidexterity implicitly (Eisenhardt & Martin, 2000) or explicitly (O'Reilly & Tushman, 2007) as a dynamic capability essentially in the hands of the senior management team may help organizations to substitute an external selection environment in which wrong choices lead to firm failure with an internal selection process that allows local failure without the destruction of the whole organization (Burgelman, 2002). It is worth noting however that, while some authors focus primarily on the role of the Top Management Teams (Lubatkin et al., 2006; O'Reilly & Tushman, 2007; Sidhu, Volberda, & Commandeur, 2004; Volberda, Van Den Bosch & Heij, 2013), others like Burgelman and Grove (2007) acknowledge that autonomous processes may also be informal and decentralized and may come about by the efforts of middle-managers seeking to divert resources to new businesses to replace their own obsolescing ones. In short, top management could be regarded as the main driver of discontinuous or radical change, whereas middle management may be expected to enact incremental change (Raisch & Birkinshaw, 2008).

Other peculiar forms or variants of ambidexterity have been reported. Let's just cite a few such as peripatric ambidexterity (a form of punctuated ambidexterity in which the top management or founding team is replaced when the company is changing its focus from exploitation to exploration and vice versa) (Prange & Schlegelmilch, 2009), or reciprocal ambidexterity (a form of structural ambidexterity that assumes a reciprocal interdependence between sub-units performing exploitation and exploration in which the outputs of exploitation from unit A become the inputs for exploration by unit B and vice versa) (Simsek et al., 2009).

These various conceptualization patterns illustrate that organizations are facing very different situations which undoubtedly impact the intensity of exploration and exploitation needed and the way to achieve ambidexterity. For instance, a sequential approach may be more adapted to stable environments (Geerts et al., 2010), whereas simultaneous ambidexterity may be more appropriate in turbulent markets (O'Reilly & Tushman, 2013). Similarly, a contextual approach is presumably well adapted to support and enhance incremental innovation at a local level but might be difficult to manage efficiently while facing disruptive technological changes (O'Reilly & Tushman, 2013). In addition, it seems conspicuous that organizations may actually be implementing different forms of ambidexterity at different levels, i.e. local level, intra-firm level and inter-firm level, concomitantly (Kauppila, 2010).

### *1.1.3. The ambiguity of the construct and the need to refocus*

Despite the fact that most studies on the subject refer to exploitation and exploration, scholars have started to encompass in the ambidexterity framework many different conceptualizations as long as they are related to opposed, polarized and sometimes conflicting capabilities or traits: operational tasks vs. strategic tasks, implementation vs. initiation, evolutionary change vs. revolutionary change, efficiency vs. flexibility to name a few (refer to Table 1.1 for a more complete list). This situation has led to considerable ambiguity regarding the theoretical nature of the construct itself (Cao, Gedajlovic, & Zhang, 2009; O'Reilly & Tushman, 2013); it has contributed to a lack of consistency in theory building (Simsek et al., 2009) and a lack of clarity in meaning and measurement (Birkinshaw & Gupta, 2013).

There is a need therefore to come back to March's very conception of balancing exploration and exploitation to ensure organization's long term viability (Lavie et al., 2010; O'Reilly & Tushman, 2013) and, by doing so, avoid "devolving into a catch-all phrase applied to a smorgasbord of organizational topics" (O'Reilly & Tushman, 2013, p.334).

*Table 1.1: Sample of prominent publications and the explorative and exploitative aspects they oppose.*

| Reference | Year | Exploitative aspect | Explorative aspect | Type of study |
|---|---|---|---|---|
| Ansoff & Brandenburg, 1971 | 1971 | Operational tasks | Strategic tasks | Conceptual |
| Duncan, 1976 | 1976 | Implementation | Initiation | Conceptual |
| March, 1991 | 1991 | Exploitation | Exploration | Theoretical |
| Tushman & O'Reilly, 1996 | 1996 | Evolutionary change | Revolutionary change | Conceptual |
| Adler, Goldoftas & Levine, 1999 | 1999 | Efficiency | Flexibility | Empirical |
| Kogut & Kulatilaka, 2001 | 2001 | Exploitation | Exploration | Conceptual |
| Katila & Ahuja, 2002 | 2002 | Search depth | Search scope | Empirical |
| Rothaermel & Deeds, 2004 | 2004 | Exploitation | Exploration | Empirical |
| Kyriakopoulos & Moorman, 2004 | 2004 | Exploitation | Exploration | Empirical |
| Gibson & Birkinshaw, 2004 | 2004 | Alignment | Adaptability | Empirical |
| He & Wong, 2004 | 2004 | Exploitative innovation | Exploratory innovation | Empirical |
| Sidhu, Volberda & Commandeur, 2004 | 2004 | Local search | Boundary-spanning exploration | Empirical |
| Chen, 2005 | 2005 | Exploitation | Exploration | Theoretical |
| Jansen, Van den Bosch & Volberda, 2005 | 2005 | Exploitative innovation | Exploratory innovation | Empirical |
| Atuahene-Gima, 2005 | 2005 | Competence exploitation | Competence exploration | Empirical |
| Han, 2005 | 2005 | Pro-profit strategy | Pro-growth strategy | Empirical |
| Chanal & Mothe, 2005 | 2005 | Exploitation | Exploration | Empirical |
| Smith & Tushman (2005) | 2005 | Cognitive integration | Cognitive differentiation | Theoretical |
| Lavie & Rosenkopf, 2006 | 2006 | Exploitation | Exploration | Empirical |
| Lubatkin, Simsek, Lin & Veiga, 2006 | 2006 | Exploitation | Exploration | Empirical |
| Hill & Birkinshaw, 2006 | 2006 | Exploitation | Exploration | Empirical |
| Jansen, Van den Bosch & Volberda, 2006 | 2006 | Exploitative innovation | Exploratory innovation | Empirical |
| Bierly & Daly, 2007 | 2007 | Exploitation | Exploration | Empirical |
| Lin, Yang & Demirkan, 2007 | 2007 | Exploitation | Exploration | Empirical |
| Tiwana, Bharadwaj & Sambamurthy, 2007 | 2007 | Alignment | Adaptability | Empirical |
| Andersen & Nielsen, 2007 | 2007 | Centralized strategy processes | Decentralized strategy processes | Empirical |
| Tarafdar & Gordon, 2007 | 2007 | Operational excellence | Strategic vision | Empirical |
| Swart & Kinnie, 2007 | 2007 | Exploitative learning | Exploratory learning | Empirical |
| Burgelman & Grove, 2007 | 2007 | Induced strategy process | Autonomous strategy process | Empirical |
| Menguc & Auh, 2008 | 2008 | Exploitation | Exploration | Empirical |
| Jansen, George, Van den Bosch & Volberda, 2008 | 2008 | Exploitation | Exploration | Empirical |
| Morgan & Berthon, 2008 | 2008 | Exploitation | Exploration | Empirical |
| Tiwana, 2008 | 2008 | Strong ties | Bridging ties | Empirical |
| Im & Rai, 2008 | 2008 | Exploitative knowledge sharing | Exploratory knowledge sharing | Empirical |
| Brion, Mothe & Sabatier, 2008 | 2008 | Exploitative innovation | Exploratory innovation | Empirical |
| Rothaermel & Alexandre, 2009 | 2009 | Exploitation | Exploration | Empirical |
| Mom, Van den Bosch & Volberda, 2009 | 2009 | Exploitation | Exploration | Empirical |
| Jansen, Tempelaar, Van den Bosch & Volberda, 2009 | 2009 | Exploitation | Exploration | Empirical |
| Cao, Gedajlovic & Zhang, 2009 | 2009 | Exploitation | Exploration | Empirical |
| Kollmann, Kuckertz & Stöckmann, 2009 | 2009 | Exploitation | Exploration | Theoretical |
| Prange & Schlegelmilch, 2009 | 2009 | Exploitation | Exploration | Empirical |
| Kim & Rhee, 2009 | 2009 | Exploitation | Exploration | Empirical |
| Cao, Simsek & Zhang, 2010 | 2010 | Exploitation | Exploration | Empirical |
| Tushman, Smith, Wood, Westerman & O'Reilly, 2010 | 2010 | Exploitation | Exploration | Empirical |
| Laplume & Dass, 2009; Laplume, 2010 | 2010 | Exploitation | Exploration | Empirical |
| Brion, Mothe & Sabatier, 2010 | 2010 | Short-term organizational focus | Long-term organizational focus | Empirical |
| O'Reilly & Tushman, 2011 | 2011 | Exploitation | Exploration | Empirical |
| Patel, Messersmith & Lepak, 2012 | 2012 | Exploitation | Exploration | Empirical |
| Jansen, Simsek & Cao, 2012 | 2012 | Exploitation | Exploration | Empirical |
| Fernhaber & Patel, 2012 | 2012 | Exploitation | Exploration | Empirical |
| Boumgarden, Nickerson & Zenger, 2012 | 2012 | Exploitation | Exploration | Empirical |
| Voss & Voss, 2012 | 2012 | Exploitation | Exploration | Empirical |
| Dupouët, Bouzdine-Chameeva & Lackshman, 2013 | 2013 | Exploitation | Exploration | Empirical |
| Cummings, 2013 | 2013 | Alliances with repeat partners | Alliances with new partners | Empirical |
| Junni, Sarala, Taras & Tarba, 2013 | 2013 | Exploitation | Exploration | Empirical |
| Ming, 2014 | 2014 | Exploitation | Exploration | Empirical |

## 1.2. Operationalization of the ambidexterity construct

### *1.2.1. Apollo and Dionysus*

Every organization is a bundle of conflicts, oppositions, tensions, counteracting forces, contrasts and contradictions, hence dualities and paradoxes have long been of great interest for organization theorists. Among the numerous ambivalent characteristics of organizations, a central and recurring theme is the importance and difficulty to accommodate with stability and change (Cummings, 2013), with order and chaos (Forgues & Thietart, 1995).

In Greek mythology, Apollo and Dionysus are brothers, both sons of Zeus. For pre-Socratic philosophers Apollo represented measure, reason, rationality, craft and order, whereas Dionysus stood for excess, chaos, the irrational, "the force that gives seminal power to the continuation of life" (Taleb, 2012, p.256). A parallel comes to light with March's definition of [the Apollonian] exploitation as "refinement, choice, production, efficiency, selection, implementation and execution" contrasting with [the Dionysian] exploration which involves "search, variation, risk-taking, experimentation, play, flexibility, discovery, and innovation" (March, 1991, p.71). As a further matter, the concept of "creative destruction", developed by Karl Marx and Werner Sombart (Reinert & Reinert, 2006) and popularized by Joseph Schumpeter (1942) as a theory of economic innovation and business cycle can be considered either as an antecedent or as a product of exploration (Abernathy & Clark, 1985; Foster & Kaplan, 2001b). It was actually Nietzsche who first coined the term with reference to Dionysus whom he considered "creatively destructive" and "destructively creative" (Nietzsche, 1886; Taleb, 2012, p.256).

Interestingly, ancient Greek culture was not contemplating Apollo and Dionysus as opposites or rivals, at least until the influence of Socrates' rationalism, but rather as two interlaced and complementary forces. Several authors conceptualize organizational ambidexterity in a similar fashion, considering that exploitation and exploration are not mutually exclusive but additive or multiplicative dimensions by nature (Gibson & Birkinshaw, 2004; He & Wong, 2004; Jansen, Van Den Bosch, & Volberda, 2006; Lubatkin et al., 2006). For these authors, exploration and exploitation are independent activities, orthogonal to each other (Fig. 2.1a). They have both to be maximized and an ambidextrous organization is one that has the capacity to ***combine*** high levels of the two activities concurrently (Brion et al., 2008; Gupta et al., 2006; Lavie & Rosenkopf, 2006).

To support the argument that exploration and exploitation may not be conflicting dimensions, Gupta *et al.* (2006) indicate for instance that exploration and exploitation may take place in complementing domains, e.g. R&D and marketing, that do not necessarily compete for the same resources. Accordingly, Lavie and Rosenkopf (2006) explain that alliances can be used for exploring and exploiting simultaneously in different domains. Going further than considering that exploration and exploitation may not be necessarily in competition, some authors defend that the two dimensions have actually a positive reinforcing effect on each other, i.e. that "a high degree of exploitative effort can often improve a firm's effectiveness in exploring new knowledge" and, in an analogous manner, that "proficiency in a firm's exploratory processes can also enhance its ability to engage in successful exploitation" (Cao, Gedajlovic, & Zhang, 2009, p.784).

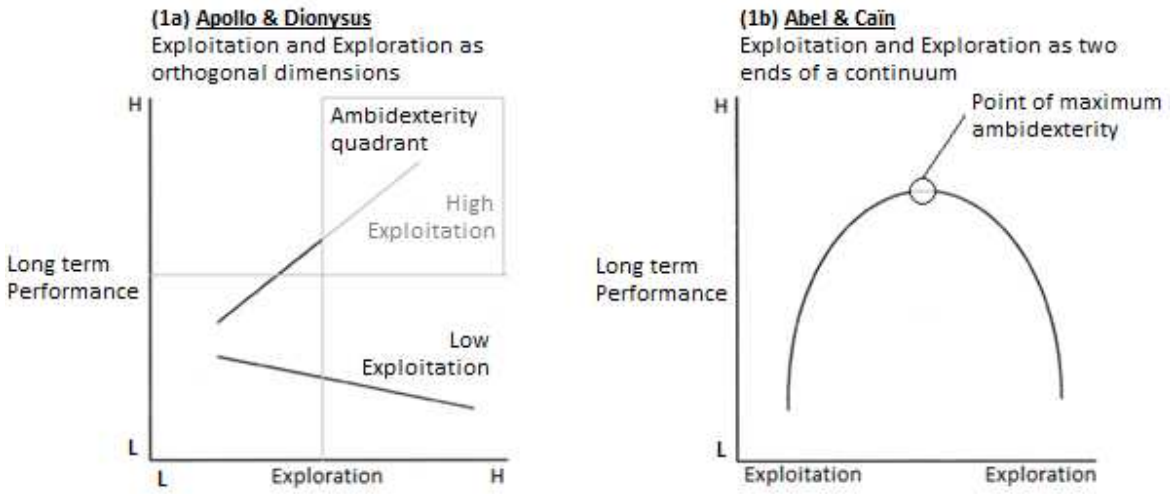



*Figure 1.1: The two conceptualizations of Exploration and Exploitation: Opposite orthogonal dimensions versus two ends of a continuum* (reproduced from Gupta et al., 2006)

In this view of combining exploration and exploitation, organizational ambidexterity is operationalized either as the sum (Brion et al., 2008; Laplume & Dass, 2009; Lubatkin et al., 2006) or as the product (Gibson & Birkinshaw, 2004; He & Wong, 2004) of the two dimensions (respectively represented by A + B and A x B in Table 1.2).

Table 1.2 lists several empirical studies and describes, when applicable, the method used to operationalize organizational ambidexterity. Insofar as it is relevant, it seems that multiplying the two dimensions is more often used (15 studies) than adding those (6 studies).

### *1.2.2. Abel and Caïn*

Other authors however believe that the two dimensions are mutually exclusive (Auh & Menguc, 2005; March, 1991; Simsek, Heavey, Veiga, & Souder, 2009; Smith & Tushman, 2005) in that they compete for the same resources within an organization, i.e. budgets and people, and produce divergent organizational outcomes because the returns from exploration are "systematically less certain, more remote in time and organizationally more distant from the locus of action" than the returns from exploitation (March, 1991, p.73). The mythological metaphor no longer applies and we propose a biblical one with two other brothers, Abel and Caïn, sons of Adam and Eve. According to the Book of Genesis, Caïn killed his brother out of jealousy because God favored Abel over him.

Following this school of thought, exploration and exploitation stand at the two ends of a continuum (Lavie et al., 2010) and there exists a tradeoff between the two dimensions within organizations which can be modelled as an inverted U-shaped curvilinear relationship with organizational performance (Figure 1.1b) (Laplume & Dass, 2009; Laplume, 2010). Managing this tradeoff accrue to find an appropriate ***balance*** between exploration and exploitation and a firm is regarded as ambidextrous if it has relatively equal emphasis on both dimensions.

To operationalize this balance, He and Wong (2004) proposed to take the absolute difference between the scores measured separately for exploration and exploitation (symbolized by |A – B| in Table 1.2). Their results showed that the relative imbalance between both dimensions is negatively related to firm performance (evidenced by its sales growth rate). They also concluded that low levels of both exploration and exploitation may not contribute to superior firm performance and that such firms should therefore not be regarded as ambidextrous. Detractors generally oppose to this balancing view the organizational coordination and communication costs involved in balancing the conflicting goals of exploration and exploitation but Cao *et al.* found that seeking for a balance ("Abel & Caïn" view) is more beneficial to resource-constrained firms, whereas striving for a

combination ("Apollo & Dionysus" view) improves the performances of firms having a better access to internal and external resources (Cao et al., 2009). These results suggest that managers operating in contexts characterized by scarce resources may benefit from a focus on managing tradeoffs between exploration and exploitation demands instead of trying to maximize one dimension at the expense of the other.

Indeed, when a company's exploration activity significantly outweighs its exploitation efforts, newly acquired knowledge may not be adequately absorbed and processed through existing knowledge. Similarly, when the level of exploration of a company is much lower than that of exploitation, less new knowledge is brought to the firm which may limit the impact of its exploitation on performance (Cao et al., 2009).

### *1.2.3. Measuring Exploration and Exploitation*

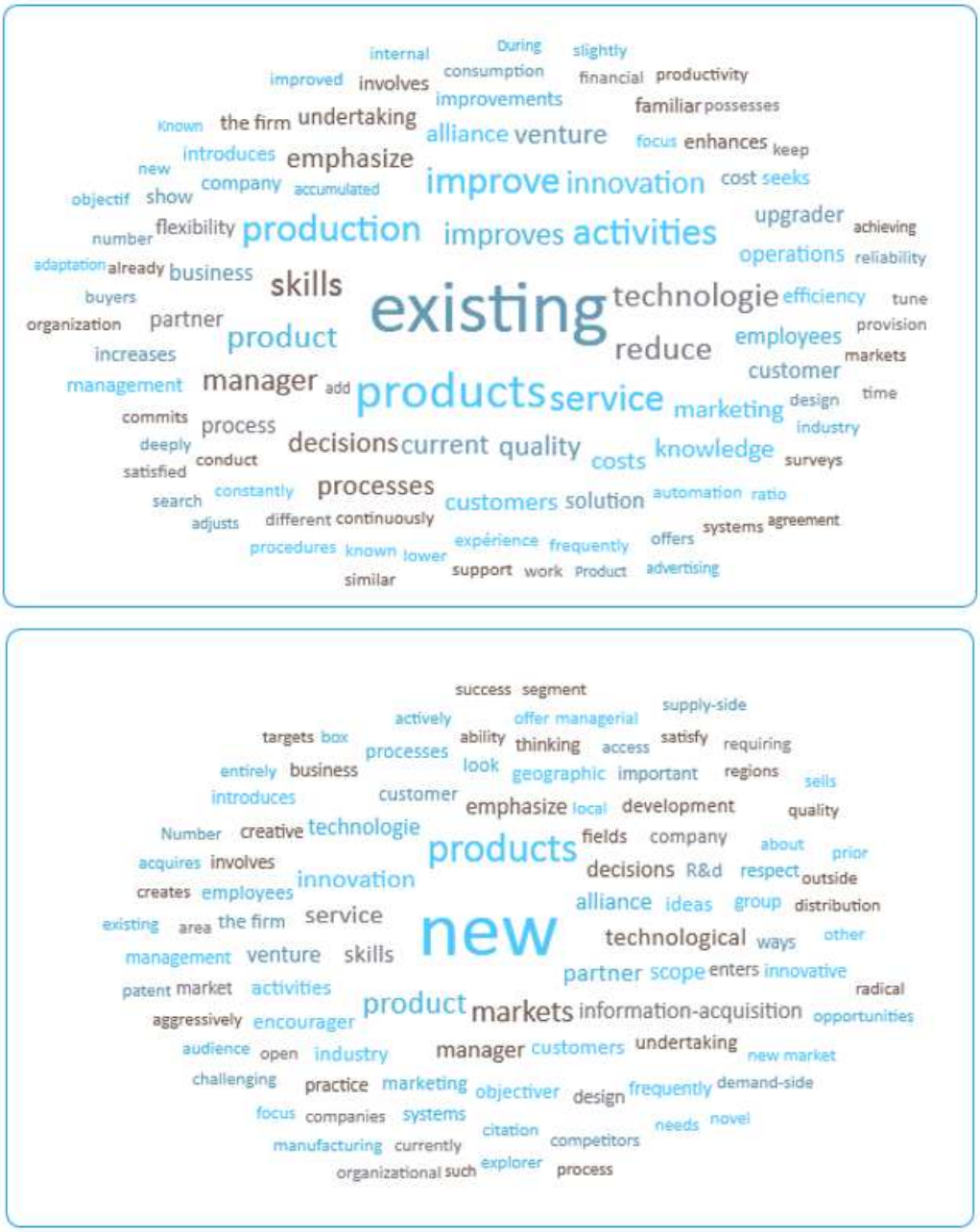
Several methods have been applied to the measure of the two dimensions. Among these, probably the most commonly used consists of questionnaires with Likert scales by which respondents assess by themselves the level of adequacy of the proposed answer with the question asked (Table 1.2). In addition to the question of reliability and accuracy of methods based on self-perception, this approach only allows an instantaneous weighing that does not capture the temporal dynamics of organizational ambidexterity.

Other studies rely on quantitative mesurements of different criterias such as the occurrence of keywords, patents (Andriopoulos & Lewis, 2009), new versus existing products or designs (Piao, 2014), or financial indicators (He & Wong, 2004; Junni et al., 2013) such as profit, sales or other return-based performance parameters (return on assets, return on equity, return on investment, return on capital employed). Counting words out of various documents eventually published by the company (e.g. financial statements and announcements) present the problem of selecting the keywords among many synonyms that make the richness of the language and limits the search to one language only even if the company operates in several geographies. As an example, Figure 1.2 shows the variety of words related to exploration and exploitation in only 25 questionnaires published *in extenso* in literature[9]. Moreover, here again, these methods offer a snapshot of the

[9] See Table 2.4 in Section 2.4.2 for the list of papers.

situation at a given moment in time. The evolution of the parameters measured gives of course an idea of how organizational ambidexterity develops over time but this analysis remains restricted to a few indicators and does not present a comprehensive holistical measure of the matter. Moreover, methods based on financials are generally backward-looking in the sense that these indicators somewhat reflect the situation as a result of past decisions or actions. To circumvent this problem, some authors have used Tobin's Q ratio to capture both short-term and long-term effects of exploration and exploitation (Goossen, Bazzazian, & Phelps, 2012; Junni et al., 2013). The numerator, the market capitalization of the company, comprises all expected future cash flows; whereas the denominator includes the company's asset value. It hypothesizes that the combined market value of the companies on the stock market should be about equal to their replacement costs. The first issue with this ratio is that it is limited to stock-listed companies. The second issue is that the hypothesis holds at the scale of the stock market, for very large numbers of companies. The third issue lies in the fact that assuming that market capitalization incorporates all expected future cash flows relies on the assumption that markets are efficient, a highly controversial and often disputed hypothesis (Shiller, 2003).

A different approach to measuring exploration and exploitation is actually not to measure the two dimensions but to model their evolution with the help of computer simulations (Laplume & Dass, 2009; Lin et al., 2007; Siggelkow & Levinthal, 2003). Powerful as it can be, this approach limits the analysis to the equations used for the simulations, often agent-based models, considering the usual conditions of *ceteris paribus* (i.e. all other things remaining the same) and, here again, assuming that agents behave rationally.




*<u>Figure 1.2:</u> Word clouds related to Exploitation (above) and Exploration (below) from the questionnaires of 20 studies published in literature* (obtained with Sphinx iQ2 software).

*<u>Table 1.2:</u> Empirical studies on explorative and exploitative aspects and the methods used to operationalize organizational ambidexterity*

(A and B represent arbitrarily the explorative and the exploitative aspects)

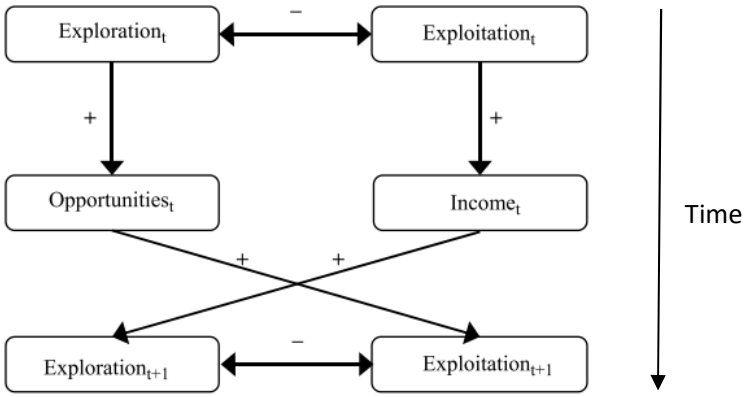
| Reference | Level of analysi | Sector | Method | Sample | Measure of Exploitative aspec | Measure of Explorative asp | Measure of Ambidexteri |
|---|---|---|---|---|---|---|---|
| Gibson & Birkinshaw, 2004 | Business unit | Various | Survey + interviews | 41 BU's from 10 MNC's | Likert-scale items | Likert-scale items | A x B |
| He & Wong, 2004 | Firm | Manufacturing | Survey + interviews | 206 firms | Likert-scale items | Likert-scale items | A x B and \|A-B\| |
| Lubatkin, Simsek, Lin & Veiga, 2006 | Firm | | Survey | 139 SME's | | | A + B |
| Hill & Birkinshaw, 2006 | Corporate venture units | | Survey | 95 corporate venture units | | | A x B |
| Lin, Yang & Demirkan, 2007 | Alliance | Various | Archival study + simulation | 95 companies in 5 US industr | (1 - Exploration index) | Exploration index = Total of new alliance partners / Total of all alliance partners | \|A - B\| |
| Jansen, George, Van den Bosch & Volberda, 2008 | Business unit | Financial services | Survey | 89 branches | | | A x B |
| Morgan & Berthon, 2008 | Firm | | | | | | A x B |
| Tiwana, 2008 | Alliance | | Survey | 42 project alliances | | | A x B |
| Im & Rai, 2008 | Inter-organization | | Survey | | | | A x B |
| Brion, Mothe & Sabatier, 2008 | Firm | Various | Survey | 307 firms | Likert-scale items (based on He & Wong, 2004; Lubatkin *et al.*, 2006) | Likert-scale items (based on He & Wong, 2004; Lubatkin *et al.*, 2006) | A + B |
| Rothaermel & Alexandre, 2009 | Firm | | | | | | \|A - B\| |
| Mom, Van den Bosch & Volberda, 2009 | Individual | | | | | | A x B |
| Jansen, Tempelaar, Van den Bosch & Volberda, 200 | Firm | | | | | | A + B |
| Cao, Gedajlovic & Zhang, 2009 | Firm | High technologies | Survey | 122 SME's in China | Likert-scale items | Likert-scale items | A x B and \|A-B\| |
| Cao, Simsek & Zhang, 2010 | Firm | | | | | | A + B |
| Tushman, Smith, Wood, Westerman & O'Reilly, 2010 | Firm & Business unit | | | | | | A x B |
| Laplume & Dass, 2009; Laplume, 2010 | Firm | n.a. | Simulation | n.a. | Depth of knowledge a firm attains in a given dimension of its knowledge | Number of dimensions in a firm's knowledge structure | A + B |
| Brion, Mothe & Sabatier, 2010 | Firm | Various | Survey + interviews | 108 large French firms | Performance management & formalization (4-item Likert scale each) | Creativity & risk-taking (4-item Likert scale each) | A x B |
| Jansen, Simsek & Cao, 2012 | Business unit | | | | | | A x B |
| Fernhaber & Patel, 2012 | Firm | | | | | | \|A - B\| |
| Boumgarden, Nickerson & Zenger, 2012 | Firm & Business unit | | | | | | \|A - B\| |
| Voss & Voss, 2012 | Firm | Non-profit professional | Survey | 173 theaters in the US | Product exploitation & Market exploitation (3 items scale for each) | Product exploration & Market exploration (3 items scale for each) | A x B |
| Cummings, 2013 | Alliance | Motion picture industry | Archival study | 490 films produced by 285 companies | Film production companies with only repeat partners | Film production companies with only new partners | continuous |
| Junni, Sarala, Taras & Tarba, 2013 | Various | Various | Meta-analysis | 17 studies on impact of ER or ET; 52 studies on impact of ER and ET | Various | Various | A x B; A + B; \|A - B\|; continuous |
| Ming, 2014 | Firm | Hard disk drive (HDD) industry | Survey | 98 firms | Number of existing designs produced by the firm in a year | Number of new existing designs first introduced by the firm in a year | A x B |

### *1.2.4. Reconciling the brothers or the paradox of Exploration and Exploitation*

Organizations make conscious choices to support exploitation or exploration activities by allocating resources, thereby facing tradeoffs as in all cases those resources are finite (Park et al., 2002). By supporting the improvement of existing technologies and current competencies instead of developing new skills and capabilities, organizations achieve immediate reliability at the future risk of becoming outdated (Leonard-Barton, 1992). Likewise, by investing resources in the search of new knowledge at the expense of the upgrade of available knowledge, organizations trade off short-term productivity for long-term survival (March & Simon, 1958). The problem is central as it comes down to "deciding whether the present should be hedged for the future" (Lavie et al., 2010, p.116), but the problem is also delicate as tradeoffs undoubtedly generate tensions, and the effectiveness in managing these tensions impacts the very survival propensity of the whole organization.

Indeed, according to Barnard (1938), few organizations survive among innumerable failures because successful cooperation in organizations is the abnormal condition. The norm in human history, according to him, is faulty cooperation, disorganization, disintegration and the destruction of the organization. In line with this view, Selznick (1957) contends that organizational rivalry may be the most important, perennial problem in organizational life because it threatens the unity of the enterprise. Poor cooperation and ill-managed rivalry may cause the organization's disbanding.

However, when properly managed, the tradeoffs between exploration and exploitation tend to strengthen the relationship between these activities on the long run despite the tensions they might induce at any given moment in time (Brown & Eisenhardt, 1997). Indeed, as summarized in Figure 1.3, exploitation produces income that can be used to spur future exploration while exploration triggers opportunities that the organization can later exploit to generate a new stream of income (Lavie et al., 2010).




*<u>Figure 1.3:</u> The paradox of Exploration and Exploitation competing for resources but stiffening each other over time* (reproduced from Lavie et al., 2010, p.117)

Going further than showing a long term synergy between exploration and exploitation, Cao, Gedajlovic and Zhang (2009) showed in their study of 122 China-based small- and medium-sized private high-tech enterprises that ***simultaneously combining*** the two dimensions ***and balancing*** them positively impacts firm performance (measured by a mix of sales growth, profit growth, market share growth, operational efficiency, cash flow and market reputation). In other words, there seems to be a synergistic effect from achieving high levels of both balancing and combining exploration and exploitation activities because it provides a greater base for the firm to take advantage of its existing and new competencies, and it brings more opportunities to leverage knowledge and resources across activities.

Hence, as Gupta, Smith and Shalley concluded (2006, p.697): "we do not believe that a universal argument can be made in favor of either continuity or orthogonality. The relationship between exploration and exploitation depends very much on whether the two compete for scarce resources and whether or not the analysis focuses on a single or on multiple domains". They argued that within a single domain (i.e., <u>one</u> individual or <u>one</u> subsystem), both dimensions are generally mutually exclusive (two ends of a continuum, our "Abel and Caïn" perspective); whereas they are orthogonal (our "Apolo and Dionysus" perspective) across different and loosely coupled domains (i.e., individual<u>s</u> or subsystem<u>s</u>) so that high levels of one dimension may coexist with high levels of the other dimension in another domain.

## 1.3. Organizational ambidexterity and long term survival

> *"I returned, and saw under the sun, that the race is not to the swift, nor the battle to the strong, neither yet bread to the wise, nor yet riches to men of understanding, nor yet favour to men of skill; but time and chance happeneth to them all."*
>
> Ecclesiastes 9:11
> (King James Version)

### *1.3.1. Organizational ambidexterity and long term survival*

A McKinsey study of the life expectancy of firms in the S&P 500 showed that their average lifespan was 90 years in 1935, and that it had dropped to 30 years in 1975. The authors estimated it to be only 15 years by 2005 (Foster & Kaplan, 2001). In a more recent study, one of the same authors predicted that, at the current churn rate, 75% of the S&P 500 firms in 2011 will be replaced in 2027 by new firms entering the index (Foster, 2012). Similarly, the average half time of a business competency has dropped from 30 years in 1984 to 5 years in 2014 (Ismail, Malone, & Van Geest, 2014). In their study of the largest American manufacturing firms of the 20th century, Louca and Mendonca (2002) reported that out of the 266 companies that were existing in 1917, only 28 remained alive by 1997. And, likewise, of the top 100 U.S.-based industrial companies listed in *Fortune* magazine in 1965, only 19 remained in this top ranking in 2005 (Burgelman & Grove, 2007). It is even worse for SMEs whose population changes constantly, with many new businesses being born every year and many ceasing to operate. In particular young and small firms show high mortality rates as they are generally less resilient to crisis, they are more fragile financially with more restructions to access fundings, and they rely much more on domestic economic growth than do major companies with international operations. Yet, companies who survive the first years of existence are not "off the hook" and their survival remains at risk. During the last financial crisis for instance, the number of firms with 10 to 250 employees has decreased much more sharply in Europe than has the number of large companies, while the number of micro enterprises with less than 10 employees has remained relatively stable (Vetter & Köhler, 2014). Hence, medium-sized companies who have usually passed the first years of existence as micro-enterprises and have succeeded to grow nevertheless endure difficulties to survive on the longer run.

There are many observations of this kind, they support the ecological contention that organizations increasingly endure inertia as they age (Hannan & Freeman, 1984; Winter, 1964), as they suffer from path dependencies (Leonard-Barton, 1992; Teece et al., 1999) and as they become unable to change (Lavie, 2006; Leonard-Barton, 1992; Miller, 1993; Volberda, 1996). Dew and colleagues even came to conclude cynically that "the strategic manager's job is in fact futile in the face of environmental disruption" (Dew, Goldfarb, & Sarasvathy, 2006).

As noted above, many researchers have attempted to better understand the organizational causes of success and failure, and most of them acknowledged that exploring new avenues *and* exploiting existing competencies is, among other elements, necessary to cope with changes in organizational environment. To cite a few: "Maintaining an appropriate balance between exploration and exploitation is a primary factor in system survival" said March (1991, p.71); "different nonlinear strategic dynamics situations require different balances of induced [exploitation] and autonomous [exploration] strategy processes, and the balanced cycles of these processes are at the heart of corporate longevity" Burgelman and Grove argued (2007, p.967, brackets added); and Levinthal and March (Levinthal & March, 1993, p.105) claimed that "survival requires a balance, and the precise mix of exploitation and exploration that is optimal (…)". The implicit assumption that organizational ambidexterity is necessary for long-term performance was even referred to by some as the "ambidexterity premise" (Raisch & Birkinshaw, 2008, p.392). These statements became an enduring belief among management scholars but remained largely a normative assumption. Indeed, as Piao observed very recently (2014), this proposition received surprisingly very little scrutiny and has never been really substantiated empirically. As it can be seen from table 1.3 taken as a representative sample of the most prominent empirical studies on the matter, much of the work to date has considered financial performance (profitability, earnings, sales over assets, cash flows), sales performance (sales growth, market share growth) or eventually knowledge and innovation (patents, Tobin Q's) as dependent variables, but very few publications have looked into longevity implications. Precisely, two publications out of a total of 48 empirical studies in our sample address the subject: Burgelman and Grove's (2007) and Piao's (2014).

In her survey of 98 firms in hard disk drive industry (HDD) over a period of 20 years, Piao measured longevity as the number of years firms have remained in the industry until the year of exit, assuming that the exit of a firm corresponds to its dissolution. However, following

Christensen, Suarez, & Utterback (1998) observation that *virtually* all the exits in the HDD had been dissolutions, she neglected the possibility that firms may have voluntarily divested their HDD activities or restructured their portfolio of activities at some point in time. Moreover, she defines the term 'dissolution' as "the demise of a company or *part of a company*" (p.214, emphasis is ours), which indicates that exiting the industry does not mean *per se* that the whole company has filed for bankruptcy or has been totally disbanded. There are ample examples of companies that have adapted to environmental change by profoundly re-inventing their business models and are now operating in industries or technologies totally different from the one they began in. IBM, the manufacturer of mechanical office equipment turned into a service and consulting company, is probably the most iconic example of such a revolutionary change. O'Reilly & Tushman (2007) give a non-exhaustive list of 23 of such long-lived companies averaging 105 years of existance that have moved from one industry to a totally different one. This said, Piao findings give support to a positive effect on organizational longevity of a form of skewed ambidexterity in the sense that, according to her, firms need to find the right balance between a high intensity of exploitation and a moderate intensity of exploration in order to benefit from the strong main effects of both dimensions while avoiding overly strong interactions and the tensions a high intensity of both can create.

Burgelman and Grove (2007) take a different approach by combining longitudinal field research and executive experience about Intel Corporation's evolution over a period of more than 35 years. This somewhat unique approach was made possible as one of the authors, Andrew Grove, hired in 1968 as the third employee of the just-incorporated young company Intel, actively participated in transforming Intel from a start-up firm into a multi-billion dollars giant. He was appointed as Intel's president in 1979, CEO in 1987 and Chairman and CEO in 1997. This study contributes to reconciling the common view that attributes organization's long-term success to strategy, with the proposition that leadership style is the main determinant of long-term performance. They argue that "corporate longevity depends on matching cycles of autonomous and induced strategy processes to different forms of strategic dynamics, and that the role of alert strategic leadership is to appropriately balance the induced and autonomous processes throughout these cycles" (p.965). In this proposition, the authors recognize the importance of balancing exploration (equated to

autonomous processes or strategies)[10] and exploitation (assimilated to induced processes or strategies) with regards to environmental changes and especially to "rule-changing" ones (i.e. changes that materially alter the competitive value of existing product-market positions and/or distinctive competences of the players).

### *1.3.2. The effect of exploitation on long term survival*

An increase in exploitation intensity is positively related to financial performance (Lavie et al., 2010). Organizations engaged in exploitation to the exclusion of exploration often generate "returns that are proximate and predictable but not necessarily sustainable" (Raisch & Birkinshaw, 2008, p.392). They endure the risk of being trapped in suboptimal equilibrium (Levinthal & March, 1993), a situation that renders adaptation to change difficult. Indeed, by funneling most available resources and efforts to exploitation, companies seize opportunities in their familiar environments. Because they survived environmental selection, they want to continue abide by the rules (Burgelman & Grove, 2007), search for solutions in the neighborhood of their current knowledge or expertise and become ever more expert in their current domains (Foster and Kaplan's "cultural lock-in" (Foster & Kaplan, 2001b)). While these competences may lead to competitive advantage and success, at least initially, environmental changes could turn them into competency traps, what Kogut and Kulatilaka (2001, p.754) call "an accumulated learning in old techniques", or core-rigidities (Leonard-Barton, 1992). Exploitation also drives learning by doing which increases the rigidity of the firm (Kogut & Kulatilaka, 2001). As Miller (1993, p.116) said: "…most organizations lapse into decline precisely because they have developed too sharp an edge. They amplify and extend a single strength or function while neglecting most others. Ultimately, a rich and complex organization becomes excessively *simple* – it turns into a monolithic, narrowly focused version of its former self, converting a formula for success into a path toward failure". In this situation, information systems and routines reflect only a narrow range of skills and concerns, and the lion's share of resources is going to one central activity which leads to momentum – the

[10] Burgelman, interviewed by Germain and Lacolley (2010), makes explicitly the link between autonomous and induced strategic processes with exploration and exploitation respectively,but he explains why he considers this link as rather superficial. Nevertheless, he further emphasizes the need for organisations to balance the generation of new opportunities, such as in exploration processes, and the exploitation of existing opportunities, which is the point stressed out here.

tendency to extrapolate previous directions of evolution in strategy and structure (Miller & Friesen, 1984); to convergence – the idea that organizations incrementally refine an existing orientation (Tushman & Romanelli, 1985); and ultimately to organizational inertia – a resistance to changes that runs against a fundamental existing orientation (Hannan & Freeman, 1984).

That said, Piao's empirical findings seem to contradict this well documented conventional wisdom by suggesting that a high exploitation intensity, independent of exploration, actually helps prolong organizational longevity (Piao, 2014).

### *1.3.3. The effect of exploration on long term survival*

Smith (1986) insists upon the fact that organizations necessarily need to undertake experimentation if they want to survive. Experimentation, or exploration, implies shifting away from the organization's current knowledge base towards new technical skills, market expertise, or external alliances (Lavie & Rosenkopf, 2006; Smith & Tushman, 2005), hence allowing learning, diversification of activities and lower exposure to competition, which results in better chances to resist "the gale of change" (Foster & Kaplan, 2001b). Thiétart and Forgues (1995, p.28) further explain that "experimentation with new organizational paradigms permits the development of catalogues of configurations from which the organization will be able to choose when the forces of change are more powerful than organizational viscosity and resistance". Yet, researchers in organizational learning and adaptation cautionary advice against the risk of exploration because, whereas the upside of good decisions may be very high, the downside of bad ones can lead to "major disasters" (Burgelman & Grove, 2007, p.966). Organizations engaged in exploration to the exclusion of exploitation bear the costs of experimentation without gaining the benefits generated by new opportunities (March, 1991), they are trapped into an "endless cycle of failure and unrewarding change" (Levinthal & March, 1993, p.106) with "too many underdeveloped new ideas and too little distinctive competence to sustain their long-term viability" (March, 1991, p.71). In this situation, innovations are replaced by new ideas before they have had the opportunity to contribute to the company's revenues (Junni et al., 2013).

*Table 1.3: Empirical studies on explorative and exploitative aspects and the main variables studied*

(ER stands for ExploRation and ET for ExploiTation)

| | | | Main dependent var. | | Environmental Dynamism | | Environmental Competitiveness | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Reference | Exploitative aspect | Explorative aspect | Main dependent | Measure of Dep. Var | Measure | Effect | Measure | Effect | Other Indep., Control & Moderating Var. | Length of the study |
| Adler, Goldoftas & Levine, 1999 | Efficiency | Flexibility | | | | | | | | |
| Katila & Ahuja, 2002 | Search depth | Search scope | | | | | | | | |
| Rothaermel & Deeds, 2004 | Exploitation | Exploration | | | | | | | | |
| Kyriakopoulos & Moorman, 2004 | Exploitation | Exploration | | | | | | | | |
| Gibson & Birkinshaw, 2004 | Alignment | Adaptability | Performance | Self-assessed with 4-item scale | | | | | Performance management, social context, organization context | |
| He & Wong, 2004 | Exploitative innovation | Exploratory innovation | Performance | Sales growth rate | n.a. | n.a. | n.a. | n.a. | Location, level of technology, firm age, firm size, share of export in turnover | 3 years |
| Sidhu, Volberda & Commandeur, 2004 | Local search | Boundary-spanning exploration | Exploration orientation | 16 items Likert-scale | 3 out of the 4 item instrument from Miller (1987) | Higher environmental dynamism induces stronger ER orientation. | n.a. | n.a. | Organization mission, strategic orientation, technology inflexibility, environment monitoring resources, Organization size | |
| Jansen, Van den Bosch & Volberda, 2005 | Exploitative innovation | Exploratory innovation | | | | | | | | |
| Atuahene-Gima, 2005 | Competence exploitation | Competence exploration | | | | | | | | |
| Han, 2005 | Pro-profit strategy | Pro-growth strategy | | | | | | | | |
| Chanal & Mothe, 2005 | Exploitation | Exploration | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. |
| Lavie & Rosenkopf, 2006 | Exploitation | Exploration | | | | | | | | 11 years |
| Lubatkin, Simsek, Lin & Veiga, 2006 | Exploitation | Exploration | | | | | | | | |
| Hill & Birkinshaw, 2006 | Exploitation | Exploration | | | | | | | | |
| Jansen, Van den Bosch & Volberda, 2006 | Exploitative innovation | Exploratory innovation | Financial performance | Profitability | 5 item Likert-scale | High environmental dynamism has a positive impact on ER, a negative impact on ET. Low environmental dynamism impacts negatively ER and | 4 item Likert-scale | High competitiveness has a positive impact on ET and no effect on ER | Centralization, formalization | |
| Bierly & Daly, 2007 | Exploitation | Exploration | | | | | | | | |
| Lin, Yang & Demirkan, 2007 | Exploitation | Exploration | Performance | Net sales / current assets | Volatility of the net sales of all firms in the industry (= standard error of the regression slope coefficient | Having an ambidextrous formation of alliances helps firms in an uncertain environment but not in a | n.a. | n.a. | Firm size, centrality, structural holes in the network, network homogeneity, network size | 8 years |
| Tiwana, Bharadwaj & Sambamurthy, 2007 | Alignment | Adaptability | | | | | | | | |
| Andersen & Nielsen, 2007 | Centralized strategy | Decentralized strategy | | | | | | | | |
| Tarafdar & Gordon, 2007 | Operational excellence | Strategic vision | | | | | | | | |
| Swart & Kinnie, 2007 | Exploitative learning | Exploratory learning | | | | | | | | |
| Burgelman & Grove, 2007 | Induced strategy process | Autonomous strategy process | **Corporate longevity** | n.a. | "rules of the game" (normative, technological, economic, cognitive) | Cycles of induced and autonomous strategy must be balanced to match different forms of strategic dynamics | n.a. | n.a. | Leadership style | 35 years |
| Menguc & Auh, 2008 | Exploitation | Exploration | | | | | | | | |
| Jansen, George, Van den Bosch & Volberda, 20 | Exploitation | Exploration | | | | | | | | |
| Morgan & Berthon, 2008 | Exploitation | Exploration | | | | | | | | |
| Tiwana, 2008 | Strong ties | Bridging ties | | | | | | | | |
| Im & Rai, 2008 | Exploitative knowledge sharing | Exploratory knowledge sharing | | | | | | | | |
| Brion, Mothe & Sabatier, 2008 | Exploitative innovation | Exploratory innovation | Exploratory and exploitative innovation | Likert-scale items (based on He & Wong, 2004; Lubatkin et al., 2006) | n.a. | n.a. | n.a. | n.a. | Creativity, risk-taking, performance management, size, sector, level of centralization, externalization of innovation. | n.a. |
| Rothaermel & Alexandre, 2009 | Exploitation | Exploration | | | | | | | | |
| Mom, Van den Bosch & Volberda, 2009 | Exploitation | Exploration | | | | | | | | |
| Jansen, Tempelaar, Van den Bosch & Volberda | Exploitation | Exploration | | | | | | | | |
| Cao, Gedajlovic & Zhang, 2009 | Exploitation | Exploration | Performance | Sales growth, profit growth, market share growth, operational efficiency, cash flow and market reputation (self-reported by CEO's & CTO's) | Environmental munificence (3-years industry sales growth) & environmental instability (standard deviation of the sales growth of the firms of the same industry) | No effect of environmental munificence on the impact of Balanced ambidexterity on performance. Positive effect of Combined ambidexterity on | n.a. | n.a. | Size, geographic location | 1 year |
| Prange & Schlegelmilch, 2009 | Exploitation | Exploration | Marketing strategy implementation | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. |

*<u>Table 1.3:</u> Empirical studies on explorative and exploitative aspects and the main variables studied (continued)*

| | | | Main dependent var. | | Environmental Dynamism | | Environmental Competitiveness | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Reference | Exploitative aspect | Explorative aspect | Main dependent | Measure of Dep. Var | Measure | Effect | Measure | Effect | Other Indep., Control & Moderating Var. | Length of the study |
| Kim & Rhee, 2009 | Exploitation | Exploration | Knowledge | n.a. | Frequency & amplitude of environmental changes | Static environment: negative effect of internal variety. Dynamic environment: inverted U-shaped effect of internal variety | n.a. | n.a. | Internal variety (turnover rate, horizontal & vertical socialization) | n.a. |
| Cao, Simsek & Zhang, 2010 | Exploitation | Exploration | | | | | | | | |
| Tushman, Smith, Wood, Westerman & O'Reilly, | Exploitation | Exploration | | | | | | | | |
| Laplume & Dass, 2009; Laplume, 2010 | Exploitation | Exploration | Performance | Sales | Percentage of competence-enhancing and competence-destroying rule changes | More ER is needed in environment with competence-destroying rule changes | Number of producers scanned by buyers in making their purchasing decision | Effect of ER is more pronounced when competitive intensity is high | Boundary conditions (mimicry & transparency) | |
| Brion, Mothe & Sabatier, 2010 | Short-term organizational focus | Long-term organizational focus | Innovation ambidexterity | 4-item Likert scale for each of Exploitation innovation and Exploration innovation, product of both | n.a. | n.a. | n.a. | n.a. | Competence exploration, competence exploitation | 3 years |
| O'Reilly & Tushman, 2011 | Exploitation | Exploration | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | Strategic intent, common identity, reward system, ability to resolve tensions | n.a. |
| Patel, Messersmith & Lepak, 2012 | Exploitation | Exploration | | | | | | | | |
| Jansen, Simsek & Cao, 2012 | Exploitation | Exploration | | | | | | | | |
| Fernhaber & Patel, 2012 | Exploitation | Exploration | | | | | | | | |
| Boumgarden, Nickerson & Zenger, 2012 | Exploitation | Exploration | | | | | | | | |
| Voss & Voss, 2012 | Exploitation | Exploration | Ticket revenue per available seat | Total ticket revenue reported divided by theater's annual seating capacity | n.a. | n.a. | Competitive density scores based on IRS Form 990 by city and state | Number of competitors: positive impact on Product ER, negative impact on Product & Market ET, no | Firm size (lagged firm budget size, number of seats), firm age, marketing expenditures per seat & average price per seat. | 3 years |
| Dupouët, Bouzdine-Chameeva & Lackshman, 2013 | Exploitation | Exploration | Innovation from Information Systems | | n.a. | n.a. | n.a. | n.a. | Learning process, real option reasoning | |
| Cummings, 2013 | Alliances with repeat partners | Alliances with new partners | Performance | Cummulated earnings | n.a. | n.a. | n.a. | n.a. | Generalists vs. Specialists | 5 years |
| Junni, Sarala, Taras & Tarba, 2013 | Exploitation | Exploration | Performance | Growth, profit, patents, Tobin's Q (objective & perceptual) | n.a. | n.a. | n.a. | n.a. | Level of analysis, study design, industry | n.a. |
| Ming, 2014 | Exploitation | Exploration | **Corporate** | Number of years firms | n.a. | n.a. | Density as a proxy for general | No impact on organizational | Form factors, years lapse, leap, nation, age, sales & | 20 years |

If a moderate intensity of exploration has a positive impact on longevity, it seems therefore that too much of it puts the organization's long-term survival at jeopardy. Piao's results suggest a curvilinear inverted-U-shaped relationship between the level of exploration and organizational sustainability (Piao, 2014) indicating that an optimum must exist in the amount of exploratory efforts to be exerted in order to extend the organization's lifespan. Kim et al. (Kim & Huh, 2015) confirmed such an inverted U-shaped curvilinear relationship between the extent of exploratory innovation and organizational longevity in their recent analysis of data from the Korean IT industry during a period extending from 1981 to 2011.

### *1.3.4. The effect of organizational ambidexterity on long term survival*

If organizational ambidexterity is the ability of an organization to both explore and exploit (O'Reilly & Tushman, 2013), whatever it is achieved by combining the two activities or by balancing them should have a positive impact on long-term survival since exploitation ensures its current viability, whereas exploration secures its future success (March, 1991). This holds true if the two dimensions do not interfere with each other. Yet, they do compete for scarce resources and for the skills and attention of top management teams. Piao (2014) has shown that the interaction between exploration and exploitation in the same timeframe triggers a partial offsetting effect in the sense that an increase in exploitation intensity weakens, without annihilating completely, the positive effect of exploration on organizational longevity. In her study, exploitation intensity appears to moderate the relationship between exploration and survival, hence her conclusion that firms may need to find the right balance between a *high* intensity of exploitation and a *moderate* intensity of exploration. They should not strive at maximizing both.

## 1.4. Organizational ambidexterity and environmental dynamism

> *"The history of life contains long periods of boredom and short periods of terror."*
>
> Stephen Jay Gould

As Anderson and Tushman put it (Anderson & Tushman, 2001, p.676): "organizations are imbedded in their environments, even as they influence those environments, and some environmental conditions must pose much sterner challenges to organizational survival than others do".

Interactions between organizations and their environment (Starbuck, 1979), especially the relationships between environmental variation and organizational actions (Wholey & Brittain, 1989), have long been an important topic in organization theory and strategic management. The causal relation between a firm and its environment is not assumed to be unidirectional (Volberda, 1996). This assertion is at the core of the co-evolutionary perspective which emerges as an important organizing framework (Sidhu et al., 2004). This framework considers that organizations and their environments co-evolve through multidirectional influences within and between organizations, their environment and the other interacting organizational populations (Lewin & Volberda, 1999; Volberda & Lewin, 2003). It focuses on the juncture between managerial efforts and selection pressures imposed by the environment. This approach differs from previous theoretical frameworks such as strategic-choice theory (Child, 1997), which is essentially centered on managerial intentions in adaptation processes at the level of the firm; or organization ecology theories (Hannan & Freeman, 1977), whose focus is on variation-selection-retention processes at the population-level with no regards for managerial intent.

But, what characterizes the organization's environment? Aldrich (1979) proposed six environmental dimensions that Dess and Beard (1984) formalized for profit-making organizations in a more parsimonious set of three main characteristics: *munificence* (Aldrich's capacity of the environment to provide the resources needed to sustain growth), *dynamism* (combining Aldrich's stability vs. instability and turbulence) and *complexity* (Aldrich's homogeneity vs. heterogeneity and concentration vs. dispersion).

Focusing on organizational environments' stability patterns, Farjoun (2007) distinguished two polar types of industry contexts: an *evolutionary context* where the environment is stable; and

a *perpetual change context* in which the environment changes continuously. He also considered two intermediate and integrative contexts: a *punctuated equilibrium* where stable periods alternate with periods of flux and exogenous discontinuity; and a *differential change context* characterized by the coexistence of continuity and change triggered either by exogenous sources or by rapid intense rivalry.

In their attempts to conceptualize and measure changes in organizational environments, Wholey and Brittain (1989) decomposed environmental dynamism, that they equated with environmental "variation", "instability" or "volatility" (p.867, p. 869), into three components: the *frequency* of environmental change indicates whether the time between changes is short (fine-grained) or long (coarse-grained); the *amplitude* measures the distance between the environmental state before and after the change; and the *predictability* which is the portion of change that can be foreseen and which appears to be inversely related to the degree of unanticipated variability in frequency and amplitude (Kim & Rhee, 2009). Surprisingly, some authors (Kim & Rhee, 2009; Suarez & Oliva, 2005) withdrew predictability from their models even though studies have revealed that it is precisely the key environmental dimension associated with organizational mortality. Indeed, a longitudinal comparative study of the American cement industry from 1888 to 1980 and the minicomputer industry from 1958 till 1982 (Anderson & Tushman, 2001) has showed that, when controlling for ecological and macroeconomic conditions, exit rates are strongly associated with uncertainty but not to complexity or munificence. This study revealed two kinds of uncertainty creating hazardous environmental conditions: unpredictable changes in demand on the one hand, and technological discontinuities on the other hand.

Contrary to the authors who disregarded the level of environmental predictability, Lavie *et al.* (2010) differentiated *environmental dynamism*, which presumes a certain degree of predictability, from *exogenous shocks*, which refer to "sudden and unexpected environmental jolts beyond the control of any organization" (p.119). Meyer (1982, p.515) defines those "jolts" as "transient perturbations whose occurrences are difficult to foresee and whose impacts on organizations are disruptive and potentially inimical" (figure 1.4). Burgelman, on his side, differenciates "continuities", which are patterns that extend for a long time, from "contingencies", which are events that do not form a pattern and hence are "unexpected good luck or bad luck events" (Burgelman, 2015, p.9).

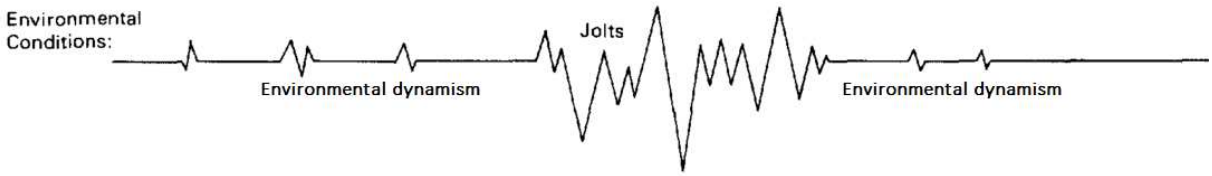



*Figure 1.4: Schematic representation of environmental dynamism versus exogenous shocks or jolts* (adapted from Meyer, 1982, p.534)

This differentiation between continuous, incremental change (referred to as first-order change by Meyer *et al.*, 1990) and discontinuous, radical change (referred to as second-order) has been applied to almost all levels of analysis by organizational scholars: industry (evolution vs. revolution: Schumpeter, 1942), organizations (adaptation vs. metamorphosis: Miller & Friesen, 1984), technology (competence-enhancing vs. competence-destroying changes: Tushman & Anderson, 1986), and even at the individual level (single-loop and double-loop learning: Argyris & Schön, 1978). However, as stressed out by Meyer and colleagues, first-order change has received considerably more attention than second-order change in the field of strategic management (Meyer, Brooks, & Goes, 1990). Table 1.4 compares different aspects of both dimensions.

Several academics have claimed that the level of dynamism and competitiveness in an organization's environment may be an important boundary condition for organizational ambidexterity (Gibson & Birkinshaw, 2004; Levinthal & March, 1993), and the binary concept of exploration and exploitation has recently come to prominence in research about organizational adaptation to environmental changes (Gupta et al., 2006). However, as observed by Lavie and colleagues (Lavie et al., 2010), empirical evidence on the environmental antecedents of exploration and exploitation has been scarce with more attention centered on the organizational factors that spur propensity to explore instead of exploit. A similar observation was made by Sidhu *et al.* (Sidhu, Commandeur, & Volberda, 2007) when they were saying that "scholars have thus far excluded environment from the analysis when inquiring into the effect of exploration-exploitation (…), assuming the effect to be invariant across different dynamism levels" (p.24).

Nonetheless, despites this relative paucity, we summarize hereafter the main reported findings, sometimes contradictory, that describe the complex relationships between organizational

ambidexterity and each of the two uncertainty-related environmental dimension, i.e. dynamism and exogenous shocks.

| | Environmental Dynamism | Exogeneous Shocks |
|---|---|---|
| Form of change | Incremental evolution<br>First-order change (Meyer *et al.* , 1990) | Punctuated discontinuities<br>Second-order change (Meyer *et al.* , 1990) |
| Level of uncertainty | (relatively) Low | High |
| Categories | "Clear enough fuure" & "Alternate future"<br>(Courtney *et al.* , 1997)<br><br>"Variation" & "Foreseen uncertainty"<br>(De Meyer *et al.* , 2002)<br><br>"Known unknowns"<br>(Hillson, 2004)<br><br>"White swans"<br>(Taleb,, 2007) | "A range of futures" & "True ambiguity"<br>(Courtney *et al.* , 1997)<br><br>"Unforeseen uncertainty" & "Chaos"<br>(De Meyer *et al.* , 2002)<br><br>"Unknown unknowns"<br>(Hillson, 2004)<br><br>"Black swans"<br>(Taleb,, 2007) |
| Examples of antecedents | Globalization & interconnectedness<br>(Friedman, 2005)<br><br>Competitive intensity<br>(Volberda, 1996)<br><br>Costs fluctuations (raw materials, utilities, currencies, labor) & speculation<br><br>Market trends (variations in customer's demand and supplier's offer)<br>(Jansen *et al.* , 2006)<br><br>Change of capitalistic paradigm (power shift from managers to shareholders) | Crises (financial, economic, political) and resulting measures (e.g. credit crunch)<br>(Schmitt *et al.* , 2010)<br><br>"Disruptive technologies" (Christensen, 1998)<br>"Creative destruction" (Schumpeter, 1934)<br><br>Changes in normative & regulatory framework |

*Table 1.4: Forms of changes and examples of antecedents*
(Courtney, Kirkland, & Viguerie, 1997; De Meyer, Loch, & Pich, 2002; Friedman, 2005; Hillson, 2004; Jansen et al., 2006; Meyer et al., 1990; Schmitt, Probst, & Tushman, 2010; Schumpeter, 1934; Taleb, 2007; Volberda, 1996)

### *1.4.1. Environmental dynamism*

*Environmental dynamism* encompasses, among others, changes in technologies, variations in customer preferences, fluctuations in product demand or supply of materials (Jansen et al., 2006; Lavie et al., 2010), and globalization (Friedman, 2005)(Table 1.4). In addition to simple fluctuations, these progressive changes are driven by large, social, political, environmental (in the ecological sense) or technological underlying trends sometimes called "megatrends" which are generally slow to form[11].

[11] The consulting and research firm Frost & Sullivan has listed the following megatrends as World's top global ones to 2020: urbanization; smart cities; generation Y; women empowerment; rise of middle class (especially in

Some authors (e.g., Jansen et al., 2006) make a difference between environmental dynamism (the rate of change and the degree of instability of the environment) and environmental competitiveness (the extent to which external environment is characterized by intense competition), but we consider here that the latter constitutes actually a component of the former in the fact that competition intensity impacts the degree of instability of the environment. This simplification allows us to concentrate our survey on the central subject of this dissertation: the context of growing uncertainty.

The changes may impact the organization in a direct way (e.g., by adapting pricing policy or shifting sourcing patterns) as well as indirectly through learning (March, 1991) and experience (Tushman & Romanelli, 1985) by modifying the strength and the nature of the relationships between organizational and environmental variables (Forgues & Thietart, 1995). In our eyes, *environmental dynamism* leads to the two first types of uncertainty postulated by De Meyer *et al.* and highlighted in the introductory part of this dissertation (see section 1.2.2.), i.e. "variation" and "foreseen uncertainty", respectively (De Meyer, Loch, & Pich, 2002).

Dynamic environments accelerate the obsolescence of products (Jansen, Van Den Bosch, & Volberda, 2005) and hence induce the need for organizations to innovate by developing new ones. Sidhu *et al.* (2004) found that environmental dynamism leads to expanded search for information in order to reduce managerial uncertainty, and Keller and Weibler (2014) showed that environmental dynamism is positively related to engagement in exploration. These empirical results tend to support the assertion that turbulent environments favor organizations forms that are quick at taking advantage from "new opportunities and the appearance of new habitats" (Hannan & Freeman, 1984, p.163). By experimenting with different types of

China and India); reverse brain drain (highly educated and skilled workers from countries like China and India going back to their homeland); next game changers (the N11, next big emerging markets after the BRIC countries: Bangladesh, Egypt, Indonesia, Iran, Mexico, Nigeria, Pakistan, Philippines, South Korea, Turkey and Vietnam); future outsourcing hotspots (not defined by labour cost or productivity but by specialization in niche areas like business analytics, software application development…); future Fortune Global 500 (an anticipated 30% increase in the number of Asian companies signaling a shift of economic power); new trade zones; satellite technology; virtual world; robotics; future consumer electronics; geo-socialization (next level of social networking); wireless intelligence; future broadband technologies; next emerging technologies (nanomaterials, flexible electronics, SMART materials…); global power generation; zero emission technologies; E-mobility; infrastructure development (emerging transporting corridors leading to mushrooming economic and technology clusters along these corridors); new business models (personalization, car sharing, "pay by the hour"…); and SMART factory (fully automated).
http://www.bar-oriyan.com/Portals/0/mega%20trands%20exec%20summary%20v3%20(1).pdf

innovations, these organizations create a "catalogue of responses to different and, as yet, unknown demands from the competitive environment" (Forgues & Thietart, 1995, p.23).

In addition to promoting the engagement in exploration, environmental dynamism has been found to also impact the efficiency of the exploration initiatives by moderating positively the relationship between exploratory innovation and financial performance (Jansen et al., 2006). In other words, organizations pursuing exploration in dynamic environments see their financial performance improve, whereas organizations focusing predominantly on exploiting existing products, services and markets in such changing environmental conditions are likely to whitness a decrease of their financial performances (Jansen et al., 2006). Refining this empirical observation with an agent-based simulation model, Kim and Rhee (Kim & Rhee, 2009) predict that "exploitative orientation would perform better when the environment changes with low frequency and small amplitude" (p. 15) and that "exploratory orientation would perform better when the environment changes either with low frequency and large amplitude or with high frequency and small amplitude" (p.16).

Thus, in peaceful times of relative stability, companies may either opt to exploit niche markets or to explore new lines of business (Lewin, Long, & Carroll, 1999) and benefit from adaptive learning (Cyert & March, 1963), but they should instil more exploration as environmental dynamism increases, and by doing so, strive for more balance between exploration and exploitation. The more dynamically competitive the environment, the more organizations may have to pursue both activities simultaneously and become more ambidextrous (Auh & Menguc, 2005; Jansen et al., 2006, 2005; Raisch & Birkinshaw, 2008).

Following the line of thinking and empirical results presented hereabove, we can expect that infrequent environmental changes with substantial amplitude (a situation that corresponds to Tushman and Anderson's (1986) punctuated equilibrium), or even more chaotic situations owing to exogeneous shocks, equally call for ambidextrous capabilities to be developed. This is the question that we address in the next section.

### *1.4.2. Exogenous shocks*

*Exogenous shocks* cover most likely deregulation, technological breakthroughs (more disruptive or frame-braking than simple changes) and crises (Meyer et al., 1990; Schmitt et al., 2010)(Table 4). They force organizations to move from one dynamic state to the other through

a discrete bifurcation process (Forgues & Thietart, 1995), consistent with the quantum change theory of Miller and Friesen (1984), Greiner's revolution stages of crisis (Greiner, 1972, 1998), and Mintzberg and Waters' researches (1985). *Exogenous shocks* generate the two last types of uncertainty postulated by De Meyer *et al.* and highlighted in the introductory part of this dissertation, i.e. "unforeseen uncertainty" and "chaos", respectively (De Meyer et al., 2002). In addition to being causes of uncertainty, these sources of change are destabilizing, they are sources of instability and internal disorder as "they create demands which are not necessarily consistent with the planned objectives" (Forgues & Thietart, 1995, p.28). At the same time, "the forces of change favor, paradoxically, the emergence of a new form of order and stability. (…) Disorder gives an opportunity to explore new ways of doing and acting" (opcit, p.28). As Schmitt and colleagues (2010, p.133) put it: "crisis conditions function as an amplifier of the existing trade-offs between the two orientations", exploration and exploitation.

The idea of organizational ambidexterity was initially conceptualized by Duncan (1976) as alternating sequences of organic and mechanistic structures. Mechanistic structures support routine operations, functionalization and formal duties (Lavie et al., 2010), therefore being ideal to entail exploitation, whereas organic structures are much less rigid, hence facilitating search for new knowledge and exploration (Burns & Stalker, 1961). Such a temporal sequencing is probably well adapted to rather stable environmental conditions because organizations have time to manage the shifts and benefit from adaptive learning (Cyert & March, 1963), but this approach seems inappropriate under situations of swift and uncertain environmental change (Schmitt et al., 2010).

According to Tushman an O'Reilly (Tushman & O'Reilly, 1996), an environmental context of punctuated discontinuities is best dealt with by separating spatially the exploration and exploitation activities (the concept of structural ambidexterity introduced in section 1.2.2. above). Conversely, Jansen *et al.* (2005) observed that organizations operating in highly dynamic competitive environments rely mostly on contextual ambidexterity instead of instating structural separation between units.

As observed by Raisch and Birkinshaw (2008), except these references, very few studies have formally considered environmental influence on the structural, contextual and leadership-related antecedents of organizational ambidexterity. Another exception comes though with Schmitt, Probst and Tushman (2010) who studied organizational behavior in times of economic crisis by discussing the case of Samsung Electronics, a company that experienced high growth

and successful diversification for many years before to be disrupted by the Asian economic crisis in Novembrer 1997. Contrary to other Korean companies which suffered dramatically from the turbulent economic conditions of the time, Samsung Electronics navigated the crisis successfully and even managed to become a global company during this period. Here again they noted the scarcity of literature on this subject and the contradictory empirical evidence of a positive relationship between ambidexterity and environmental hostility considering moreover that "whether and how exploitation and exploration emerge in an economic crisis have been inadequately addressed" (p.130). They however argued, on the basis of their analysis of the Samsung case, that structural separation has a positive impact on the the pursuit of exploration and exploitation activities during economic crises because separation "allows cross-fertilization between units and prevents cross-contamination" and "evades the impending threat of having to sacrifice efficiency for innovative activities and vice versa" (p.143). Conversely, Khanagha, Volberda and Oshri (2014) showed, in their longitudinal study of a large corporation's transition to a new business model triggered by a major transformation in the ICT industry (i.e. the avent of Cloud computing), that there is "a need for recursive iterations between different modes of separated and integrated structures" (p.322) and hence that structural or spatial separation alone was not the optimal approach when facing such a "business model disruption" (p.324).

As a conclusion, changing environmental conditions call for pursuing organizational ambidexterity but the amplitude, the frequency and, most of all, the level of uncertainty of these variations impact the way organizational ambidexterity should be implemented. While the litterature does reveal empirically a moderating effect of environmental factors on the ambidexterity-performance linkage (Raisch & Birkinshaw, 2008), we have still little knowledge on the organizational *mechanisms* by which those exploratory and exploitative practices ease or hinder organizational adaptation to environmental contingencies (Kim & Rhee, 2009).

This said, organizations are open systems, they evolve in environments which have their own dynamics and with which a continuous exchange of information, resources and energy takes place (Thompson, 1967). Consequently, they are not all equally affected by environmental changes. Moreover, disruptions have some idiosyncratic characteristics that pose unusual challenges for established firms (Khanagha et al., 2014). Some organizations may suffer more than others which have better capabilities to generate sufficient slack resources (financial and human) during the implementation of responses to discontinuities. We can therefore assume

that size matters in these circumstances. This is precisely the reason why we are particularly interested to look at the possibility for smaller players to put ambidexterity into practice. We focus on this part of the extant literature in the following chapter.

## 1.5. Organizational ambidexterity and medium-sized firms

As indicated in the introductory section of this dissertation, small and medium-sized enterprises (SMEs) represent a vital component for most economies. Despite this, they have been largely overlooked by management scholars, partially because data are not public and hence not readily available (Lubatkin et al., 2006). The extant literature on organizational ambidexterity has rather focused on larger firms which generaly compete with different businesses in multiple markets.

Yet, medium-sized enterprises make ideal units of analysis in research on organizational ambidexterity because they allow for a "fine-grained examination of exploitation and exploration" (Voss & Voss, 2013, p.3). Like larger firms, they "generally face the kind of competitive pressures to jointly pursue exploitation and exploration" but they "lack the amount of slack resources and the kind of hierarchical administrative systems that can help or impede larger firms in managing their contradictory knowledge processes and, thus, affect the attainment of ambidexterity" (Lubatkin, Simsek, Ling, & Veiga, 2006, p.647). Large organizations can run multiple experiments without jeopardizing their survival, even in case of failure. When properly managed, they have the possibility to reproduce internally the variation-selection-retention processes of markets (Burgelman, 1991). They also often have financial resources allowing to eventually acquire new businesses and, by then, internalize new knowledge. Smaller organizations, conversely, have to place life-or-death bets on single or very few experiments (O'Reilly, Harreld, & Tushman, 2009) which makes them more fragile towards environmental changes and more exposed to the consequences of wrong strategic decisions.

The size of organizations may therefore provide a survival advantage, and it is important to study how firms which do not have the luxury of the size, i.e. the SMEs, can do to implement organizational ambidexterity in order to make them "better able to attain and sustain their advantages in the marketplace" and "more able to shield their future cash flows from external

selection pressures" (Lubatkin et al., 2006, p.653). Indeed, these authors' empirical study of 139 North-American SMEs employing 20 to 500 individuals supports the hypothesis that the extent to which SMEs pursue an ambidextrous orientation is positively related with their subsequent relative performance measured by comparing the firm's performance to that of their major competitors on profitability and growth. Digging further in the way SMEs put ambidexterity into practice, Cao *et al.* (2009) showed that balancing exploration and exploitation (our "Abel & Caïn" view described in section 1.3.2.) is more beneficial in terms of financial and commercial performance to resource-constrained firms, whereas a combination of the two dimensions of ambidexterity (our "Appollo & Dionysus view described in section 1.3.1.) is better for firms having greater access to internal and/or external resources.

Other voices however contented that small firms benefit more from a strategy focusing on either flexibility or efficiency, but not on an ambidextrous approach of both, and that none of these strategies outperform the other, implying that efficiency and flexibility strategies may be equally effective (Ebben & Johnson, 2005). These results have later been moderated by arguying that the effectiveness of theses strategies may differ across different industry environments, i.e. stable or dynamic (Xie, 2012).

In addition to financial and slack resources, the quality of management, taken in its Penrosian sense (its ability to search for latent opportunities for a full utilization of production factors)(Penrose, 1959), is probably even more important in smaller firms than in larger ones for the implementation of organizational ambidexterity. Indeed, because SMEs have fewer hierarchical levels, their top managers "are much closer to the firm's operating core" (Lubatkin et al., 2006, p.649), they "play both strategic and operational roles" (p.647), and hence they "experience the added dissonance of competing knowledge demands inherent in the pursuit of an ambidextrous orientation" (p.647). These managers are generally closer to the markets of their companies and therefore more aware of changing trends in customer demands. It has been showed that the level of behavioural integration of the top-management team, i.e. the collaborative behaviour, information exchange and joint decision making between team members, influences positively the extent to which SMEs pursue an ambidextrous orientation, which in turn, as we have seen, influences positively their relative performance (Lubatkin et al., 2006).

As a conclusion, even though several studies report a positive impact of implementing organizational ambidexterity in medium-sized companies, this statement does not yet make

unanimity among the academic community. And, moreover, there remains many open questions about how to orchestrate the allocation of resources between old and new business domains and how to manage the interface between exploration and exploitation (O'Reilly & Tushman, 2013). On the one hand, these questions are probably even more relevant in a context of limited resources characterizing SMEs, while on the other hand, SMEs appear obviously as an appropriate litmus test to study these questions (Lubatkin et al., 2006).

## 1.6. Summary of the literature review, theoretical gaps and avenues for our research

Research tells us that organizations, if they want to survive, should innovate and prepare for the future while improving efficiency of their current business at the same time. They can meet the challenge of increasingly complex competitive environments by combining exploitation and exploration. Exploitation refers to the leveraging of existing capabilities whereas exploration refers to the acquisition or the development of new ones. Although interrelated, these tasks require different underlying organizational processes, structures, strategies, and cultures. The ability of an organization to conduct both either simultaneously or sequentially is called organizational ambidexterity. Obvious as it may seem in principle, the task is particularly challenging in daily practice as an excess of exploitation may lead to a "success trap" by which the organization streamlines its operations to a point of oversimplification, overrationalization and inertia, whereas an excess of exploration leads to the "failure trap" of too many underdeveloped ideas eating up resources without delivering any outcome (Junni et al., 2013).

The paradox of a an organizational ambidexterity potentially conflictual on the short term but allowing higher performance on the long run is a hypothesis generally well accepted (Lavie et al., 2010). It would let companies absorb more effectively the periods of heavy and unpredictable fluctuations in their environment. However, if its positive effect on performance (financial and commercial) and innovation has been shown empirically, it does not hold true for its impact on the longevity of organizations which is one of its founding assumptions.

Nevertheless, our analysis of academic literature allows us to draw some preliminary conclusions of practical interest for managers.

First, it appears that companies have an incentive to maximize as much as possible the two components of ambidexterity, namely the exploration and exploitation, provided they have the necessary financial and human resources ("Apollo & Dionysus"). Otherwise, it is necessary to arbitrate between these two dimensions ("Cain & Abel"). We can therefore consider that an organization is ambidextrous if it is either able to explore and exploit simultaneously, which requires a management able to reconcile the two trends and appease conflicts that may arise, or to oscillate between exploitative phases and exploratory phases, which requires intellectual flexibility and organizational plasticity.

The need to combine exploration and exploitation must however be reflected by decision-makers with regards to the exposure of their organization to the volatility of their environment. Some sectors are less exposed and some business environments are less volatile, they can afford higher emphasis on one dimension or the other (Jansen et al., 2006). Thus, in an environment stable by nature, companies can focus on operations: the risk of failure is low and the cost of ambidexterity is not justified (lower right quadrant of Figure 1.5). In a turbulent environment (volatile and uncertain), companies in sectors with little exposure to changes must open to the outside by exploring new technologies and new business models to prepare for the next disruption which, despite the low exposure, is not less likely to impact it sooner or later (upper left quadrant of Figure 1.5).

Conversely, businesses heavily exposed to a very uncertain environment (such as for example activities with high technological content operating in an international context) will benefit from the implementation of an ambidextrous strategy (upper right quadrant of Figure 1.5). In this case, it seems justified for these organizations to trade part of their short-term productivity against their long-term survival.

Then, it seems that the key to long-term survival in an increasingly changing environment is the ability of enterprises to dynamically adjust the balance between exploration and exploitation in response to contextual changes. To do this, companies have multiple means to operationalize organizational ambidexterity (structural, sequential and contextual measures) but the real world cannot remain complacent with static typologies described in academic literature. In practice, organizational ambidexterity is a complex and evolving process that must adapt dynamically to internal and external factors, most often through the implementation of a mix or a superposition of simultaneous measures, varying in intensity, at different levels of the company and by

regularly changing this mix in response to external stimuli and internal newly acquired capabilities.

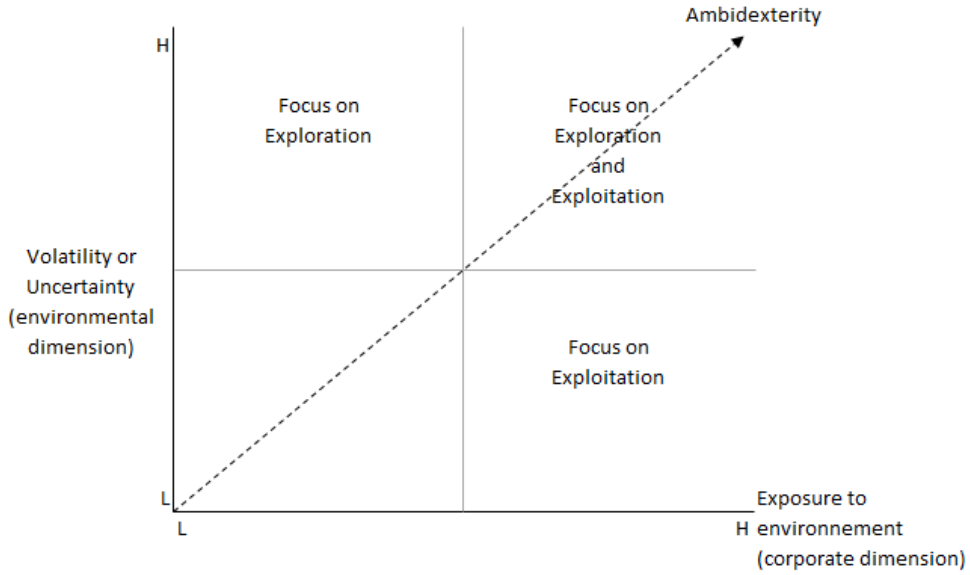



*Figure 1.5: Influence of environmental volatility and company exposure to its environment on the Exploration-Exploitation strategy to implement*

The question is therefore not only to determine whether organizational ambidexterity impacts faborably firms' survival in dynamic environments but also, assuming it does, to elucidate *how* smaller firms can effectively implement an ambidextrous orientation. As pointed by Tushman and O'Reilly: "articulating *why* ambidexterity is important is not the same as *how* it is implemented" (Tushman & O'Reilly, 2011, p.18, emphasis is original). Obviously, devising a strategy is the easy part but strategic execution is much more difficult. The same authors explain (p.18) that "in the implementation of an ambidextrous design, execution appears to trump strategy". Even when the management resolves to explore and exploit, strategic execution requires choices often hard to make to effectively balance these contradictory pressures. The authors claim that "while directionally correct, the research is not granular enough to be of much use to an operating manager (…). To be practically useful, what is needed is greater insight into the specific micromechanisms required for a manager to implement and operate an ambidextrous strategy" (opcit., p.8).

Furthermore, as opposed to research on corporate life cycles, the literature on organizational ambidexterity has generally taken a static approach while it has been shown that firms have to

dynamically adapt to environmental changes and variations in market demands (Tushman & Anderson, 1986). Raisch and Birkinshaw (2008) point the need for new research that investigates "how organizations adapt and develop ambidextrous structures, contexts, and leadership patterns over time to respond to varying boundary conditions" (p.401), and they claim that "such a process perspective requires a methodological shift in organizational ambidexterity research". While observing that existing empirical studies mainly rely on cross-sectional surveys measuring ambidexterity and environmental conditions with data on manager's perceptions, they propose (p.402) to "focus on the actual realization of ambidexterity by deploying archival data on exploitative and explorative moves that have been implemented" in order to contribute to the emergence of a process perspective of organizational ambidexterity. Hence, there is a relative consensus among prominent scholars to seek for more qualitative, in-depth studies with a dynamic perspective and following a longitudinal survey design as time helps separe noise from real meaning[12].

In addition, eventhough small and medium-sized enterprises represent a vital component for most economies, they have been largely overlooked by management scholars, partially because data are not public and therefore not readily available (Lubatkin et al., 2006). The extant literature on organizational ambidexterity has rather focused on larger firms which generaly have access to more resources to compete with different businesses in multiple markets; there is therefore a need for in-depth researches centred specifically on SMEs.

Hence, if our study aims at providing an empirical verification of the positive effect of different measures on the survival of a medium-sized firm in the form of a testimony describing how this firm has gone through several crisis and challenges; it is our intention, beyond the confirmation of a causal link, to contribute a more detailed understanding of how measures have been practically implemented because the evolution of our economies (globalization, hyper-connectivity…) gradually makes environmental stability disappear and exposes companies to a context of ever greater volatility.

The following section details the design followed for our research before presenting and discussing the results.

[12] As pointed by Taleb (2007a), it explains why the news in the media is full of noise and why history is largely stripped of it.

# Section 2. Research design

**Thesis defended**

Medium-sized companies can operate Organizational Ambidexterity to dynamically adapt to unanticipated environmental changes and hence improve their survival chances

**INTRODUCTION**

**Introduction**

**Context**
- A question of survival
- A changing world

**Main goal of the research**
- Research question
- Literature to which the research will contribute

**THEORIES & CONCEPTS**

**Section 1 Organizational Ambidexterity as a construct**
- The origins of Organizational Ambidexterity
- The operationalization of Organizational Ambidexterity
- Organizational Ambidexterity and long term survival
- Organizational Ambidexterity and environmental dynamism
- Organizational Ambidexterity and medium-sized firms

**RESEARCH DESIGN**

**Section 2 Epistemological framework & methodology**
- Epistemological framework
- Strategy of investigation & methodology
- Data management

**EMPIRICAL FINDINGS**

**Section 3 Results & discussion**

***Step 1: The company and its environment***

**3.1 A narrative about the company's history**
- Four main epochs
- Strategic intents, underlying dynamics, and structure

**3.2 Characterizing the company's environment**
- Is the Company's environment dynamic?
- Is the Company's environment uncertain?

***Step 2: Quantifying Organizational Ambidexterity and its components***

**3.3 Ambidexterity over time**

**3.4 Ambidexterity: structure or network**

**3.5 The key-components of Organizational Ambidexterity**
- The key-components of Exploration intensity
- The key-components of Exploitation intensity
- The key-components of Organizational Ambidexterity

***Step 3: Searching for underlying processes***

**3.6 Corporate plasticity**

**3.7 Causation & Effectuation**

***Step 4: Discussion of the results***

**3.8 Discussion and attempt to generalize**

**CONCLUSION**

**Conclusion**
- Concluding discussion
- Contributions, limitations & path forward

## 2.1. Epistemological framework

> *"Much of the world with which we deal is essentially socially constructed. Studying social construction processes implies that we focus more on the means by which organization members go about constructing and understanding their experience and less on the number or frequency of measurable occurences."*
>
> (Gioia, Corley, & Hamilton, 2013, p.16)

Being practitioner, we want to contribute knowledge of academic value but particularly of practical relevance. Qualitative research is often presented as more favourable than quantitative research to this end (Pratt, 2009), hence the research design selected for our study for which we adopt a critical realist posture and combine both. Following Bhaskar (1978), we defend a realist ontological assumption that posits a world independent of human knowledge but, at the same time, we accept a socially and historically constructed epistemic relativism of knowledge (Mingers, 2002; Mingers, Mutch, & Willcocks, 2013).

Critical realism develops a stratified conception of the world: a real domain composed of generative mechanisms and structures independent from the observable patterns of events, an actual domain in which events occur, and an empirical domain which is the domain of individuals' feelings and interpretations of experienced events. Particularly interesting for our research on how to survive unexpected environmental changes is the conception that generative mechanisms and social structures have an emergent power which manifests or not precisely depending on the contextual conditions. This notion stems from Bashkar's idea that social sciences study objects evolving in open systems (Bhaskar, 1978) in which causal explanations is not about the deterministic association of patterns of events but the activation of causal tendencies under certain conditions (Tsoukas, 1989). Therefore, the "Humean" view of causality ("A implies B") acknowledged by quantitative positivists is reworked by critical realists who express the causal powers of generative mechanisms as "A implies B in context C" (Walsh, 2015), but of course still in a Kantian logical framework (the cause A must logically preceed the effect B).

Faithful to our epistemological posture, we are mainly interested in abductively finding explanations for the events observed in order to enrich the current view of the manner in which

the generative mechanisms are activated and the underlying processes put to work with regards to contextual conditions (Avenier & Thomas, 2015). Our study, mostly of abductive explanatory nature, will reflect iterations between theory and data, using the data to identify some new aspects of a dynamic perspective of organizational ambidexterity. The theoretical contribution expected will essentially consist in theory refinement, not to provide law-like rules but to offer heuristic propositions or "solidly-argued grounds upon which to make decisions for intervening in a situation, taking into account the role of the contexts in generative mechanisms' activation" (opcit. p.89). Aiming at refining existing theory, we follow Glaser and Strauss who consider "theory as a process; that is, as an ever-developing entity, not as a perfected product" (Glaser & Strauss, 1967, p.32).

We acknowledge that the first part of our work is of empirical nature in that we transform nominal values about exploration and exploitation and about contextual events into numerical variables but we do not consider with this that the world can be reduced to these empirically observed and measured numerical data (a classical positivist view of the world). On the contrary, we use this first approach to try to detect similarities in the evolution of the internal (organizational) and external (contextual) parameters and then analyze these convergences in order to abductively derive, in a second analysis grounded in the company's history, elements of understanding of plausible generative mechanisms or underlying processes supporting organizational ambidexterity. This combination of quantitative and qualitative methods echoes the recommendation of Mingers, Mutch and Willcocks (2013) who claim that critical realism supports mixed-method research strategy (i.e., a variety of methods in the same research study) on the ground that a particular object of research may well have different characteristics.

## 2.2. Strategy of investigation

### *2.2.1. Research setting*

The research setting is the biotechnology industry, a science-based and market-driven industry. The United Nations in their Convention on Biological Diversity (art. 2)[13] define biotechnology as "any technological application that uses biological systems, living organisms, or derivatives thereof, to make or modify products or processes for specific use". The emergence of biotechnology can be interpreted as a radical process innovation that broke the barriers of entry

[13] https://www.cbd.int/convention/articles/default.shtml?a=cbd-02

of other industries (Rothaermel & Deeds, 2004) such as the pharmaceutical industry (red biotech), the environment and agricultural industry (green biotech) and the chemical industry (white biotech also referred to as industrial biotech). Because it builds on different knowledge base (microbiology and molecular biology) than "conventional" chemical industries, biotechnology can be considered as a competence-destroying innovation (Powell, Koput, & Smith-doerr, 1996).

Although there is no clear official definition of "high technology", the OECD showed that using research and development intensity[14] as an industry classification indicator is possible[15]. Biotechnology is steadily ranking first on this basis since 1973[16] (Table 2.1).

| Industry name | Total R&D-intensity (1999, in %) |
|---|---|
| Biotechnology and Pharmaceuticals | 10.46 |
| Aircraft & spacecraft | 10.29 |
| Medical, precision & optical instruments | 9.69 |
| Radio, television & communication equipment | 7.48 |
| Office, accounting & computing machinery | 7.21 |
| Electrical machinery & apparatus | 3.60 |
| Motor vehicles, trailers & semi-trailers | 3.51 |
| Railroad & transport equipment | 3.11 |
| Chemical & chemical products | 2.85 |
| Machinery & equipment | 2.20 |

*Table 2.1: Classification of high technology industries on the basis of their R&D intensities* (reproduced from OECD).

Our research is more specifically taking place in the field of industrial biotechnology which is defined as "the application of biotechnology for the industrial processing and production of chemicals, materials and fuels. It includes the practice of using microorganisms or components of micro-organisms like enzymes to generate industrially useful products, substances and chemical building blocks with specific capabilities that conventional petrochemical processes

[14] R&D intensity is generally measured by dividing the R&D expenditures of a company by its sales.
[15] The OECD does not only take the manufacturing but also the usage rate of technology into account.
[16] Note that this classification is subject to an aggregation problem by combining biotechnology and pharmaceuticals as we have just seen that only a part of the biotechnology sector can be directly associated to the pharmaceutical industry (i.e., the red biotechnology).

cannot provide" (KET's High-Level Expert Group, 2011). This industry is characterized by a large exposure to new (disruptive) technologies, a growing competition from far-eastern countries (China, India), an accelerating speed of development, high entry barriers because of capital intensiveness (large investments) and knowledge intensiveness, long development cycles with specific threats such as a relatively low success rate and a limited lifetime of intellectual property protection measures (patent cliff). Hence, this industry is highly expansive and exposed to a very competitive and dynamic environment.

### *2.2.2. Unit of analysis*

The present research relates to medium-sized companies. The first question that arises in this matter is to define what is a *mid-size company*. To do so, we started from what is generally included in the broader category of *small and medium-sized enterprises* (SME) and we observed that there is actually no universally accepted definition of it. This situation reflects the relative nature of "small" and "medium" size classifications, which apply differently to companies in different sectors such as manufacturing, agricultural or services; as well as to companies in different countries or regions with varying economic structures. Indeed, a one thousand workforce company can be seen as relatively big to Western European or American standards while it is considered as relatively small or average in a country like China. Making direct statistical comparison between countries therefore involves many challenges among which the fact that these countries often use different definitions for "SME". As an example, Table 2.2 compares the different criterias taken into consideration in defining and categorizing SMEs in the United States, the European Union, Australia, and Canada.

In Japan, criteria such as workforce and capital or total amount of investment are used to define SMEs, but even though the same criteria are used, tresholds that apply to each element vary by sector and also by criteria. To illustrate this point, let's consider the criteria "workforce" and "capital/investment": a firm in Japan will be considered as an SME if it employs less than 300 persons and has a capital of less than 300 million Yen in manufacturing, construction and transportation sectors, but these upper bounds fall to 100 persons and 100 million Yen in wholesale trade sector, 100 persons and 50 million Yen in services industry, and 50 persons and 50 million Yen in retail trade (United Nations, 2005).

All this shows the difficulty in defining clearly what an SME is and the lack of consensus resulting therefrom. Moreover, size expressed in number of employees, is relative as it results

from criteria such as local productivity but also from managerial choices (e.g. the level of process automation).

But, what makes medium-sized companies important units of analysis? SMEs represent a vital component of most economies as well as important players in the well-being of local and regional communities. In the US in 2006, they accounted for 99.7% of the 6.0 million firms defined as non-farm employers, they employed 50.2% of the 119.9 million nonfarm private sectors workers, and they contributed about 50% of the private non-agricultural GDP (USITC, 2010a). Besides employment and economic activity, SMEs provide another unique contribution to the economy by the role they play in innovation. A study released by SBA Advocacy (US SBA, 2009) demonstrates that small firms produce significantly more patents than large firms and that, according to patent impact metrics, their patents are more important technologically. What's more, SME's appear to be more profit- and cost-efficient than large enterprises in that they produce more innovations for a given amount of R&D expenditures (Vossen, 1998).

The relative importance of this category of enterprises is similar in the European Community with an overwhelming majority (99.8%) of SMEs - some 20.9 million – in the EU-27's non-financial business economy (European Commission, 2011; data of 2008). These companies account for two out of every three jobs (66.7%) and for 58.6% of total value added, with a particularly high relative importance in the southern Member States. The contribution to value added being lower than the contribution to employment suggests inherent characteristics of SMEs such as their inability to benefit from economies of scale and their relatively low level of capital intensity.

The Commission of the European Communities has acknowledged the decisive role of this class of companies for the future prosperity of the EU by placing their needs at the heart of the Lisbon Growth and Jobs Strategy in 2000 and by issuing a "Small Business Act for Europe" in 2008 (Commission of the European Communities, 2008) in which it is stated (p.2) that "In a globally changing landscape characterised by continuous structural changes and enhanced competitive pressures, the role of SMEs in our society has become even more important" and "Vibrant SMEs will make Europe more robust to stand against the uncertainty thrown up in the globalised world of today".

Yet, despite their ubiquity and their impact on economic development, SMEs tend to be overlooked by management scholars. Instead, extant literature on organizational ambidexterity has tended to focus on larger firms, generally because data are more readily available since

most SMEs are private firms not subject to the disclosure requirements of publicly traded companies (Cao, Gedajlovic, & Zhang, 2009).

| Country or Region | Definition | | | | |
|---|---|---|---|---|---|
| United States | | All manufacturing firms and non-exporting service firms[a] | Exporting service firms[b] | | Farms |
| | | | Most | High value[c] | |
| | Number of employees | < 500 | < 500 | < 500 | < 500[d] |
| | Annual revenue | Not applicable | ≤ $7 million | ≤ $25 million | ≤ $250,000 |
| European Union | | | | | |
| | Number of employees | < 250 | | | |
| | Annual turnover[e] OR Balance sheet total[g] | ≤ €50 million ($61 million[f]) ≤ €43 million ($52 million[f]) | | | |
| Australia | | | | | |
| | SME (nonfarm) Number of employees | ≤ 200 employees | | | |
| | SME (farm) Estimated value of operations | A$22,500–A$400,000 ($18,866–$335,400[h]) | | | |
| Canada | | | | | |
| | Number of employees | < 250 | | | |
| | Annual revenue | < C$50 million ($48 million[i]) | | | |

*Sources:* USITC, *Small and Medium-sized Enterprises: Overview of Participation in U.S. Exports*, 2010, table 1.1, 1-3; EC, Directorate-General for Enterprise and Industry, *The New SME Definition: User Guide and Model Declaration*, undated, 14 and 16; Government of Australia, Australian Bureau of Statistics, "Definition of Small Business," April 3, 2009; Government of Canada, Industry Canada, "Small Business Quarterly," February 2010; IMF, "Representative Exchange Rates for Selected Currencies," June 1, 2010.

[a] Includes exporting and nonexporting manufacturing firms and nonexporting services firms.
[b] Selected by the Commission on the basis of size and export potential, and includes wholesale trade services; professional, scientific, and technical services; and finance and insurance services.
[c] Computer services was the only sector in this category.
[d] This threshold was imposed by USITC staff to partially harmonize definitions across sectors.
[e] Annual turnover equals the firm's annual value of income from sales and services less rebates paid; does not include value-added tax or other indirect taxes paid.
[f] Based on an exchange rate of US$1.00 = €0.8227 (as of June 1, 2010).
[g] Annual balance sheet total refers to the value of a firm's main assets.
[h] Based on an exchange rate of US$1.00 = A$1.1926 (as of June 1, 2010).
[i] Based on an exchange rate of US$1.00 = C$1.0479 (as of June 1, 2010).

*Table 2.2: Definitions of SME in the United States, the European Union, Australia, and Canada* (reproduced from USITC, 2010)

In this dissertation, the unit of analysis is a company in an intermediary size level that cannot be considered as a micro-enterprise (also referred to as non-employers enterprise) nor as a very large one. The firm regarded hereto is a company (Galactic SA) incorporated in Belgium and involved in industrial biotechnology which is complying with the European definition of mid-

size companies (less than 250 employees), at least for its local entities, and to the US definition (less than 500 employees) at a group level. It was founded in 1994 with 4 members, now employing about 400 people in 7 different locations on 3 continents, and selling about 100,000 tons of products in 65 different countries. Throughout its history, the company which is still to be considered as a medium-sized enterprise has been confronted with major changes in its environment and has had to survive turbulent times, re-inventing itself in order to develop into a group of companies that includes sole ventures as well as joint ventures with external foreign partners. Figure 2.1 shows the group structure as it was at the time this dissertation was written.

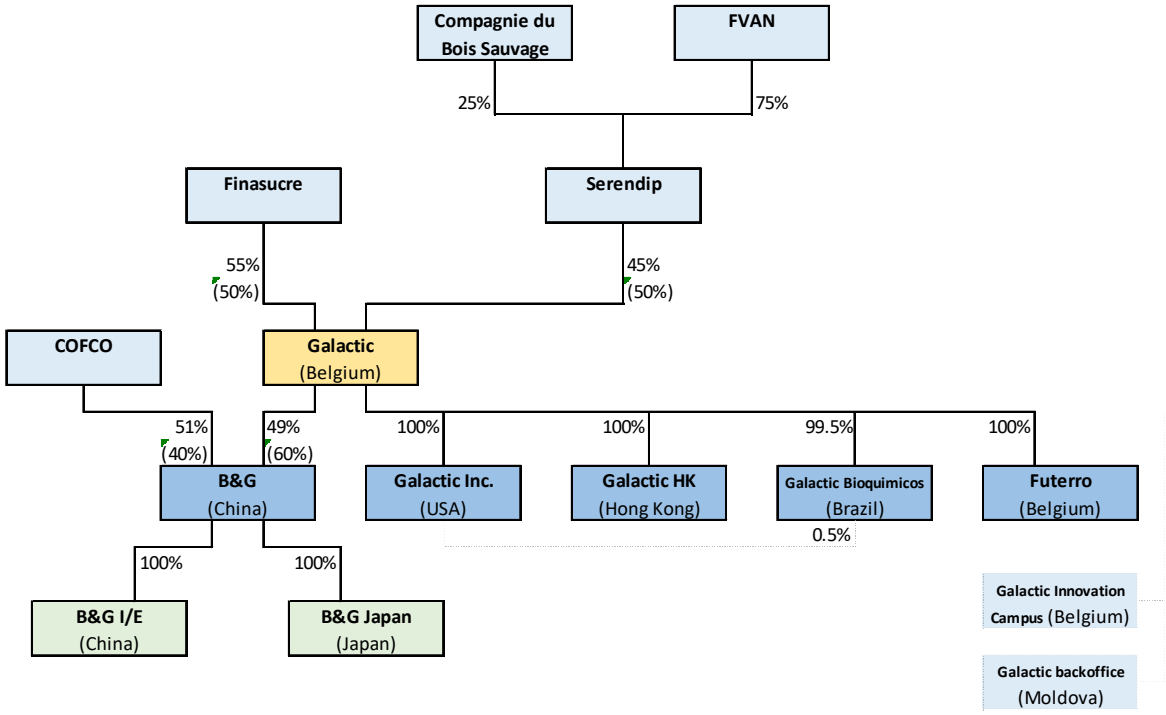



*Figure 2.1: Group structure in 2015-2016*
*(% of control in brackets; the dotted line rectangles are not fully-incorporated companies but other operational locations)*

The chemistry of nature is what inspires Galactic to imagine a world in which chemistry meets nature. Today, this world opens up countless possibilities to replace expensive petrol based solutions with sophisticated alternatives. They are equal in performance to say the least, and far more superior in respect to the environment. Handed to us by nature, Galactic products are completely natural themselves. Therefore they hold a promise for future challenges.

Galactic activities can be divided in three main categories: Natural Solutions, Biopolymers, and Bioprocess Platform.

As a matter of facts, the company is the second largest producer of lactic acid and derivatives with manufacturing units in Europe (Belgium), Asia (joint venture in China) and America (US) and sales offices in Japan, Hong Kong and Brazil. Its products are used in human food, animal nutrition, polymers, pharmaceuticals, cosmetics, paints, inks, agrochemicals and many other applications. Lactic acid is made by fermentation of carbohydrates with the help of microorganisms; therefore part of what is generally referred to as industrial biotechnology or 'white biotechnology', a sector of great interest in the current context as it uses renewable (agricultural) resources instead of fossil ones as raw material. The company is therefore positioning itself as a provider of natural solutions to all industries it serves. In order to reduce its exposure to growing competition leading to a commoditization of lactic acid, the company is exploiting its core competencies in fermentation to develop beyond lactic acid with a wider range of natural solutions (proteins, starter cultures and fermentates).

Both the market of lactic acid and the one of natural food protection ingredients, in which Galactic is active, display firm growth thanks to strong drivers such as a growing need for food safety, for healthy and environmentally friendly solutions (in food and non-food segments), and for performing and low-cost-in-use alternatives to existing ingredients and chemicals.

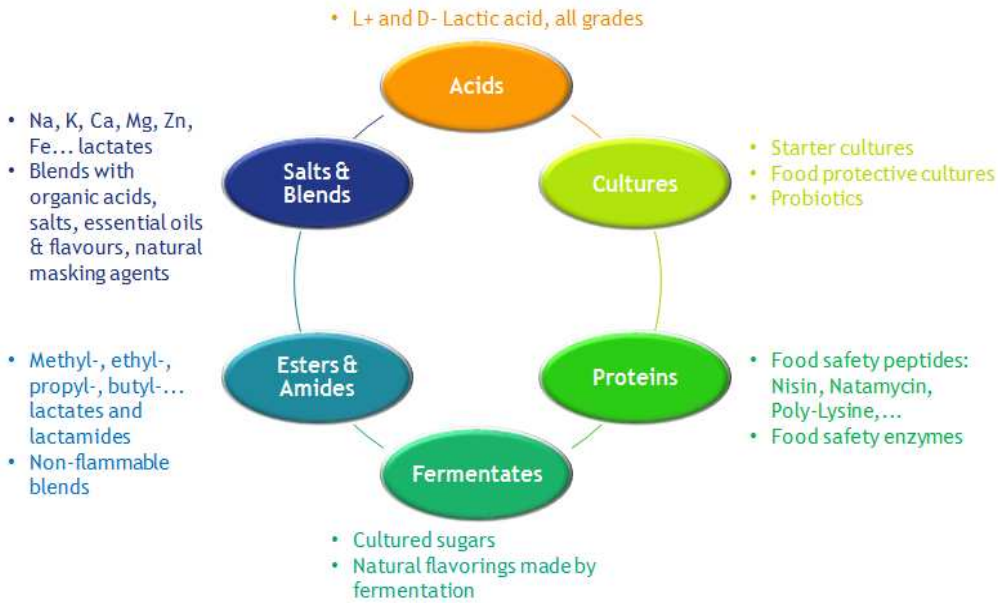



*Figure 2.2: Galactic's current product offering enables value-adding combinations for the food and non-food industries*

Galactic also pioneered research and development on PLA (polylactic acid) almost 20 years ago. PLA is a bio-plastic produced from lactic acid. In 2007, Total Petrochemicals recognized the potential of Galactic's technology and the companies decided to enter into joint venture. Futerro was set up with the mission to further develop PLA technology and make it robust enough to enable industrialization. Futerro's mission is not to become a large scale PLA producer but to focus on R&D and licensing of its technologies. The market of bio-based plastics in general and of PLA in particular is estimated to grow in the coming years, therefore offering a nice opportunity to companies having efficient technologies in this field.

In addition to its production and sales activities, the company is also valuing its R&D by licensing patents and technologies and offering R&D services. Based on its 20 years of expertise in fermentation processes and thanks to a state-of-the-art R&D infrastructure, the company continues to develop a pipeline of technologies among which some are particularly interesting, i.e. bio-succinic acid, bio-propionic acid and bio-acrylic acid. Indeed those chemicals are currently derived from fossil resources, their respective markets are large and growing, and there is a real interest in the industry to have them produced from renewable resources. Since its inception in 1994, Galactic has filed for 34 patent families of which 17 have been licensed out. Besides R&D activities for its own account and licensing out some of its own technologies, the company also provides R&D services such as on-demand fermentation and/or purification campaigns for external companies and incubation of biotech start-ups in its innovation campus.

### *2.2.3. Longitudinal case study*

The purpose of our research is not to determine whether organizational ambidexterity impacts faborably firms' survival in dynamic environments but, assuming it does, to elucidate *how* smaller firms can effectively implement an ambidextrous orientation. As explained before, "articulating *why* ambidexterity is important is not the same as *how* it is implemented" (Tushman & O'Reilly, 2011, p.18, emphasis is original). Our challenge here lies in the identification of generative mechanisms and underlying processes supporting the ambidextrous orientation of a company. According to Sarasvathy and Kotha (2001), that challenge is uniquely met by the case study methodology, and Yin (2009, p.1) tells us that "in general, case studies are the preferred strategy when 'how' or 'why' questions are being posed, when the investigator has little control over events, and when the focus is on a contemporary phenomenon within

some real-life context". We therefore intend to use our personal position as director in this company since its inception to conduct a longitudinal in-depth case study covering the last 25 years of its existence.

We believe that the analysis over a relatively long period of time allows to highlight an evolutionary dynamic that the study of short time intervals does not allow. This approach should also make it possible to sort relevant information out of the noise information inherent to any human activity[17].

Studying one single organization may limit the generalizability of our findings but, "by concentrating on one organization with 20 years of continuity in leadership, the research could access sources with intimate knowledge of the details of the firm's evolution and could examine in depth how the organization had dealt with partial failure – and the threat of complete failure – at a critical point in its history" (Burgelman, 1991, p.242). The clear and non-negotiable timeframe of a DBA thesis will help us to overcome the risk of getting trapped in relentlessly developing local knowledge without taking time to carry out the scholarly activity of conceptual generalization (Avenier & Cajaiba, 2012). Moreover, "a longitudinal case study approach not only provides us with the opportunity to look at different stages (…), but also allows us to explore the sequence of events" (Khanagha, Volberda, & Oshri, 2014, p.324) which will be particularly valuable in our case to reflect on the dynamic aspect of the exploitative and exploratory moves that have been implemented by the company studied. We expect nonetheless that our findings will offer "heuristic generalization opportunities for refining our analytical understanding" of the phenomena at play (Tsoukas, 2011, p.295). We intend to extend upward the conceptual generality of the local contextualized knowledge that we will generate by connecting it to extant literature and "examining whether the reviewed literature offers insights that sufficiently illuminate the practical problem to then help practitioners design a promising way to deal with the problem" (Avenier & Cajaiba, 2012, p.203).

[17] Taleb gives a clear example of that by comparing news and history. The news (by essence imbedded in the short term) is full of noise (useless information) whereas history is largely stripped of it (Taleb, 2007a).

## 2.3. Methodology

To answer our research question, we have adopted a four-steps approach as described hereunder.

*Step 1: A narrative about the company history and an analysis of its environment*

In line with the recommendations for longitudinal case studies (Thiétart, 2014; Yin, 2009), we started the analysis by reconstructing the timeline of events by writing a narrative tracing the company's history on the basis of various archival sources (see section 3.7. "Data-generation" and Appendix II "The history of Galactic"). In doing so, we follow Burgelman's ecological view of reality who believes that, in contrast to a reductionist approach that isolates variables and looks at relationships between these, historical methods adopt an ecological approach which "examines how individual components interact to become systems whose nature cannot be completely understood from looking only at the sum of the parts" (Burgelman, 2011, p.11).

But, why a narrative?

> *« Un récit ideal commence par une situation stable qu'une force quelconque vient perturber. Il en résulte un état de déséquilibre ; par l'action d'une force dirigée en sens inverse, l'équilibre est rétabli ; le second équilibre est bien semblable au premier, mais les deux ne sont jamais identiques. Il y a par conséquent deux types d'épisodes dans un récit : ceux qui décrivent un état (d'équilibre ou de déséquilibre) et ceux qui décrivent un passage d'un état à l'autre. »*[18]
>
> Tzvetan Todorov (1973), *Introduction à la littérature fantastique*, Paris, Seuil.

Dumez (2016, p.129) concludes from this extract that a narrative is the construction of a passage from one equilibrium to another. We have a slightly different reading and we take from the Todorov citation, stretching it a little, that if the description of stable situations may eventualy require narratives, describing dynamic changes definitely imposes the use of narratives. The difference between descriptions and narratives lies precisely in the implied influence of time.

[18] "*An ideal narrative begins with a stable situation being disturbed by any force. This results in an unbalanced state; by the action of a force directed in opposite direction, the balance is restored; the second equilibrium is similar to the first, but the two are never identical. There are therefore two types of episodes in a narrative: those which describe a state (balanced or unbalanced) and those that describe the passage from one state to another*."

Actions and interactions unfold over time and Dumez (2016, p.129, translation is ours) tells us that "the researcher who wants therefore to explain social dynamics, dynamics of interactions between individuals or of institutional development, must go through the narrative. (…) The narrative then has a status of knowledge production, of exploration, a tool to discuss theories". Following Popper (1956), Dumez adds (2016, p.13, translation is ours) that "we must break with the idea that we should exclude the description and the narration as extra-scientific, literary and subjective forms: qualitative research must describe and tell, and the description and the narration should be considered as scientific and objectifying methods susceptible of criticism".

In analyzing the key events of the company's history, we identified four major periods characterized by different strategic intents (see Section 3.1.1 "The four main epochs of the company's history") as well as three exogenous variables heavily impacting the company's day-to-day operations (see Section 3.2 "The company's environment"). These variables are easily measurable and allow for an objective confirmation of the highly volatile and uncertain nature of the company's environment even besides unexpected events of accidental nature.

### *Step 2: Quantifying different components of Organizational ambidexterity*

The second step of our methodology was to list the main managerial decisions over a period of 25 years, from 1991 to 2015. To do so, we followed the event listing method prescribed by Miles and Huberman (1994) and also used for instance by Sarasvathy & Kotha (2001) in their study of effectuation in the management of Knightian uncertainty. A set of 410 decisions has been collected from various archival sources (see section 2.4.1 "Data generation"), dated, organized in chronological order and coded (see section 2.4.2 "Code-book design") in order to measure the different dimensions of organizational ambidexterity. In total, 12 criterias have been identified and measured for each decision listed and 6 compounded indexes have been computed which lead to a first dataset of about 7,400 data covering the 25 year period under scrutiny (see section 2.4.3 "Data analysis").

In a similar way, 277 contextual events have been recorded, dated and sorted in 8 different categories describing variations in the environment in which the company evolved during this same period of time. Another 3 counpounded indexes have then been computed. Altogether, this formed a second dataset of about 3,050 data.

### *Step 3: Searching for underlying processes*

> *"Not everything that can be counted counts, and not everything that counts can be counted."*
>
> Albert Einstein

The objective of this third step in our approach is to abductively search the manner in which the generative mechanisms and underlying processes of organizational ambidexterity are activated with regards to contextual conditions by triangulating between data from the narrative, the various archival documents gathered and the measurements that emerged from the quantitative analysis of managerial decisions and contextual events.

A case study generally consists of a summary of the case itself (a literary presentation) without *a priori* model (an approach often used in sociology) followed by a largely inductive analysis. We add a systematic analysis of quantitative nature by the coding of documents using a code-book which is based on existing and clearly identified theories (organizational ambidexterity; exploration-exploitation; causation-effectuation). The juxtaposition of qualitative and quantitative modes of analysis intents to combine their discrete advantages, offset their inherent liabilities and, as a consequence, achieve a deeper understanding of how ambidexterity is operated in practice than either method could have produced alone (Meyer, 1982).

### *Step 4: Discussion and attempt to generalize*

The fourth stage of our journey consists to discuss further our findings in order to identify the elements specific to our research unit and its own environment on the one side, and to draw generalizable elements on the other side.

## 2.4. Data

### *2.4.1. Data collection*

Our research relied on various archival sources such as minutes of management meetings, minutes of board meetings, internal memos, press releases, announcements, communications to unions and staff members, e-mails etc… Table 2.3 presents an overview of these data sources.

| Document type | Number of Documents |
|---|---|
| Information from competitors | 342 |
| Business notes, memos, presentations & reports | 294 |
| Management meetings (minutes & material) | 185 |
| Board meetings (minutes, decisions & material) | 108 |
| Periodic information to the Works Council (since 2012) | 59 |
| Press articles, press releases & announcements | 59 |
| Minutes of Works Council meetings (since 2012) | 21 |
| Information from shareholders | 18 |
| Licensing agreements, joint-venture agreements | 16 |
| Conferences material, general presentations | 11 |
| Grant files & reports | 5 |
| **Total number of documents** | **1118** |

*Table 2.3: The archival sources of data used in our research*

A list of 410 major actions or decisions taken by the company all along its 25 years of history has been established on the basis of the analysis of the various documents listed above. Figure 2.3 shows the evolution of the number of observations (actions, decisions) recorded for each year of the period covered by the study[19].

The exponential growth of actions/decisions per year reflects the development of the company and its transformation from a very small entity with a few employees to an international organization with about 400 staff members in six locations on three continents. We could however also argue that our data set is richer in the last years and poorer in the earlier years of the period covered because older documents were harder to retieve. To circumvent this problem and to be able to compare data from different years, we averaged the measures for each year (see section 3.9 “Data analysis” for more details).

[19] The year 2010 was apparently particularly rich in documents mainly because of a high number of patents filed this year.

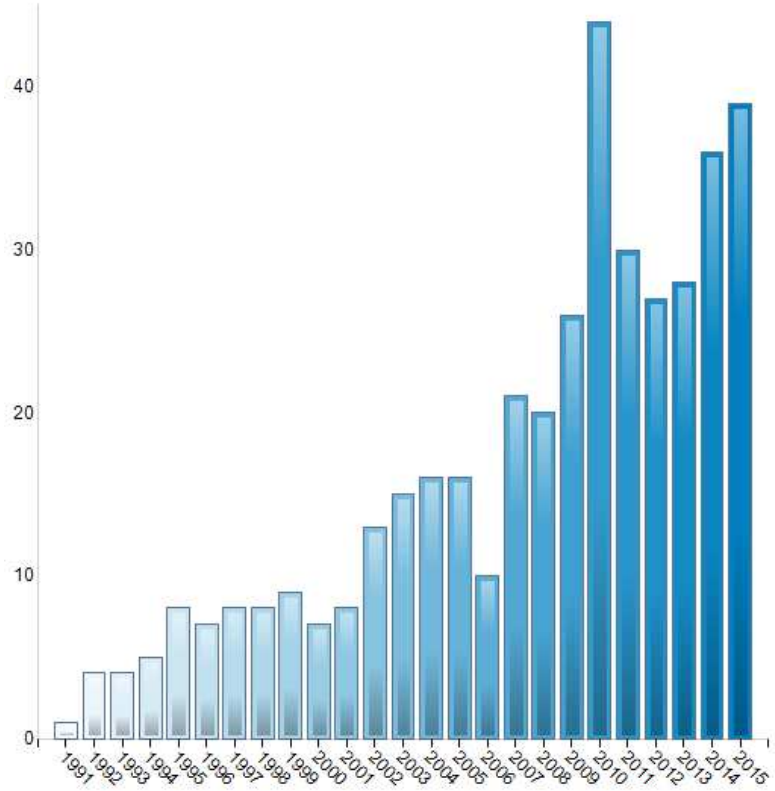



*Figure 2.3: Number of observations (actions or decisions taken by the company) in each year from 1991 to 2015 (mean = 17.70; median = 19.00; standard deviation = 6.05)*

In parallel to the listing of decisions taken by the management over the years, we have recorded 277 contextual events that characterized the company's environment over the same period of time. These context events include external environmental incidents that occured beyond the control of the organization (Cheng & Van de Ven, 1996) but which were likely to influence positively or negatively its development. To search for these events, we analysed the archival sources specific to the company as mentioned hereabove (memos, meeting minutes, communications etc…) and other sources external to the company such as databases (IMF[20] database for feedstock and utility prices, OANDA[21] database for foreign exchange rates) as well as press releases, financial statements and reports from financial analysts about competitors. All the recorded events were dated and sorted along the following categories, most of which were mentioned already in Table 1.4.

[20] International Monetary Fund Commodities Data (www.imf.org/external/np/res/commod/External_Data.xls).
[21] Oanda database on historical rates (www.oanda.com/lang/fr/currency/historical-rates/).

- Competitive intensity has been proposed as a key environmental moderator of ambidexterity and firm performance. Competitive intensity, also referred to as Environmental Competitiveness, reflects the degree of competition, i.e. the number of competitors or the number of areas in which there is competition (Jansen et al., 2005). More specifically, competitive intensity reflects the extent to which organizations succeed in maintaining zero-sum relations with the others as they compete for the same pool of limited resources (Barnett, 1997). Jansen et al. (2006) found that competitiveness increases the need to pursue exploration and exploitation simultaneously but Levinthal & March (1993) claimed that outcomes of exploration tend to rapidly diffuse among competitors in competitive environments. New entrants benefit more from exploitation when competitive intensity decreases whereas defenders benefit more from exploration when it increases (Auh & Menguc, 2005).
- Market trend must be taken here in its marketing acception, based on offer and demand, and not in regards to financial nomenclature, i.e. a perceived tendency of financial markets to move in a particular direction over time. We refer to market trends in our study for variations in customers preferences and/or suppliers propositions. As an example, in 2005, the specter of inflation resurfaced with the constant increase of crude oil prices, but, at the same time, supported a growing interest for new energy sources and non-fossil technologies.
- Resource availability: we refer to resources here as *external* economic factors required by the company to accomplish its activity (feedstocks, raw materials, utilities and eventually labour force). The analysis of the archival sources indicated periods of scarcity for some of these external resources disrupting supply chain and leading to shortages. Excluded from this section are the *internal* aspects generally considered in resource-based view approach of corporate strategy which emphasizes leveraging firm competences to create competitive advantage (Brown & Eisenhardt, 1997).
- Crises: Schmitt and colleagues (2010, p.130) define a crisis as “an ambiguous situation that poses a major threat to organizational survival (…), whose causes and effects are unknown (…), to which there is little time to respond (…), and which requires decisions or judgments that will result in a change for the better or the worse (…)”. Therefore, a crisis disrupts the activities of an organization and, at best, provides an opportunity to reorganize itself to be more efficient in the future. In other less favorable cases, or if inevitable crises are not properly managed, they can jeopardize the very existence of the

organization. We include in this category the economic and financial crisis, political events, natural catastrophes, technological disasters and firm-level crises such as labor strikes out of the control of the company but which have had a direct impact on the course of its development. An example of crisis that impacted the company came in 2009 with the credit crunch that resulted from the global financial crisis and its aftershocks and that posed existential threats to leading global financial firms while capital-intensive sectors such as life sciences and biotech were under pressure from a tighter credit environment, or in 2014 with the financial crisis in Russia which resulted from the collapse of the Russian ruble triggered by the falling oil prices, a major export of Russia, and international economic sanctions imposed on Russia following Russia's annexation of Crimea and the Russian military intervention in Ukraine. This situation impacted Galactic sales in this region directly but also indirectly by affecting meat producers in Western Europe who are exporting their products to Russia. But, as said, crisis can also offer opportunities for faster development such as in 2012 when the lactic acid production plant of a Japanese competitor was stopped for months because of Fukushima nuclear disaster the year before and that B&G Japan took this opportunity to fill the empty space and increase its market share.

- Cost fluctuations obviously influence the company's competitiveness, especially when they are not resented with the same intensity by the different economic actors. Again, we consider here only macro-economic fluctuations in market forces which result in moves of feedstock prices, raw materials or utilities, eventually amplified by speculation and decisions at political level. The surge of sugar price in 2009 offers a good example of such volatility when the New York #11 index increased by 45.8% over the previous year (yearly average).
- Currencies and exchange rates fall obviously beyond the control of a company, even if it eventually uses hedging tools, i.e. forward contracts, swaps, options, futures and other derivative products.
- Regulatory framework: changes of normative environment promote or hinder the development of entire fields of activity and local governments may institute policies that influence organizations' predisposition toward either exploration or exploitation (Lavie et al., 2010, p.145). For instance, when in 2013 the European Commission receives green light to authorize the use of lactic acid to reduce microbial surface contamination in beef carcasses, a new market opens up to lactic acid producers. The same happened in 2006 when the European Union decided to ban the use of antibiotics

as growth promoters in animal feed or in 2003 when the public health agency within the USDA (FSIS) issued a new regulation by which meat processors must take actions to protect Ready-to-Eat Meat and Poultry products against the growth of a foodborne pathogen called Listeria monocytogenes. On a more negative note, difficulties arose in 2008 when China Marine Bureau declared lactic acid a « hazardous material » whereas it was not listed as hazmat by the United Nations nor by any other country, or the year before when the Chinese Export Tax refund was suddenly reduced from 13% to 5% which implied an immediate and unexpected drop of 8% in sales margin for all exports from the company's Chinese facility. Furthermore, normative rules are not only based on laws and regulations but they also include cultural norms, ethics, and administrative principles (Burgelman, 2015).

- Disruptive technology as proposed by Christensen (1997) echoes Shumpeter's creative destruction (Schumpeter, 1934). It is "a technology that changes the bases of competition by changing the performance metrics along which firms compete" (Danneels, 2004, p.149). Whereas one usually think of disruptive technologies for major advances "that will transform life, business, and the global economy"[22], we refer to it more modestly for technological innovations which have the potential to change the rationale of the industry in which our unit of analysis is evolving and hence put its future development at risk.

As can been seen from the distribution of contextual events (Figure 2.4), the company was primarily exposed to changes in competitive environment, variations in currencies, and costs fluctuations. These three categories of events account for 80% of the environmental events recorded.

[22] The McKinsey Global Institute lists for instance: the mobile Internet, automation of knowledge work, internet of things, Cloud, advanced robotics, autonomous and near-autonomous vehicles, next-generation genomics, energy storage, 3-D printing, advanced materials, advanced oil and gas exploration and recovery, and renewable energy.

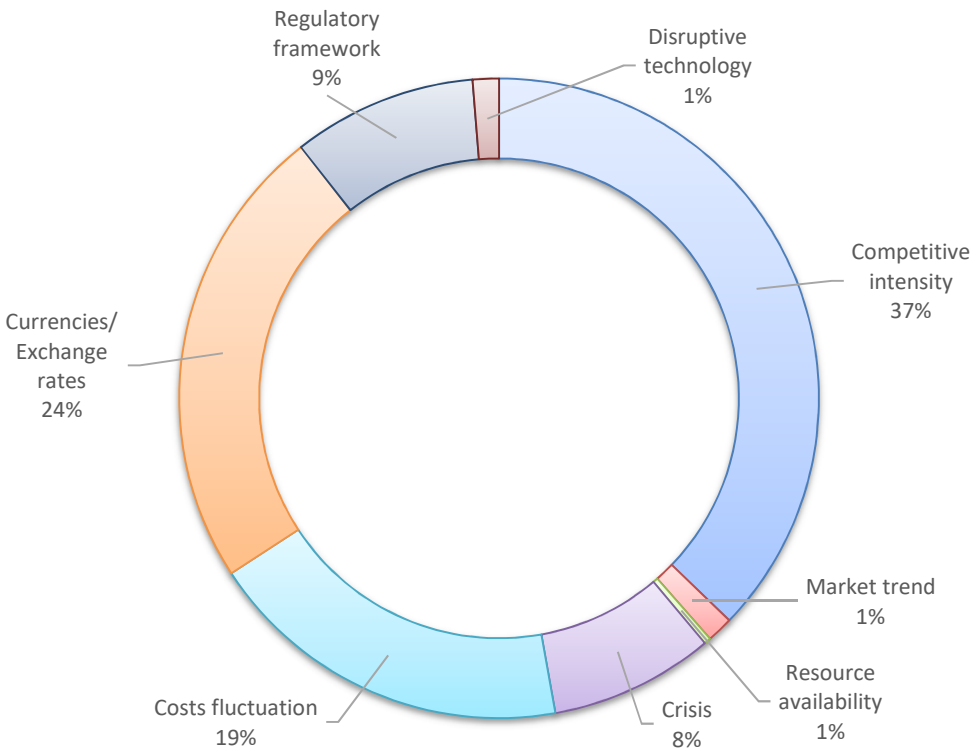



*Figure 2.4: Distribution of contextual events by category (277 records in total)*

Other antecedents of change raised in Table 1.4 such as 'globalization and interconnectedness' (Friedman, 2005) and 'change of capitalistic paradigm' which indicates a shift of power from executives to shareholders (Cannella, 1995) are not contemplated here. Lavie and colleagues (2010) pointed that trends for globalization entail greater attention to socio-environmental antecedents of exploration–exploitation but such kind of tidal waves are part of much longer cycles, incremental by nature, for which clear inflections cannot be detected in a study like ours. What is more, the greater shareholder power progressively gained in the second half of the twentieth century by institutional investors and in the beginning of the twenty-first century by hedge-funds and activist shareholders (Wells, 2016) was more a subject for large public corporations where managers wielded the real power than for small or medium sized companies such as our unit of analysis.

Following Cheng & Van de Ven (1996), events were coded as per the estimated impact they may have had on the development of the company. Hence, five levels have been defined and impact values attributed: extremely positive (+2), positive (+1), neutral (0), negative (-1), or extremely negative (-2). It is worth insisting that this analysis was perfomed from the

perspective of the company which means that an event might be considered positive (for the company) eventhough it might have adverse effect on other economic agents. An example illustrates this point: Fukushima Daiichi nuclear disaster in 2011 was a terrible accident that harmed populations and hit dramatically the Japanese economy. To this extend it was rated as negative (-1) because it hindered B&G Japan's growth by way of consequence. However, this unfortunate event led in the next year to another fact which was rated as positive (+1) in terms of competitive intensity when the company's main competitor in Japan located close to Daiichi prefecture had to cease production for several months, a situation that offered an opportunity for B&G Japan to fill the space and rapidly grow its market share.

### *2.4.2. Code-book design*

*Pure coding*, directly from the material itself as in "*grounded theory*" approaches, may not be applicable to refining an existing theory. The grounded theory methodology operates almost in a reverse fashion from social science research in the positivist tradition (Glaser & Strauss, 1967). In this approach, no theoretical assumption should be used *ex ante*: the theory emerges from the material itself (Dumez, 2016). Conversely, our case aims at refining an existing theory. We therefore adopt a *theoretical coding* as discribed by Bohm (2000). In this way, the material is encoded from categories coming straight from the theory. Dumez (2016, p.73) opposes to this method the obvious risk of circularity and wonders how this approach can bring forth surprises, unexpected results, and changes of point of view from the retained material. However, in addition to the measures taken to avoid or lessen the risk of circularity (see section 2.3.2 hereinabove), we believe that Dumez' questioning applies to researches aiming at finding new theories but not to our case which, again, seeks to refine, confirm or invalidate an existing theory (organizational ambidexterity) in a clearly defined context (see sections 2.2.1. "Research setting" and 2.2.2. "Unit of analysis").

Our study could not be subjected to an independent double coding due to the limited time allowed for a DBA but also because the material analyzed, largely made of internal company documents, resorts to a specific jargon difficult to apprehend for external researchers. A deep understanding of the company, its culture and products, as well as the impediments and extraneous influences was also deemed necessary to be able to proceed to an objective, appropriate, relevant and fruitful coding.

Dumez (2016, p.77), inspired by Aristotelian scholasticism, teaches us that the core of the coding work is to mount in generality but not too much, that is to say, to look for the nearest generality by working on the specific difference. This forms the basis of our methodology in designing our code-book inspired from Gioia's "systematic inductive approach to concept development" (Gioia et al., 2013) that we applied to the questionnaires used in 20 different researches on organizational ambidexterity published in literature. As per Burgelman (2011), finding the right balance between "particular generalization" and "general particularization" is precisely the role of longitudinal qualitative research. Indeed, in his attempt to bridge history and reductionism, Burgelman explains that "historians make sense out of extensive narratives by giving them some limited general applicability (they generalize the particular)", to "show how past processes have produced present structures", whereas "social scientists use limited narratives to illustrate presumably general theories (they particularize the general)" (Burgelman, 2011, p.17-18). Our longitudinal case study, and especially the methodology we have adopted to analyse the data with the help of a strictly-structured coding, exactly targets this goal of being positioned between the historian's particular generalization and the reductionist's general particularization in order to avoid the shortcomings of these two extremes (i.e. the general, abstract, non-experiential, statistical aspects of reductionism on the one hand; the particular, concrete, experiential aspects of the historian's approach on the other hand).

Organizational ambidexterity can be considered as a contruct in that it can be measured and that "its primary purpose is to delineate a domain of attributes that can be operationalized and preferably quantified as variables" (Gioia et al., 2013, p.16). As indicated in Section 1, many different methods have been used to operationalize organizational ambidexterity but none of them seemed appropriate to capture the different dimensions of the construct in a way that allowed its measure althrough the 25 years of history of our unit of analysis. The literature on organizational ambidexterity has generally taken a static approach by mainly relying on cross-sectional surveys and much of the work to date has consisted in empirical studies using financial performance (profitability, earnings, sales over assets, cash flows), sales performance (sales growth, market share growth) or eventually knowledge and innovation (patents, Tobin Q's) as dependent variables. In order to be able to measure ambidexterity each and every year of the company's history in a reliable and comparable way, we had to identify its components and design a method to evaluate each of these components. To do so, we developed a methodology inspired from Gioia's method for grounded theorizing (Gioia et al., 2013) which enabled us to identify 1st-order concepts from the 20 recent empirical papers mentioned above. These papers,

listed in Table 2.4, were predominantly selected for the level of details in describing their methodologies. The 1st-order concepts coalesced into 2nd-order themes which were then grouped into aggregate dimensions forming the basis of our code-book. Figure 2.5 summarizes this logical process.

| Reference | Year |
|---|---|
| Rothaermel & Deeds, 2004 | 2004 |
| Kyriakopoulos & Moorman, 2004 | 2004 |
| Gibson & Birkinshaw, 2004 | 2004 |
| He & Wong, 2004 | 2004 |
| Sidhu, Volberda & Commandeur, 2004 | 2004 |
| Atuahene-Gima, 2005 | 2005 |
| Lavie & Rosenkopf, 2006 | 2006 |
| Lubatkin, Simsek, Lin & Veiga, 2006 | 2006 |
| Jansen, Van den Bosch & Volberda, 2006 | 2006 |
| Bierly & Daly, 2007 | 2007 |
| Lin, Yang & Demirkan, 2007 | 2007 |
| Morgan & Berthon, 2008 | 2008 |
| Brion, Mothe & Sabatier, 2008 | 2008 |
| Mom, Van den Bosch & Volberda, 2009 | 2009 |
| Cao, Gedajlovic & Zhang, 2009 | 2009 |
| Brion, Mothe & Sabatier, 2010 | 2010 |
| Voss & Voss, 2012 | 2012 |
| Patel, Messersmith & Lepak, 2013 | 2013 |
| Cummings, 2013 | 2013 |
| Ming, 2014 | 2014 |

*Table 2.4: List of research papers used to isolate concepts, themes and aggregate dimensions as basis for our code-book*

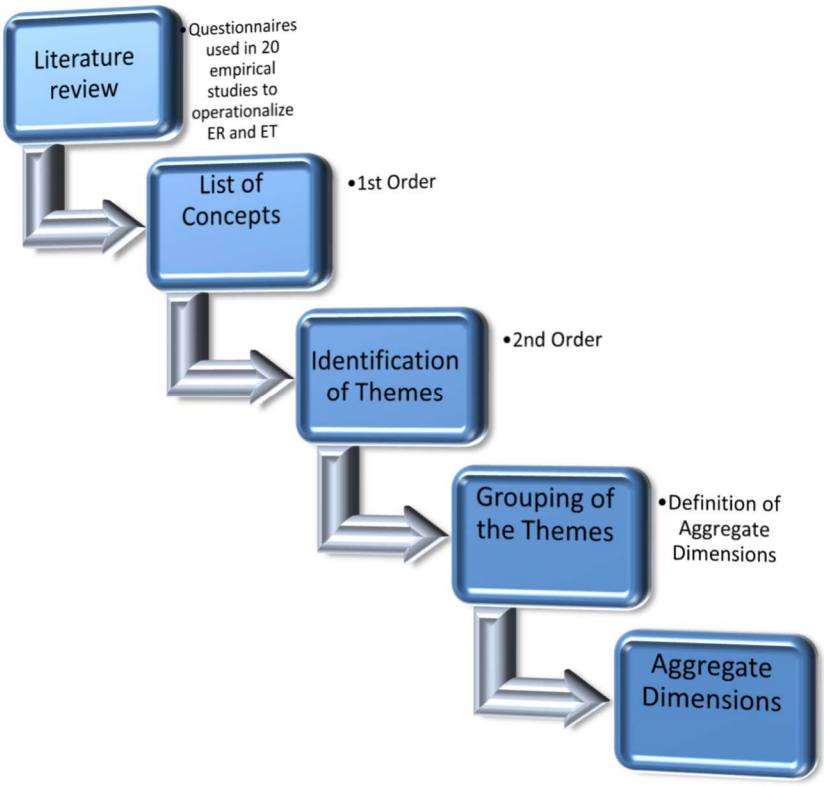
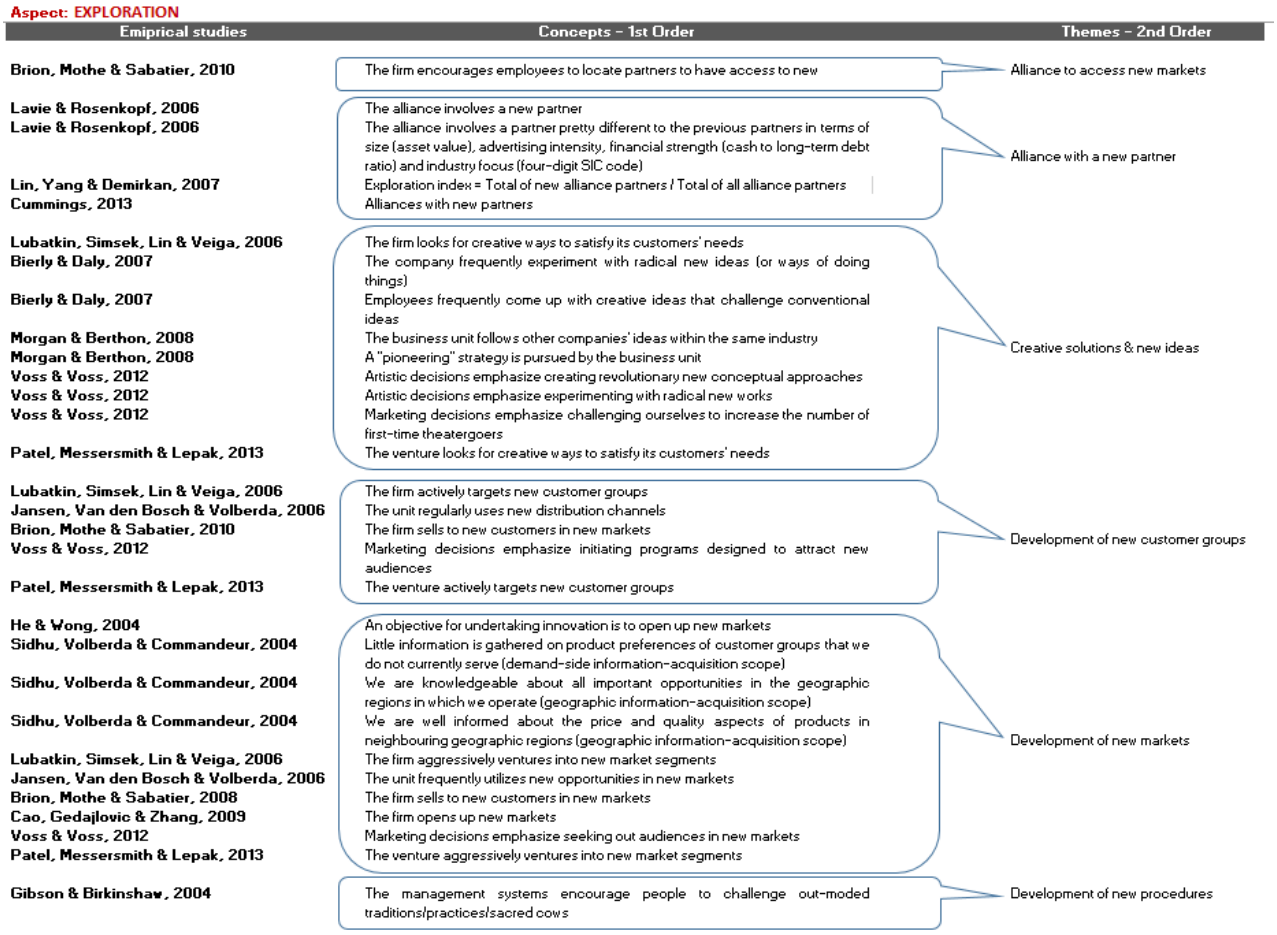



*Figure 2.5: Logical process followed to identify aggregate dimensions for the code-book*

Next, Gioia recommends to build a "data structure" which provides a graphic representation of the progression from raw data (the questionaires from 20 empirical studies) to selected themes. Figure 2.6 shows a partial example of such a data structure; the complete data structure with all the concepts and themes for both exploration and exploitation appears in Appendix IV.




*<u>Figure 2.6:</u> Example of "data structure" for Exploration (partial)*

In the process of clustering the concepts into main themes, we found out that some concepts existed for one aspect (exploration for instance) but did not emerge for the other aspect (exploitation in this case). We therefore created themes not substantiated in the literature but necessary to mirror the ones that came out for the other aspect. They are highlighted in italic in Table 2.5. which presents the aggregated dimensions that we have identified for each aspect of organizational ambidexterity as defined earlier, i.e. exploration and exploitation. For some themes however, it was not possible to proceed with this "mirroring". The opposite for "Economy of scale" for instance would make no real sense and would therefore never be selected during the analysis of our data. This was also the case of "Reduction of costs and consumptions". We resolved to keep those two themes on the exploitation side only without counterparts for exploration.

| Aggregate dimensions | Aspects<br>EXPLOITATION | EXPLORATION |
|---|---|---|
| **Type of alliance** | | |
| | Alliance with an old partner | Alliance with a new partner |
| | *Alliance to penetrate existing markets* | Alliance to access new markets |
| | Exploitative alliance (focus on downstream activities) | Exploratory alliance (focus on upstream activities) |
| **Organizational actions** | | |
| | Improvement of efficiency | Flexibility to changes |
| | Improvement of existing activities | Development of new activities |
| | Improvement of existing procedures | Development of new procedures |
| | Improvement of existing skills or knowledge | Development of new skills or knowledge |
| | *Plannification - Predictable consequences of actions* | Unknown future - Unknown consequences of actions |
| | Economy of scale | |
| | Reduction of costs or consumptions | |
| **Supply-side actions** | | |
| | Improvement of existing technologies | Development of new technologies |
| | Improvement of production processes | *Development of new production processes* |
| | Improvement of existing products | Development of new products |
| **Demand-side actions** | | |
| | *Expansion of market shares in existing markets* | Development of new markets |
| | Deeper penetration of existing customer groups | Development of new customer groups |
| **Experience vs. Creativity** | | |
| | Building on accumulated experience | Creative solutions & new ideas |
| | Providing existing solutions to customers | *Providing new solutions to customers* |
| **Timeframe** | | |
| | Short-term goals | *Long-term goals* |
| **Intellectual Property (IP)** | | |
| | Exploiting existing IP (licensing-out) | Development of new IP (patenting) |
| | | Acquiring new IP (licensing-in) |

*Table 2.5: Aggregate dimensions identified for Exploration and Exploitation after a first round of clustering*

(In italic, the themes that did not come directly from the material but were created to mirror the ones identified in the other aspect. The aggregate dimension "Intellectual Property " has been added.)

This logical and systematic approach left us with six aggregate dimensions, i.e. type of alliance, organizational actions, supply-side actions, demand-side actions, experience versus creativity, and timeframe. Yet, looking at the company's activities and the extant literature on organizational ambidexterity, we came to believe that one dimension of interest was missing and was not covered by any other dimension: the intellectual property (IP).

IP did not show up in our analysis because the 20 empirical studies our analysis was based on were using questionaires (the very reason why they were selected) whereas patent-related researches are mostly based on recording and processing numerical data such as number of patent owned, number of patent applications, number of patent awarded etc… (Andriopoulos & Lewis, 2009; Benner & Tushman, 2002; Katila & Ahuja, 2002). The role of intellectual

property seems obvious on the exploration side of the ambidexterity spectrum as new ideas, creations, processes, technologies and other intangible assets must be protected (patenting) and measures must be taken to be in a position to prove by way of evidence priority and pre-emptive rights (notarial deeds, i-depot[23]). Acquiring licenses from other companies or research centers (licensing-in) is also a way to explore new directions. Likewise, IP is affecting the other side of the spectrum, exploitation, as granting licenses to other organizations can be seen as an alternative approach to extract value from new developments, hence to exploit the results of exploration activities. Moreover, beyond the intellectual property strategies enacted by the companies, the IP regulatory environment has also and impact on the propensity to explore or exploit: Lavie and his colleagues (2010) for instance claim that the value of exploration is reduced and firms may whithhold their investments in exploration and focus more on exploitation in the case of insufficient government protection of intellectual rights.

When taking IP into account we were however confronted with one theme on the exploration side for which we found no exact counterpart in the exploitation side, i.e. "Acquiring new IP (licensing-in)". Here again we decided to keep it anyway as we thought it would be worse not to consider it at all than to add it without counterpart.

After this first round of structuring exercise, we ended up with 7 aggregate dimensions covering 19 themes describing exploitation and 18 themes characterizing exploration. However, soon after we started to use our newly-built code-book to analyse our data-set made of managerial decision or actions taken by the company during its 25 years of existence, we realized that more aggregation could be effected in order to gain in clarity and simplicity without losing in accuracy and precision, i.e. to mount in generality as recommended by Dumez (2016, p.77).

- In the aggregate dimension "Organizational actions": the themes "Improvement//development of existing//new activities", "Improvement//development of existing//new procedures" and "Improvement//development of existing//new skill or knowledge" have been merged in a more general "Improvement//development of existing//new activities, procedures and knowledge". Similarly, the themes "Economy of scale" and "Reduction of costs or consumptions" have been condensed in one single theme.

[23] The i-DEPOT is a legal means of evidence that issues a date stamp on a given idea or creation. It proves the rightful ownership of a specific creation at a specific date. The i-DEPOT is organized by the Benelux Office for Intellectual Property and is equivalent to the "envelope soleau" in France.

- In the aggregate dimension "Supply-side actions": the three themes have been merged into one "Improvement/development of existing//new technologies, processes and products".
- In the aggregate dimension "Demand-side actions": the two themes have coalesced into one "Expansion in//development of existing//new markets and customer groups".
- In the aggregate dimension "Experience vs. Creativity": the themes "Building on accumulated experience//Creative solutions & new ideas" and "Providing existing//new solutions to customers" have been merged into a simpler "Accumulated experience, existing solutions//Creative (new) solutions, new ideas".
- In the aggregate dimension "Intellectual property": the themes have been condensed into one "Exploiting existing IP (licensing-out)//new IP: development (patenting) or acquisition (licensing-in)".

The second round of clustering for which we kept our 7 aggregate dimensions narrowed down the number of themes to 12 and 11, respectively for exploitation and exploration aspects (Table 2.6).

| | Aspects | |
|---|---|---|
| **Aggregate dimensions** | **EXPLOITATION** | **EXPLORATION** |
| **Type of alliance** | Alliance with an old partner<br>Alliance to penetrate existing markets<br>Exploitative alliance (focus on downstream activities) | Alliance with a new partner<br>Alliance to access new markets<br>Exploratory alliance (focus on upstream activities) |
| **Organizational actions** | Improvement of efficiency<br>Improvement of existing activities, procedures or knowledge<br>Plannification - Predictable consequences of actions<br>Economy of scale, reduction of costs, improvement of yield | Flexibility to changes<br>Development of new activities, procedures or knowledge<br>Unknown future - Unknown consequences of actions |
| **Supply-side actions** | Improvement of existing technologies, processes or products | Development of new technologies, processes or products |
| **Demand-side actions** | Expansion in existing markets or existing customer groups | Development of new markets or customer groups |
| **Experience vs. Creativity** | Building on accumulated experience, providing existing solutions | Creative solutions & new ideas |
| **Timeframe** | Short-term goals | Long-term goals |
| **Intellectual Property (IP)** | Exploiting existing IP (licensing-out) | Development (patenting) or acquisition (licensing-in) of new IP |

*Table 2.6: Aggregate dimensions identified for Exploration and Exploitation after a second round of clustering*

Then came the question of measuring the weight of each theme by transforming nominal values about exploration and exploitation into numerical variables which forms the core of the next section describing the method pursued to analyse our data-set with the help of the coding grid now available.

### *2.4.3. Data analysis*

The 410 managerial actions and decisions listed as explained in section 2.4.1 have been rated in Excel in regards to all selected themes to allow a first layer of analysis. In order to provide a deeper analysis with the help of more sophisticated statistic tools, the Excel dataset has also been uploaded in Sphinx iQ2, a software developed by the French company *Le Sphinx Développement*.

The main purpose of coding and then rating in Excel was to transform nominal values about exploration and exploitation, i.e. our themes, into numerical variables. To do so, we attributed arbitrarily a value of +1 to each exploration-related theme and a value of -1 to each exploitation-related theme[24] (Figure 2.7). Themes that were not applicable to a given managerial action or decision were ticked as "nihil" and attributed a value of zero. Figure 2.8 shows an extract of the coding file that has been constructed for the purpose of this research and which contains the 410 managerial actions or decisions ("observations") mentioned earlier.

[24] With one exception, Exploratory Alliance vs. Exploitative Alliance, for which we attributed values of +2 and -2, respectively, to avoid skewness with the two other components of the aggregate dimension "Type of Alliance", i.e. "Alliance with old/new partner" and "Alliance to penetrate existing/new market", which were kept with values of +1/-1. Example: with weights of +1/-1 for the theme Exploratory/Exploitative Alliance, an exploratory alliance with an old partner to penetrate existing market would have resulted in a compounded score for the aggregate dimension of +1-1-1 = -1, indicating an excess of exploitation over exploration and missing the exploratory intension of this type of alliance. Using a weight of +2/-2 leads us to a compounded score of +2-1-1 = 0 which better reflects the balance between the exploratory intension and the exploitative implementation of this exemplative endeavor.

| Partnership | Value |
|---|---|
| Old partner | -1 |
| Nihil | 0 |
| New partner | 1 |
| Existing market | -1 |
| Nihil | 0 |
| New market | 1 |
| Exploitative alliance | -2 |
| Nihil | 0 |
| Exploratory alliance | 2 |

| Org. Actions | Value |
|---|---|
| Improvement of efficiency | -1 |
| Nihil | 0 |
| Development of flexibility | 1 |
| Improvement of existing activities, procedures, knowledge | -1 |
| Nihil | 0 |
| Development of new activities, procedures, knowledge | 1 |
| Plannification (predictibility) | -1 |
| Nihil | 0 |
| Intuition (unknown future) | 1 |
| Economy of scale, reduction of costs, improvement of yield | -1 |
| Nihil | 0 |

| Supply-side Actions | Value |
|---|---|
| Improvement of existing technologies, processes, products | -1 |
| Nihil | 0 |
| Development of new technologies, processes, products | 1 |

| Demand-side Actions | Value |
|---|---|
| Expansion in existing markets, customer groups | -1 |
| Nihil | 0 |
| Development of new markets, customer groups | 1 |

| Experience vs. Creativity | Value |
|---|---|
| Accumulated experience, existing solutions | -1 |
| Nihil | 0 |
| Creative (new) solutions, new ideas | 1 |

| Timeframe | Value |
|---|---|
| Short term goals | -1 |
| Nihil | 0 |
| Long-term goals | 1 |

| Intellectual property | Value |
|---|---|
| Exploiting existing IP (licensing-out) | -1 |
| Nihil | 0 |
| New IP: development (patenting) or acquisition (licensing-in) | 1 |

*Figure 2.7: Rating grid for the 7 aggregate dimensions and their themes.*
(Positive values attributed to themes of exploratory nature, negative values attributed to themes of exploitative nature, zero values for themes that do not apply or to which no clear exploratory or exploitative nature could be attributed. The wording of some themes has been shortened or summarized for clarity and ease of use.)

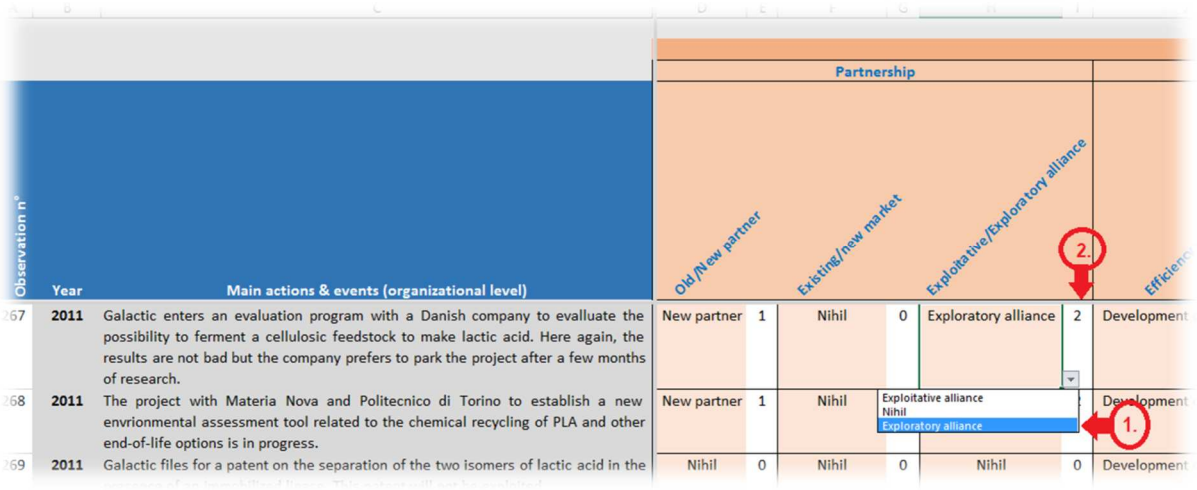



*Figure 2.8: Extract of the coding file in Excel.*
(Number 1 shows the selection of the aspect for the theme "Exploitative/Exploratory alliance" in the aggregate dimension "Partnership" from a rolling menu in the case of the observation n°267. Number 2 shows the rating linked to the selection that appears automatically according to the grid displayed in Figure 2.7)

The sum of positive scores for a given managerial action or decision therefore reflects its exploration intensity. Similarly, the absolute value of the sum of negative scores reflects the exploitation intensity of the managerial action or decision considered. The use of the absolute value is only there to convert negative values into positive ones to avoid a value judgement by

which we would infer that Exploitation is by essence negative for an organization as we have clearly indicated in the previous sections that exploitation is absolutely necessary to firms who wants to ecape from the well-known “failure trap” (underdeveloped new ideas)(Junni et al., 2013). Consequently, the net result of summing all negative and positive scores shows whether this managerial action or decision is more of exploratory or exploitative nature. And, logically, perfect organizational ambidexterity is approached when the score reaches zero.

At this point, we see emerging a method to quantify numerical indexes such as “Exploration Intensity” (the sum of all positive rating scores), “Exploitation Intensity” (the absolute value of the sum of all negative rating scores), and an “Ambidexterity Score” (sum of all positive and negative rating scores) for each decision taken or action implemented by the company. Table 2.7 shows some selected examples (3 examples of exploratory nature, 3 examples of exploitative nature, and 1 example of ambidextrous balance of both).

In accordance with the foregoing, we define:

- **Exploration Intensity** ($ER_{Intensity}$) as:

$$\mathrm{ER}_{\mathrm{Intensity}} = \sum_{x \in \mathbb{R}_{>0}} x_i$$

with $\mathbb{R}_{>0} = \{x \ni \mathbb{R} \mid x > 0\}$

and $x_i$ = rating score of the i$^{th}$ theme

(Equation 2.1)

- **Exploitation Intensity** ($ET_{Intensity}$) as:

$$\mathrm{ET}_{\mathrm{Intensity}} = \left| \sum_{x \in \mathbb{R}_{<0}} x_i \right|$$

with $\mathbb{R}_{<0} = \{x \ni \mathbb{R} \mid x < 0\}$

and $x_i$ = rating score of the i$^{th}$ theme

(Equation 2.2)

- **Ambidexterity Score** ($A_{mb}S$) as:

$$A_{mb}S = \sum_{x \in \mathbb{R}_{>0}} x_i + \sum_{x \in \mathbb{R}_{<0}} x_i = \sum_{x \in \mathbb{R}} x_i$$

(Equation 2.3)

| Observation n° | Year | Actions & decisions | Old/New partner | Existing/new market | Exploitative/Exploratory alliance | Efficiency vs. Flexibility | Activities, procedures, knowledge | Plannification vs. Intuition | Technologies, processes, products | Markets, Customer groups | Experience vs. Creativity | Timeframe | Costs, consumptions & yields | IP | Ambidexterity score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 81 | 2002 | B&G, a joint-venture between Galactic and BBCA Biochemicals, is created in China. The JV will license Galactic's existing technologies to produce lactic acid and derivatives. The Chinese shareholder has 51% of the shares but Galactic retains the control of the operations (60% of voting rights). The newly-formed compay will produce and sell its products in the whole Asia-Pacific region. | 1 | 1 | -2 | -1 | 1 | -1 | 0 | 1 | 0 | 1 | 0 | -1 | 0 |
| 140 | 2007 | Creation of Futerro (50:50 JV with Total Petrochemicals) to continue the development of Galactic's PLA technology (access to expertise in polymers' application development) | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 10 |
| 283 | 2012 | Galactic sells a license to Total on its technology for L-lactic acid, D-lactic acid and PLA recycling (Loopla®). According to the licensing contract and thanks to a preliminary ruling agreement with the tax authorities, the total amount of those licenses received in cash in 2012 is viewed as the present value of future annual licensing fees which is therefore booked in the balance sheet as deferred revenue that will be amortized in the following 8 years (non-cash). The resulting improvement of the cash position allowed the company to bring back its long-term debt-to-equity ratio to a healthier level. | -1 | -1 | -2 | -1 | -1 | -1 | 0 | -1 | -1 | -1 | 0 | -1 | -11 |
| 307 | 2012 | The situation in China was further deteriorating. The global demand for lactic acid was declining as a result of the global economic meltdown. In the first quarter of 2012 for instance the total exports of lactic acid from China declined by 51% compared to the same period of the previous year and the competition was fierce since all lactic acid producers were trying to maintain their sales volumes. The directors of the B&G board then decided to launch a profit recovery initiative and the management resolved to implement the same product promotion strategy based of customer-centric marketing approach as the one Galactic was executing in Europe to enhance the promotion of figher-value specialties. | 0 | 0 | 0 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | 0 | -8 |
| 363 | 2014 | Galactic supports a PhD thesis at the Catholic University of Louvain which purpose is to isolate and characterize new strains of bacteriocins-producing microorganisms directed specifically against Gram negative pathogens. | -1 | 0 | 2 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 7 |
| 372 | 2015 | Galactic signs a MOU with a major dairy producer, to evaluate the possibility to produce lactic acid out of one of its dairy byproducts that will be piling up with the sharp increase in milk production expected following the cancellation of EU milk quotas. The two companies start lab scale tests in order to develop a process adapted to this new raw material and reaching the quality stadards required by the market. | 1 | -1 | 2 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 8 |
| 383 | 2015 | Galactic implements a new Customer Relationship Management system (CRM) which allows to improve its market prospection activities with the help of clearly defined workflows and better sales follow-up procedures. The system is deployed in Europe and North America. Asia and Latin America will follow later. | -1 | -1 | -2 | -1 | -1 | -1 | -1 | 0 | -1 | -1 | 0 | 0 | -10 |

*Table 2.7: Themes' rating and Ambidexterity Scores for selected examples of managerial decisions or actions.*

The first observation (n°81) in Table 2.6 depicts the creation in 2002 of a joint-venture (an alliance) between Galactic, our unit of analysis, and a Chinese partner (new partner: +1). The purpose of this partnership was to build and operate (exploitative alliance: -2) a new production factory for lactic acid and some derivatives to be sold in the Asia-Pacific region (new market: +1; new customer group: +1). It was the first time Galactic entered in such kind of venture (new activity, procedures, knowledge: +1). Of course such an investment of about USD 50 million was well thought out and thoroughly planned (plannification: -1) as a part of a long-term strategic move (timeframe: +1) with the intension to pursue its growth in a sustainable and efficient manner by coming operationaly closer to some far-away markets (efficiency: -1). Besides capital instalments, Galactic contributed its existing technologies in the frame of a licensing agreement (IP licensing-out: -1). Granting a license on existing technologies does not help improving them and hence the "Technologies, processes, products" is kept at 0. The sum of all ratings brings an Ambidexterity Score of 0 for this decision which indicates a good balance between the exploration of new possibilities (new partner, new market, new customers, new activity) and the exploitation of existing assets (exploitative alliance with licensing of existing technologies to produce existing products with foreseeable returns).

The example above contrasts with another joint-venture (observation n°140) created in 2007 by Galactic together with Total Petrochemicals with the aim to continue Galactic's development initiated already in 1992 of a brand-new technology to manufacture a biopolymer of lactic acid (PLA, polylactic acid). The purpose for Galactic to enter into this joint-venture named Futerro, a "première" for Galactic (new activity: +1) was to access Total's expertise in developing applications for polymers (new partner: +1; new market: +1; exploratory alliance: +2). As a matter of fact, Total is a major player in the polyolefines industry worldwide and, therefore, represented a partner of choice in the development of a new polymer (new technologies, processes, products: +1). Although the PLA is intended to be used for clearly identified markets such as packaging films, textile fibers and rigid plastics, the subject of the joint venture was at this stage very upstream and still not very customer oriented (demand-side actions: 0). It is well known in this industry that the development of a new plastic is part of a long, multi-year cycle (timeframe: +1), for which the chances of success remain very uncertain (unknown future, intuition: +1). If successful, this project of magnitude would add to Galactic a string to its bow by giving access to an entirely new market and thereby reducing its exposure to the traditional market of lactic acid (flexibility:+1). Such type of strategic move is obviously in favor of exploration and leads therefore to an Ambidexterity Score of +10.

The following example (observation n°283) differs strongly from the previous one by placing it at the other end of the ambidexterity continuum with a largely exploitation-oriented Ambidexterity Score of -11. Indeed, in 2012, Galactic and Total Petrochemicals, its partner since 5 years (old partner: -1), reached an agreement by which Galactic was to grant a license (IP licensing-out: -1) on its existing technologies (without improving them further though, hence the 0 rating for "Technologies, processes, products") by essence related to the company's accumulated experience (Experience vs. Creativity: -1). The payment of this license in one single cash instalment by the licensee had an immediate (timeframe: -1) positive impact on Galactic's cash position (efficiency: -1).

Observation 307 pictures a different situation in which the management of B&G (Galactic's Chinese subsidiary) had to react to a sharp deterioration of its working environment triggered by a global economic meltdown and heightened competition. The decisions taken involved drastic savings on production and administrative costs (costs, consumptions, yields: -1; improvement of processes: -1) as well as a deep change of marketing approach inspired by the one Galactic was implementing in Europe (expansion in existing markets: -1) for short-term results (timeframe: -1). Such type of managerial decision is obviously very much in favor of exploitation with an Ambidexterity Score of -8.

The next observation (n°363) is a classical example of exploratory alliance (+2) with a university with whom the company worked before (old partner= -1) to support a pHD research on new products and processes (+1) for a new activity (+1) with far-reached (timeframe: +1) unsure results (unknown future: +1). If experience is obviously necessary, the very nature of such research is to appeal to the creativity of the researcher and the university department to generate innovative approaches and new ideas (Experience vs. Creativity: +1), a clearly exploratory process which leads to an Ambidexterity Score of +7.

Another exploitation-minded partnership (ambidexterity score: +8) comes with observation n°372 when Galactic signed a memorandum of understanding with a major dairy company (new partner: +1; exploratory alliance: +2) to investigate the possibility to produce lactic acid aimed at traditional markets (existing market: -1) from a new raw material (flexibility: +1). This collaboration targets the development of new knowledge (+1) and new technologies and processes (+1) by building on both teams' creativity (+1) for a possible joint-investment in a production plant in the future (unknown future: +1; timeframe: +1).

A final example comes with observation n°383 which shows a typical exploitative type of managerial decision linked to the implementation of a new computer system for improved sales operations (efficiency: -1; existing markets: -1) in partnership with a business consultant (exploitative alliance: -2) with whom Galactic used to work before (old partner: -1). A well plannified project (plannification: -1) with a tight implementation schedule (timeframe: -1) which leads not surprisingly to an ambidexterity score of -10.

The examples stressed out hereabove show how an ambidexterity score could be determined for each and every of the 410 managerial decisions or actions recorded in our data-set. To highlight how the company was able to divide its efforts between Exploration and Exploitation over time, we had then to define a score for each year. To do this, we have opted for the use of arithmetic means of the set of scores obtained each year in order to allow the comparison between years. Indeed, a simple addition of the scores for each year would have led to bias due to the variable number of observations each year.

Hence, we define:

- **Average Exploration Intensity** ($\overline{\mathrm{ER}}^{y}{}_{\mathrm{Intensity}}$) for year *y*:

$$\overline{\mathrm{ER}}^{y}{}_{\mathrm{Intensity}} = \frac{1}{n}\sum_{i} \mathrm{ER}_{\mathrm{Intensity}_i}$$

with $\mathrm{ER}_{\mathrm{Intensity}_i}$ = Exploration Intensity score of observation *i*

and $n$ = number of observations in year *y*

(Equation 2.4)

- **Average Exploitation Intensity** ($\overline{\mathrm{ET}}^{y}{}_{\mathrm{Intensity}}$) for year *y*:

$$\overline{\mathrm{ET}}^{y}{}_{\mathrm{Intensity}} = \frac{1}{n}\sum_{i} \mathrm{ET}_{\mathrm{Intensity}_i}$$

with $\mathrm{ET}_{\mathrm{Intensity}_i}$ = Exploitation Intensity score of observation *i*

and $n$ = number of observations in year $y$

(Equation 2.5)

- **Average Ambidexterity Score** ($A_{mb}S$) for year $y$:

$$\overline{A_{mb}S}^{y} = \frac{1}{n}\left[\sum_{i} ER_{Intensity_i} + \sum_{i} ET_{Intensity_i}\right]$$

(Equation 2.6)

Table 2.8a and 2.8b give the data for year 2014 as an example of computation of those three indexes for this year.

| Observation n° | Year | Actions & decisions | Old/New partner | Existing/new market | Exploitative/Exploratory alliance | Efficiency vs. Flexibility | Activities, procedures, knowledge | Plannification vs. Intuition | Technologies, processes, products | Markets, Customer groups | Experience vs. Creativity | Timeframe | Costs, consumptions & yields | IP | Exploration intensity | Exploitation intensity | Ambidexterity score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 336 | 2014 | The company decides to sell out the customer base of the PLA recycling activity it had initiated in 2010 and all related tangible assets. | 0 | 0 | 0 | -1 | -1 | -1 | 0 | -1 | -1 | -1 | 0 | 0 | | -6 | **-6** |
| 337 | 2014 | Galactic invests in a computer-based Warehouse Managing System (WMS) with QR-codes to improve internal logistics. | 0 | 0 | 0 | -1 | -1 | -1 | -1 | 0 | -1 | -1 | 0 | 0 | | -6 | **-6** |
| 338 | 2014 | Once again, the aggressiveness of competition drives prices down significantly, especially in lactates and blends. Galactic reacts by promoting new "Low Cost In Use" solutions which, more efficient, allow a lower dosage and hence savings to the customers even at higher unit prices. A "win-win" approach. Galactic was then primarily targeting the competition's customers as well as those of its customers that were felt at risk. This new "XT" product range was made possible thanks to some of the company's recent researches. | 0 | 0 | 0 | -1 | -1 | -1 | -1 | -1 | 1 | -1 | 0 | 0 | | -5 | **-5** |
| 339 | 2014 | The price pressure was also beginning to be felt on some specialty products such as calcium lactate whose price fell by about 20% at some specific Asian accounts. Galactic preferred to reduce its production throughput to focus on higher-end markets instead of fueling a downward price trend. | 0 | 0 | 0 | -1 | 0 | -1 | 0 | -1 | -1 | -1 | 0 | 0 | | -5 | **-5** |
| 340 | 2014 | The implementation of a new market strategy and business model to focus on providing specialties and tailor-made solutions continues. | 0 | 0 | 0 | -1 | -1 | -1 | 0 | -1 | -1 | -1 | 0 | 0 | | -6 | **-6** |
| 341 | 2014 | Galactic increases the intensity of co-developments with its prospects and customers in the frame of the GIC-based TSR procedure. 53 projects are conducted in the lab this year. | -1 | -1 | 2 | -1 | 1 | 1 | 1 | -1 | 1 | -1 | 0 | 0 | 1 | | **1** |
| 342 | 2014 | Galactic works at kicking off the operations with Galactic Italia. | 0 | 0 | 0 | -1 | -1 | -1 | 0 | -1 | -1 | -1 | 0 | 0 | | -6 | **-6** |
| 343 | 2014 | Galactic works at kicking off the operations with Galactic Deutschland. | 0 | 0 | 0 | -1 | -1 | -1 | 0 | -1 | -1 | -1 | 0 | 0 | | -6 | **-6** |
| 344 | 2014 | The resarch program on the transformation of lactic acid into acrylic acid together with the universities of Liège and Louvain (Project nicknamed "NOVOVAL") comes to an end. | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 10 | | **10** |
| 345 | 2014 | The R&D project with the Meurice Institute for the development of a new range of bacteriocins-containing fermentates is in progress. | -1 | 0 | 2 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 7 | | **7** |
| 346 | 2014 | Galactic and Purac, who joined forces to attack Jungbunzlauer in court for patent infringement lose the case. They decide not to appeal the court's decision. | -1 | -1 | -2 | -1 | -1 | -1 | 0 | 0 | -1 | -1 | 0 | -1 | | -10 | **-10** |
| 347 | 2014 | The ECLIPSE project on algae to PLA is in progress. | 1 | 0 | 2 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 9 | | **9** |
| 348 | 2014 | Galactic and Naturex continue their collaboration on the bioconversion of vegetable juices by fermentation. Tests are conducted at industrial scale. | 1 | -1 | 2 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 8 | | **8** |
| 349 | 2014 | Galactic and Naturex continue their collaboration on DUOCOOK and DUOFRESH. | 1 | -1 | 2 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 8 | | **8** |
| 350 | 2014 | The sales team has been greatly expanded from previous years and the current team is deemed sufficient to revive sales according to the new customer-centric strategy. All sales forces (including our application engineers) is on the road to meet with customers and prospects, discover their needs and offer new solutions. Some of the company's latest innovations such as the Adagio range of products, for which new applications were found, began to take off in the market, about three years after their first introduction. | 0 | 0 | 0 | -1 | -1 | -1 | 0 | -1 | -1 | -1 | 0 | 0 | | -6 | **-6** |
| 351 | 2014 | The company starts a new production line for ultra-pure lactic acid dedicated to very demanding segments such as personal care industry. These new products were successfully introduced at an international exhibition in Hamburg, Germany. | 0 | 0 | 0 | 1 | 1 | -1 | 1 | 1 | 1 | -1 | 0 | 0 | 3 | | **3** |
| 352 | 2014 | Galactic starts producing butyl lactate in Belgium. | 0 | 0 | 0 | -1 | 1 | -1 | 1 | -1 | -1 | -1 | -1 | 0 | | -4 | **-4** |

*<u>Table 2.8a:</u> Themes' rating and average intensity and ambidexterity scores for the year 2014 (part A).*

| Observation n° | Year | Actions & decisions | Old/New partner | Existing/new market | Exploitative/Exploratory alliance | Efficiency vs. Flexibility | Activities, procedures, knowledge | Plannification vs. Intuition | Technologies, processes, products | Markets, Customer groups | Experience vs. Creativity | Timeframe | Costs, consumptions & yields | IP | Exploration intensity | Exploitation intensity | Ambidexterity score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 353 | 2014 | Galactic tests an alternative technology to improve the biomass removal step in its lactic acid process. | 0 | 0 | 0 | -1 | 1 | 1 | 1 | 0 | 1 | 1 | -1 | 0 | 3 | | 3 |
| 354 | 2014 | Galactic resumes it work on the development of an innovative process to manufacture sodium lactate in powder form. This time the project will be brought to the end and an industrial production will be put in place in 2015. | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 6 | | 6 |
| 355 | 2014 | Galactic and B&G R&D teams continue to work on eradicating a fermentation impurity that causes carbon losses. | 0 | 0 | 0 | -1 | -1 | -1 | -1 | 0 | -1 | -1 | 0 | 0 | | -6 | -6 |
| 356 | 2014 | Production and R&D teams continue to work together on improving carbon yield at the fermentation level. | 1 | 0 | 2 | -1 | -1 | -1 | -1 | 0 | 1 | 1 | -1 | 0 | | | 0 |
| 357 | 2014 | The erection of a GMP-certified production unit for sodium lactate solutions targetting the pharmaceutical industry continues with the independent expert. | 1 | 1 | -2 | 1 | 1 | -1 | -1 | 0 | -1 | -1 | 0 | 0 | | -2 | -2 |
| 358 | 2014 | Futerro files for a patent on a process and apparatus for purification of a stream containing a cyclic ester of an alpha-hydroxycarboxylic acid (PCT/EP2014/052154). | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 7 | | 7 |
| 359 | 2014 | Futerro files for a patent on a process for recovering and improving production of meso-lactide from a crude lactide containing stream (PCT/EP2014/059220 - WO2014180836). | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 7 | | 7 |
| 360 | 2014 | Futerro files for a patent on how to use PLA in skinplate application (PCT/EP2014/063310 - WO2014206996). | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 7 | | 7 |
| 361 | 2014 | Futerro files for a patent on increasing the efficiency of a PLA poduction unit by recycling of internal residues (PCT/EP2014/077076 - WO201586613). | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 7 | | 7 |
| 362 | 2014 | Futerro files for a patent on the production of meso-lactide, D-lactide and L-lactide by back-biting of PLA (PCT/EP2014/077077 - WO201586614). | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 7 | | 7 |
| 363 | 2014 | Galactic supports a PhD thesis at the Catholic University of Louvain which purpose is to isolate and characterize new strains of bacteriocins-producing microorganisms directed specifically against Gram negative pathogens. | -1 | 0 | 2 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 7 | | 7 |
| 364 | 2014 | Galactic supports a 2-years R&D project with the Meurice Institute for the development of propionic-based antifungal products for the food industry. | -1 | 0 | 2 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 7 | | 7 |
| 365 | 2014 | Galactic works on the synthesis of special heavy esters for a large German agrochemical company. | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 7 | | 7 |
| 366 | 2014 | Galactic launches GALATEA® in partnership with Taradon Laboratory. GALATEA® is a new concept for the beauty industry based on a combination of three enzymes with anti-ageing properties aiming to protect the body against oxidative stress. Taradon is a small belgian biotech company renting offices and lab space in the GIC. | 1 | 1 | -2 | -1 | 1 | -1 | 1 | 1 | 1 | -1 | 0 | 0 | 1 | | 1 |
| 367 | 2014 | B&G starts producing calcium lactate for the animal feed industry. Galactic is interested since it had to pull out of this market a couple of years before because of a lack of raw material (lactic acid-containing byproduct from USA). However, B&G is unable to satisfy Galactic needs and Galactic decides ultimately to stop importing this product, pulling out again from this market he just re-entered a few months before. | 0 | 0 | 0 | -1 | -1 | -1 | 0 | -1 | -1 | -1 | 0 | 0 | | -6 | -6 |
| 368 | 2014 | The downward trend of the Euro versus the US dollar enhanced Europe's competitiveness on the international scene, and by that improved the situation of Galactic's Belgian site. This coupled with a gradual appreciation of the Chinese Renminbi and an increase of freight cost from China to Latin America prompted Galactic to shift the sourcing for the East coast of this region from B&G to Galactic Belgium. Several thousand tons of different products and numerous customers were concerned. This change further helped the sales team in Europe to focus on specialties and enrich the product-mix without caring too much about filling the plant with volumes. As a consequence, several commodity customers were left to the competition when Galactic decided to cut off the downward spiraling price trend. | 0 | 0 | 0 | -1 | -1 | -1 | 0 | -1 | -1 | -1 | -1 | 0 | | -7 | -7 |
| 369 | 2014 | Despite the negative impact of the substantial volume shift from China to Belgium and competitive pressure from international competitors due to high raw material cost in China as well as due to exchange rate disadvantages, B&G performed rather well all through the year, especially thanks to strong momentum on the domestic market. The development of the sales of newly launched products was positive and contributed to the profitability of the company, especially after the successful expansion of the capacity to manufacture Ultra-Pure Lactic Acid and the focus to sell additional volumes for Feed Acidifiers and lactic acid in the feed industry in China. The financial position of B&G was solid, stock levels of finished products were low and the free cash-flow was positive which convinced the board of directors to increase the leasing and technology license fees paid to the shareholders. | 0 | 0 | 0 | -1 | -1 | -1 | 0 | -1 | -1 | -1 | 0 | 0 | | -6 | -6 |
| 370 | 2014 | Galactic Inc. implements a new remuneration system for its sales team based on KPI's and bonuses to support its sales strategy. | 0 | 0 | 0 | -1 | -1 | -1 | 0 | 0 | -1 | -1 | 0 | 0 | | -5 | -5 |
| | | **Averages :** | 0,06 | -0,03 | 0,33 | -0,08 | 0,17 | -0,08 | 0,39 | -0,25 | 0,14 | -0,08 | -0,11 | 0,11 | 6,22 | -5,75 | **0,57** |

*Table 2.8b: Themes' rating, average intensity and ambidexterity scores for the year 2014 (part B).*

We can see in the example of Table 2.8 (a, b) that the company succeeded to balance relatively well its exploration and exploitation efforts while keeping comparatively high intensities of both with however a slightly higher focus on exploration (average exploration intensity of 6.22; average exploitation intensity of 5.75) which resulted in an Ambidexterity Score of 0.57 for this year. We refer the reader to Section 3.4 for a discussion on the evolution of these indexes over the 25 years of history of the company.

We also averaged the rating scores of each individual themes every year; an information that revealed precious when looking at the relative impact of these themes on the way the company became and remained ambidextrous. This will help us identify which theme companies should predominantly pay attention to in their quest for ambidexterity; and it will provide us matter to substantiate our managerial recommendations in the concluding section of this dissertation.

In order to go further in understanding how organizational ambidexterity could be developed and implemented by a company, or at least to know how Galactic did, we resolved to add two different lenses to our analysis. First, from a perspective internal to the firm, we measured **structural ambidexterity**. Second, from a perspective external to the firm, we measured **network ambidexterity**.

As we recall from our literature review, it was Duncan (1976) who first advocated for companies to put in place "dual structures" requiring different time perspectives and management capabilities to accommodate simultaneously the conflicting alignments needed for efficiency and innovation. Two decades later, Tushman and O'Reilly (1996) picked up on the concept and emphasized structural separation between activities aiming at managing evolutionary (incremental) change and revolutionary (discontinuous) change in simultaneous fashion. The idea here is therefore to design a measure that reflects whether the decisions taken by the management of Galactic over its 25 years of existence called for a separation between departments (or at least involved only one single department) or incited collaboration (applying to two or more departments)(Figure 2.9). Crossing this type of information with the evolution of ambidexterity over time will provide insights about how ambidexterity can be executed from an internal/organizational perspective.

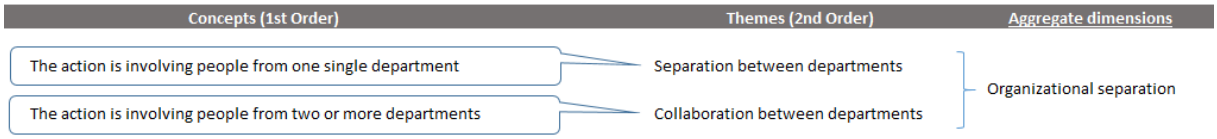



*Figure 2.9: Concepts and themes for structural ambidexterity.*

So, we went through all 410 decisions or actions recorded in our data-set and attributed numerical values of +1 and -1, respectively for the ones involving only one department and for the ones concerning two or more[25], and 0 when it did not apply (Figure 2.10).

| Structural Ambidexterity | Value |
|---|---|
| Action involving only one department (separation) | 1 |
| Nihil | 0 |
| Action involving two or more departments (collaboration) | -1 |

*Figure 2.10: Rating grid for structural ambidexterity.*

Here too, averaging the rating scores obtained for all observations on a given year leads to an indication of the propensity of the company to favor separation or collaboration between its departments during this same year.

We also define:

- **Partnership Intensity** of a single observation as 0 if the observation indicates no partnership or alliance outside the organization[26], and 1 if the observation reveals such a partnership. Therefore, the Partnership Intensity of a given year is logically the sum of all the partnership decisions taken over this year.

[25] Note that the attribution of +1 and -1 values here is not correlated in any way to the attribution of +1 and -1 values to exploratory and exploitative aspects when computing ambidexterity scores. In other words, a value of -1 given to one observation for measuring structural ambidexterity does not suggest that this observation is of exploitative nature. The rating of themes for measuring ambidexterity scores and the rating of structural ambidexterity have been conducted independently from each other.

[26] We here refer to "the organization" as the whole Galactic group. A project conducted by Galactic SA together with one of its subsidiaries is not considered as a partnership or an alliance except when the decision is about Galactic collaborating for the first time with an external entity to form a joint-venture company.

For network ambidexterity, the task was easier as all the ingredients for its measure were already available from the rating exercise made before to determine exploration/exploitation intensities and the resulting ambidexterity scores. Extant literature (Grant & Baden-Fuller, 2004; Lin et al., 2007; Park et al., 2002; Rothaermel & Deeds, 2004) tells us that the formation of alliances or partnerships can be seen as a form of exploration and exploitation as much as exploratory alliances provide opportunities to access new knowledge and investigate new market and technologies wheras exploitative alliances can be used to benefit from complementary resources and to leverage existing competencies across organizational boundaries.

We therefore define:

- **Network Ambidexterity Score** as the sum of the ratings attributed to the themes "Old//New partner", "Existing//New market" and "Exploitative//Exploratory alliance".
- **Average Network Ambidexterity Score** for a given year as the arithmetic mean of all Network Ambidexterity Scores recorded that year.

In Table 2.10, we take again the same examples of managerial decisions as before but this time with the results related to partnership intensity and network ambidexterity.

In these examples, several actions decided by the management were involving different departments in the organization at the same time (rating -1). The sale of licenses for instance (observation n°283) engages different teams in the due diligence process during which the potential licensee evaluates the technology of interest as its superiority must be demonstrated in practical terms (technical feasibility), financial terms (cost competitiveness), intellectual property terms (freedom to operate) etc… In a similar way, dealing swiftly with fast deteriorating economic conditions (observation n°307) requires that actions be taken simultaneously and collaboratively by different services such as production (a profit recovery initiative aimed at implementating cost savings) and sales departments (new marketing approach). Conversely, pure R&D projects can be conducted by a single team (rating +1), in this case the R&D department, eventually in partnership with external institutional (observation n°363) or private (observation n°372) organizations. Interestingly, the rating for structural ambidexterity is less contrasted when joint-ventures are concerned because their activities may either associate several departments such as in the set up of a fullblown production and sales

joint-company (rating -1 for observation n°81), or it may involve only one team as in the case of a pure R&D joint-company (rating +1 for observation n°140)[27].

Here again, averaging the ratings of all observations of a given year gives the value of the index for this year. The use of averages allows for a direct comparison between years even if they are made of a different number of observations. Correspondingly, compounded averages of several years allow for a direct comparison between epochs as shown in Table 2.9[28].

On the margins of a vision of ambidexterity at the level of the organization (structural ambidexterity) and its direct entourage (network ambidexterity), our review of the extant literature had highlighted a dimension on the scale of the individual called **contextual ambidexterity**. However, the very nature of most documents constituting the corpus of our archival sources (see Section 2.4.1 Data generation) did not permit a clear enough identification of stretch, discipline, support and trust; i.e. the attributes describing organizational context as per Ghoshal and Bartlett (1994) brought forward by Birkinshaw and Gibson (2004) as the cornerstones of contextual ambidexterity. This can be explained by the fact that our archival sources contain essentially documents made by managers and intended to managers (minutes of management meetings, minutes of board meetings, internal memos etc…) whereas contextual ambidexterity precisely displaces the decision process from a centralized management team to decentralized sub-units or even to the individual employees themselves. Consequently, in spite of an attempt to structure a coding grid using the same Gioia's type of systematic approach as previously adopted to analyze the other aspects of organizational ambidexterity (Figure 2.11), we had to resolve to leave the analysis of individual context on the side. This, however, could be the subject of a forthcoming study.

[27] The contribution of support departments such as legal, HR, accounting and financial teams, as important as they are in the process of starting a new company, is not considered here as we focus the concept of ambidexterity on either activities of exploitative nature (engineering, production, sales) or exploratory nature (business development, research and development).

[28] Table 2.9 is shown here only to illustrate our point about the use of averages to compare the years between them as well as periods covering several years (epochs) between them. The meaning of each epoch and the interpretation of these results are further discussed in Section 3.

| | Year | Structural Ambidexterity |
|---|---|---|
| ANTIQUITUS | AO1991 | 1,00 |
| | AO1992 | 1,00 |
| | AO1993 | 1,00 |
| FEODALIS | AO1994 | 1,00 |
| | AO1995 | -0,13 |
| | AO1996 | -0,14 |
| | AO1997 | 0,38 |
| | AO1998 | 0,14 |
| | AO1999 | 0,00 |
| | AO2000 | 0,14 |
| | AO2001 | 0,29 |
| MODERNITAS | AO2002 | -0,23 |
| | AO2003 | 0,00 |
| | AO2004 | 0,06 |
| | AO2005 | -0,06 |
| | AO2006 | -0,33 |
| | AO2007 | 0,25 |
| | AO2008 | 0,50 |
| | AO2009 | 0,38 |
| | AO2010 | 0,43 |
| | AO2011 | 0,23 |
| CONTEMPORALIS | AO2012 | 0,19 |
| | AO2013 | 0,26 |
| | AO2014 | 0,20 |
| | AO2015 | -0,13 |

| | |
|---|---|
| **Average for ANTIQUITUS** | **1,00** |
| **Average for FEODALIS** | **0,21** |
| **Average for MODERNITAS** | **0,12** |
| **Average for CONTEMPORALIS** | **0,13** |

*Table 2.9: Example of average ratings (here the structural ambidexterity score) for each year from 1991 and 2015 and for each major epoch of the company's history.*

| Observation n° | Year | Actions & decisions | Structural Ambidexterity score | Old/New partner | Existing/new market | Exploitative/Exploratory alliance | Partnership intensity | Network Ambidexterity score |
|---|---|---|---|---|---|---|---|---|
| 81 | 2002 | B&G, a joint-venture between Galactic and BBCA Biochemicals, is created in China. The JV will license Galactic's existing technologies to produce lactic acid and derivatives. The Chinese shareholder has 51% of the shares but Galactic retains the control of the operations (60% of voting rights). The newly-formed compay will produce and sell its products in the whole Asia-Pacific region. | -1 | 1 | 1 | -2 | 1 | 0 |
| 140 | 2007 | Creation of Futerro (50:50 JV with Total Petrochemicals) to continue the development of Galactic's PLA technology (access to expertise in polymers' application development) | 1 | 1 | 1 | 2 | 1 | 4 |
| 283 | 2012 | Galactic sells a license to Total on its technology for L-lactic acid, D-lactic acid and PLA recycling (Loopla®). According to the licensing contract and thanks to a preliminary ruling agreement with the tax authorities, the total amount of those licenses received in cash in 2012 is viewed as the present value of future annual licensing fees which is therefore booked in the balance sheet as deferred revenue that will be amortized in the following 8 years (non-cash). The resulting improvement of the cash position allowed the company to bring back its long-term debt-to-equity ratio to a healthier level. | -1 | -1 | -1 | -2 | 1 | -4 |
| 307 | 2012 | The situation in China was further deteriorating. The global demand for lactic acid was declining as a result of the global economic meltdown. In the first quarter of 2012 for instance the total exports of lactic acid from China declined by 51% compared to the same period of the previous year and the competition was fierce since all lactic acid producers were trying to maintain their sales volumes. The directors of the B&G board then decided to launch a profit recovery initiative and the management resolved to implement the same product promotion strategy based of customer-centric marketing approach as the one Galactic was executing in Europe to enhance the promotion of figher-value specialties. | -1 | 0 | 0 | 0 | 0 | 0 |
| 363 | 2014 | Galactic supports a PhD thesis at the Catholic University of Louvain which purpose is to isolate and characterize new strains of bacteriocins-producing microorganisms directed specifically against Gram negative pathogens. | 1 | -1 | 0 | 2 | 1 | 1 |
| 372 | 2015 | Galactic signs a MOU with a major dairy producer, to evaluate the possibility to produce lactic acid out of one of its dairy byproducts that will be piling up with the sharp increase in milk production expected following the cancellation of EU milk quotas. The two companies start lab scale tests in order to develop a process adapted to this new raw material and reaching the quality stadards required by the market. | 1 | 1 | -1 | 2 | 1 | 2 |
| 383 | 2015 | Galactic implements a new Customer Relationship Management system (CRM) which allows to improve its market prospection activities with the help of clearly defined workflows and better sales follow-up procedures. The system is deployed in Europe and North America. Asia and Latin America will follow later. | -1 | -1 | -1 | -2 | 1 | -4 |

*Table 2.10: Example of ratings to measure structural ambidexterity, partnership intensity and network ambidexterity.*

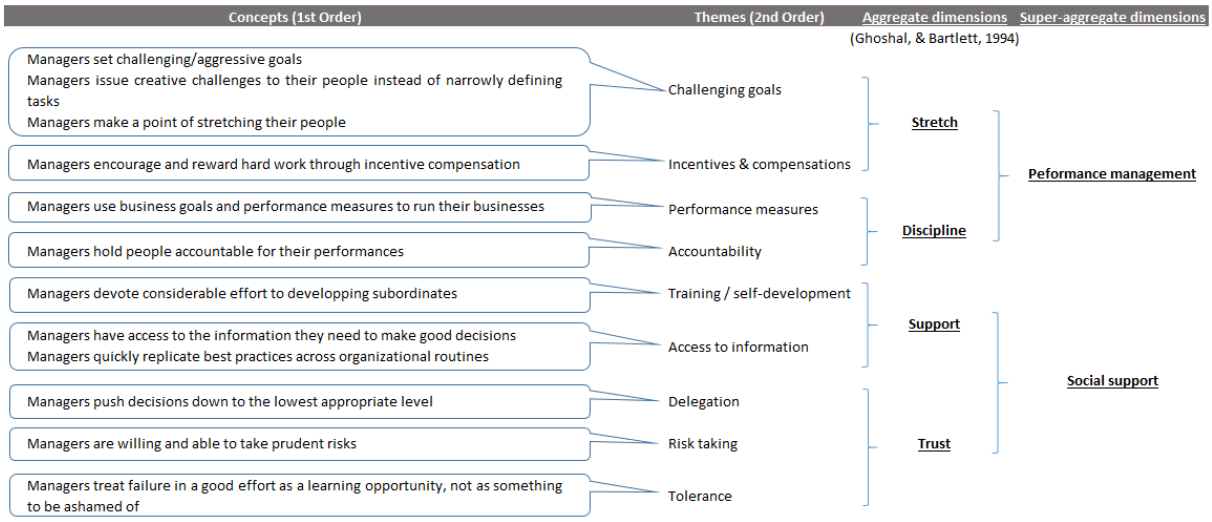



*Figure 2.11: Concepts, themes and aggregate dimensions of contextual ambidexterity*
*(references:* Birkinshaw & Gibson, 2004; Gibson & Birkinshaw, 2004*).*

Another line of thought somewhat connected to organizational ambidexterity refers to the principles of **Causation and Effectuation**. In this regard, it is worth mentioning that we came across these notions in a rather inductive manner after we finished writing our literature revue, when we were drawing up our narrative about the history of our unit of analysis. Indeed, it was when we came to describe one of the major strategic inflections in the history of the company that, returning to the corpus of theories in management science, we discovered these principles initially posited by Sarasvathy in 2001 (Sarasvathy, 2001). As a reminder, causation processes focus on selecting among available means to create a given effect[29] whereas effectuation processes focus on selecting among possible effects that can be created with a given set of means; and we recall the metaphor of the chef cooking a dinner (Sarasvathy, 2001) who can either start from the menu and select ingredients and utensils (a causation process of exploitative nature), or he can start from available ingredients to design a possible menu (an effectual approach of exploratory nature).

In a similar way as previously described, we have applied Gioia' systematic methodology to cluster first-order concepts into second-order themes to lead ultimately to aggregate dimensions (Table 2.11). The concepts and themes as well as the bibliographic sources are detailed in Appendix V.

[29] Sarasvathy defines an effect as the operationalization of an abstract human aspiration (Sarasvathy, 2001, p.245).

| Aggregate dimensions | Aspects<br>CAUSATION | EFFECTUATION |
|---|---|---|
| **Type of analysis** | | |
| | Definition of targets (market surveys)<br>Selection of resources needed<br>Analysis to provide expected return ("gain more") | Definition of resources available<br>Choice of possible targets<br>Assessment of affordable loss / acceptable risk ("lose less") |
| **Organizational actions** | | |
| | Design of strategy - Plannification<br>Deployment of defined business model - Control to reach target<br>Prediction of an uncertain future | Seizing opportunities - Exploiting contingencies<br>Development of new business models<br>Control of an unpredictable future |
| **Supply-side actions** | | |
| | Improvement of existing products<br>Exploitation of preexisting knowledge | Development of new product |
| **Demand-side actions** | | |
| | | Alliance - Partnership<br>Seeking pre-commitments from customers |

*Table 2.11: Aggegate dimensions and their constitutive themes for Causation and Effectuation.*

For the sake of practicability, we further condense the themes in order to end up with the rating grid of Figure 2.12.

| Org. Actions | Value |
|---|---|
| Design of strategy. Plannification. Deployment of defined business model | -1 |
| Nihil | 0 |
| Seizing opportunities. Exploiting contingencies. Development of new business model | 1 |

| Supply-side Actions | Value |
|---|---|
| Improvement of existing technologies, processes, products | -1 |
| Nihil | 0 |
| Development of new technologies, processes, products | 1 |

| Demand-side Actions | Value |
|---|---|
| Nihil | 0 |
| Seeking pre-commitments from customers | 1 |

| Type of analysis | Value |
|---|---|
| Analysis to provide expected return ("gain more") | -1 |
| Nihil | 0 |
| Affodable loss/acceptable risk ("lose less") | 1 |

*Figure 2.12: Rating grid for Causation versus Effectuation (-1 for causation; +1 for effectuation).*

Not surprisingly, our 4 aggregate dimensions are rather well alligned with Sarasvathy's 4 main principles of the Effectuation process (Sarasvathy, 2001, p.252):

- Our dimension "organizational actions" corresponds to the principle of "controlling an unpredictable future (effectuation) rather than predicting an uncertain one (causation)" (opcit.). The logic behind the causation process is "to the extent that we can predict the

future, we can control it" (opcit.) which is what companies aim at when designing their strategies, planning their operations and deploying their predefined business models. Conversely, the rationale supporting the effectuation process is "to the extent that we can control the future, we do not need to predict it" (opcit.) which is a situation that can be achieved when companies are flexible enough to be able to seize opportunities, exploit contingencies and adapt their business models. As a matter of fact, this dimension covers the same themes as the one we named "plannification versus intuition" when coding for exploration intensity, exploitation intensity and ambidexterity score. It shows the proximity of the two theoretical frameworks, i.e. organizational ambidexterity and causation/effectuation, although the former is presented as an organizational paradox potentially present in all types of companies (Brown & Eisenhardt, 1997) whereas the latter is seen more in a processual way among entrepreneurial ventures essentially [30] (Farjoun, 2007; Jacquemin & Lesage, 2016; Sarasvathy, 2001a, 2001b; Sarasvathy & Kotha, 2001; Sarrouy-Watkins & Hernandez, 2015).

- Our dimension "supply-side actions", which opposes the exploitation of existing products or knowledge to the development of new ones, echoes Sarasvathy's "exploitation of contingencies rather than exploitation of preexisting knowledge", the former being of effectual nature whereas the latter is of causal nature. Here too, the dimension covers the same themes as used to measure ambidexterity score, i.e. "technologies, processes, and products".
- The "demand-side actions" which seeks to include prospects and potential customers very early in the business development cycle through alliances, partnerships and/or pre-commitments "as a way to reduce and/or eliminate uncertainty and to erect entry barriers" (opcit.) resorts from an effectual logic. In this case, we decided not to include the partnership-related themes used to characterize the ambidexterity score because the underlying idea of this aspect of the effectual process is to integrate potential customers into the development cycle of new products or services and not merely to engage in operational alliances or even in pure research partnerships. We paid attention to really keep the "demand-side" aspect of this process in mind when rating for this dimension.

[30] Some authors including Sarasvathy herself claim that effectuation theory may not be restricted to the domain of entrepreneurship and that it may not be limited to small start-up firms (Wittbank & Sarasvathy, 2010).

- Our dimension about “type of analysis” contains the elements put forward by Sarasvathy in her principle about “affordable loss rather than expected return” that she justifes as follows (opcit.): “Causation models focus on maximizing the potential returns for a decision by selecting optimal strategies. Effectuation predetermines how much loss is affordable and focuses on experimenting with as many strategies as possible with the given limited means. The effectuator prefers options that create more options in the future over those that maximize returns in the present”. This dimension is related to the theme “economy of scale, reduction of costs, improvement of yields” defined for the ambidexterity score.

Table 2.12 gives the ratings obtained to measure causation versus effectuation intensity for the same examples of managerial actions and decisions as before.

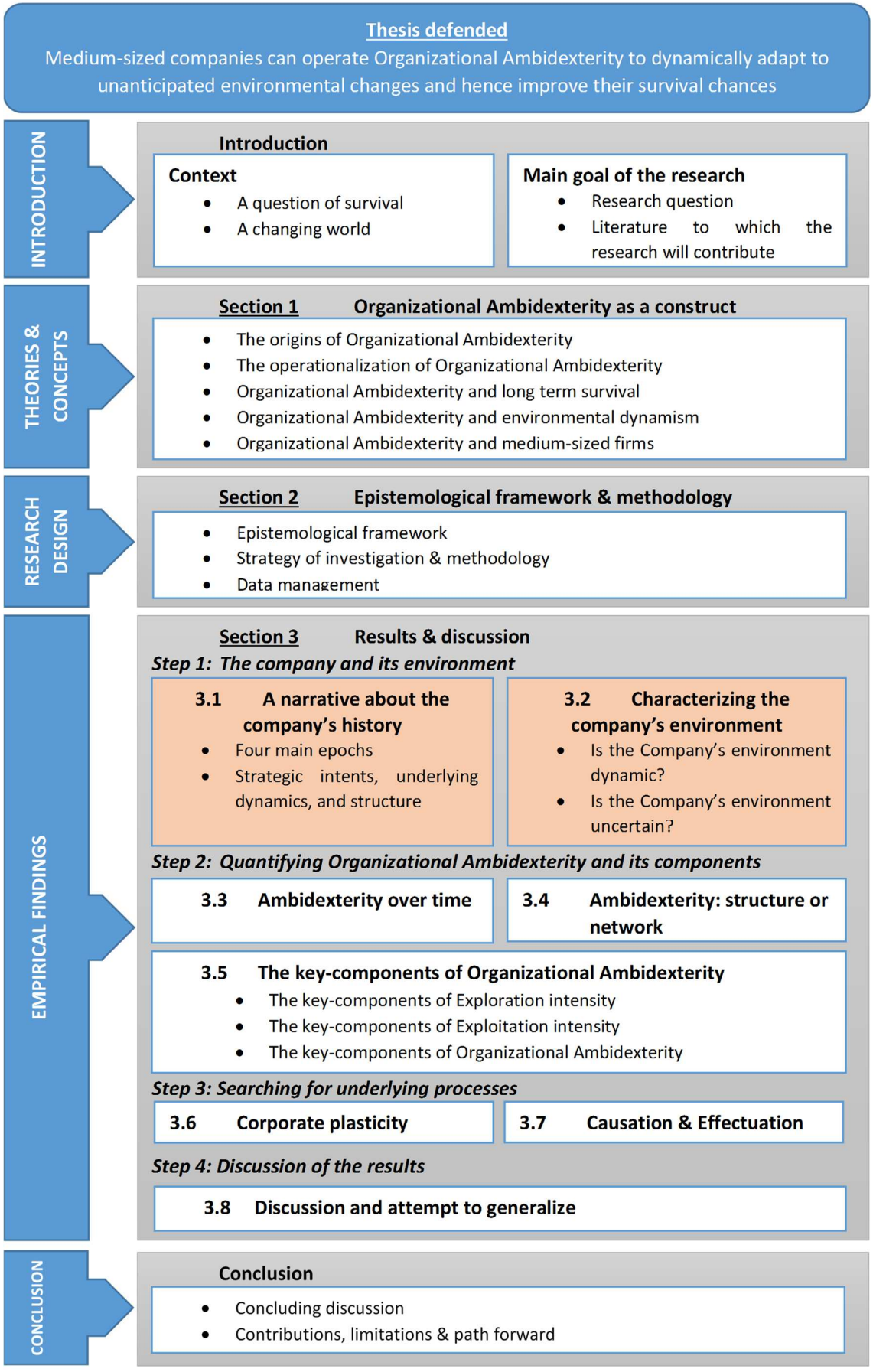
| Observation n° | Year | Actions & decisions | Organizational actions | Supply-side actions | Demand-side actions | Type of analysis | Causation vs. Effectuation |
|---|---|---|---|---|---|---|---|
| 81 | 2002 | B&G, a joint-venture between Galactic and BBCA Biochemicals, is created in China. The JV will license Galactic's existing technologies to produce lactic acid and derivatives. The Chinese shareholder has 51% of the shares but Galactic retains the control of the operations (60% of voting rights). The newly-formed compay will produce and sell its products in the whole Asia-Pacific region. | -1 | 0 | 0 | 0 | -1 |
| 140 | 2007 | Creation of Futerro (50:50 JV with Total Petrochemicals) to continue the development of Galactic's PLA technology (access to expertise in polymers' application development) | 1 | 1 | 0 | 0 | 2 |
| 283 | 2012 | Galactic sells a license to Total on its technology for L-lactic acid, D-lactic acid and PLA recycling (Loopla®). According to the licensing contract and thanks to a preliminary ruling agreement with the tax authorities, the total amount of those licenses received in cash in 2012 is viewed as the present value of future annual licensing fees which is therefore booked in the balance sheet as deferred revenue that will be amortized in the following 8 years (non-cash). The resulting improvement of the cash position allowed the company to bring back its long-term debt-to-equity ratio to a healthier level. | -1 | 0 | 0 | 0 | -1 |
| 307 | 2012 | The situation in China was further deteriorating. The global demand for lactic acid was declining as a result of the global economic meltdown. In the first quarter of 2012 for instance the total exports of lactic acid from China declined by 51% compared to the same period of the previous year and the competition was fierce since all lactic acid producers were trying to maintain their sales volumes. The directors of the B&G board then decided to launch a profit recovery initiative and the management resolved to implement the same product promotion strategy based of customer-centric marketing approach as the one Galactic was executing in Europe to enhance the promotion of figher-value specialties. | -1 | -1 | 0 | -1 | -3 |
| 363 | 2014 | Galactic supports a PhD thesis at the Catholic University of Louvain which purpose is to isolate and characterize new strains of bacteriocins-producing microorganisms directed specifically against Gram negative pathogens. | 1 | 1 | 0 | 0 | 2 |
| 372 | 2015 | Galactic signs a MOU with a major dairy producer, to evaluate the possibility to produce lactic acid out of one of its dairy byproducts that will be piling up with the sharp increase in milk production expected following the cancellation of EU milk quotas. The two companies start lab scale tests in order to develop a process adapted to this new raw material and reaching the quality stadards required by the market. | 1 | 1 | 0 | 0 | 2 |
| 383 | 2015 | Galactic implements a new Customer Relationship Management system (CRM) which allows to improve its market prospection activities with the help of clearly defined workflows and better sales follow-up procedures. The system is deployed in Europe and North America. Asia and Latin America will follow later. | -1 | -1 | 1 | 0 | -1 |

*Table 2.12: Example of ratings to measure causation versus effectuation intensities of managerial decisions or actions.*

Armed now with a fairly comprehensive dataset covering the 25 years of the history of the company and a quite detailed code-book that allowed to rate and quantify the components of various aspects of organizational ambidexterity, we will devote the next section to the analysis of their evolution over time and to the identification of their interactions. Then, after this analysis of quantitative nature, we will try to put our findings into perspective in view of the events that have marked the history of the company and of the strategic inflections that have resulted therefrom in order to better understand how generative mechanisms and underlying processes of organizational ambidexterity are activated with regards to contextual conditions.

# Section 3. Results and Discussion

## Step 1: The company and its environment



## 3.1. A narrative about the company's history

History entails the lining up of events in an orderly sequence of cause and effect. Throughout human history we have found it meaningful to think of events as somehow interconnected (de Rond & Thiétart, 2004). Understanding the causation of events is a condition of our capacity to understand what is going on around us (Carr, 1961). The categorization of the past into discrete and quantified named blocks is called "periodization".

Some scholars, focusing on strategic change, have documented major epochs (Mintzberg, 1978), periods of quantum changes (Danny Miller & Friesen, 1984b), reorientations (Tushman & Romanelli, 1985) in strategy making (Burgelman, 1991), and many have adopted the metaphor of organic growth, such as in life-cycle theory, as a heuristic device to explain development in an organizational entity from its inception to its termination. Life-cycle models depict the process of change in an organization as progressing through a necessary sequence of stages whose content is prescribed by an institutional, natural or logical program (Van de Ven & Poole, 1995). Miller & Friesen (1984a) for instance have described and tested five common stages of corporate life-cycle: birth, growth, maturity, revival, and decline.

In our attempt to narrate the history of Galactic, we decided not to follow this rather classical and somewhat reductionist view, but to 'periodize' the company's history in phases, or epochs (Mintzberg, 1978), that better fit its own development over time. We believe this approach will help shedding light on the various aspects of organizational ambidexterity that have been operationalized by the company throughout its life.

### *3.1.1. The four main epochs of the company's history*

We align the main phases of the company's history to the main periods of human History as they both describe, one at a micro-level and the other at a macro-level, a journey towards more complexity and they show some similarities. In a nutshell, these major epochs are:

> ***Antiquitus***. This Latin word means 'prior' or 'ancient'. In our timeline, it designs the period that precedes the official inception of the company but which is of importance in understanding the intentions and cultural elements that lead to its incorporation. This period ends with the creation of the company in 1994.

***Feodalis*** which starts when the company was created. In human History the Middle Ages, also referred to as the Postclassical Era or the Medieval period, were considered as a period of darkness and ignorance separating the Classical period of learning and culture from the humanist ideals of the Renaissance. This is not the meaning that we want to stress out here. As a matter of fact, the Feudal period provided the foundation for the transformations of the humanists' own Renaissance. It was a period, especially the High Middle Ages, during which the population of Europe increased greatly as technological innovations allowed trade to flourish (the growth of the company' sales was then organic and focused on its exports). It was also a period in which a political structure emerged whereby knights and lower-status nobles owed service to their overlords in return for privileges (a situation quite close to the hierarchical organization of a growing entrepreneurial company centered on its CEO and founder). And, it was a period where travels like Marco Polo's and the setting up of trading posts in some far-away countries pushed the boundaries of the society. In short, the Middle Ages were not that much of a dark period of illiteracy and blindness but rather times where cultural and technological developments transformed the European society, leading it to the early modern period. For Galactic, this period of growth, structuration and development started in 1994 and lasted until 2001.

***Modernitas***. The Modern Period in human History began with the voyage of Christopher Columbus in 1492 and more generally covers the establishment of a global network with, at about the same time, the opening of a maritime route to the East. In Europe, it comprised, among other episodes, the European Renaissance ($14^{th}$ – $16^{th}$ century), the Age of Discovery ($15^{th}$ – $17^{th}$ century) and the Age of Enlightenment ($18^{th}$ century). For Galactic, this age started in 2001 with the desire to expand geographically, not only by setting up sales relationships with customers and distributors in many countries sourced from Galactic's Belgium-based only factory as was done before, but with the idea to erect and operate production facilities on other continents. This period that ended in 2011 was characterized by a rapid growth (both in terms of company activities and in terms of population, i.e. company staff), many organizational and structural changes (similar to the Industrial Revolution in the human History), and by environmental challenges (e.g. episodes of heightened competition and price wars, like the Napoleonic campaigns have been in human History – relatively speaking; and the

global crisis in 2008 that can be paralleled with the Long Depression that lasted from 1873 to 1896).

***Contemporalis***. We consider that the Contemporary Period began for the company with the acquisition of a new research center end of 2011. This acquisition ignited a revolution[31] in the company's way to approach its markets and develop new products. This is the time when the company progressively transformed from being a mere producer of lactic acid and a few derivatives into becoming a provider of a much wider portfolio of natural solutions. To support this transition, the company decided to merge its corporate R&D and European sales/marketing departments, both in management terms (same leadership) and in organizational terms (same building infrastructure). The intention was to reduce the distance between the company scientists and the market and hence improve the time-to-market for its new developments. In human History, it is generally accepted to consider that the Contemporary Period started with World War I[32] and lasts until now. Fortunately enough, this period did not start with a real war for the company but it was nevertheless the strategic response to a global trend by which lactic acid was evolving more and more towards a commodity status. This change in the company's business model somewhat mirrors the evolution of human History throughout the 20th century, and even more so during the 21st century, that has put the human individual (here: the customer) at the center of all activities as the focal point and the dynamic force (Friedman, 2005). The point is no longer to define what the company has to offer but to better understand what the customer wants to buy. It seems trivial but it is not, in a capital-intensive industry with long development cycles and low success rate such as the one in which Galactic evolves.

Figure 3.1 compares the main phases in the company's history with the major time periods of the human History and highlights their similarities.

[31] The term "revolution" is here used in a "Tushmanian" sense which considers changes at the firm level (Romanelli & Tushman, 1994; Tushman & O'Reilly, 1996), as opposed to Meyer who uses this word specifically for the industry level and prefers the term "metamorphosis" to depict changes at the level of the company (Meyer et al., 1990).

[32] This is an anglosaxon perspective. French historians prefer to consider 1789, the French revolution, as the turning point between the modern era and the contemporary period.

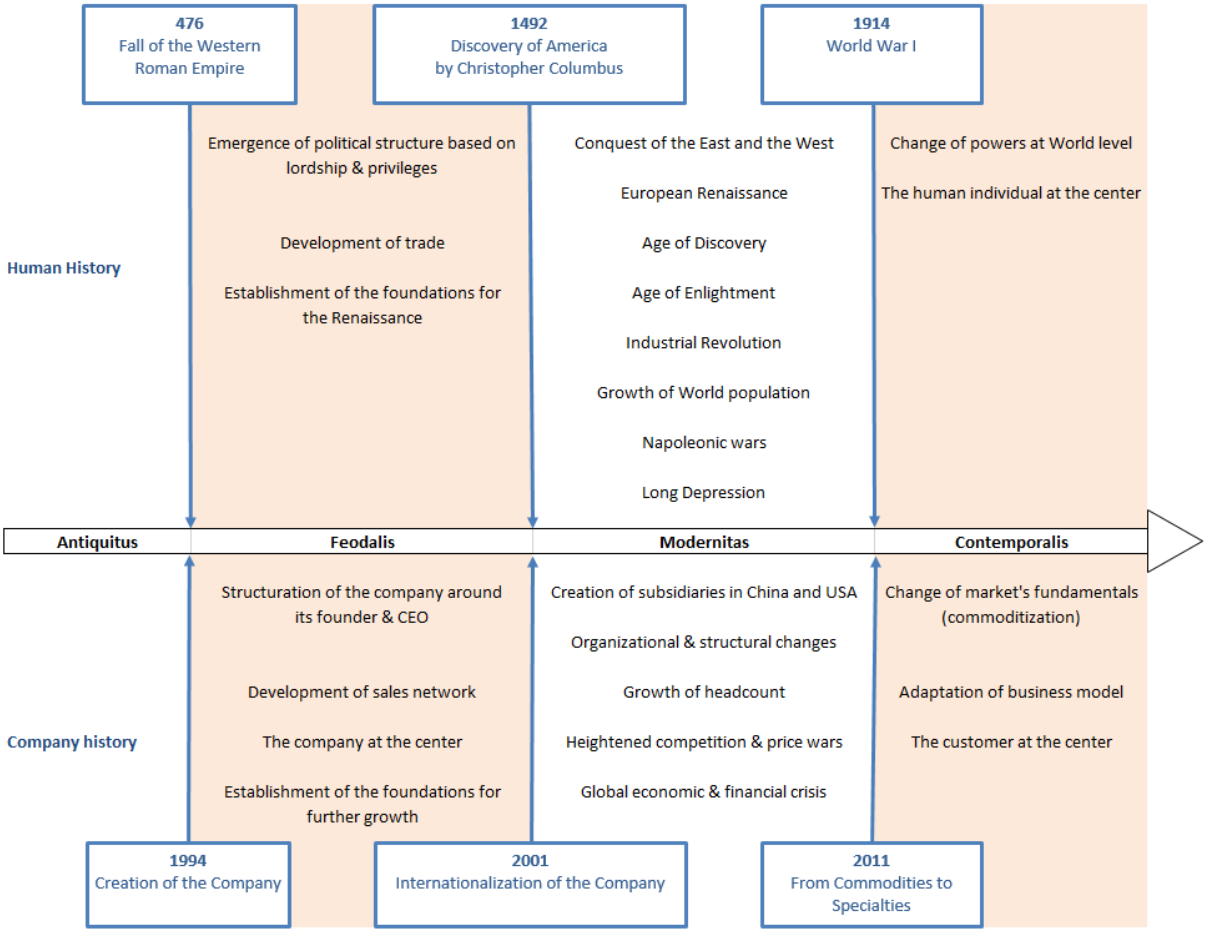



*Figure 3.1: Comparison of the company's major epochs with the major time periods of the human History.*

Appendix II narrates each of these major phases with some level of detail in order to reconstruct the company's history and identify the internal and external changes that have paved its evolution until now. To provide the reader with a better understanding of the environmental context in which the company evolved, we include here and there short vignettes describing the external factors and main events that have shaped the company's direct environment. In that we follow the recommendation of Dumez (2016, p.131) when he says that "Timelines (chronologies) should be multiple. Different dimensions must be taken into account to understand the dynamics of action or interaction: technology, political environment, regulatory decisions, organizational changes etc. Causal mechanisms can intervene between events belonging to different dimensions and these mechanisms can be isolated only if the order of succession of events is determined with sufficient accuracy".

In the next chapter we present some characteristics of the three main epochs that emerged from our analysis of the various documents consulted during the writing of the narrative of the company's history.

### *3.1.2. Strategic intents, underlying dynamics, and structures*

> *"Whether initial success is the result of competence or luck, top management's role is to articulate an organizational strategy that will help secure continued survival."*
>
> (Burgelman, 1991, p.283)

If we exclude the period prior to the creation of the business, three main epochs emerge which were characterized by profoundly distinct strategic intents. We define a "strategic intent" as the intention, openly acknowledged or not, which underlies and motivates the strategic actions implemented by an organization. With this definition we go further than the generally accepted meaning often reduced to a mere motivational statement of the means by which the top-management wants the organization to achieve its mission[33]. During the Feodalis period (1994-2001), the intent revolved essentially around structuring the company at all levels of the organization and gaining a reputation as second producer worldwide. The next period, Modernitas (2001-2011), saw the company internationalizing its activities by opening subsidiaries in the Far East first and then to the West. Later, during Contemporalis (as from 2011), the firm had to undergo a profound change to survive increased competition and commoditization[34] of its main products by implementing a strategy based on specialization[35].

[33] Hamel and Prahalad (1989) define Strategic Intent as "an ambitious and compelling dream that energises and that provides the emotional and intellectual energy for the journey to the future". Strategic Intent as a concept was born in Post-World war II Japan when it emerged as world leader in economy. Hamel and Prahalad observed that Western companies were adjusting their ambitions to the resources available whereas Japanese corporations leveraged resources by accelerating the pace of organizational learning and fostering the desire to succeed among their employees to attain seemingly impossible goals.

[34] In business literature, commoditization is defined as the process by which goods that have economic value and are distinguishable in terms of attributes (uniqueness or brand) end up becoming simple commodities in the eyes of the market actors. The key effect of commoditization is that the pricing power of the manufacturer or brand owner is weakened: when products become more similar from the customers' point of view, they will tend to buy the cheapest (https://en.wikipedia.org/wiki/Commoditization).

[35] We don't use the word "specialization" as opposed to "generalization" (when businesses try to encompass as many features and capabilities as possible, also sometimes referred to as "diversification") but to indicate that the company moved its focus from commodity to specialty products. Specialty products have unique characteristics for which enough customers are willing to make a special purchasing effort, they are not easily substituted by other

The interfaces between epochs look like turning points which Burgelman calls "strategic inflection points" to describe "the giving way of one type of industry dynamics to another; the change of one wining strategy into another; the replacement of an existing technological regime by a new one" (Burgelman & Grove, 1996, p.10). In our case, the first turning point, when the company was created in 1994, is not really an inflection point but more accurately a starting point. It complies however relatively well with Burgelman's replacement of technological regimes since the firm was actually incepted to exploit a new purification technology initially developed by its founder and which would revolutionize the lactic acid industry. Twenty years later, about 80% of the worldwide production relies on this technology or close variants of it. Ironically, it is precisely the cost efficiency of this new technology that will later be responsible of a move from differentiated to undifferentiated price competition and from monopolistic to (almost) perfect competition. This commoditization effect will be at the core of another inflection point in the company's strategic development in 2011.

In fact, the two strategic inflection points in the history of the company, respectively around 2001 and 2011, find their origin in fundamentally different environmental factors even if they were both perfectly intentional. In 2000, Galactic's management started to perceive a profound mutation in the market structure. Indeed, thanks to the expansion of the processed food industry consecutive to the urbanization of the world population, to changing eating diets in developing countries towards the rising consumption of meat and dairy products, and to the spreading of new applications for lactic acid and lactates, demand was growing exponentially and the offer would need to follow with ever larger production units. In addition to size, lowering production costs was calling for the integration of lactic production units to existing massive crop-processing sites. A comprehensive strategic analysis was launched that concluded on the need to settle down closer to fast-growing foreign markets (Asia, United States) and reduce dependency to beet sugar as single raw material. The decision to start this geographical expansion with Asia was supported by the growth potential in this area, particularly pulled by China's rocketing development, and by the competitive environment in this region of the world. This was at this time the only continent where Purac, the world leader, did not have a factory. In Japan, another producer was suffering from extremely high production costs therefore limiting the company to a few niche markets, whereas the dozen of Chinese producers were

products or products from other suppliers. The uniqueness of specialty products perceived by customers supports market strategies based on differentiation (Porter, 1980). Conversely, commodity products are the same as other products of the same type offered by other producers or manufacturers, they are easily interchangeable. Market strategies based on commodities generally require low cost positions or cost leadership (opcit.).

manufacturing low quality products which were also poorly marketed. China looked also attractive because the Central Government had decided to list lactic acid production among the priorities of its newly adopted five-year plan. As a result of this strategic repositioning, Galactic opened a joint-venture company in China in 2002, a fully-owned subsidiary in the US in 2005 and a sales office in Japan in 2009. As we can see, the inflection of the company' strategy was then primarily triggered by new opportunities in the market place. We will see later in this study that other environmental conditions such as feedstock prices and foreign currencies were also forming a positive context at this moment in time supporting a global expansion of the company's activities. In structural terms, the internationalization phase that followed the 2001 strategic reorientation was accompanied by decentralization of the company's decision-making structures.

Environmental conditions were much less supportive in 2011 with a gloomy macroeconomic context and extremely expensive feedstocks and rocketing oil prices in addition to a heightened competition intensity and the slow but relentless commoditization of its flagship products already depicted. As its structure and size did not allow Galactic to become a low cost champion, coping easily with raw materials volatility and defeating competition directly[36], the company needed to respond and adapt quickly to the new environmental situation by focussing on specialties and turning attention to its customers[37]. In short, the management decided to turn the company from being a "me-too" commodity seller for the main part in the food industry to being a reliable innovative solution provider in food, feed and industrial segments. To achieve that, the company resolved to re-centralize the decision-making processes and merge the sales, marketing and R&D departments with the view to reduce the distance between its scientists and the market in order to better anticipate customers needs and reduce the "time-to-market" for its innovations. An ambitious program called "Competing for Growth: a new shape for a sustainable future" was designed around three pillars: exploiting the company's core competencies in product and process development; enhancing the company's market and application knowledge through market-driven initiatives and through partnering with customers; and improving the company's image and notoriety through increased market presence and enhanced communication. In concrete terms, the first action was to improve what

[36] Burgelman & Grove (2007, p.969) explain that "Forces driving toward commoditization (…) may change the rules (e.g. lead customers to expect lower price and higher quality) so that manufacturing process rather than product innovation becomes the new basis of competition".

[37] Small businesses that can not take the lead on their competitors by doing better can choose to turn to their customers and offer more specialized products or services that the customers will value better (Xie, 2012), and competition will then become "irrelevant" (Kim & Mauborgne, 2004).

the company called “customer reach”, i.e. targeting and satisfying customers’ needs, by focusing on key-segments and prioritizing markets. Hence, it was decided to increase the sales force, to split them in two teams, i.e. food and non-food, to increase technical resources, and to align those on the sales teams in two teams as well. At the same time, a priority was to restructure the distribution network, not only following a geographical segmentation as it was the case formerly, but by selecting specialists of each market segment instead of generalists “one-stop-shop” type of distributors. A second action was to enhance operational agility by accelerating the speed of response and promoting collaboration. For the former, the speed of response, a point of attention was brought to better anticipate and plan the sales *ex-ante* (before orders are coming in) so that a better execution *ex-post* by logistic departments would be possible. A system of key-performance indicators (KPI’s) was also put in place to raise the team members’ awareness towards the main business drivers and success factors. For the latter, promoting collaboration, the management was hoping that the freshly acquired Galactic Innovation Campus would help breaking the boundaries between the teams (hence improving internal communication) but also that these new facilities would allow to organize product and application demonstrations, trainings of customers and distributors, and co-developments with them. The management restored also a marketing department worthy of the name and reinforced this team as well.

Therefore, if the inflection of the company’ strategy in 2001 was primarily prompted by the emergence of new opportunities in the marketplace and a positive environmental context, it was caused 10 years later by serious threats and negative environmental circumstances likely to jeopardize the vital prognosis of the company.

Figure 3.1 summarizes the key-features of the three main epochs of the company’s history in terms of strategic intent, underlying dynamic and structure.

| | Feodalis | Modernitas | Contemporalis |
|---|---|---|---|
| **Strategic intent** | Structuration | Internationalization | Specialization |
| **Underlying dynamic** | From Products to Customers | From Products to Customers | From Customers to Products |
| **Structure** | Centralized<br>(Key-people in Belgium)<br>(Departments organized in silos) | Decentralized<br>(Key-people in China & USA)<br>(Departments organized in silos) | Recentralized<br>(Key-people in Belgium)<br>(Sales & Bus. Dev./R&D merged) |

*Table 3.1: Comparison of the company’s major epochs in terms of strategic intent, underlying dynamic and structure.*

The implementation of the different sequences of strategic intent that followed each inflection point was accompanied by a change in the organizational structure of the company. Clearly, the first years of the company's life (Feodalis) were organized centrally around a limited management team based in Belgium. As a consequence of the company's decision to expand abroad from 2001 onwards (Modernitas), it became necessary to review this organization in order to send overseas members of its management team. Indeed, a medium-sized structure such as Galactic has neither human resources nor sufficient financial resources to duplicate the management teams. The same people have thus had to manage different teams on different continents and commute on a regular basis between those different locations. This way of doing allowed a fast transfer of knowledge between the head office and the newly created entities as well as the rapid establishment of a corporate culture and a sense of belonging among the latter to the former. However, the distance separating the different entities both culturally and geographically, as well as the autonomy of management given to the leaders sent to these local entities have gradually led to a certain decentralization of the decision-making bodies[38]; a trend reinforced by the involvement of middle-managers primarily made of natives from the countries in which the local entities were implemented and the growth in size of these local teams. This may have had an important impact on the inflection of organizational ambidexterity pattern between Feodalis and Modernitas that will be discussed later (Section 3.3.1.) as some studies have shown positive association between exploration and decentralization (Jansen et al., 2006) arguing that "exploration entails non-routine problem solving and search for new knowledge that may make information processing inefficient under centralized decision making" (Lavie et al., 2010, p.122). The second strategic inflection, around 2011 (Contemporalis), saw the reverse movement taking place gradually, that is to say a movement of recentralization[39] of the decision-making structures with the return to the Belgian headquarters of the members of the top-management team (first from China and later from USA). As said, Galactic had decided at that time to reorient its overall strategy to react to the slow but relentless commoditization of its flagship products and turn the company from being a "me-too" commodity seller essentially in the food industry to being a reliable innovative solution provider in food, feed and industrial

[38] "An organizational structure is called "decentralized" when decision making has been disaggregated into a number of subunits, or divisions, each making its own decisions" (Siggelkow & Levinthal, 2003, p.651).

[39] Interestingly, Siggelkow and Levinthal (2003) found out with the help of an agent-based simulation model that temporarily decentralized firms that later reintegrate can display higher performance than pure forms of permanently centralized or decentralized structures. They claim that temporary decentralization has the ability to dislodge a firm from a given set of practices in such a way that it escapes its developmental trajectory. They however warn that such a radical organizational change can be detrimental for minor environmental variations, but that it can have a long-term benefit in case of larger environmental shocks.

segments. The company deemed that such a Copernician revolution implying a change of underlying dynamic (from product-focused to customer-centred) had to be coordinated from the headquarter with the reinforcement of product development teams, market development teams, sales teams and marketing teams on the one hand but also, at the same time, with a strengthening of operational efficiency. We will see in Section 3.3.1. that it had, here again, an effect on the organizational ambidexterity pattern followed by the company.

But let us look at the company's environment before investigating further the way organizational ambidexterity develops over time.

## 3.2. The company's environment

> *"Leaders cannot create the context in which they operate. Their distinctive contribution consists in operating at the limit of what the given situation permits. If they exceed these limits, they crash; if they fall short of what is necessary, their policies stagnate."*
>
> *On China,*
> Henry A. Kissinger

The title of the present dissertation hypothesizes a world of growing uncertainty. Simimarly, our research question postulates that companies have to dynamically adapt to *unanticipated* environmental changes. Therefore, prior to studying how our unit of analysis (the company Galactic) eventually did to achieve this, we believe scientific rigor imposes to verify if its environment is indeed dynamic and unpredictable.

### *3.2.1. Is the company's environment dynamic?*

The rate of change and the degree of instability of the environment, often referred to as "environmental dynamism", encompasses multiple facets. In order to characterize the company's environment and quantify its dynamism, a set of data has been constituted with the various external events that affected the company's development. Each and every of these events has been rated in terms of impact (positive or negative) and amplitude, and sorted in regards of the category it belongs to, i.e. competitive intensity, market trend, resource availability, crisis, costs fluctuation, currencies and exchange rates, regulatory framework, and disruptive technology (see Section 2.4.1 for more details).

Figure 3.2 shows the combination of all these elements and helps capture the evolution of the environmental dynamism that surrounded the company throughout its 25 years of existence. As we can see the company evolved in a **largely negative context almost all the time** with a negative intensity[40] exceeding by far the positive intensity every year since the year 2000. The company obviously succeeded to grow and expand despite this long lasting awkward predicament. In addition to being negative, the firm's environment was obviously worsening

[40] As a reminder, the negative (positive) intensity measured for a given year is the result of the addition of all negative (positive) contextual events that happened this year weighted by the extend of their impact on the company (Section 2.4.1).

with time (Figure 3.3), at least until the year 2008 when the downward trend stabilized before to start improving slightly in 2014 (mainly, as we will see further, thanks to a modest upgrade of the competitive landscape).

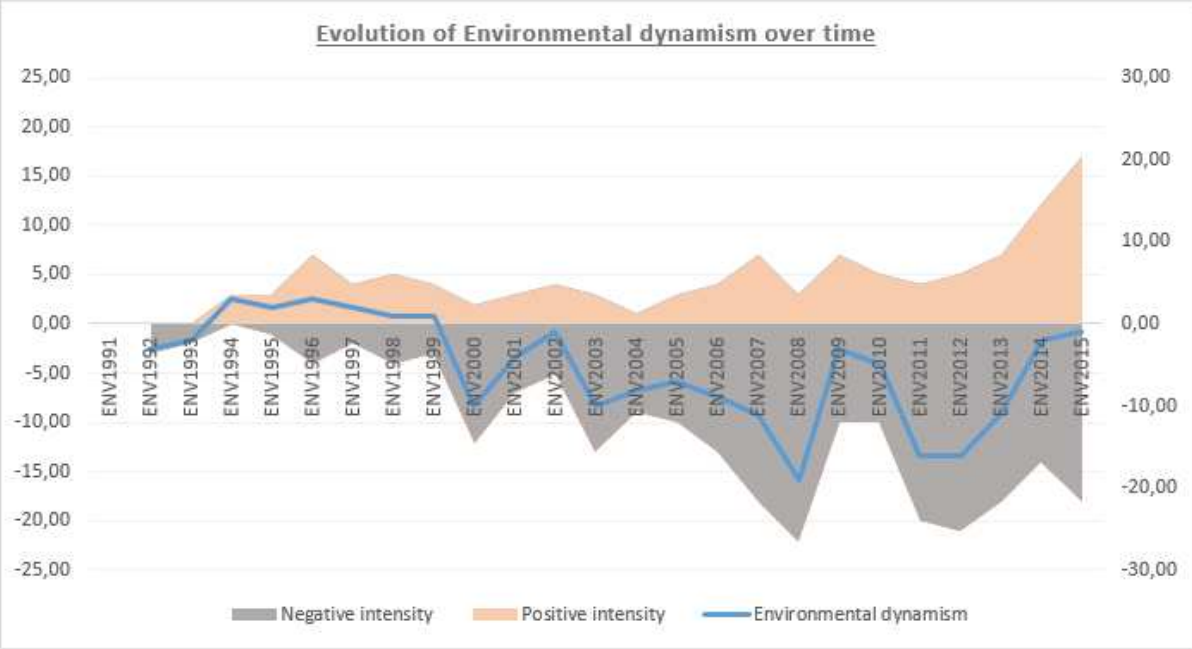



*Figure 3.2: Evolution of environmental context over time: negative and positive intensities (left axis), environmental dynamism (right axis)*

What is also worth a comment is that the amplitude of cumulated changes, i.e. the difference between the absolute values of positive and negative intensity scores, increased over the years which is an indication of a **growing volatility surrounding the company**. This is not only due to the environment itself but also to the expansion of the firm in new domains, i.e. new geographic areas and new markets, which increases its exposure to new environmental components (as we factored in these new components only when they started to impact the company[41]).

[41] As an example, we included the effect of the fluctuation of the Japanese Yen only when the company started to operate in Japan.

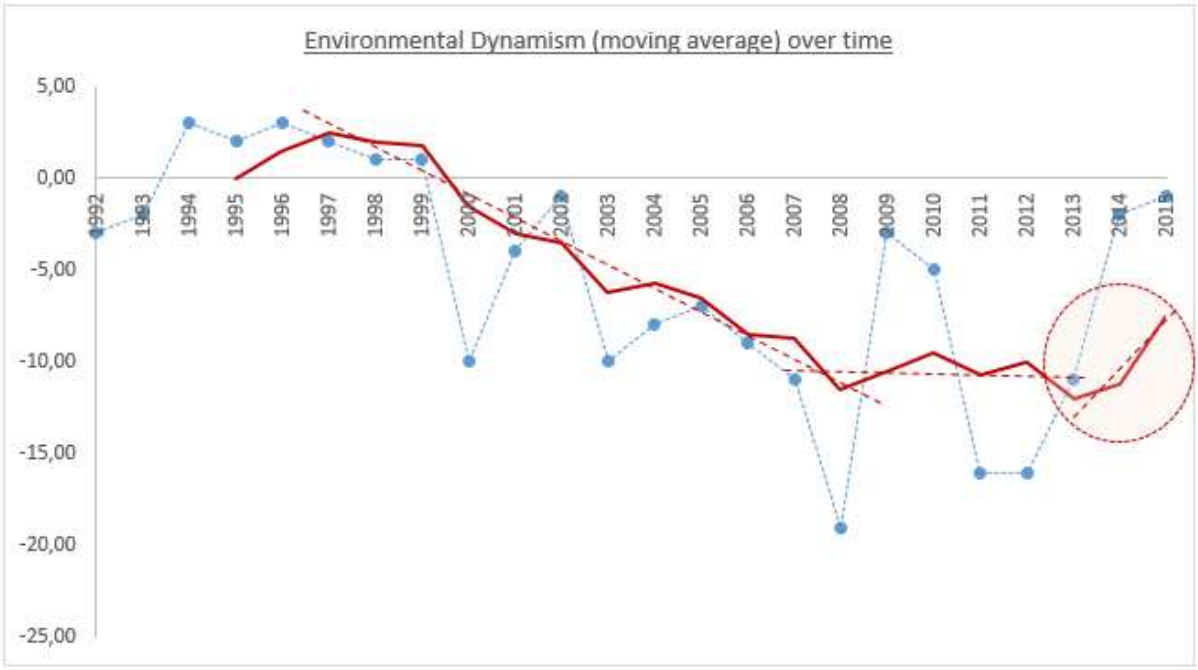
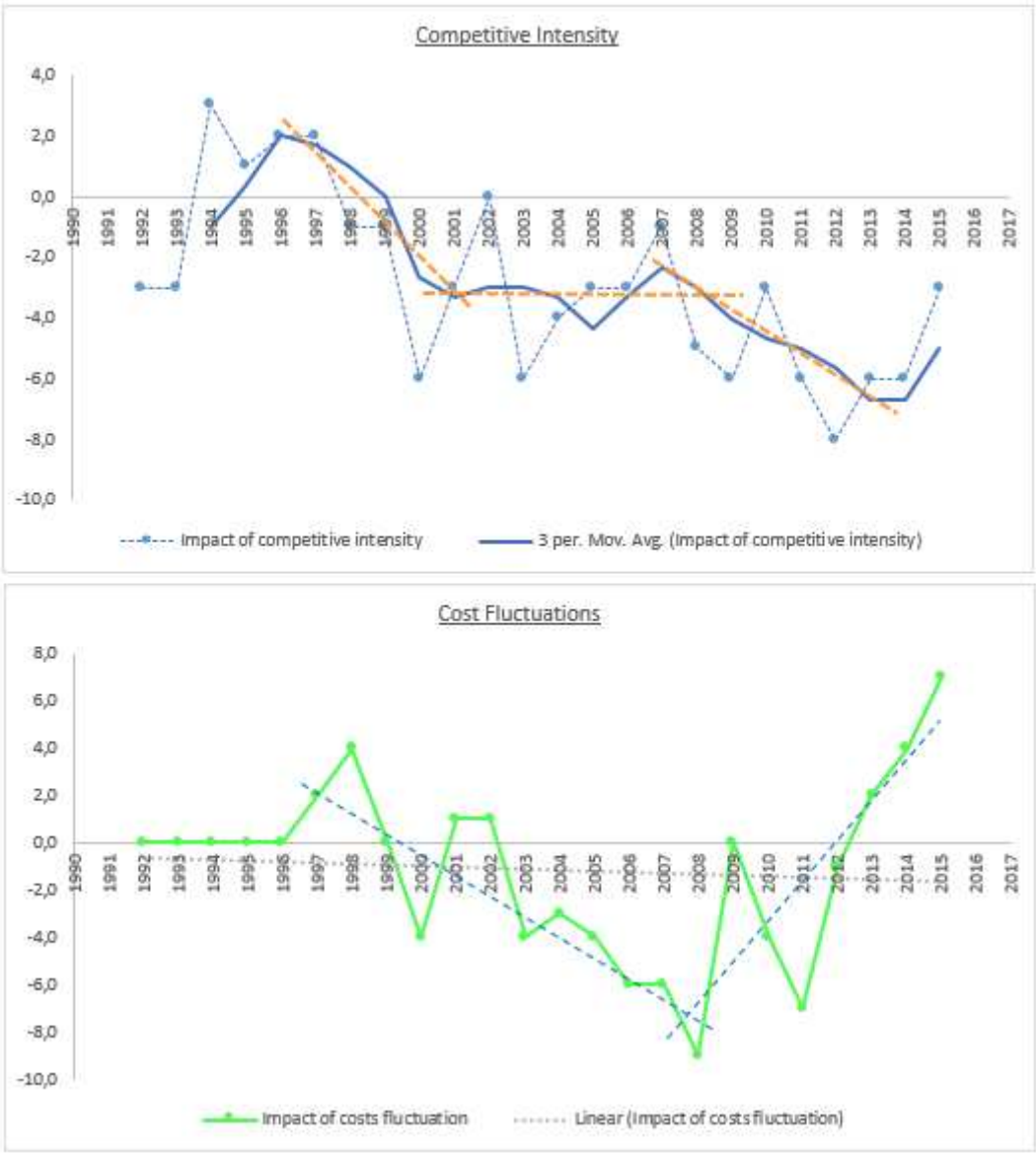


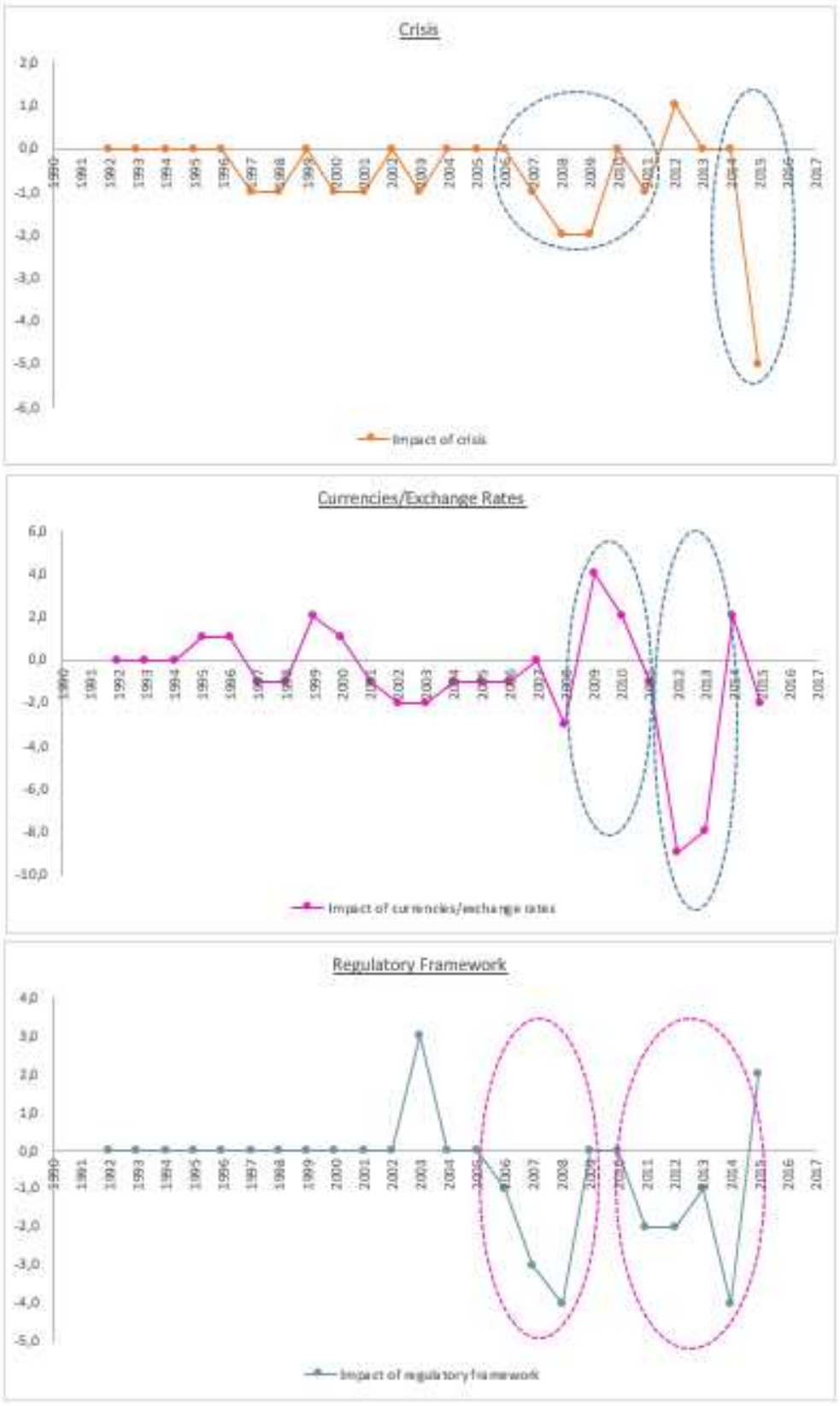

*Figure 3.3: Evolution of environmental context over time (with moving average, in red, to dampen the data volatility from one year to the other in order to better capture the real trend behind the data distribution)*

Analyzing the evolution of each environmental component [42] reveals different profiles: incremental evolution for competitive intensity and costs fluctuations (Figure 3.4.a), more erratic patterns (exogenous shocks) for others such as crisis, currencies and exchange rates, and regulatory framework (Fugure 3.4.b). It demonstrates the **complexity in which the firm must navigate** and how difficult it is for managers to read such an environment and anticipate the multiple changes.

[42] We focus here on the five main components and discard disruptive technology, resource availability and market trend which account only for 3% of the number of events recorded in our dataset as shown earlier (Figure 2.4). The 8 parameters are however taken into account when looking at the environmental dynamism as a whole (Figure 3.2 and 3.3).




*<u>Figure 3.4.a:</u> Components of environmental context which display a predominantly incremental (slow) evolution.*




*<u>Figure 3.4.b:</u> Components of environmental context which display a an erratic evolution sprinkled with exogenous shocks.*

The elements presented above allow us to infer with confidence that **the company is indeed evolving in a dynamic environment and** that **the level of dynamism is growing** as a result of external factors (e.g. growth of competitive intensity) but also because of its own development which leads to a larger exposure to contextual changes (internationalization and diversification of its activities). In other words, **the more a company expands in a dynamic environment, the more it becomes exposed to the effects (positive or negative) of this uncertain environment**. Some environmental changes cumulate their effects which increase the level of uncertainty[43] affecting the company's operations but others, impacting the company in opposite directions, neutralize or mitigate their effects which tends to reduce the volatility surrounding the company.

Yet, we don't only postulate in our research question that the company evolves in a *dynamic* environment but also that this environment is *uncertain* and *unpredictable*. Dynamism and uncertainty are different things. For instance, some industries are considered cyclical by nature (e.g. consumer discretionary goods[44], luxury goods, the airline industry or – to some extend – the car industry) and others, such as the electric power industry, are strongly regulated[45]; they are less prone to unforeseen variations. Therefore, if environmental dynamism is a necessary condition for uncertainty, it is not a sufficient one which leads to the next question to be answered: is the company evolving in an uncertain, unpredictable context as induced by our research question?

[43] We consider here the Knightian uncertainty, sometimes called "true uncertainty", which consists of a future whose distribution is unknown and unknowable, hence unpredictable by essence, as opposed to the notion of "risk" for which the future responds to a known distribution and can therefore be estimated with statistical tools (Knight, 1921).

[44] Consumer discretionary goods is a sector focused on products and services that consumers purchase with discretionary income. It is highly sensitive to the business cycle as discretionary expenses are easier to cut from a consumer's budget during hard times than essential costs.

[45] A regulated industry is an industry closely controlled by the government.

### *3.2.2. Is the company's environment uncertain?*

As schematically presented in the Figure 3.5.a/b, environmental behaviour can take different forms over time (Cheng & Van de Ven, 1996):

i. the system quickly levels off to a state of equilibrium and the system is said stable
ii. the system settles to periodic or cyclical behaviour
iii. the system never settles down to a repeating pattern, in which case the system can be:
    - Chaotic (also called deterministic with nonlinear dependencies)
    - Purely random (also called stochastic).

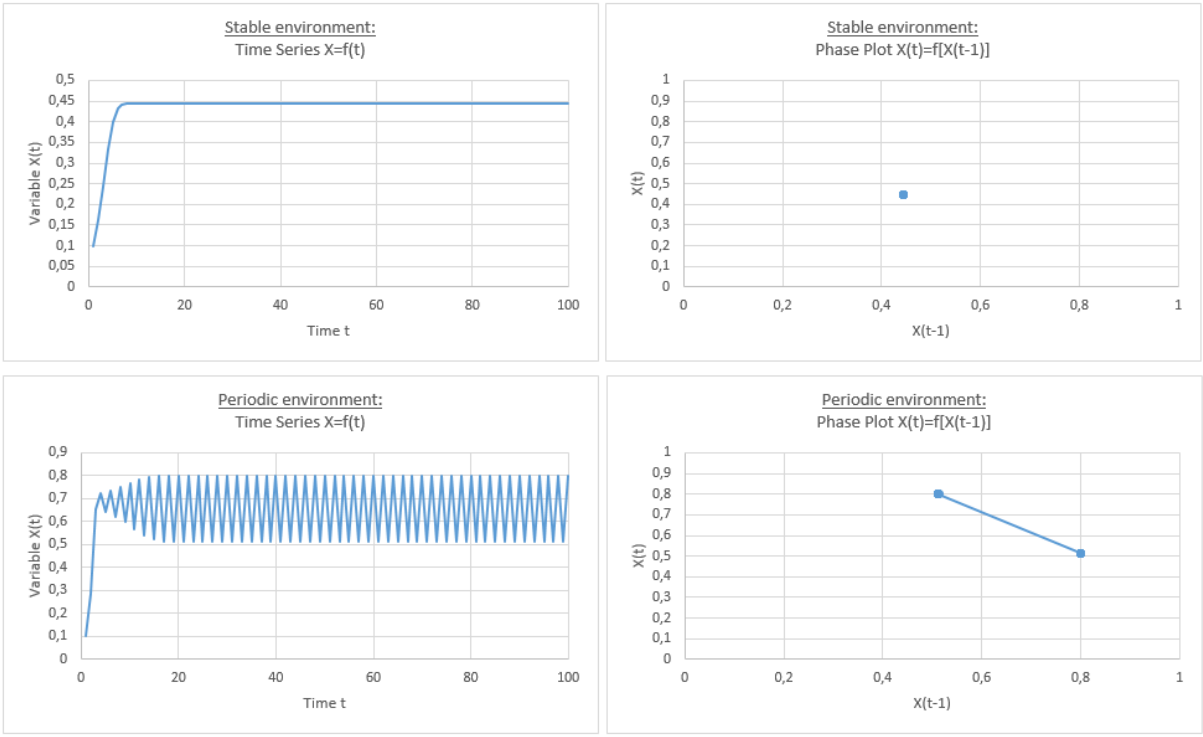
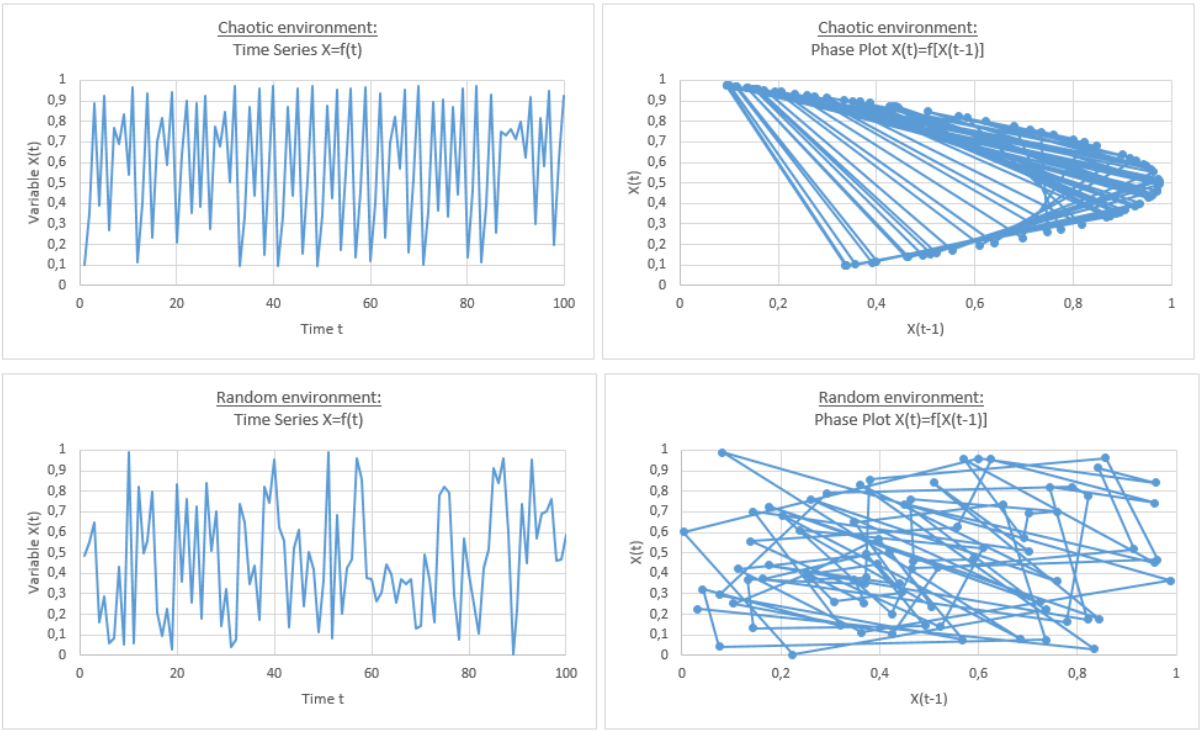



*Figure 3.5.a: Time series and phase plots showing stable and periodic behaviors*
*(The stable and periodic graphs have been obtained with a logistic map of the form $X_t = k \,.\, X_{t-1} \,.\, (1 - X_{t-1})$ with X being a descriptive variable of the environment and k, a constant governing the degree of nonlinearity, being equal to 1,8 and 3,2 for stable and periodic systems, respectively)(adapted from Cheng & Van de Ven, 1996; Koput, 1992)*




*<u>Figure 3.5.b:</u> Time series and phase plots showing chaotic and random behaviors*
*(The chaotic graphs have been obtained with a logistic map of the form*
*$X_t = k \,.\, X_{t-1} \,.\, (1 - X_{t-1})$ with X being a descriptive variable of the environment and k, a constant governing the degree of nonlinearity, being equal to 3,9)(adapted from Cheng & Van de Ven, 1996; Koput, 1992)(The random graphs have been obtained by using the RAND() function in Excel)*

Stable and cyclical behaviours can be analysed by linear methods through linear correlations, i.e. linear stochastic models such as autoregressive (AR) and moving average (MA) models, and yet they are predictable to a certain degree. The intrinsic dynamics of the system are governed by the linear paradigm that small causes lead to small effects (Kantz & Schreiber, 2004).

Conversely, the irregular behaviour of a system can be attributed either to some random external input, or to dynamic nonlinear chaotic input to the system (Kantz & Schreiber, 2004). "**Dynamic** means that the values a variable takes on at a given time are a function (at least in part) of the values of that same variable at an earlier time. **Nonlinearity** implies that the dynamic feedback loops vary in strength (loose or tight coupling) and direction (positive or negative) over time" (Cheng & Van de Ven, 1996, p.607, emphasis is ours). Another characteristic property of a chaotic system is its **sensitivity to initial conditions** by which "small initial differences or fluctuations in variables may grow over time into large differences, and as they move further from equilibrium they bifurcate or branch out into numerous possible

pathways" (Cheng & Van de Ven, 1996, p.608). In this nonlinear world, small causes lead to big effects – Lorenz' famous metaphor of the flap of a butterfly's wing which creates, a few months later, a storm. Another way to put it is that, in a chaotic system, similar causes don't lead to similar effects. The pathways that are taken in the branchings cannot be predicted (Cheng & Van de Ven, 1996) since "a forecast based on imprecise information will be inaccurate, and the magnitude of inaccuracy (…) will increase exponentially as the time period covered by the forecast increases" (Brockman & Chowdhury, 1997, p.500). It is an exponential instability (Forgues & Thietart, 1995).

Ultimately, "the most striking feature of chaos is the unpredictability of the future despite a deterministic time evolution" (Kantz & Schreiber, 2004, p.65). Indeed, as a matter of fact, determinism does not preclude the possibility of chaos. Determinism and predictability are not equivalent. Moreover, chaos and order can be observed in juxtaposition within the same system (an interesting discussion on this subject can be found in Peitgen, Jürgens, & Saupe, 1992, pp.9-14).

So, if chaos or randomness are detected in the company's environment, we can conclude to the instability and the unpredictability of this environment, and we can start looking at how the company has done to cope with this situation.

### Detection of chaos and randomness

The goal of time-series analysis is to learn about the dynamics behind some observed time-ordered data. It consists mainly in compressing a large sample of data into a few characteristic numbers which help enhancing our knowledge about the underlying system provided that we can interpret these characteristic numbers properly. Bradley & Kantz (2015) give an illustrative example with the computation of the mean and the variance: if the observed data are a sample from a Gaussian distribution, these numbers characterize it completely; if, on the other hand, the data stem from a bimodal distribution, the mean value is very atypical and the variance is not meaningful.

Several methods have been developed to detect chaos in time series. The calculation of correlation dimension gives an estimate of the system complexity whereas the determination of Kolmogorov entropy and Lyapunov characteristic exponents quantify the level of chaos in the system (Rosenstein, Collins, & Luca, 1993). The Grassberger-Procaccia algorithm

(Grassberger & Procaccia, 1983) which determines the correlation dimension is probably the most popular method used to quantify chaos but Rosenstein and colleagues (1993, p.117) as well as Brooks (1998) tell us that it is very sensitive to variations of its calculation parameters and it is usually applicable only to long, noise-free time series. The Kolmogorov-Sinai entropy, which is actually a measure of the loss of information due to unpredictability (Kantz & Schreiber, 2004), is the sum of the positive Lyapunov exponents. It is difficult to put in practice since spurious exponents are hard to identify and can be positive as well[46] (Bradley & Kantz, 2015). We therefore follow Rosenstein et al. (1993) who consider sufficient to calculate only the largest Lyapunov exponent ($\lambda_1$) to provide a useful characterization of a chaotic system.

In the previous section, we have referred to an exponential instability linked to a chaotic system being sensitive upon initial conditions. In such a system, initial values of a time series that are close together separate exponentially as time passes. If $d_0$ describes the distance between these two values at $t_0$, the distance between them after n periods of time ($d_n$) can be described by:

$$d_n = d_0 . e^{\lambda n} \qquad \text{(equation 3.1)}$$

In this relation, the Lyapunov exponent, λ, measures the rate of separation of the trajectories of the two values over time. Therefore,

- If λ is positive, nearby trajectories diverge exponentially, the system is sensitive to initial conditions. It is chaotic. This is actually true for λ between 0 and ∞, as λ = ∞ characterizes random noise.
- If λ = 0, nearby trajectories do not diverge, the distance between them remains constant, the system is not sensitive to initial conditions and is therefore called *marginally stable*.
- If λ is negative, nearby trajectories converge to a stable fixed point. Such a system exhibit asymptotic stability. The more negative the Lyapunov exponent, the faster the system reaches a stable fixed point and the greater its stability. λ = -∞ describes superstable fixed points.

Equation 3.1 can be transformed by taking the logarithms in order to isolate λ:

$$\lambda = \frac{1}{n} . \ln \frac{d_n}{d_0} \qquad \text{(equation 3.2)}$$

[46] Spurious Lyapunov exponents are exponents in the reconstructed state space that are not defined in the true state space.

Theoretically, the Lyapunov exponent is a measure of this rate of separation after infinite time (to the limit for $t \to \infty$), and equation 3.2 becomes equation 3.3.

$$\lambda = \lim_{t\to\infty} \frac{1}{t-t_0} \cdot \ln \frac{d_t}{d_0} \qquad \text{(equation 3.3)}$$

However, in practice we cannot afford the luxury of infinitely long integrations and we calculate instead the instantaneous largest Lyapunov exponent with enough integrations to settle to approximately its asymptotic value. Equation 3.3 is then transformed into equation 3.4 which stands if the number of iterations N (or replacement steps in the algorithm that we used – see below) is large enough.

$$\lambda = \frac{1}{N} \cdot \sum_{n=1}^{N} \log_2 \frac{dx_{n+1}}{dx_n} \qquad \text{(equation 3.4)}$$

To analyse our data, we use the algorithm developed by Wolf, Swift, Swinney, & Vastano (1985). We have slightly modified the program[47] to make it "user-friendlier" and to have the Lyapunov exponent calculated for each time step (EVOLV in the Fortran program). It then allows to plot the whole evolution of the Lyapunov exponent over the period under scrutiny in order to see the temporal convergence to its asymptotic value and conclude on the presence or the absence of chaos (with some reserves discussed in section 3.2.5). The modified program is showed in Appendix V. The reader can find a short and clear description of the calculation methodology followed by Wolf and colleagues in Cheng & Van de Ven, 1996.

This algorithm is sometimes contested because it does not test for the presence of exponential divergence but it only assumes its existence and thus it is said to yield a finite exponent for stochastic data also (where the true exponent is actually infinite)(Kantz & Schreiber, 2004, p.69). This is not much of a problem in our case since our purpose is to detect either chaos or randomness to confirm the unpredictability of the environment in which the company is evolving. As discriminating deterministic chaos from pure stochastic volatility is not at the core of our work, we are satisfied with Wolf's asumptions but we nevertheless discuss this point further hereunder where we confirm that Wolf's algorithm delivers indeed a positive and not infinite Lyapunov exponent for pure random time series.

[47] The author thanks Prof. Emeritus Robert Brasseur of the Center for Numerical Molecular Biophysics, University of Liège, Belgium, for helping with the programmation.

The Figure 3.6 below shows typical convergence patterns obtained with Wolf's program for the time series presented as examples of different forms of environmental behaviors in Figure 3.5.a/b.

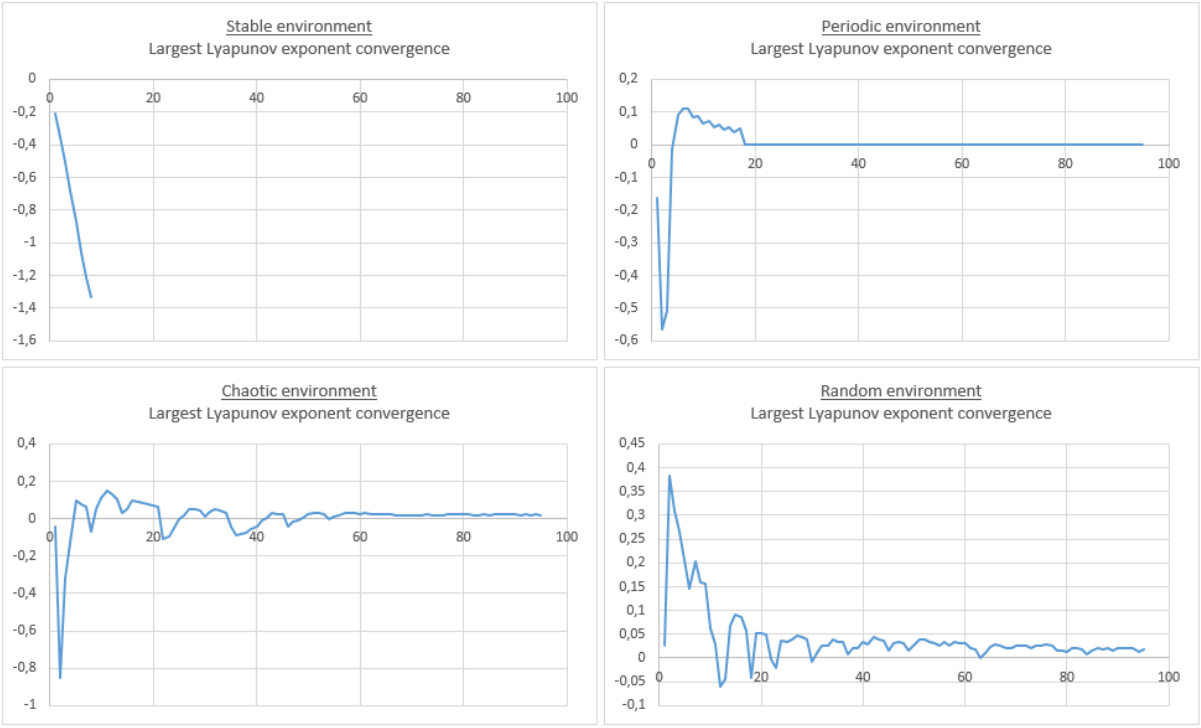



*Figure 3.6: Largest Lyapunov exponent convergence plots for different envionmental behaviors (The corresponding time series and phase plots are the ones showed in Figure 5.1a and 5.1.b. The input parameters used are: DIM = 3; TAU = 1; dt = 1; SCALMX = 1E-4; SCALMN = 0,3; EVOLV = 1 – see below for further explainations. The Largest Lyapunov exponent could not be accurately calculated for the stable environment, it should logically be -∞. Similarly, the program did not deliver a calculated value for the periodic environment, it should logically be 0. The largest Lyapunov exponent was 1.96E-2 and 1.84E-2 for chaotic and random environments, respectively)*

As explained, the Lyapunov exponents measure the amount of uncertainty of the system or, said differently, the rate at which the system loses information. The exponents are then expressed in bits of information per unit of time or in bits per iteration for discrete systems such as experimental time series.

## Environmental variables tested

As indicated in the narrative about the company's history, our experience on the field tells us that, beside unexpected events of accidental nature, the company is highly impacted in its day-to-day operations by (at least) three exogenous factors: sugar prices, crude oil prices, and EUR-

USD exchange rates. Our analysis of the different components of environmental dynamism (Section 3.2.1) showed indeed the predominance of costs variations and foreign exchange fluctuations in the events recorded throughout the company's history (they account together for 43% of the events in our environmental dataset). A third variable, competitive intensity, also appeared predominant but, as opposed to currencies and costs factors such as sugar or oil prices, there is no official index recording fine-grained data about the competitors that the company is facing on the marketplace; and our dataset reports only 113 competition-related events which is not enough to allow for accurate detection of chaos or randomness.

We therefore decided to focus on three **highly impacting exogenous factors**, i.e. sugar prices, crude oil prices, and EUR-USD exchange rates, and not to study all possible variables to test the company's environment. This decision is justified by the obvious impossibility to observe a complex dynamic system in its globality (Durieux & Vandangeon-Derumez, 1996). Yet, Thiétart and Forgues (1995) tell us that it is not necessary to identify and measure the whole set of variables to study complex system dynamics. Indeed, in a phase space reconstructed from the measurement of a single variable, this variable displays the same properties as the underlying system even if it is only a partial representation of it because "many important properties of dynamical systems are invariant under diffeomorphism, this means that conclusions drawn about the reconstructed dynamics also hold for the true dynamics of the system" (Bradley & Kantz, 2015, p.2). As a matter of fact, if one variable observed in its phase space is chaotic, we can conclude that the whole system is chaotic. The only risk relies to type II error in statistical hypothesis testing, i.e. rejecting a true hypothesis as incorrect or, stated otherwise, failing to detect an effect that is present[48]. Hence, if we detect chaos with one single variable, we can conclude that the system is chaotic but if we fail to detect it, we cannot conclude that chaos is absent. We nevertheless resolved to analyse three environmental variables instead of one.

i. **EUR-USD exchange rates** affect the company because of dual transactions (the company sells its products on credit and receives payment in USD after a delay) and translation effects (the company has operations overseas and needs to translate the foreign currency values of each of these assets and liabilities into its home currency to consolidate its financial accounts).

[48] With this statement, we diverge from Durieux & Vandangeon-Derumez (1996) who claim that the risk encountered is a type I error.

ii. **Crude oil** prices impact the company because of their direct effect on energy prices in general (as many industrial processes, Galactic technologies consume relatively high amounts of energy) but also because of their indirect influence on the markets of biosourced products which are competing with oil-based chemicals. There exist several indexes for oil prices (WTI, Brent…) but we use here crude oil (petroleum) index displayed by the International Monetary Fund. It consists in a simple average of three spot prices; Dated Brent, West Texas Intermediate, and the Dubai Fateh, that we are using as a proxy for energy prices in general. To which extend oil prices influence other energy sources such as natural gas is still subject to debate but there is little discussion about the fact that there is a connection. Economic theory suggests that natural gas and crude oil prices should be related because natural gas and crude oil are substitutes in consumption and also complements, as well as rivals, in production. In general, the observed pattern of crude oil and natural gas prices tend to support this theory (Villar & Joutz, 2006).

iii. **White sugar** is Galactic's prime feedstock in Belgium and therefore the first component of lactic acid production variable cost. The price actually paid every year by the company depends on various factors such as the world sugar price, the negotiation process with the suppliers and the situation of the European Sugar Regime that is regularly reformed. Yet, sugar being a commodity and Galactic being not a super-large purchaser, there is little room for negotiation. Refined white sugar is traded in USD/metric ton in London at the London Futures Exchange (LIFFE) with a contract known as N°5 contract. Raw sugar is traded in US cents per pound in New York at the IntercontinentalExchange (ICE) with a contract known as the N°11 contract. Both trades are moving similarly with the former being always more expensive than the latter. The difference between the two corresponds to a margin for refiners who transform raw sugar into white sugar. We here use the New York N°11 as proxy of the world sugar price.

Another property of chaotic systems is to be isomorphic in time (Durieux & Vandangeon-Derumez, 1996). If chaos is found in a monthly time series for instance, then the system will be chaotic for a shorter time period. Of course, the detection of chaos require enough granularity in the data, i.e. enough values in the time series. As Thiétart & Forgues (1997, p.127) point out: "The search for chaos is a tricky endeavour, especially when dealing with a finite time series. As the available statistical techniques are based on asymptotic estimates, the reliability of the

results is dependent on the size of the series". The risk with too few data would be to fail to detect chaos when it actually exists, here again a type II error in statistical hypothesis testing. This being said, to ascertain whether the evolution of our environmental variables displays a chaotic behaviour, we nevetherless used monthly average measures (small data set) and daily average measures (large data set) to cross-check and confirm our findings. On the one hand, the large data set benefits from more values and hence from a better granularity. On the other hand, it is *per se* more exposed to noise than the small data set.

The time period covered and number of data in both data sets are given for each variable in the Table 3.2.

| | **Small data set** | **Large data set** |
|---|---|---|
| **Frequence of measurements** | Monthly | Daily |
| **Period covered** | 1985-2016 | 1994-2016 |
| **Number of values:** | | |
| EUR-USD FX rate | 376 | 5866 |
| Crude oil price | 376 | 5668 |
| Sugar price | 376 | 5631 |
| **Sources:** | | |
| EUR-USD FX rate | https://www.oanda.com/lang/fr/currency/historical-rates/ | https://www.oanda.com/lang/fr/currency/historical-rates/ |
| Crude oil price | International Monetary Fund http://www.imf.org/external/np/res/commod/index.aspx | https://www.quandl.com/collections/markets/crude-oil |
| Sugar price | International Monetary Fund http://www.imf.org/external/np/res/commod/index.aspx | World bank http://www.indexmundi.com/commodities/?commodity=su |
| **Description:** | | |
| EUR-USD FX rate | Exchange rate (daily closing bid prices from interbank market) | |
| Crude oil price | Crude Oil (petroleum), simple average of three spot prices; Dated Brent, West Texas Intermediate, and the Dubai Fateh | |
| Sugar price | Sugar, Free Market, Coffee Sugar and Cocoa Exchange (CSCE) contract no.11 nearest future position | |
| **Units:** | | |
| EUR-USD FX rate | - | |
| Crude oil price | USD/barell (bbl) | |
| Sugar price | US cents/pounds (lb) | |

*Table 3.2: Composition of the data sets used to analyze the company's environment*

### Input parameters & program robustness

Wolf et al. (1985) in their reference paper (more than 7200 citations in Google Scholar), advise to check the stationarity of the results to ensure robust exponent estimates. We have therefore tested the program with our data (the large data set in order to increase our chance to detect

chaos, if any, and reduce the risk of type II error discussed above) while varying the different input parameters of the program.

These input parameters are the following and the results of the calculation of the largest Lyapunov exponents with different values of input parameters are shown in Table 3.3:

- DIM is the dimension of the phase space reconstruction. This is a critical input parameter. When the attractor reconstruction is performed in a space whose dimension is too low, "catastrophes" are likely to result with elements growing at a dramatic rate, providing an enormous contribution to the estimated exponent. This is confirmed with our data for small DIM values in Table 3.3. which lead to infinite exponents. If the dimension is too large, one can expect noise in the data. Increasing the dimension past what is minimally required has the effect of unnecessarily increasing the level of contamination of the data (Wolf et al., 1985, p.297). This is why we performed our calculations for the other input parameters always with the lowest dimension giving a finite $\lambda_1$.
- Reconstruction time delay (TAU) and the time between the data samples (dt), required only for normalization of the exponent (Wolf et al., 1985, p.312) were kept constant (value = 1 as in Wolf et al., 1985, p.299).
- SCALMX is the estimate of the length scale on which the local structure of the attractor is no longer being probed. We have tested a wide range of values for this parameters (from 0,000001 to 0,1) and we can see in Table 3.3 that the program delivers a relatively stable exponent as long as the value is small enough to avoid an infinite result.
- SCALMN is the length scale on which noise is expected to appear. Here again, we have tested a wide range of values (from 0.01 up to 10). We observe only small variations of the largest exponent calculated for rather big variations of the parameter.
- EVOLV is the time step in the evolution time program, i.e. a constant propagation time between replacements attempts. We have tested values of 1 to 10 on EUR-USD data only and saw no real impact on the exponent calculation in our case.

Our various tests indicate a good reproducibility in the calculation of the largest Lyapunov exponent. Despite small variations, the $\lambda_1$ calculated are fairly stable. The order of magnitude is respected and, more importantly to our discussion, all calculated values are positive.

| Variables | Number of values (NPTS) | Input Parameters | | | | | | Largest Lyapunov Exponent (λ1) |
|---|---|---|---|---|---|---|---|---|
| | | DIM | TAU | dt | SCALMX | SCALMN | EVOLV | |
| EUR-USD FX rate (1) | 5866 | **1** | 1 | 1 | 1,00E-04 | 0,3 | 1 | NaN |
| | | **2** | 1 | 1 | 1,00E-04 | 0,3 | 1 | ∞ |
| | | **3** | 1 | 1 | 1,00E-04 | 0,3 | 1 | ∞ |
| | | **4** | 1 | 1 | 1,00E-04 | 0,3 | 1 | ∞ |
| | | **5** | 1 | 1 | 1,00E-04 | 0,3 | 1 | 5,21E-04 |
| | | **6** | 1 | 1 | 1,00E-04 | 0,3 | 1 | 5,44E-04 |
| | | **7** | 1 | 1 | 1,00E-04 | 0,3 | 1 | 5,63E-04 |
| | | 5 | 1 | 1 | **1,00E-01** | 0,3 | 1 | ∞ |
| | | 5 | 1 | 1 | **1,00E-02** | 0,3 | 1 | ∞ |
| | | 5 | 1 | 1 | **1,00E-03** | 0,3 | 1 | ∞ |
| | | 5 | 1 | 1 | **1,00E-04** | 0,3 | 1 | 5,21E-04 |
| | | 5 | 1 | 1 | **1,00E-05** | 0,3 | 1 | 5,21E-04 |
| | | 5 | 1 | 1 | **1,00E-06** | 0,3 | 1 | 5,21E-04 |
| | | 5 | 1 | 1 | 1,00E-04 | **10** | 1 | 1,46E-03 |
| | | 5 | 1 | 1 | 1,00E-04 | **1** | 1 | 1,46E-03 |
| | | 5 | 1 | 1 | 1,00E-04 | **0,3** | 1 | 5,21E-04 |
| | | 5 | 1 | 1 | 1,00E-04 | **0,1** | 1 | 7,91E-04 |
| | | 5 | 1 | 1 | 1,00E-04 | **0,01** | 1 | 1,36E-03 |
| | | 5 | 1 | 1 | 1,00E-04 | 0,3 | **1** | 5,21E-04 |
| | | 5 | 1 | 1 | 1,00E-04 | 0,3 | **2** | 5,21E-04 |
| | | 5 | 1 | 1 | 1,00E-04 | 0,3 | **3** | 5,21E-04 |
| | | 5 | 1 | 1 | 1,00E-04 | 0,3 | **10** | 5,23E-04 |
| Crude oil price (2) | 5668 | **2** | 1 | 1 | 1,00E-04 | 0,3 | 1 | ∞ |
| | | **3** | 1 | 1 | 1,00E-04 | 0,3 | 1 | 1,41E-03 |
| | | **4** | 1 | 1 | 1,00E-04 | 0,3 | 1 | 1,44E-03 |
| | | **5** | 1 | 1 | 1,00E-04 | 0,3 | 1 | 1,47E-03 |
| | | **6** | 1 | 1 | 1,00E-04 | 0,3 | 1 | 1,31E-03 |
| | | **7** | 1 | 1 | 1,00E-04 | 0,3 | 1 | 1,30E-03 |
| | | 3 | 1 | 1 | **1,00E-01** | 0,3 | 1 | ∞ |
| | | 3 | 1 | 1 | **1,00E-02** | 0,3 | 1 | ∞ |
| | | 3 | 1 | 1 | **1,00E-03** | 0,3 | 1 | 1,41E-03 |
| | | 3 | 1 | 1 | **1,00E-04** | 0,3 | 1 | 1,41E-03 |
| | | 3 | 1 | 1 | **1,00E-05** | 0,3 | 1 | 1,41E-03 |
| | | 3 | 1 | 1 | 1,00E-04 | **10** | 1 | 1,52E-03 |
| | | 3 | 1 | 1 | 1,00E-04 | **1** | 1 | 1,52E-03 |
| | | 3 | 1 | 1 | 1,00E-04 | **0,3** | 1 | 1,41E-03 |
| | | 3 | 1 | 1 | 1,00E-04 | **0,1** | 1 | 1,52E-03 |
| | | 3 | 1 | 1 | 1,00E-04 | **0,01** | 1 | 1,52E-03 |
| Sugar price (3) | 5631 | **2** | 1 | 1 | 1,00E-04 | 0,3 | 1 | ∞ |
| | | **3** | 1 | 1 | 1,00E-04 | 0,3 | 1 | ∞ |
| | | **4** | 1 | 1 | 1,00E-04 | 0,3 | 1 | 1,21E-03 |
| | | **5** | 1 | 1 | 1,00E-04 | 0,3 | 1 | 1,24E-03 |
| | | **6** | 1 | 1 | 1,00E-04 | 0,3 | 1 | 1,27E-03 |
| | | **7** | 1 | 1 | 1,00E-04 | 0,3 | 1 | 1,29E-03 |
| | | 4 | 1 | 1 | **1,00E-02** | 0,3 | 1 | ∞ |
| | | 4 | 1 | 1 | **1,00E-03** | 0,3 | 1 | 1,21E-03 |
| | | 4 | 1 | 1 | **1,00E-04** | 0,3 | 1 | 1,21E-03 |
| | | 4 | 1 | 1 | **1,00E-05** | 0,3 | 1 | 1,21E-03 |
| | | 4 | 1 | 1 | 1,00E-04 | **10** | 1 | 1,60E-03 |
| | | 4 | 1 | 1 | 1,00E-04 | **1** | 1 | 1,60E-03 |
| | | 4 | 1 | 1 | 1,00E-04 | **0,3** | 1 | 1,21E-03 |
| | | 4 | 1 | 1 | 1,00E-04 | **0,1** | 1 | 1,49E-03 |
| | | 4 | 1 | 1 | 1,00E-04 | **0,01** | 1 | 1,60E-03 |

(1) Exchange rate EUR-USD (daily closing bid prices from 1994 to 2016)
(2) Crude Oil (petroleum), simple average of three spot prices; Dated Brent, West Texas Intermediate, and the Dubai Fateh (daily average from 1994 to 2016)
(3) World sugar N°11 sugar price (daily average from 1994 to 2016)

*Table 3.3: Influence of input parameters on the calculation of largest Lyapunov exponents for 3 time series*

*(EUR-USD exchange rate, crude oil price, and world sugar price; daily averages from 1994 to 2016; in blue the values of the parameter that are changed while the other input parameters are kept constant)*

## Our results confirm the absence of long term predictability

i. EUR-USD exchange rate

The Figure 3.7 hereunder compares the time series and largest Lyapunov convergence plots for monthly average and daily average EUR-USD exchange rates from 1985 to 2016 and 1994 to 2016.

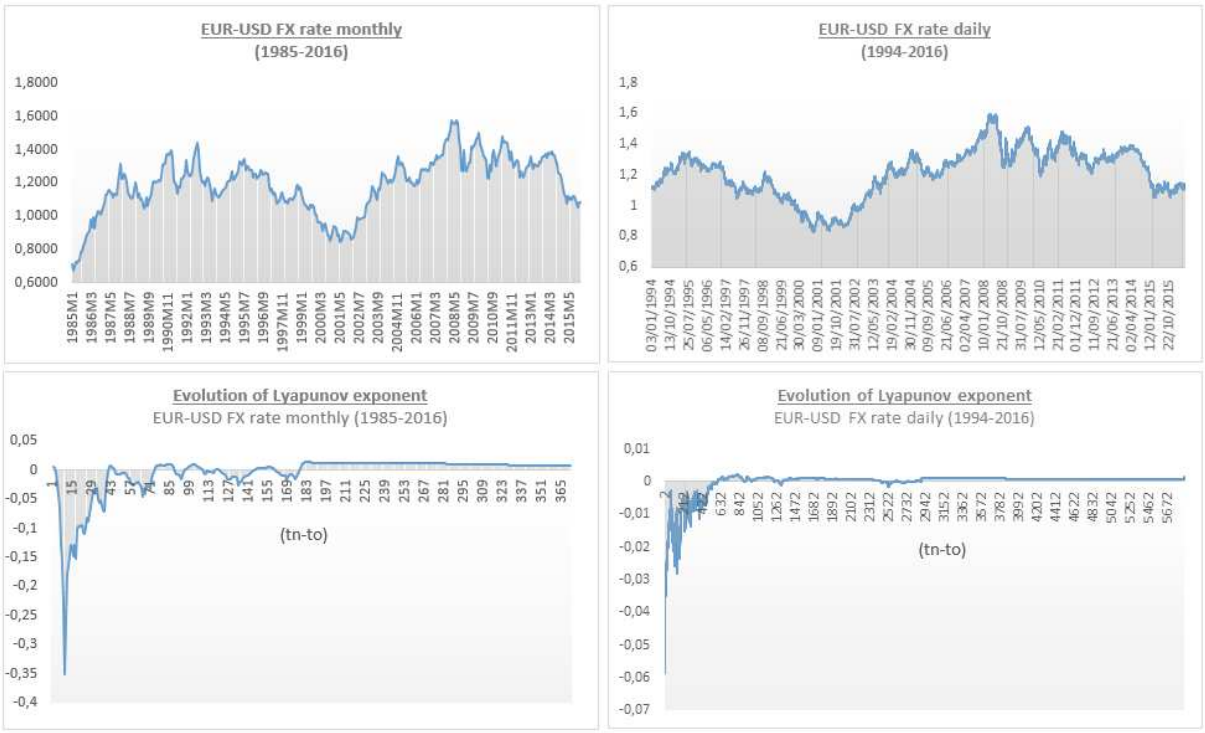



*Figure 3.7: Time series for monthly and daily EUR-USD exchange rate and related Lyapunov exponents convergence plots*
*(monthly averages from 1985 to 2016 and daily values from 1994 to 2016)*

We find $\lambda_1$ values, positive in both cases, of 0,00736 and 0,000521 bits/iteration respectively (Table 3.4). This result gives support to Hsieh (1989) who searched for chaos in the exchange rates of five currencies and found that daily exchange rates are not independent of past changes. He found little linear dependence and detected strong nonlinear dependence which is a signature of a chaotic evolution over time.

| Monthly | Daily |
|---|---|
| **Input parameters** | **Input parameters** |
| dim=4 | dim=5 |
| tau=1 | tau=1 |
| dt=1 | dt=1 |
| scalmx=0.0001 | scalmx=0.0001 |
| scalmn=0.3 | scalmn=0.3 |
| evolv=1 | evolv=1 |
| | |
| **Output parameters** | **Output parameters** |
| zlyap= 7,36E-03 | zlyap= 5,21E-04 |

*Table 3.4: Input parameters and largest Lyapunov exponent calculated for monthly and daily EUR-USD exchange rate*
*(monthly averages from 1985 to 2016 and daily values from 1994 to 2016)*

### ii. Crude oil price

Commodities are variables that are inherently subject to resource constraints. They are therefore prone to display chaotic structures (Baumol & Benhabib, 1989). Adrangi, Chatrath, & Kathy (2001) tested for the presence of low-dimensional chaotic structure in crude oil. They found strong evidence of nonlinear dependencies but the evidence was not consistent with chaos.

Our results, positive largest Lyapunov exponents for both monthly and daily data (Table 3.8), confirm nonlinearity. Whether we can conclude on the presence of deterministic chaos or pure randomness will be discussed in the next section.

### iii. Sugar price

Similar to the previous two variables analyzed, sugar price evolution leads to positive largest Lyapunov exponents (Table 3.9) suggesting but not proving (see discussion in section 3.2.6) the presence of chaos.

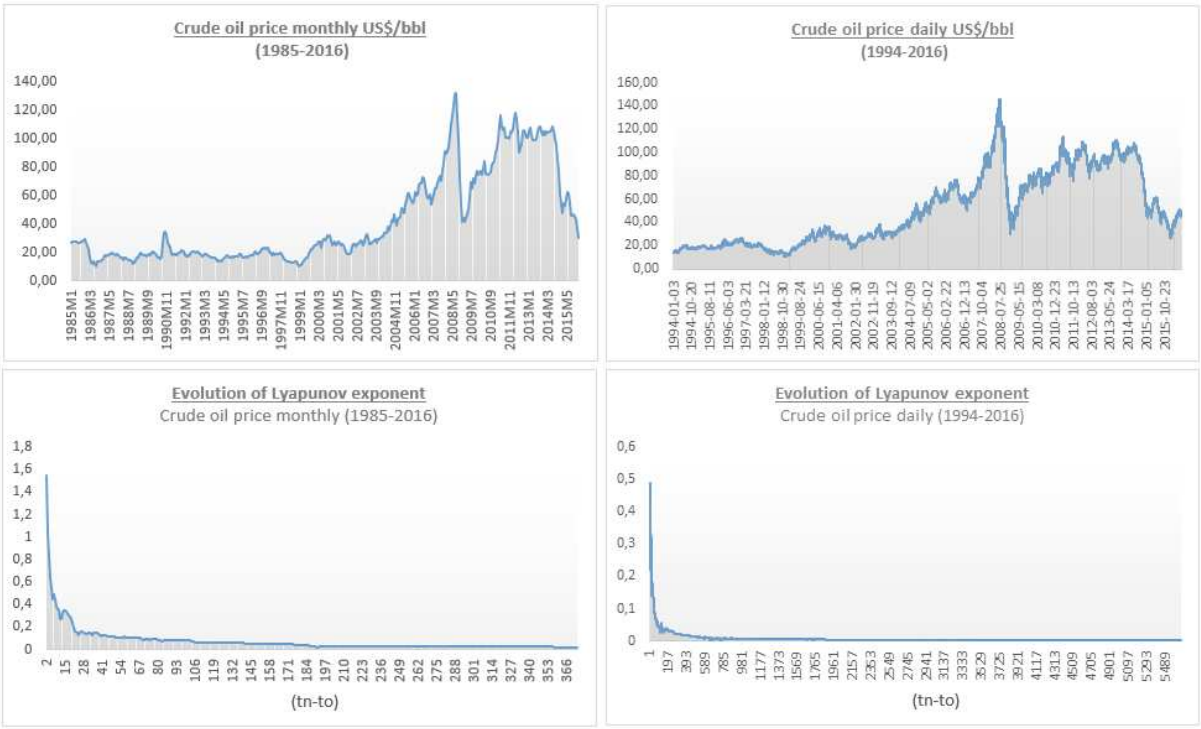



*Figure 3.8: Time series for monthly and daily crude oil prices and related Lyapunov exponents convergence plots*
*(monthly averages from 1985 to 2016 and daily values from 1994 to 2016)*

| Monthly | Daily |
|---|---|
| **Input parameters** | **Input parameters** |
| dim=2 | dim=3 |
| tau=1 | tau=1 |
| dt=1 | dt=1 |
| scalmx=0.0001 | scalmx=0.0001 |
| scalmn=0.3 | scalmn=0.3 |
| evolv=1 | evolv=1 |
| | |
| **Output parameters** | **Output parameters** |
| **zlyap= 1,71E-02** | **zlyap= 1,52E-03** |

Table 3.5: Input parameters and largest Lyapunov exponent calculated for monthly and daily crude oil prices
*(monthly averages from 1985 to 2016 and daily values from 1994 to 2016)*

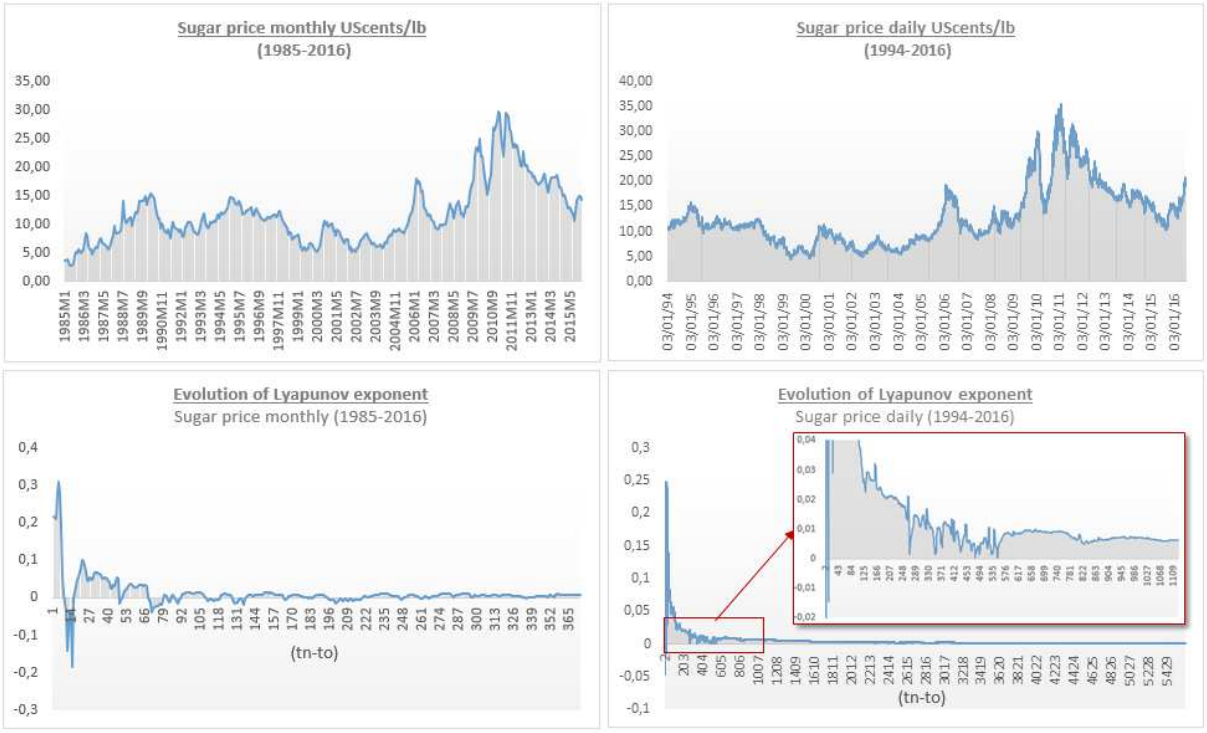



*Figure 3.9: Time series for monthly and daily sugar prices and related Lyapunov exponents convergence plots*
*(monthly averages from 1985 to 2016 and daily values from 1994 to 2016)*

| Monthly | Daily |
|---|---|
| **Input parameters** | **Input parameters** |
| dim=2 | dim=4 |
| tau=1 | tau=1 |
| dt=1 | dt=1 |
| scalmx=0.0001 | scalmx=0.0001 |
| scalmn=0.3 | scalmn=0.3 |
| evolv=1 | evolv=1 |
| | |
| **Output parameters** | **Output parameters** |
| zlyap= 8.79E-03 | zlyap= 1,21E-03 |

*Table 3.6: Input parameters and largest Lyapunov exponent calculated for monthly and daily sugar prices*
*(monthly averages from 1985 to 2016 and daily values from 1994 to 2016)*

Our results generally confirm previous studies although there is no consensus in the literature on the subject. Blank (1991) found positive exponent in agricultural futures price, i.e. soybeans, among other variables. His results were consistent with the hypothesis of underlying generative mechanisms characterized by deterministic chaos but this was based on 336 observations only.

Decoster, Labys, & Mitchell (1992) also found evidence for nonlinear structure in commodity futures including sugar. Conversely, Wei & Leuthold (1998) found that five commodity futures markets were following chaotic patterns (corn, soybeans, wheat, hogs and coffee) but surprisingly not sugar, a result supported by Adrangi & Chatrath (2003) who found strong evidence of nonlinear dependence in the returns of sugar futures markets but not consistent with chaos.

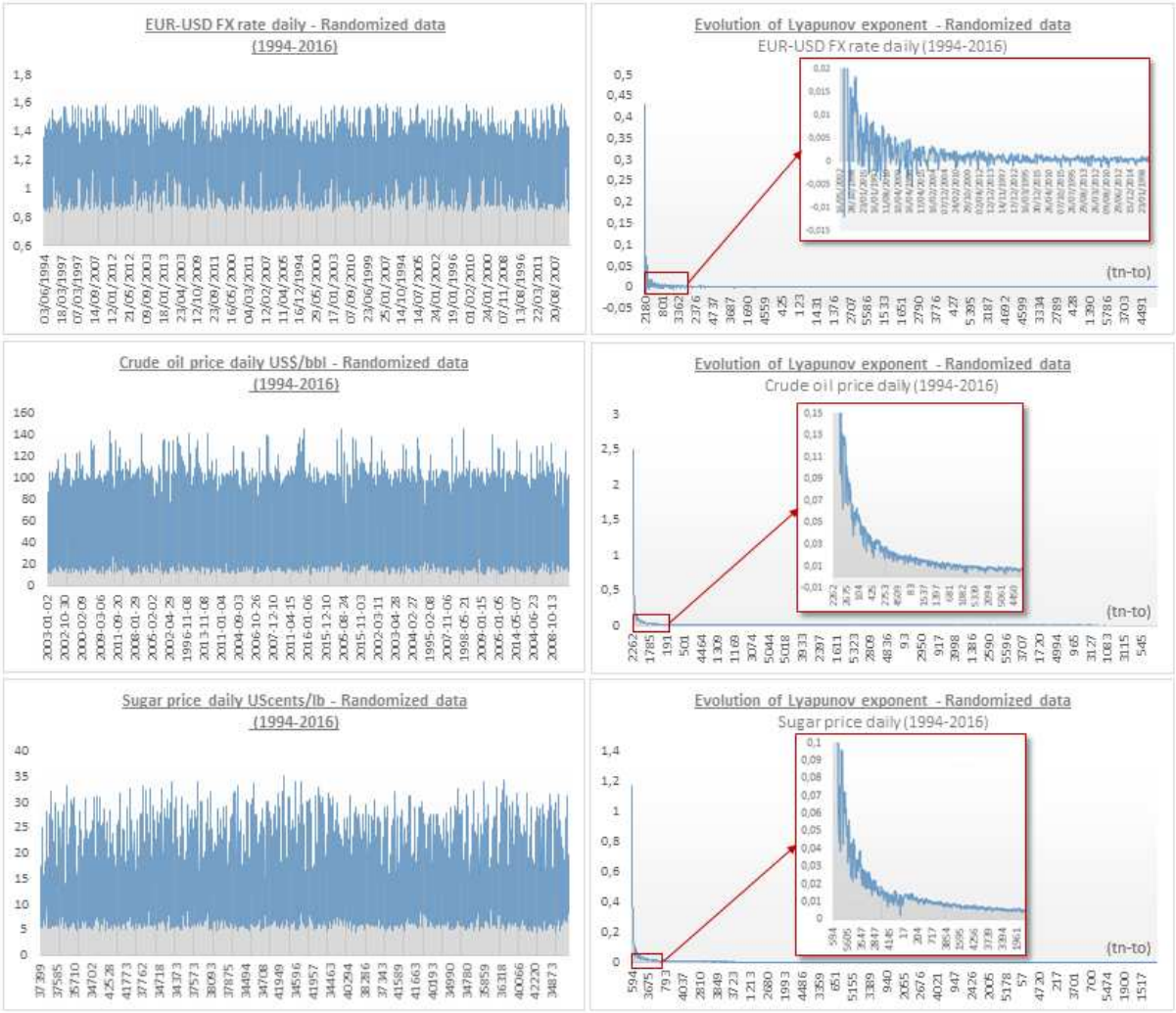
### Deterministic chaos or stochastic volatility

In spite of being nonlinear, chaotic systems are sensitive to initial conditions and hence they are deterministic. Conversely, stochastic systems possess some inherent randomness by which a same set of initial conditions (inputs) may lead to an ensemble of different outputs. If the former systems might be relatively predictable on the very short term, they very quickly lose their predictability because of the exponential development of the error made in the definition of the initial conditions (due to measurement error or exogenous noise). The latter systems, pure random ones, are unpredictable in all situations. As already said, this is not the purpose of this dissertation to discriminate between chaos and randomness in our environmental data. In our case, suffice to confirm that they belong to one of these categories (positive $\lambda_1$) to conclude on the environmental uncertainty surrounding the company.

Our curiosity has nevertheless been triggered by this question and we decided to investigate it a little further. In addition to satisfying our curiosity, it helps delineating the limits of the algorithm used. We therefore followed Brooks' advice (Brooks, 1998, p.267) and we created sets of data with the same distributional properties and possibly the same autocorrelation structure as our initial data sets, but with nonlinear dependence removed. Scheinkman and Lebaron (1989) suggest to "scramble" the data by sampling randomly the original data to form new random data series. To do so, we have used the RAND() function in Excel software to "randomize" our data. If we get substantially different, lower but yet positive, largest Lyapunov exponents for our initial data sets than for the randomized ones, we can conclude on the strong evidence of deterministic chaos in our raw data.

The Figure 3.7 shows on the left hand side the randomized time series corresponding to the three large data sets used in section 3.2.5, i.e. daily values of EUR-USD exchange rates, crude oil prices and sugar prices from 1994 to 2016; and on the right hand side, the related largest Lyapunov exponents convergence plots.

A simple visual comparison between the data series of Figures 3.7, 3.8, 3.9 and Figure 3.10 confirms the randomization process.




*<u>Figure 3.10:</u> Randomized time series and related Lyapunov exponents convergence plots*
*(based on the same daily data as in Figures 3.7, 3.8, and 3.9)*

While the largest Lyapunov exponents estimated by Wolf's algorithm are in every case positive (Table 3.7) , thereby indicating that nearby data trajectories diverge exponentially, this cannot be taken as evidence for sensitive dependence on initial conditions since the corresponding exponents for the randomized data are also positive and of the same order of magnitude. Brooks (1998) came to the same conclusion when analyzing the daily returns of the British Pound against ten other currencies from 1974 to 1994 with a more sophisticated filtering technique based on surrogate data.

| | Largest Lyapunov exponent $\lambda_1$ | |
|---|---|---|
| | Raw data | Randomized data |
| **EUR-USD FX rate** | 5,21E-04 | 5,52E-04 |
| **Crude oil price** | 1,52E-03 | 8,49E-04 |
| **Sugar price** | 1,21E-03 | 8,43E-04 |

*Table 3.7: Comparison of the largest Lyapunov exponents calculated for the raw data and for the randomized ones*
*(based on the same daily data as in section 3.2.5)*

Although our exponents estimates confirm the exponential divergence of the three environmental variables studied, we are not in a position to conclude on their chaotic (deterministic) behaviors versus nonlinear stochastic (non-chaotic) behaviors. Calculation of the whole spectrum of Lyapunov exponents or using BDS statistics (after the initials of W. A. Brock, W. Dechert and J. Scheinkman) could help shed light on this question but this goes beyond the scope of this dissertation.

### Conclusion on the uncertainty of the company's environment

The narrative revealed how largely exposed the company's day-to-day activities are to its environment and particularly to three variables: sugar, a commodity traded on the international scene and first cost driver; energy which price is linked to crude oil market; and EUR-USD exchange rates because of a large portion of dollar revenues increasing translation risk. The analysis of the evolution of these variables over the lifetime of the company since its inception lead to the determination of positive largest Lyapunov exponents in the three cases.

Since a positive largest Lyapunov exponent is a strong signature of chaos (or, with the algorithm used, randomness), and that all three variables tested lead to positive largest Lyapunov exponents no matter which input parameters was used in the program, we conclude that the company's environment displays unpredictable and uncertain behaviour. Indeed, the possible presence of chaos "has important implications for the predictability of the underlying system, since the fact that all initial conditions are in practice estimated with some error (either measurement error or exogenous noise), will imply that long term forecasting of the system is impossible as all useful information is likely to be lost in just a few iterations" (Brooks, 1998, p.265). Where chaos occurs, the two basic forecasting devices, extrapolation and estimation of a structural forecasting model, become questionable (Baumol & Benhabib, 1989).

Galactic has invested quite heavily in large bulk storage capacities for sugar to mitigate the risk related to sugar price volatility. By doing so, the company is able to select the time of closing purchasing contracts, therefore reducing its exposure to spot prices. The company is also using hedging tools to mitigate currency-related risks, i.e. currency swaps and forward contracts. However, if these measures offer a certain protection or at least a certain flexibility on the short term, they are relatively shortlived and they cannot protect the company against volatility in the long run.

Hence, a second conclusion can be drawn: **the company is** indeed **evolving in a highly uncertain environment**.

At this point of our investigation, it seems appropriate to look already at how the company's various development phases identified in the narrative section are positioning in regards to the evolution of the exogenous parameters that we have just analyzed and to which it appears that the company is highly exposed. Indeed, in the narrative part of this dissertation we identified three phases (epochs) in the company's history since its incorporation (the period named "Antiquitus" being anterior to the company creation). As we have seen in Section 3.1, this periodization was not made arbitrarily. Each epoch corresponds to a clear step in the development of the company from a start-up company to an establihed international organization. Each epoch is also characterized by a strategic intent and a company structure that differ from the other epochs. The phasing that emerges from the analysis of the company's history results from an inside-out dynamic, or in other words from strategic decisions taken by the management, as a result of either the emergence of new opportunities in the market place or the appearance of serious threats and negative environmental circumstances.

However, as it can be seen on the Figure 3.11.a/b, an interesting correspondance surfaces from the superposition of these phases and the time evolution of the three highly impacting exogenous factors (variables) selected to confirm the environmental uncertainty surrounding the company. The apparent synchronism between the phasing of the company's evolution and the environmental variables analysed gives credit to the the now well-established Lewinian theory of co-evolution (Lewin & Volberda, 1999; Lewin et al., 1999; Lichtenstein, 2000; McKelvey, 1999; Volberda & Lewin, 2003).

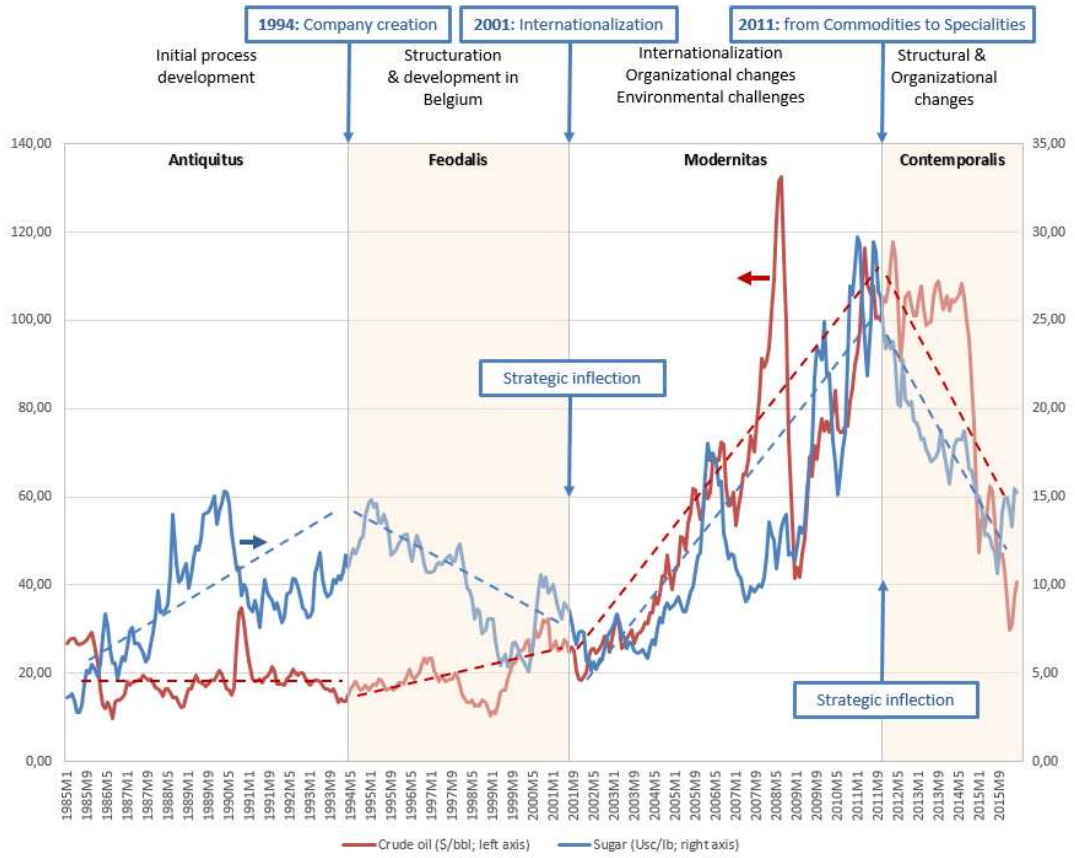



*Figure 3.11.a: Superposition of the company's epochs and the time evolution of Crude Oil prices and World Sugar prices.*

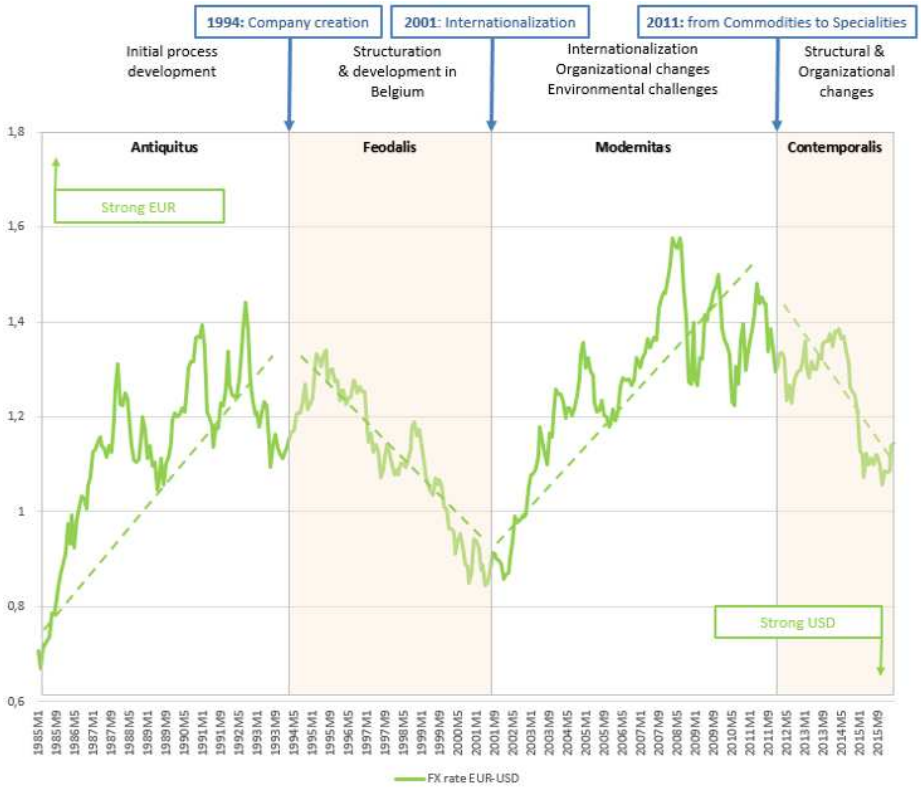



*Figure 3.11.b: Superposition of the company's epochs and the time evolution of EUR/USD exchange rates.*

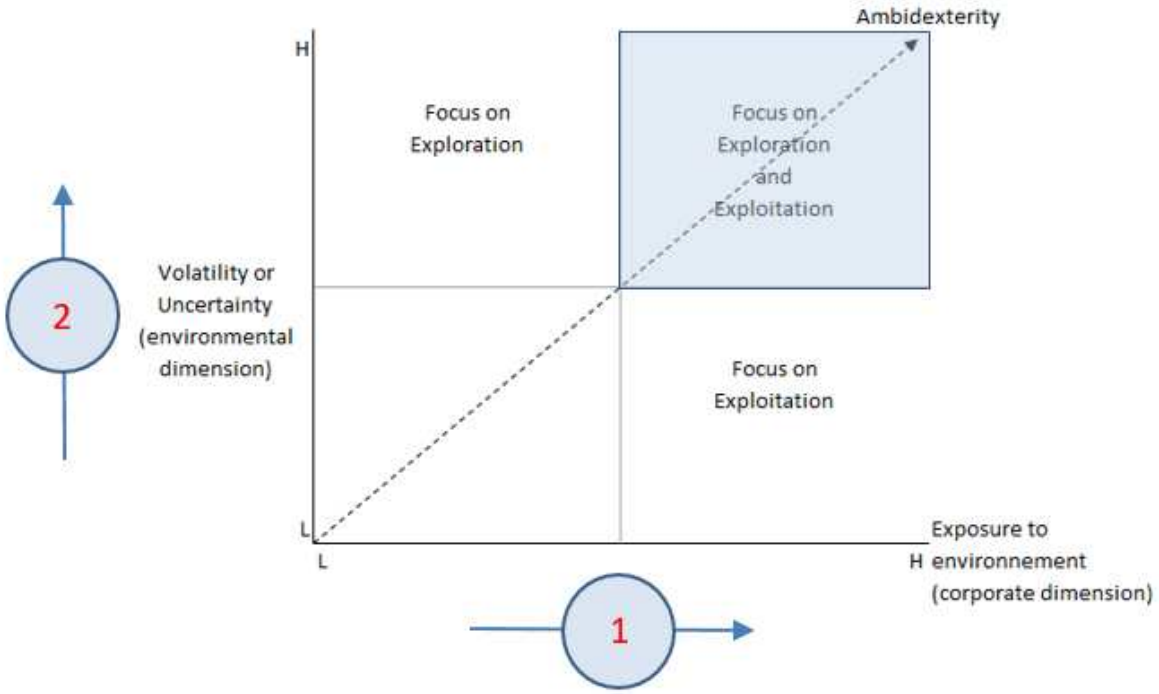
Intersections of patterns of ongoing strategic activities with fortuitious events play an important role in shaping the opportunities and threats that a company faces throughout its evolution. This led Burgelman (2011, p.13) to propose “strategic recognition”, that he defines as “the capacity of senior and top management to see the strategic implications of a confluence of forces” as a key adaptive organizational capability. Burgelman further elaborates (2011, p.15) on the concept of “strategic inflection point” signaled by “strategic dissonance” (Burgelman & Grove, 1996), a progressive divergence of strategic actions from strategic intent that is an indicator of contextual change. If this happens, the incumbent survives and eventually enters a new era of profitable growth provided that it is able to come up with a new strategy that takes advantage of the new environmental conditions. Elseways, it may survive but with severely reduced performance prospects or even may disappear.

It is the aim of our research to see if and how organizational ambidexterity, a dynamic capability (O’Reilly & Tushman, 2007), eventually provided a structure that helped keep actions aligned with the company’s strategic intents, but also helped inflect the company’s strategic direction when it was needed so that its survival could be secured.
However, before going further, let us pause for a moment to summarize the few conclusions that can already be drawn from the analysis of the company's environment.

### *3.2.3. Conclusions on the company's environment*

We have shown that the company is evolving in a dynamic context and that the level of dynamism to which the company is exposed is growing as a result of external factors but also because of its own expansion (move n°1 in Figure 3.12). We have also pointed out that the company's environment is highly uncertain and hence unpredictable (n°2 on Figure 3.12) and that the volatility surrounding the company's operations is growing over time.

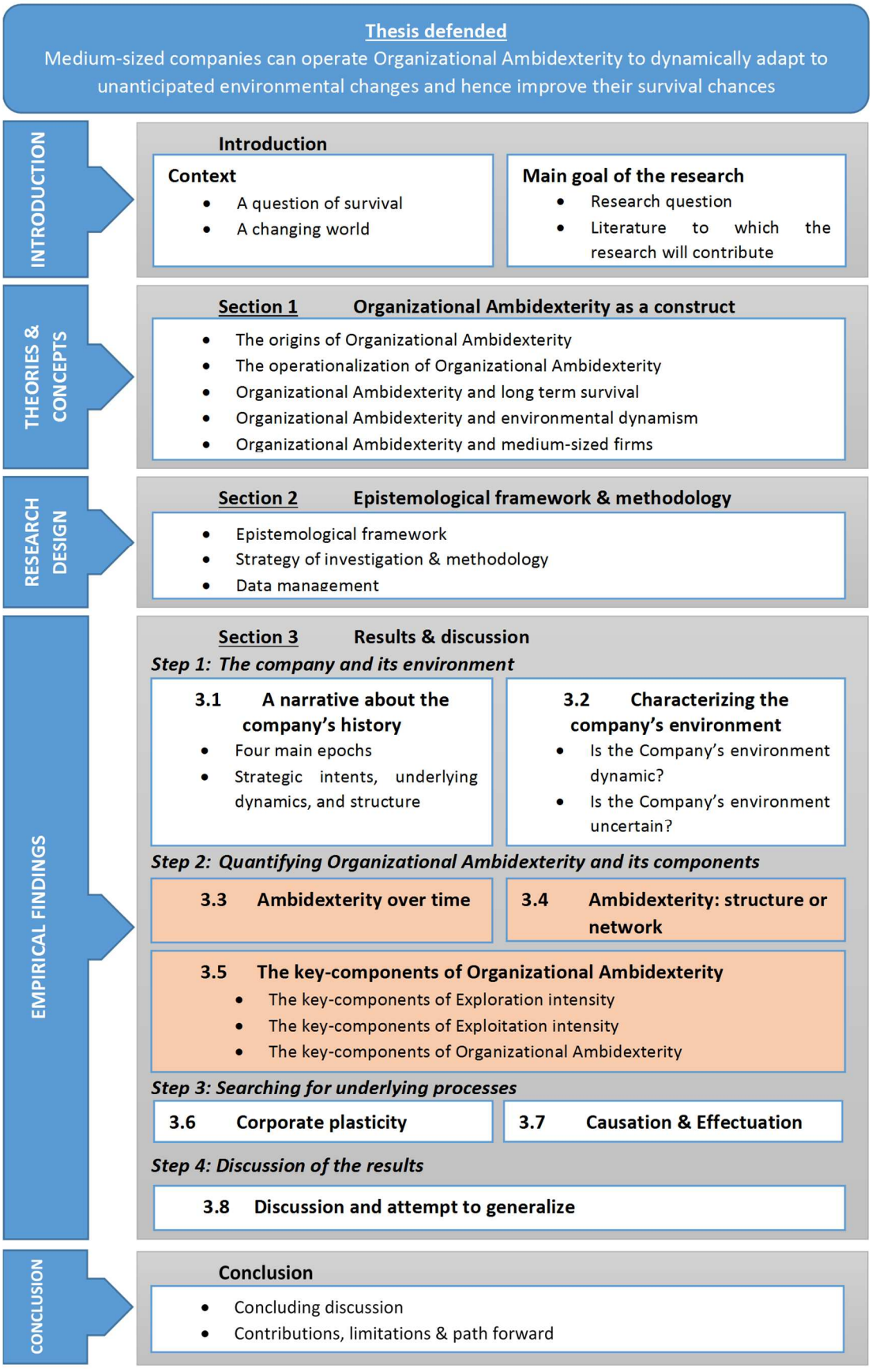
We can therefore ascertain that the company is lodged in the fourth quadrant (top right side) of the Figure 3.12 (i.e., a large exposure of the company to a highly uncertain environment) which suggests that it would benefit from a truly ambidextrous organization.




*<u>Figure 3.12:</u> Influence of environmental volatility and company exposure to its environment on the Exploration-Exploitation strategy to implement (similar to Figure 1.4)*

The following sections serve the purpose of measuring organizational ambidexterity in the various periods of the company's history from its incorporation to the present time as well as providing elements to discuss how this ambidextrous behaviour has eventually been implemented.

## Step 2: Quantifying organizational ambidexterity and its components



## 3.3. The evolution of ambidexterity over time

### *3.3.1. Ambidexterity, Exploration and Exploitation over time*

Our Ambidexterity Score is a combination of Exploration Intensity and Exploitation Intensity. Figure 3.9 shows the development of these three elements over the 25 years time period covered by our study.

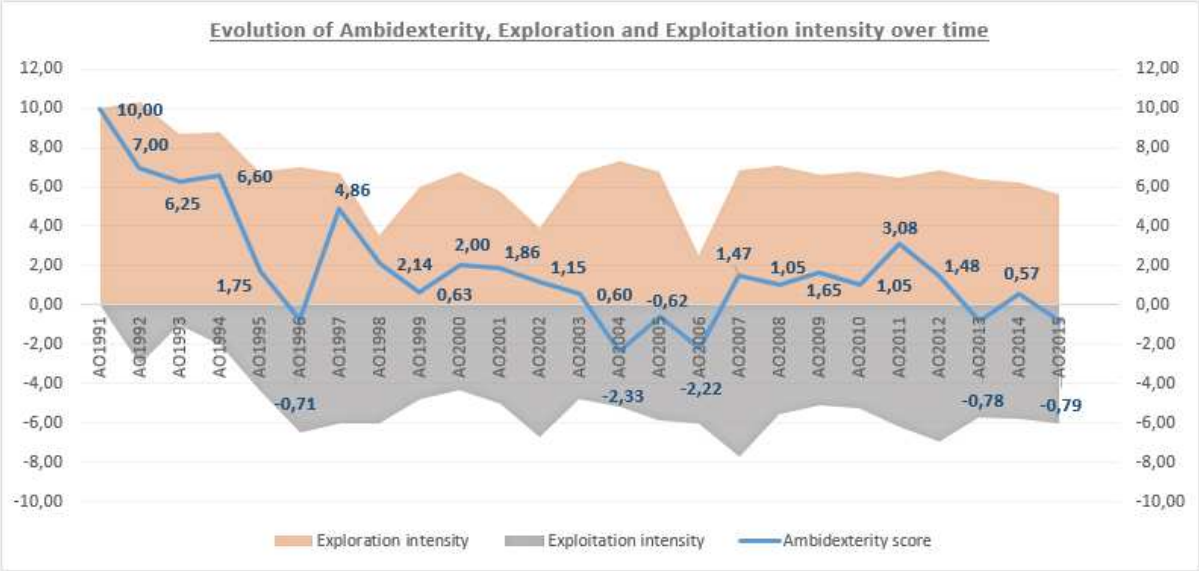



*Figure 3.9: Evolution of the Ambidexterity score from 1991 until 2015 (a positive score means an excess of Exploration intensity over Exploitation intensity).*

As we choose arbitrarily to have exploration intensity reflected by positive figures (orange surface) and exploitation intensity by negative ones (grey surface), perfect organizational ambidexterity is approached when the ambidexterity score (blue line) reaches zero.

From 1991 to 1993, there is a strong predominance of exploration as R&D is the core activity of the company-to-be (at this point, it is still a separate department of another company, ATC, that will be spinned out in 1993 – see the narrative in Appendix II for more details). The hint of exploitation in 1992 eventhough the company has not yet any factory is explained by the fact that the whole R&D team had moved to a new location, a former nightclub in Brussels, in order to have more space to shelter pilot scale equipments. From 1993 to 1996, exploitation intensity increases as the freshly incorporated company starts building and operating its first factory. After that, both exploration and exploitation are maintained at relatively high levels of intensity despite the rapid growth of the company (which indicates that the firm has succeeded in growing both activities at about the same pace).

Before going further into details, a few straightforward observations can be drawn from the sight of this graph:

1. The company, deeply rooted in exploration at the beginning of its activities, has quickly put in place exploitation activities while maintaining a high level of exploration. This result is conducive to indicate that the company is quickly driving towards organizational ambidexterity which is reached in a relatively stable manner about 5 years after its inception (1999). After that point, the ambidexterity score is oscillating around the zero value which indicates a good relative balance of exploitation and exploration activities.
2. The company succeded to implement and maintain a high level of both exploration and exploitation scores (intensity scores between 4 and 7 every year as from the start of the production activities in 1995).
3. There seems to be an excess of exploration over exploitation activities in average over the whole period which reflects the innovation/exploration-driven culture of the company.

The data averaged for each epoch (Table 3.8) help summarize these findings as they show:

- A convergence of the ambidexterity score to a value close to zero (actually, 0.12 for the CONTEMPORALIS period) with a good balance between exploration and exploitation intensities (absolute values of 6.26 and 6.08, respectively)
- A gradual reduction and stabilization of the exploration intensity
- A gradual increase and stabilization of the exploitation intensity in line with the growth of the company's commercial operations (production & sales)

**These observations give credit to the concept of dynamic or adaptive ambidexterity** defined as the firm's ability to adapt the balance of exploration and exploitation activities to organizational and contextual circumstances over time, while constantly maintaining the two activities in order to capture their synergistic qualities (Laplume & Dass, 2009; Luger, 2014).

| | Year | Ambidexterity score | Exploration intensity | Exploitation intensity |
|---|---|---|---|---|
| ANTIQUITUS | AO1991 | 10,00 | 10,00 | 0,00 |
| | AO1992 | 7,00 | 10,33 | -3,00 |
| | AO1993 | 6,25 | 8,67 | -1,00 |
| FEODALIS | AO1994 | 6,60 | 8,75 | -2,00 |
| | AO1995 | 1,75 | 6,75 | -4,33 |
| | AO1996 | -0,71 | 7,00 | -6,50 |
| | AO1997 | 4,86 | 6,67 | -6,00 |
| | AO1998 | 2,14 | 3,50 | -6,00 |
| | AO1999 | 0,63 | 6,00 | -4,75 |
| | AO2000 | 2,00 | 6,75 | -4,33 |
| | AO2001 | 1,86 | 5,75 | -5,00 |
| MODERNITAS | AO2002 | 1,15 | 3,89 | -6,67 |
| | AO2003 | 0,60 | 6,71 | -4,75 |
| | AO2004 | -2,33 | 7,33 | -5,18 |
| | AO2005 | -0,62 | 6,75 | -5,83 |
| | AO2006 | -2,22 | 2,50 | -6,00 |
| | AO2007 | 1,47 | 6,83 | -7,71 |
| | AO2008 | 1,05 | 7,10 | -5,56 |
| | AO2009 | 1,65 | 6,60 | -5,09 |
| | AO2010 | 1,05 | 6,77 | -5,25 |
| | AO2011 | 3,08 | 6,47 | -6,14 |
| CONTEMPORALIS | AO2012 | 1,48 | 6,81 | -6,90 |
| | AO2013 | -0,78 | 6,40 | -5,67 |
| | AO2014 | 0,57 | 6,22 | -5,75 |
| | AO2015 | -0,79 | 5,59 | -6,00 |

| | | | |
|---|---|---|---|
| **Average for ANTIQUITUS** | **7,75** | **9,67** | **-1,33** |
| **Average for FEODALIS** | **2,39** | **6,40** | **-4,86** |
| **Average for MODERNITAS** | **0,49** | **6,10** | **-5,82** |
| **Average for CONTEMPORALIS** | **0,12** | **6,26** | **-6,08** |

*Table 3.8: Ambidexterity, Exploration intensity and Exploitation intensity scores from 1991 and 2015.*

Now, looking a little deeper at the evolution of the ambidexterity score (Figure 3.10), we see three phases emerging which fit surprisingly well the three epochs we had previously determined (with, sometimes, a certain lag time as the transition between epochs is a progressive process[49]).

[49] Burgelman & Grove (1996, p.10) use a metaphore to show how transitions to new industry equilibria or new technological regimes can be gradual and difficult to perceive in an extremely dynamic industry: "Think about a computer-generated image being morphed from one state to another – you cannot tell when one ends and the other starts; only the beginning (old image) and the end (new image) are clear. In-between is a dizzying succession of intertwined, overlapping, blurred, fuzzy images".

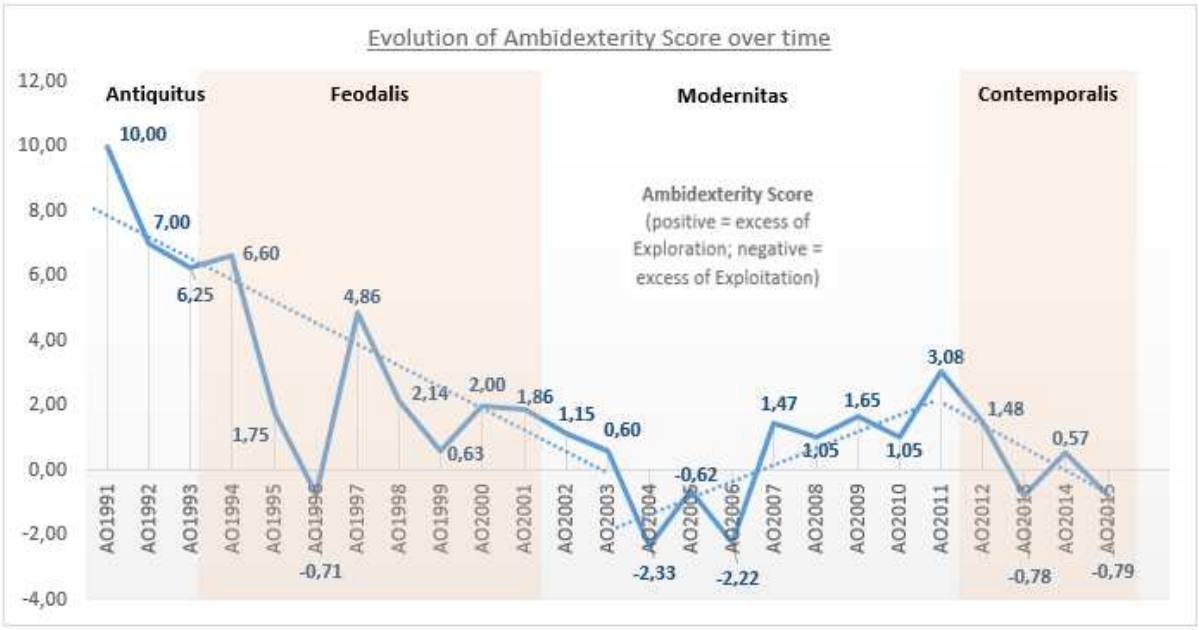



*Figure 3.10: Evolution of the Ambidexterity score superimposed the epochs of the company's history.*

The parallel with the evolution of the exogenous parameters discussed in section 3.2 (sugar price, crude oil price, and EUR/USD exchange rate) calls for the following comments:

- **When the company's environmental conditions are relaxing** (cheap oil and sugar, weak Euro), such as during our FEODALIS period (1994-2001), **the firm is progressively increasing its focus on the exploitation** of its existing activities and the ambidexterity score is going down, heading to a good balance between exploration and exploitation.
- The lowest ambidexterity score, deeply ankored in exploitation, is reached a couple of years after the US dollar was at its strongest and raw materials and utilities were still at their cheapest. This could indicate that the firm needs about this time to reorient its strategy and activate new levers. Indeed, environmental changes impact the organization in a direct way (e.g., by adapting pricing policy or shifting sourcing patterns) but also indirectly through learning (March, 1991) and experience (Tushman & Romanelli, 1985), both processes which are not immediate and take time.
- Conversely, **when the environment is deteriorating** and margins are under pressure (rising costs, lower profitability on exports due to less favorable exchange rates), a situation the company was facing from 2002 until 2011 (the epoch named MODERNITAS), **the management puts gradually the focus on exploration** in a

quest for new products and new markets delivering higher margins or less exposed to exchange rates, and the ambidexterity score is increasing quite sharply. This observation lends credence to Keller and Weibler (2014) as well as Sidhu *et al.* (2004) who showed that environmental dynamism is positively related to engagement in exploration. As pointed by Walrave and colleagues (2012), it is counterintuitive for most managers to proactively stress exploration in difficult economic times and declining contextual conditions as they usually emphasize exploitation in this situation to maintain liquidity and preserve financial means, eventually blaming the economic conditions to justify downsizing and lay-offs.

- Again, from 2011, the macroeconomic context is releasing (CONTEMPORALIS period) and the company progressively returns to a more balanced mix of exploration and exploitation.

Obviously, from these observations, it is quite difficult to distinguish between the influence of factors internal to the company involved in the phased development of its long term strategy (structuration, internationalization, specialization – centralized structure, decentralized structure, recentralized structure) and that of the external factors that offer new opportunities but also constitute threats and risks (raw material and utility prices, foreign exchange rates, competitive intensity). In the following sections we will try to understand how the company came to develop a relatively well maintained balance between exploration and exploitation during the last 15 years, that is to say, a state of organizational ambidexterity, by first analyzing whether it is a matter of structure or a matter of network.

### *3.3.2. Structural ambidexterity over time*

As we have seen in the literature review (section 1), Duncan (1976) suggested the use of "dual structures" to accommodate simultaneously the conflicting alignments needed for efficiency and innovation. This type of organization, often named "structural ambidexterity" (Tushman & O'Reilly, 1996), calls for a structural separation between activities aiming at exploiting and exploring. The time evolution of our indicator of structural ambidexterity (Figure 3.11) shows overall an excess of separation (managerial decisions and actions are limited to one department) over collaboration between departments.

In the early years prior to the company's inception, there is no collaboration at all as the company-to-be is actually still a separated department of another corporation. But, as soon as the company was created, departments commenced to collaborate and the structural ambidexterity score started to oscillate around a zero value indicating a relative balance between autonomous and collaborative actions and decisions. Looking at the average values of this indicator for each epoch of the company's development confirms this trend towards a balance (convergence of the average structural ambidexterity score from 1,00 to a steady 0,12-0,13 as from 2002 already – Table 3.9). This gives credit to Khanagha, Volberda and Oshri (2014) who concluded that there is "a need for recursive iterations between different modes of separated and integrated structures" (p.322).

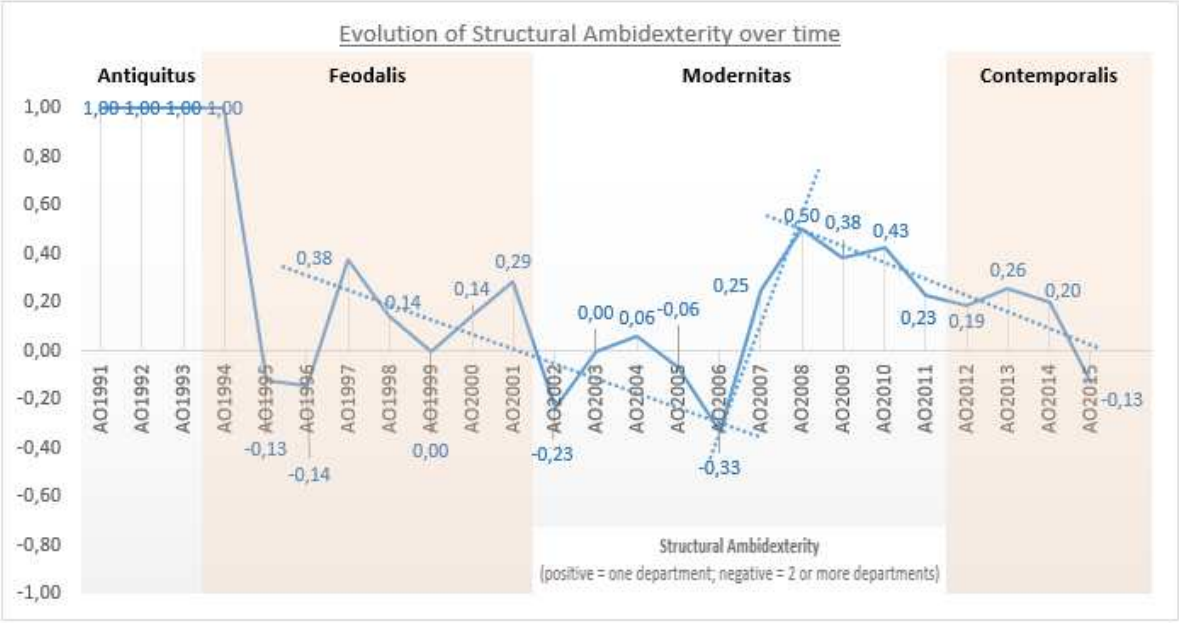



*Figure 3.11: Evolution of Structural Ambidexterity from 1991 until 2015 (a positive score indicates a separation between departments whereas a negative one illustrates collaboration).*

Although the company was very soon balancing separation and collaboration between departments, the positive values of structural ambidexterity average scores for each epoch indicate nevertheless that the company always had a tendency to favour separation over collaboration. Pursuing with the same line of thought than Schmitt, Probst and Tushman (2010), we can think that it helps "cross-fertilization between units and prevents cross-contamination, as explorative units are protected from exploitative units' routines and established processes.

(…) Separation evades the impending threat of having to sacrifice efficiency for innovative activities and vice versa" (p.143).

| | Year | Structural Ambidexterity |
|---|---|---|
| ANTIQUITUS | AO1991 | 1,00 |
| | AO1992 | 1,00 |
| | AO1993 | 1,00 |
| FEODALIS | AO1994 | 1,00 |
| | AO1995 | -0,13 |
| | AO1996 | -0,14 |
| | AO1997 | 0,38 |
| | AO1998 | 0,14 |
| | AO1999 | 0,00 |
| | AO2000 | 0,14 |
| | AO2001 | 0,29 |
| MODERNITAS | AO2002 | -0,23 |
| | AO2003 | 0,00 |
| | AO2004 | 0,06 |
| | AO2005 | -0,06 |
| | AO2006 | -0,33 |
| | AO2007 | 0,25 |
| | AO2008 | 0,50 |
| | AO2009 | 0,38 |
| | AO2010 | 0,43 |
| | AO2011 | 0,23 |
| CONTEMPORALIS | AO2012 | 0,19 |
| | AO2013 | 0,26 |
| | AO2014 | 0,20 |
| | AO2015 | -0,13 |

| | |
|---|---|
| **Average for ANTIQUITUS** | **1,00** |
| **Average for FEODALIS** | **0,21** |
| **Average for MODERNITAS** | **0,12** |
| **Average for CONTEMPORALIS** | **0,13** |

*Table 3.9: Structural ambidexterity score from 1991 and 2015 and the average for each major epoch of the company's history.*

A more detailed analysis of the evolution of structural ambidexterity scores reveals an increase of collaboration over separation during the Feodalis period and the first years of Modernitas, followed by a sudden reversion of this trend during three years, from 2006 to 2008, when the structural ambidexterity score jumps in favor of a separation between departments. After that, a gradual journey towards collaboration materializes again (see the dotted lines in Figure 3.11). Some inferences can be taken from this pattern. First, as already mentioned, the more the company grows and gets structured (Feodalis), the more the departments cooperate. Second, the creation of autonomous subsidiaries overseas (Modernitas) starts with sharing knowledge and transferring technologies which imposes even more collaboration between the departments of the mother company and the newly incepted ventures. However, third, as the subsidiaries progressively gain operational autonomy, they start exploring their own markets and develop

new knowledge on their own which leads to a disconnection between the departments of the different entities. This movement was supported and probably even amplified by the decentralization of decision-making structures that was in place at this time (see Section 3.1.2), but the suddenty of this reversion must be rooted in some external event. Indeed, when the reversion happened in 2006, there was no trace of an intended inflection of the company's strategy. It was right in the middle between two main strategic inflection points clearly identified and acknowledged (2001 and 2011). Hence a fourth insight: the disruption in structural ambidexterity pattern seems totally disconnected from the company's strategy and independent from the overall strategic intent developed and enforced by the company's top-management during this time. The sudden bifurcation of structural ambidexterity score was apparently not premedited by the management but was a spontaneous reaction to exogenous factors that were not anticipated. As a matter of fact, the change in structural ambidexterity from collaboration to separation coincides with the time when the overall ambidexterity score changes sign (see the red circle in Figure 3.12), i.e. when the company shifted attention from exploitation to exploration, which was an immediate reaction initiated by a rapidly worsening environmental context (surging sugar price, sharp increase of crude oil price and negatively-impacting movements of currencies). We infer that, at least in this case, a negative environmental context triggered a deep modification of the decision-making pattern in favor of more exploratory initiatives which in turn resulted in enhanced separation between departments as this is apparently the way the company conducts exploration (more on that in Section 3.5.1).

After that, the company quickly started again more collaborative projects (the structural ambidexterity pattern turned back towards collaboration as early as 2008) whereas the ambidexterity score reverts trend towards a more balanced mix of exploitation and exploration only three years later.

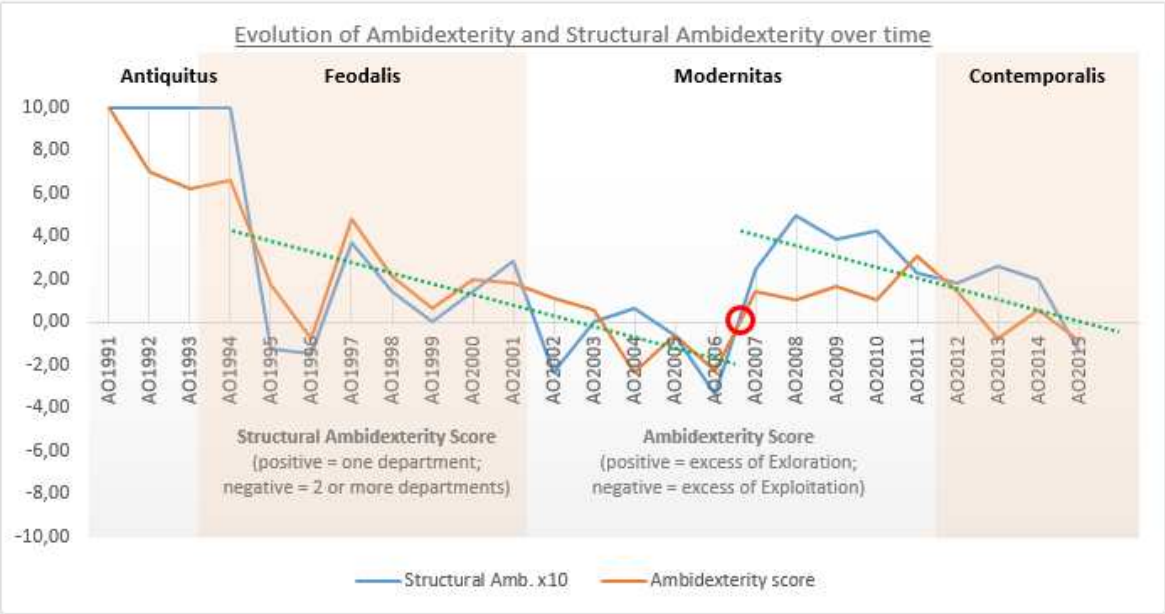



*Figure 3.12: Superposition of Ambidexterity score and Structural Ambidexterity score from 1991 until 2015 (the structural ambidexterity score has been multiplied by 10 to fit with the same Y axis as the ambidexterity score).*

### *3.3.3. Network ambidexterity over time*

While structural ambidexterity is looking at how exploration and exploitation activities are conducted from a perspective internal to the company, network ambidexterity adopts an external perspective by focusing on how it forges exploratory or exploitative cooperative links with its business environment. Eventhough the company has always had cooperations, the number of partnership events started to increase in 2002 and even more sharply after 2006. Figure 3.13 shows the evolution of partnership intensity that we define as the absolute number of partnership events, i.e. the sum of exploratory and exploitative events, each year.

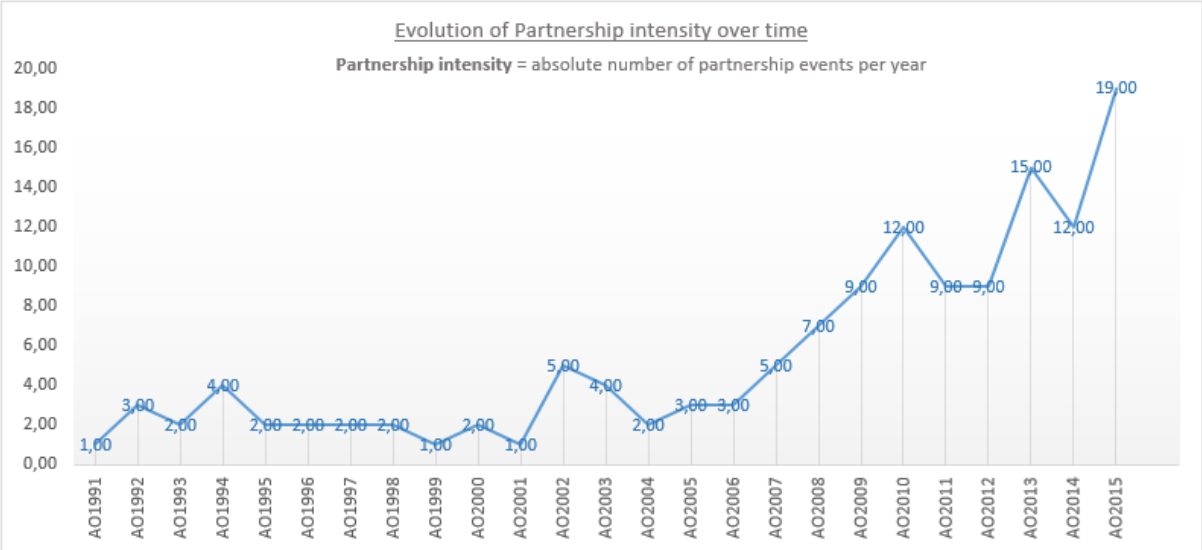



*Figure 3.13: Evolution of partnership intensity from 1991 until 2015.*

## New or old partners

The type of partnership is also an important parameter to understand how the company improved its ambidexterity score throughout its history. Indeed, we can safely assume that engaging in partnerships with new partners is by itself a venture with more exploration intensity than working with old partners, or "repeat partners" (Cummings, 2013), as it widens the landscape of possibilities, brings new ideas and enriches the dialogue with new perspectives. Yet, working with new partners is more difficult. There is a learning period during which both sides need to apprehend how to cope with the other's culture and to adjust to the other's way to operate, without even talking about confidentiality measures that need to be taken and trust that needs to be built up.

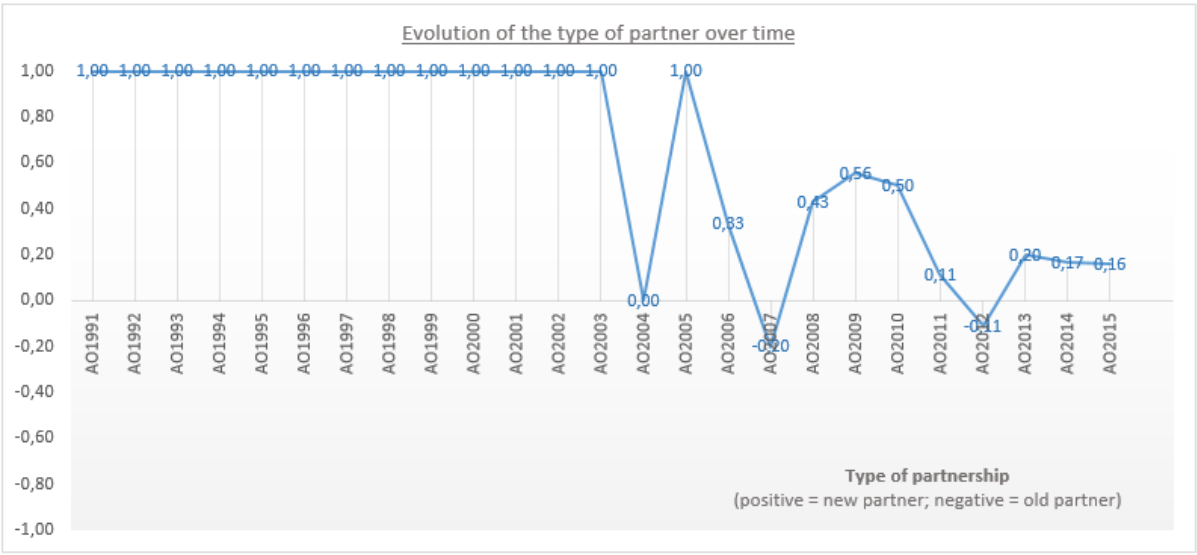


*Figure 3.14: Evolution of the type of partnerships from 1991 until 2015.*

Nevertheless, if working with old well-known parters keeps the company and its members in their confort zone, and that sharing know-how often requires the establishment of long-term relationships in which exchange occurs in a code learned and shared (Von Hippel, 1988), the company doing so exclusively somehow runs the risk to fall in a "success trap" (Junni et al., 2013), organizational inertia (Hannan & Freeman, 1984), convergence and simplicity (Miller, 1993), hence the importance to balance the types of partnerships the company is engaging into (and to strive to reach the zero value for the Y axis in Figure 3.14).

It seems obvious however that a young freshly created company is more exposed to cooperating with new partners than a relatively older company that has had the chance to develop a network of proven partners. Figure 3.14 illustrates this patern: the company entered into partnerships exclusively with new partners until 2003 and succeded to come close to a balance between old and new partners only very recently (2013 onwards). Of course, the sharp increase in the net number of partnerships each year after 2003 (Figure 3.13) helps balancing the type of partners by bringing more opportunities to contract new and older partners.

### Existing or new markets

Market knowledge is a resource with which managers can bring to light capability deficiencies existing within their company as well as emerging market opportunities that may require the development of new capabilities, a particularly significant need in a turbulent environment context (Atuahene-Gima, 2005). On this, Atuahene-Gima (2005, p.79) notes that "systematic efforts are necessary to track the market changes and to assess the firm's competence deficiencies to refine existing competencies and to develop the necessary new ones for the new environment". According to Tushman and O'Reilly (1996), an ambidextrous firm has the capabilities to both compete in mature markets (where cost, efficiency, and incremental innovation are critical) and develop new products and services for emerging markets (where experimentation, speed, and flexibility are critical).

Figure 3.15 outlines the time evolution of the type of market (new or existing) targeted by the partnerships the company entered into. The company started of course with a strong focus on new market but managed to balance the focus of its partnerships very soon after the commissioning of its first factory. The slow but steady drift towards existing markets-oriented

partnerships could, however, indicate that with time it becomes more difficult for the company to find new markets to look at with partners.

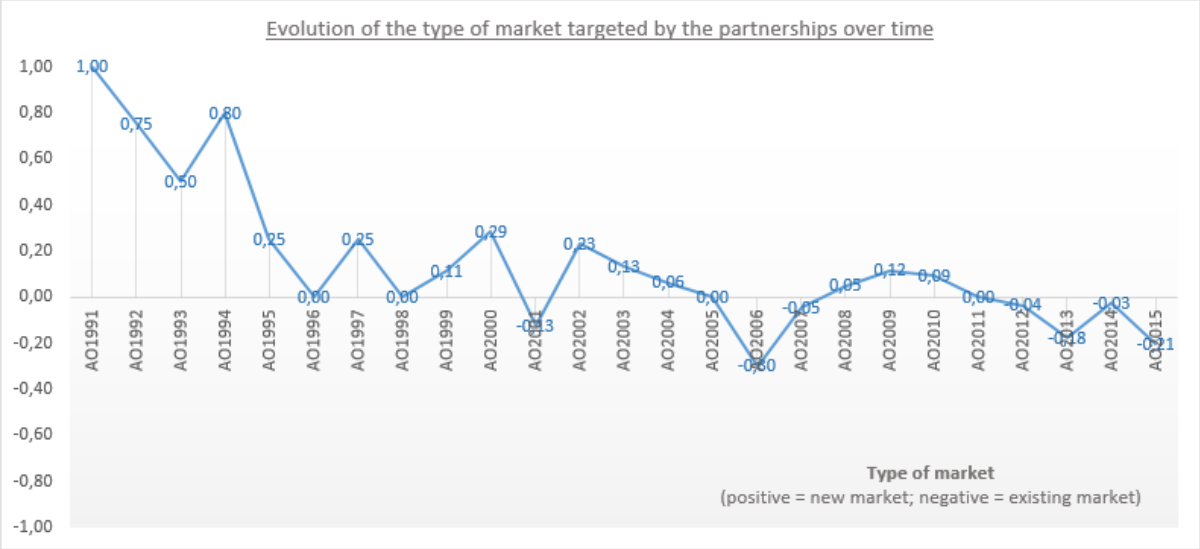



*Figure 3.15: Evolution of the type of market targeted by the partnerships from 1991 until 2015.*

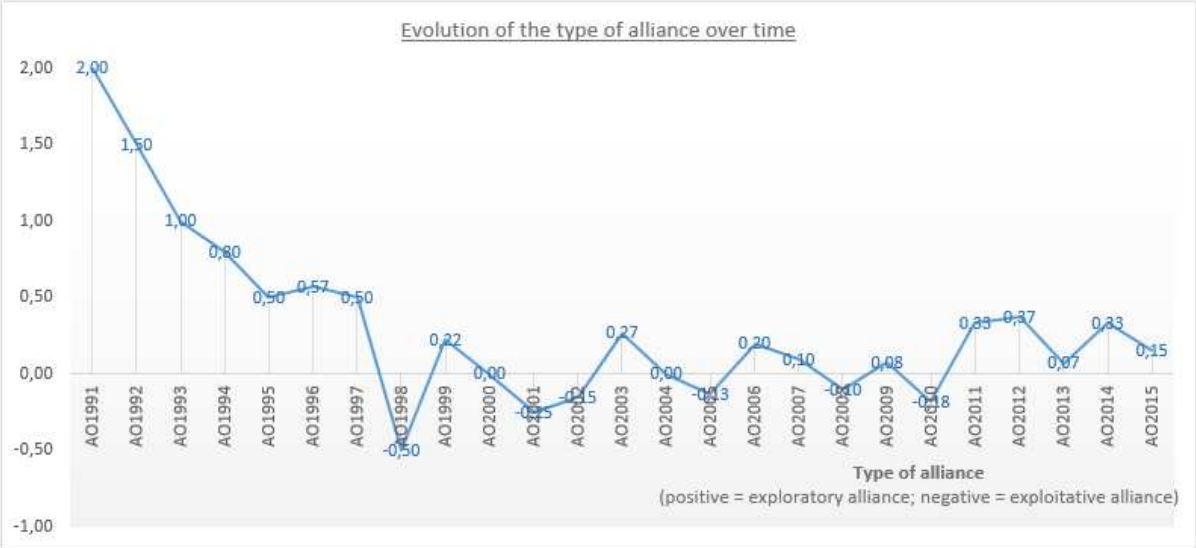
## Exploratory or exploitative alliances

An alliance can be perceived as being different from a partnership. We don't elaborate on this here and we consider both as equivalent for the purpose of this dissertation. However, for the sake of clarity and to avoid confusion, we use the expression "type of partnership" to describe whether the partnership is made of new (positive values) or old (negative values) partners whereas the expression "type of alliance" is used to describe whether the partnership is of exploratory (positive values) or exploitative (negative values) nature.

Exploratory alliances or partnerships pay attention to upsteam activities in the value chain (Rothaermel & Deeds, 2004) such as knowledge-generating research agreements. Conversely, exploitative alliances focus on downstream activities based on existing knowledge like joint marketing, OEM/VAR[50] or licensing agreements (Lavie & Rosenkopf, 2006), as well as toll manufacturing or contract manufacturing deals.

[50] An original equipment manufacturer (OEM) is a company that manufactures a basic product or a component product. A value-added reseller (VAR) is a company that purchases the original or component product from the OEM and then adds to its value by adding features or services to the product, or by incorporating it into a larger product, before finally reselling it, most commonly to end users (source: Investopedia). In our case, we have

Figure 3.16 outlines the evolution of the type of alliances the company went into in the course of its history. Even though it stayed most of the time with an excess of exploratory alliances, the company succeeded to reach a relative balance as early as 1998-1999.

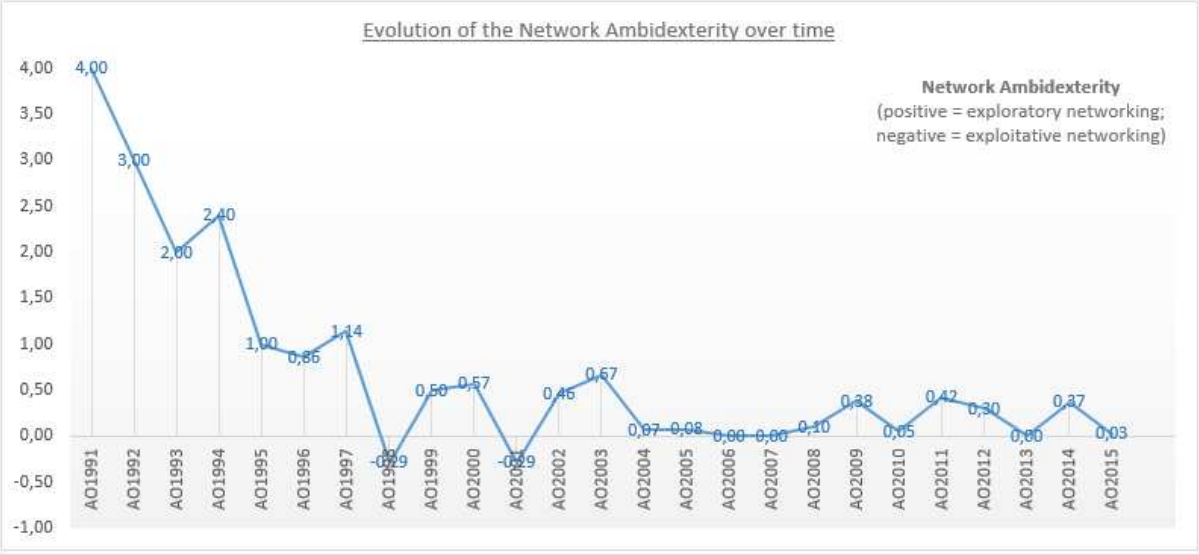



*<u>Figure 3.16:</u> Evolution of the type of alliances from 1991 until 2015.*

## Conclusion about the development of network ambidexterity over time

As a conclusion of this section about network ambidexterity, the company started not surprisingly its operations by engaging into a limited number of partnerships with new partners, mainly of exploratory nature, and targeting new markets. With time and experience, the firm sharply increased the number of collaborations with new as well as with old partners. It progressively reached a relative balance between exploratory and exploitative partnerships. The result, shown in Figure 3.17, is a compounded network ambidexterity score converging close to a zero value which reflects a good level of ambidexterity in the company's relations with external business partners.

however not considered OEM as alliances or partnerships because the core business of our company is to sell chemicals and ingredients which are, by essence, incorporated by the company's customers into their own products. Including this type of supplier-customer relationships here would have resulted in taking into account all commercial relations with customers which is not to be litteraly considered as partnerships. Similarly, sales to chemical distributors (which could be assimilated to VAR) are not included.




*<u>Figure 3.17:</u> Evolution of the aggregated network ambidexterity score from 1991 until 2015.*

| | Year | Partnership intensity | Type of partner (New/Old) | Type of market (new/existing) | Type of alliance (exploratory/exploitative) | Network Ambidexterity score |
|---|---|---|---|---|---|---|
| **ANTIQUITUS** | AO1991 | 1,00 | 1,00 | 1,00 | 2,00 | **4,00** |
| | AO1992 | 3,00 | 1,00 | 0,75 | 1,50 | **3,00** |
| | AO1993 | 2,00 | 1,00 | 0,50 | 1,00 | **2,00** |
| **FEODALIS** | AO1994 | 4,00 | 1,00 | 0,80 | 0,80 | **2,40** |
| | AO1995 | 2,00 | 1,00 | 0,25 | 0,50 | **1,00** |
| | AO1996 | 2,00 | 1,00 | 0,00 | 0,57 | **0,86** |
| | AO1997 | 2,00 | 1,00 | 0,25 | 0,50 | **1,14** |
| | AO1998 | 2,00 | 1,00 | 0,00 | -0,50 | **-0,29** |
| | AO1999 | 1,00 | 1,00 | 0,11 | 0,22 | **0,50** |
| | AO2000 | 2,00 | 1,00 | 0,29 | 0,00 | **0,57** |
| | AO2001 | 1,00 | 1,00 | -0,13 | -0,25 | **-0,29** |
| **MODERNITAS** | AO2002 | 5,00 | 1,00 | 0,23 | -0,15 | **0,46** |
| | AO2003 | 4,00 | 1,00 | 0,13 | 0,27 | **0,67** |
| | AO2004 | 2,00 | 0,00 | 0,06 | 0,00 | **0,07** |
| | AO2005 | 3,00 | 1,00 | 0,00 | -0,13 | **0,08** |
| | AO2006 | 3,00 | 0,33 | -0,30 | 0,20 | **0,00** |
| | AO2007 | 5,00 | -0,20 | -0,05 | 0,10 | **0,00** |
| | AO2008 | 7,00 | 0,43 | 0,05 | -0,10 | **0,10** |
| | AO2009 | 9,00 | 0,56 | 0,12 | 0,08 | **0,38** |
| | AO2010 | 12,00 | 0,50 | 0,09 | -0,18 | **0,05** |
| | AO2011 | 9,00 | 0,11 | 0,00 | 0,33 | **0,42** |
| **CONTEMPORALIS** | AO2012 | 9,00 | -0,11 | -0,04 | 0,37 | **0,30** |
| | AO2013 | 15,00 | 0,20 | -0,18 | 0,07 | **0,00** |
| | AO2014 | 12,00 | 0,17 | -0,03 | 0,33 | **0,37** |
| | AO2015 | 19,00 | 0,16 | -0,21 | 0,15 | **0,03** |

| | | | | | |
|---|---|---|---|---|---|
| **Average for ANTIQUITUS** | **2,00** | **1,00** | **0,75** | **1,50** | **3,00** |
| **Average for FEODALIS** | **2,00** | **1,00** | **0,20** | **0,23** | **0,74** |
| **Average for MODERNITAS** | **5,90** | **0,47** | **0,03** | **0,04** | **0,22** |
| **Average for CONTEMPORALIS** | **13,75** | **0,10** | **-0,11** | **0,23** | **0,17** |

*<u>Table 3.10:</u> Network ambidexterity score and its components from 1991 to 2015, and the average for each major epoch of the company's history.*

## 3.4. Organizational ambidexterity: structure or network

### *3.4.1. A matter of structure*

We have seen in section 3.3.2. that the company had generally favoured separation over collaboration between departments in its quest to balance exploration and exploitation activities. The same conclusion can be drawn from Figure 3.18 which shows more measurements on the side of activities handled by one department (right hand side) than on the side of activities shared between two or more departments (left hand side).

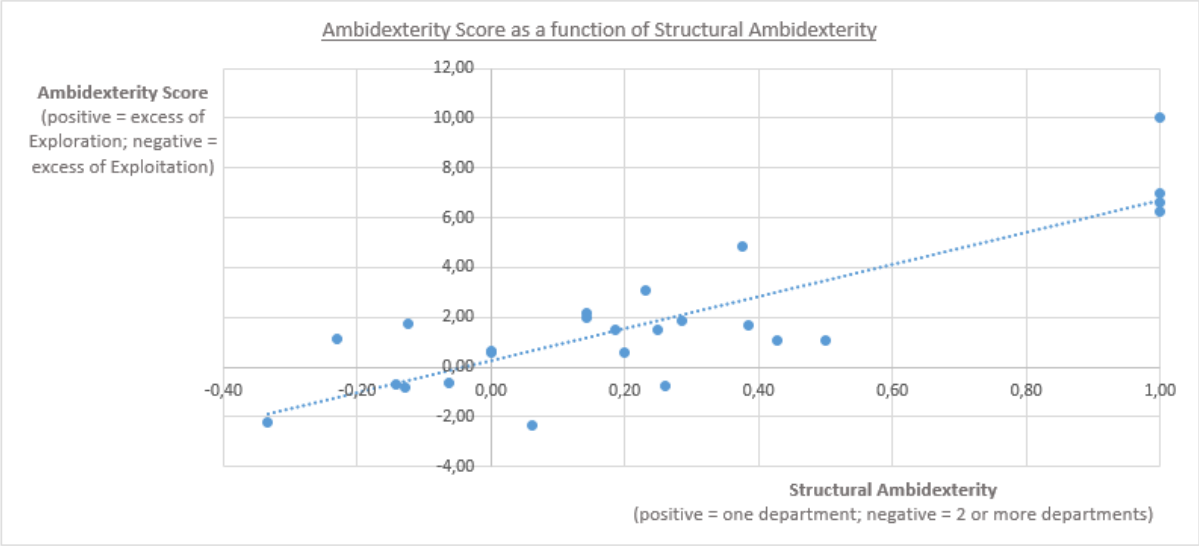



*Figure 3.18: Ambidexterity score as a function of structural ambidexterity.*

Figure 3.18 also suggests that at Galactic exploratory initiatives (positive ambidexterity scores) are more often conducted by one department (top-right quadrant) whereas exploitative ones (negative ambidexterity scores) seem to benefit from collaboration between departments. Indeed, there is a clear tendency to have a **higher exploration intensity when departments are working independently** (separation, see Figure 3.19) while, conversely, the **exploitation intensity increases when several departments are working together** (collaboration, see Figure 3.20). In other words, at Galactic, exploration is largely an autonomous process whereas exploitation is a collaborative one.

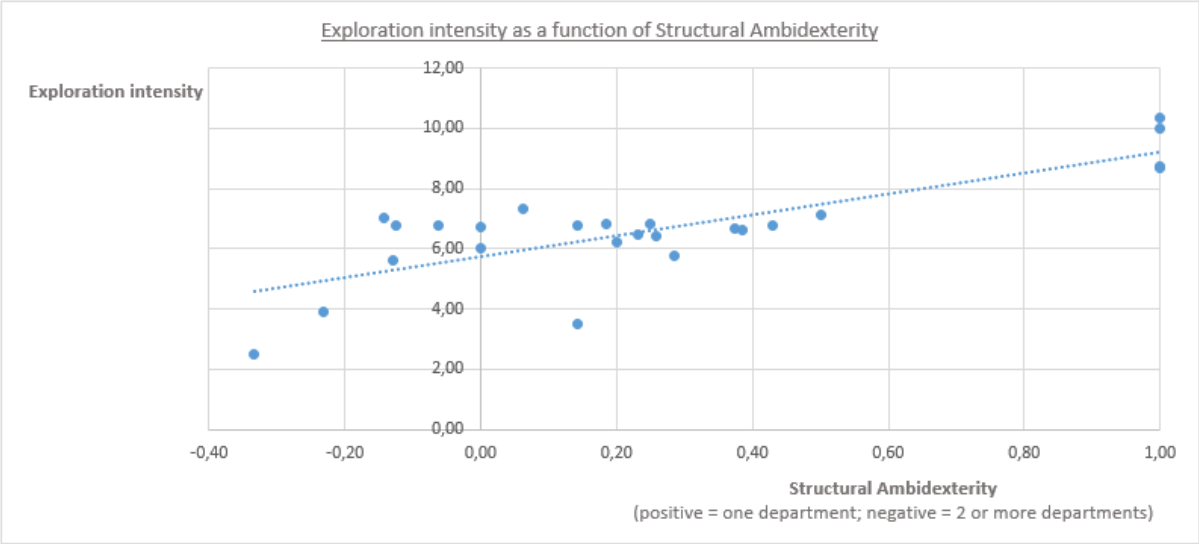



*Figure 3.19: Exploration intensity as a function of structural ambidexterity.*

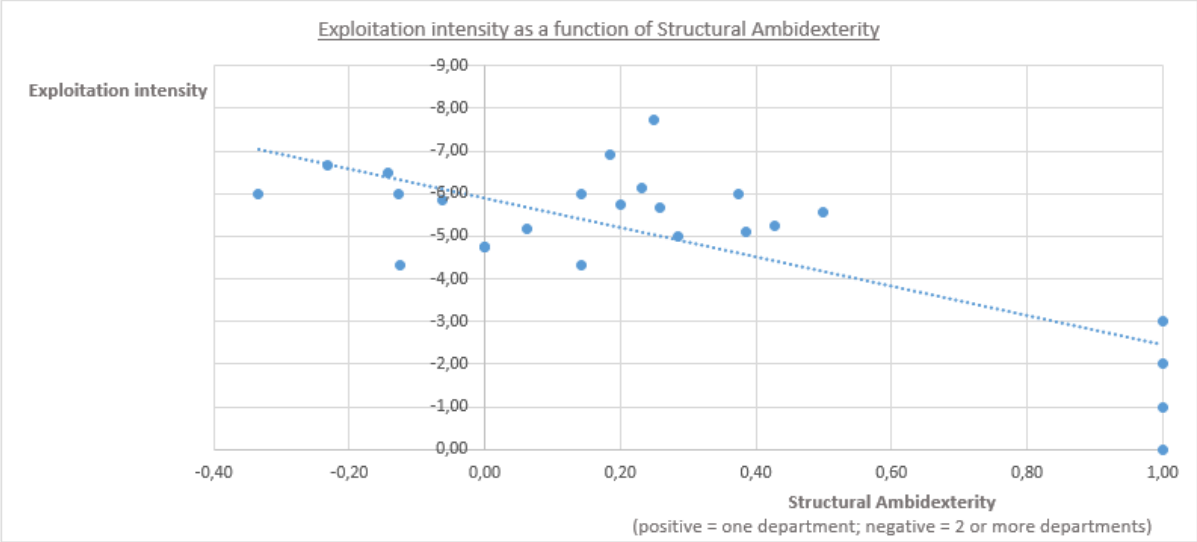
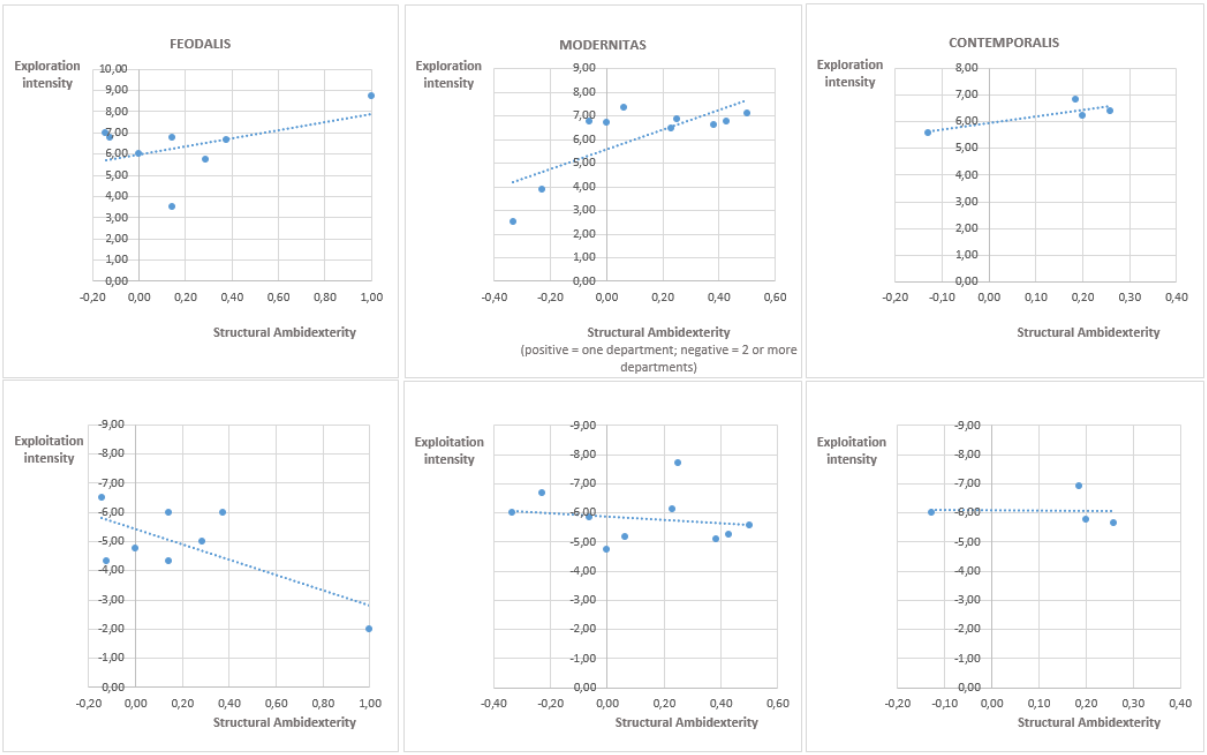



*Figure 3.20: Exploitation intensity as a function of structural ambidexterity.*

Although true throughout the company's history, the impact of structure on exploration and exploitation intensities was stronger at the beginning of the company's activities. Separation or collaboration between departments does not seem to influence largely the level of exploration and exploitation when the company reaches a certain level of maturity (Figure 3.21). This observation suggests that managers who want their organization to reach a certain level of ambidexterity should pay more attention to structure, especially in the first years of existence of their business, to allow exploratory projects to be conducted in clearly defined teams

operating autonomously but, at the same time, to establish bridges between teams so that the exploitation projects can be realized in a participative way.




*<u>Figure 3.21:</u> Exploration and exploitation intensities versus structural ambidexterity for the different epochs of the company's history.*

### *3.4.2. A matter of network*

As per Raisch and his colleagues (2009), organizational ambidexterity is likely to require both internal and external measures as interorganizational activities can enable both exploitative and explorative knowledge processes. Our results seem to support this thesis: **the more partnerships, the more the Ambidexterity Score tends to zero, indicating a balance between exploratory and exploitative forces** (Figure 3.22). However, while the number of partnerships has apparently little impact on the firm's exploration intensity (which is fairly constant and maintained at a relatively high level regardless of the intensity of partnership), it appears to have a more pronounced effect on exploitation intensity (Figure 3.23). So, it is precisely by increasing the number of partnerships of exploitative nature that the company balances the traditionally high number of exploratory collaborations specific to its very culture (the company started as a pure R&D venture) and the high technological level of the industry in which the firm is evolving.

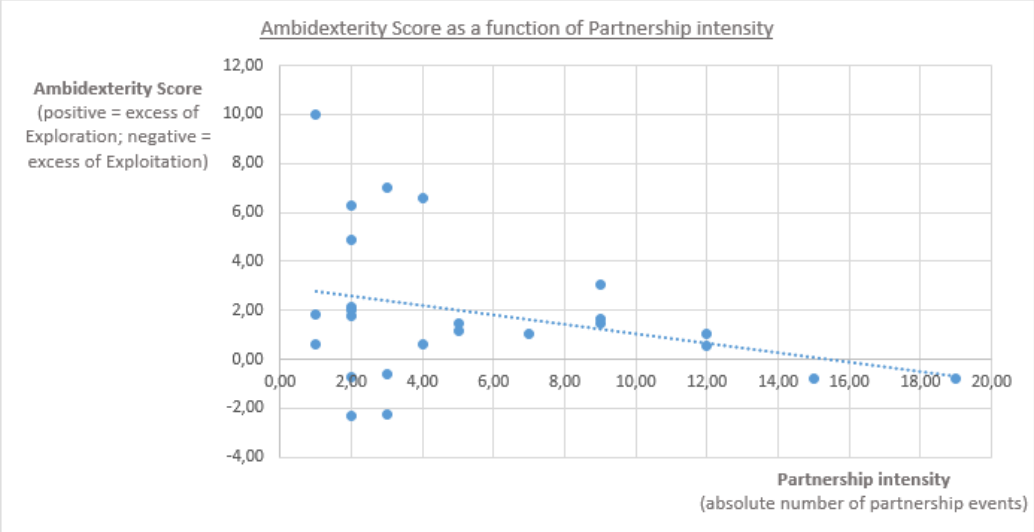



*Figure 3.22: Ambidexterity score as partnership intensity.*

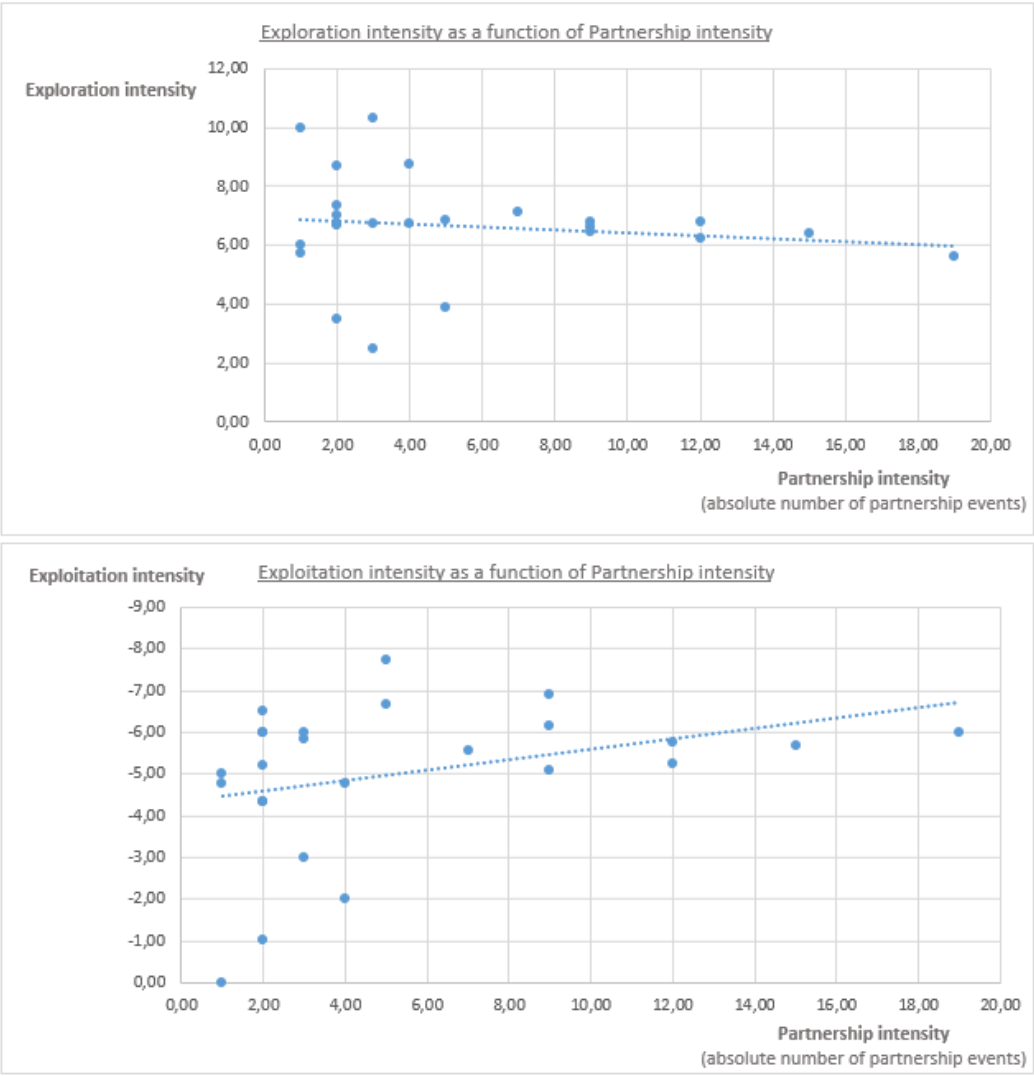



*Figure 3.23: Exploration and Exploitation intensities as functions of partnership intensity.*

As for the type of partners, new or old, it also seems to have little impact on exploration intensity whereas exploitation benefits from engaging in collaboration projects together with older partners in the frame of recurring agreements with organizations with whom Galactic has already worked before (Figure 3.24).

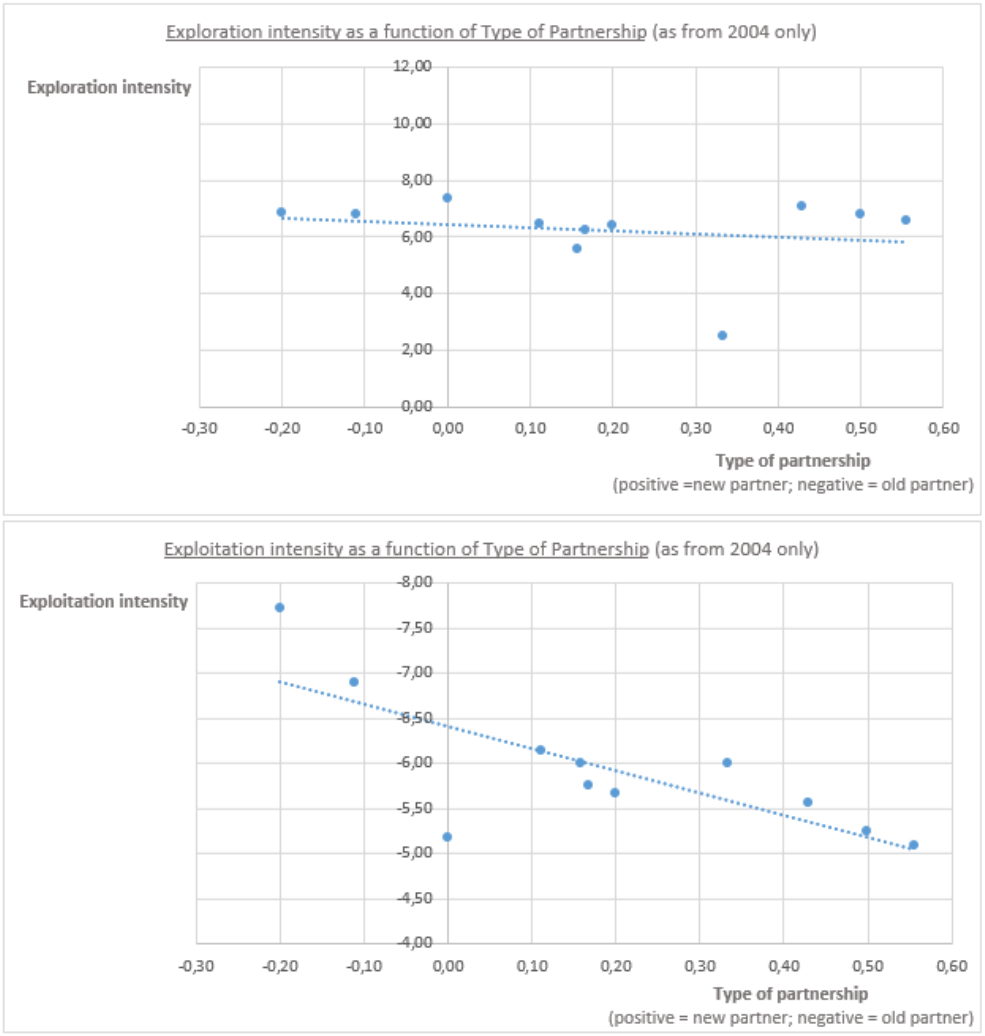



*Figure 3.24: Influence of the type of partners (new or old) on Exploration and Exploitation intensities.*
(We focus on the years after 2004 because there were only partnerships with new partners until 2003 – See Figure 3.14)

### *3.4.3. What matters the most, structure or network?*

Structure and network are not exclusive of one another, and organizations can excel on both aspects concurrently. According to Kauppila (2010), the combination of both approaches is even a way to cope with the paradox of exploration and exploitation and "reconcile the brothers" as we titled our Section 1.2.4. He claims that "interorganizational ambidexterity

implies maximization through partnerships (orthogonal exploration and exploitation) and balance (continuous exploration and exploitation) within a firm" (Kauppila, 2010, p.286).

It appears to us useful however to look at which one impacts the most ambidexterity in order to eventually help prioritizing actions when it comes to advising managers. We think it is of particular interest for small and medium enterprises that do not necessarily have the ability or the resources to work on both aspects simultaneously. We therefore decided to use multiple linear regression analysis to model the relationship between our Ambidexterity Score (dependent variable) and two independent variables: Structural Ambidexterity Score and Network Ambidexterity Score, respectively.

For this analysis, we resolved to use the software Sphinx iQ2. 391 observations out of the 410 of our dataset have been taken into consideration. Table 3.11 shows the caracteristics of the dependent and independent variables, their correlations and their influence on the model. The Cronbach alpha is 0.71 which reveals an acceptable internal consistency but the model we obtain (Equation 3.5) explains only 46.56% of the variance of the independent variable (multiple correlation coefficient R = 0.68; p(R) = <0.01; Fischer coefficient F = 169.04; p(F) = <0.01).

**Characteristics of the variables**

| Variable | Mean | Min | Max | Standard deviation | Skewness | Kurtosis |
|---|---|---|---|---|---|---|
| *Independent* | | | | | | |
| **Ambidexterity score** | 13,95 | 1,00 | 24,00 | 6,30 | <0,01 | -3,00 |
| *Dependent* | | | | | | |
| **Structural ambidexterity** | 2,19 | 1,00 | 3,00 | 0,98 | -0,43 | -1,71 |
| **Network ambidexterity** | 0,32 | -4,00 | 4,00 | 1,50 | 0,12 | -1,97 |

**Correlation matrix**

| | Ambidexterity score | Structural ambidexterity | Network ambidexterity |
|---|---|---|---|
| **Ambidexterity score** | - | | |
| **Structural ambidexterity** | 0,48 | - | |
| **Network ambidexterity** | 0,59 | 0,27 | - |

**Influence of the indepedent variables**

| | Standadized coefficients | Contribution |
|---|---|---|
| **Structural ambidexterity** | 0,35 | 40,87% |
| **Network ambidexterity** | 0,50 | 59,13% |

*Table 3.11: Ambidexterity as a combination of structure and network (caracteristics of the variables, their correlations and their influence).*

**Ambidexterity score** = 8,35
+ 2,24 * **Structural Ambidexterity score**
+ 2,21 * **Network Ambidexterity score**

(Equation 3.5)

The sum of the standardized regression coefficients of the model (0,50 + 0,35 = 0,85 <> 1) shows that these criteria are far from providing a full explanation which justifies the low level of variance explained (46,56%).

Although the model is incomplete as it does not explain even half the variance of the Ambidexterity score, the following lessons can still be learned:

- Both independent variables have a relatively high explanatory power. Their standardized correlation coefficients are relatively high (0,50 and 0,35 for Network Ambidexterity and Structural Ambidexterity, respectively)
- With a contribution of 59,13% of the explained part of the variance of the dependent variable, Network Ambidexterity has a stronger impact on the Ambidexterity score than Structural Ambidexterity which contributes for 40,87% only.

Structural ambidexterity based on separating departments taking care of exploration from the ones in charge of exploitation is frequently considered difficult to implement by SMEs which are often too small and lack resources (Lubatkin et al., 2006; March, 1991). Conversely, network ambidexterity does not require much resources and is therefore more accessible to SMEs. Our results indicate that small companies which are not in a position to allocate separate resources to exploration can nevertheless endeavor towards organizational ambidexterity by developing exploratory and exploitative partnerships. This abounds in the direction of several authors (Lavie & Rosenkopf, 2006; Rothaermel & Deeds, 2004) who suggested externalization and outsourcing as a way of resolving the paradoxical requirements of exploration and exploitation. However, acquiring external knowledge is not sufficient to benefit from it, one has also to integrate it within the organization. This is another tensions-generating challenge that was subject to research on *absorbtive capacity* or *combinative capability* which Kogut and Zander (Kogut & Zander, 1992) describe as the organization's ability "to synthesize and apply current and acquired knowledge". This led Raisch *et al.* (2009, p.690) to conclude that "ambidexterity may thus imply the managerial challenge of not only balancing exploitation and exploration but also of integrating external and internal knowledge". If we addressed the former part of this statement, a detailed analysis of the latter falls beyond the limit of our research and could advantageously be the subject of further works.

## 3.5. The key-components of organizational ambidexterity

The purpose of this section is obviously not to claim to offer a generic and global model adaptable to all situations but more modestly to condense the data specific to our case in a few simple relationships in order to better let emerge the links between components and to better measure their respective impacts on our three principal indicators, i.e. exploration intensity, exploitation intensity and ambidexterity score. This approach should enable us to highlight the most relevant elements of an ambidextrous approach applied to SMEs so as to prioritize the actions to be eventually taken by the managers who wish to develop the present activities of their organizations without jeopardizing their chances to survive the long run.

### *3.5.1. The key-components of exploration intensity*

For this analysis, the 208 observations related to exploration have been taken into consideration from the total number of 410 observations in our dataset. Table 3.13 on the next page shows the correlation matrix for the dependent and independent variables. More interestingly, Table 3.12 hereinafter gives the contribution of each independent variable on Exploration intensity sorted from the most impacting to the least impacting variable.

| | Standardized coefficient | Contribution |
|---|---|---|
| const | - | - |
| Exploitative/Exploratory alliance | 0.46 | 18.10 |
| Timeframe | 0.28 | 10.77 |
| Old/New partner | 0.26 | 10.12 |
| Plannification vs- Intuition | 0.23 | 9.07 |
| Efficiency vs- Flexibility | 0.21 | 8.09 |
| Existing/new market | 0.20 | 7.68 |
| IP | 0.19 | 7.49 |
| Markets, Customer croups | 0.17 | 6.77 |
| Experience vs- Creativity | 0.17 | 6.62 |
| Activities, procedures, knowledge | 0.16 | 6.34 |
| Technologies | 0.15 | 5.77 |
| Costs, consumptions & yields | 0.08 | 3.18 |

*Table 3.12: Contributions of each independent variable on Exploration intensity*
*(multiple correlation coefficient R = 1.00; p(R) = <0.01; Fischer coefficient F < 0.01; p(F) = <0.01).*

In short, it appears that sealing **long term** (the variable "timeframe" contributes greatly) **exploratory alliances** is the most efficient way operated by Galactic to maintain a good level of Exploration intensity. This confirms our previous conclusions (Section 3.3.3. and 3.4.2.) via

another method to scrutinize our data. Our results show that the company takes mainly benefit of external partnerships to drive its exploration activities through exploratory alliances such as research programs with other companies, R&D centers and universities. This is relatively common for medium-sized companies evolving in industries with high technological content as they can't afford supporting all research projects with their own financial means, nor have they enough scientific capabilities to address all possible subjects they might have the need to address in their R&D journey. Moreover, various types of local, regional, national and supra-national support policies incite companies to enter into partnerships and these collaborations are often a mandatory condition for projects to be eligible for grants or subsidies. SMEs are therefore inclined to join these collaborative research programs despite difficulties in terms of intellectual property and, sometimes, in terms of confidentiality.

The contribution of the variable "Old/New partner" also stands out here, and we have seen in Section 3.4.2 that the exploration activities of the company were essentially and quite logically conducted with new partners. The contribution of this variable in Table 3.12 is however surprising as it somewhat contradicts our previous observation that the type of partner, old or new, has actually little impact. We read the contribution of this variable as being a confirmation of the primary importance of entering into alliances and that the type of partner probably does not matter too much as long as partnership there is.

### *3.5.2. The key-components of exploitation intensity*

For this analysis, the 171 observations related to exploitation have been taken into consideration from the total number of 410 observations in our dataset. Table 3.14 on the previous page shows the correlation matrix for the dependent and independent variables, and Table 3.16 below gives the contribution of each independent variable on Exploitation intensity sorted from the most impacting to the least impacting variable.

| | Standardized coefficient | Contribution |
|---|---|---|
| const | - | - |
| Markets, Customer croups | 0.31 | 12.41 |
| Activities, procedures, knowledge | 0.31 | 12.31 |
| Technologies | 0.27 | 10.93 |
| Exploitative/Exploratory alliance | 0.27 | 10.82 |
| Experience vs- Creativity | 0.26 | 10.42 |
| Existing/new market | 0.25 | 9.79 |
| Costs, consumptions & yields | 0.19 | 7.75 |
| Old/New partner | 0.17 | 6.69 |
| IP | 0.16 | 6.46 |
| Timeframe | 0.15 | 5.91 |
| Plannification vs- Intuition | 0.09 | 3.39 |
| Efficiency vs- Flexibility | 0.08 | 3.12 |

*Table 3.16: Contributions of each independent variable on Exploitation intensity*
*(multiple correlation coefficient R = 0 .96; p(R) = <0.01; Fischer coefficient F = 158.18; p(F) = <0.01).*

Contrary to Exploration intensity, Exploitation intensity was predominantly supported by **focusing on existing markets and customers** as well as by paying attention to **improving activities, technologies, processes and products**. **Exploitative alliances** such as sub-contracting the manufacture of some products also impacted positively the company's exploitation intensity. We remember from Section 3.4.2 that exploitation benefits from engaging in collaboration projects together **with older partners** in the frame of recurring agreements with organizations with whom the company had already worked before. Similarly, **promoting existing solutions** and **leveraging accumulated experience** helped the company to sustain exploitation.

| | Exploration score | Exploitative/Exploratory alliance | Timeframe | Old/New partner | Plannification vs- Intuition | Efficiency vs- Flexibility | Existing/new market | IP | Markets, Customer croups | Experience vs- Creativity | Activities, procedures, knowledge | Technologies | Costs, consumptions & yields |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Exploration score | - | | | | | | | | | | | | |
| Exploitative/Exploratory alliance | 0.52 | - | | | | | | | | | | | |
| Timeframe | 0.58 | 0.12 | - | | | | | | | | | | |
| Old/New partner | 0.33 | 0.14 | 0.02 | - | | | | | | | | | |
| Plannification vs- Intuition | 0.59 | 0.31 | 0.59 | -0.02 | - | | | | | | | | |
| Efficiency vs- Flexibility | 0.38 | -0.14 | 0.31 | -0.04 | -0.02 | - | | | | | | | |
| Existing/new market | 0.36 | -0.02 | 0.06 | 0.36 | -0.10 | 0.13 | - | | | | | | |
| IP | 0.17 | -0.25 | 0.20 | -0.17 | 0.16 | 0.18 | -0.11 | - | | | | | |
| Markets, Customer croups | -0.12 | -0.21 | -0.36 | 0.08 | -0.42 | 0.19 | 0.28 | -0.17 | - | | | | |
| Experience vs- Creativity | 0.39 | 0.13 | 0.15 | -0.15 | 0.27 | 0.06 | -0.06 | 0.10 | -0.26 | - | | | |
| Activities, procedures, knowledge | 0.30 | <0.01 | -0.08 | -0.05 | 0.12 | 0.14 | 0.15 | 0.04 | 0.07 | 0.15 | - | | |
| Technologies | 0.54 | 0.15 | 0.26 | -0.08 | 0.46 | 0.10 | 0.05 | 0.15 | -0.34 | 0.60 | 0.36 | - | |
| Costs, consumptions & yields | 0.19 | -0.11 | 0.08 | 0.10 | -0.06 | 0.35 | 0.14 | 0.11 | 0.06 | <0.01 | -0.05 | 0.01 | - |

*Table 3.13: Correlation matrix for the variables explaining the Exploration score*

*(The Cronbach alpha is 0.61 which reveals a low but still acceptable internal consistency)*

| | Exploitation score | Old/New partner | Existing/new market | Exploitative/Exploratory alliance | Efficiency vs- Flexibility | Activities, procedures, knowledge | Plannification vs- Intuition | Technologies | Markets, Customer croups | Experience vs- Creativity | Timeframe | Costs, consumptions & yields | IP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Exploitation score | - | | | | | | | | | | | | |
| Old/New partner | 0.38 | - | | | | | | | | | | | |
| Existing/new market | 0.54 | 0.33 | - | | | | | | | | | | |
| Exploitative/Exploratory alliance | 0.20 | -0.26 | 0.21 | - | | | | | | | | | |
| Efficiency vs- Flexibility | 0.37 | 0.17 | -0.01 | -0.23 | - | | | | | | | | |
| Activities, procedures, knowledge | 0.45 | 0.22 | -0.05 | -0.19 | 0.61 | - | | | | | | | |
| Plannification vs- Intuition | 0.45 | 0.16 | 0.21 | -0.10 | 0.23 | 0.20 | - | | | | | | |
| Technologies | 0.33 | 0.15 | -0.08 | -0.23 | 0.24 | 0.32 | 0.37 | - | | | | | |
| Markets, Customer croups | 0.40 | 0.10 | 0.44 | 0.04 | -0.06 | -0.11 | 0.14 | -0.25 | - | | | | |
| Experience vs- Creativity | 0.44 | -0.01 | 0.05 | 0.15 | 0.08 | 0.11 | 0.15 | 0.03 | 0.12 | - | | | |
| Timeframe | 0.30 | 0.12 | 0.25 | -0.04 | 0.11 | 0.05 | 0.19 | -0.02 | 0.15 | 0.05 | - | | |
| Costs, consumptions & yields | 0.30 | 0.03 | 0.04 | -0.16 | 0.12 | 0.10 | 0.12 | 0.23 | 0.03 | 0.08 | 0.03 | - | |
| IP | 0.19 | 0.08 | 0.03 | 0.36 | 0.06 | -0.05 | <0.01 | -0.10 | -0.07 | 0.03 | -0.13 | -0.08 | - |

*Table 3.14: Correlation matrix for the variables explaining the Exploitation score*

*(The Cronbach alpha is 0.64 which reveals a low but still acceptable internal consistency)*

| | Ambidexterity score | Exploitative/Exploratory alliance | Timeframe | Plannification vs- Intuition | Efficiency vs- Flexibility | Activities, procedures, knowledge | Experience vs- Creativity | Technologies | Old/New partner | Markets, Customer croups | Existing/new market | IP | Costs, consumptions & yields |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ambidexterity score | - | | | | | | | | | | | | |
| Exploitative/Exploratory alliance | 0.55 | - | | | | | | | | | | | |
| Timeframe | 0.85 | 0.40 | - | | | | | | | | | | |
| Plannification vs- Intuition | 0.90 | 0.45 | 0.81 | - | | | | | | | | | |
| Efficiency vs- Flexibility | 0.88 | 0.30 | 0.75 | 0.78 | - | | | | | | | | |
| Activities, procedures, knowledge | 0.86 | 0.29 | 0.66 | 0.77 | 0.84 | - | | | | | | | |
| Experience vs- Creativity | 0.85 | 0.48 | 0.70 | 0.75 | 0.72 | 0.71 | - | | | | | | |
| Technologies | 0.82 | 0.31 | 0.64 | 0.79 | 0.74 | 0.77 | 0.71 | - | | | | | |
| Old/New partner | 0.22 | 0.04 | 0.13 | 0.08 | 0.11 | 0.12 | 0.05 | 0.07 | - | | | | |
| Markets, Customer croups | 0.36 | 0.06 | 0.23 | 0.21 | 0.31 | 0.27 | 0.26 | 0.10 | 0.12 | - | | | |
| Existing/new market | 0.26 | 0.07 | 0.16 | 0.11 | 0.13 | 0.13 | 0.09 | 0.07 | 0.33 | 0.38 | - | | |
| IP | 0.41 | 0.12 | 0.36 | 0.39 | 0.40 | 0.31 | 0.35 | 0.32 | -0.06 | 0.02 | -0.03 | - | |
| Costs, consumptions & yields | 0.33 | -0.01 | 0.20 | 0.26 | 0.34 | 0.28 | 0.23 | 0.36 | 0.03 | 0.12 | 0.10 | 0.12 | - |

*Table 3.15: Correlation matrix for the variables explaining the Ambidexterity Score*

*(The Cronbach alpha is 0.88 which reveals a good internal consistency)*

### *3.5.3. The key-components of organizational ambidexterity*

For this analysis, 390 observations have been taken into consideration from the total number of 410 observations in our dataset. Table 3.15 on the previous page shows the correlation matrix for the dependent variable, the ambidexterity score, and the independent variables; and Table 3.17 below gives the contribution of each independent variable on Ambidexterity Score sorted from the most impacting to the least impacting variable.

| | Standardized coefficient | Contribution |
|---|---|---|
| const | - | - |
| Exploitative/Exploratory alliance | 0.19 | 12.66 |
| Timeframe | 0.16 | 10.76 |
| Plannification vs- Intuition | 0.16 | 10.75 |
| Efficiency vs- Flexibility | 0.16 | 10.68 |
| Activities, procedures, knowledge | 0.15 | 10.48 |
| Experience vs- Creativity | 0.15 | 10.40 |
| Technologies | 0.13 | 8.83 |
| Old/New partner | 0.09 | 6.19 |
| Markets, Customer croups | 0.09 | 6.10 |
| Existing/new market | 0.08 | 5.15 |
| IP | 0.06 | 4.35 |
| Costs, consumptions & yields | 0.05 | 3.64 |

*Table 3.17: Contributions of each independent variable on Ambidexterity Score*
*(multiple correlation coefficient R = 1.00; p(R) = 0.00; Fischer coefficient F < 0.01; p(F) = <0.01).*

Not surprisingly, we find some of the most influential variables of ambidexterity among those that had the greatest impact on exploration intensity and/or on exploitation intensity (Alliances; Timeframe; Activities, procedure, knowledge; and Experience vs. Creativity). Figure 3.25 highlights these correspondances. This seems trivial when one knows that ambidexterity arises from the balance of exploration and exploitation activities, the very basis of our starting posture as explained at large in our literature review. The most influential variable, and one that finds support in both exploration and exploitation, is the formation of partnerships which impact has already been underlined in Section 3.4.3. However, the type of partner (old or new) and even, more surprisingly, the type of market (old or new) in which these partnerships take place do not appear critical to the ambidextrous character of the company. As we have just seen, the ability to form alliances of exploratory nature as well as alliances of exploitative nature is highly impacting exploration and exploitation intensities, respectively; and we can logically infer that holding both simultaneously greatly improves the ambidextrous character of the company. Clearly identifying whether projects are in the short or long term also helps ambidexterity as indicated by the high contribution of the variable “timeframe” (the projects whose timeframe

was not clear were attributed a zero rating for this variable). Although quite understandable without much explainations, this element will nevertheless gain understanding in Section 3.7 where we search for underlying processes and observe that the company resorted to different ones for short and long development cycles.


*Figure 3.25: Correpondances between the key-components of Exploration intensity, Organizational ambidexterity and Exploitation intensity*
*(Only the components with conrtibutions higher than 10% are displayed).*

Interestingly though, appear in the most influential variables some variables that did not emerge as particularly impacting on either exploration or exploitation intensities (i.e., Plannification vs. Intuition; Efficiency vs. Flexibility) which suggests that the implementation of harmonious and effective ambidextrous management should not simply focus on maximizing exploration and exploitation (the conceptualization of exploration and exploitation as orthogonal dimensions that we had called "Appolo & Dyonisos" in Section 1.2.1) but must also activate certain levers whose combination brings effects on ambidexterity greater than the sum of their effects on each of its components.

The first of these levers lies in the **pursuit of intuitive projects in parallel of well planned ones** (variable “Plannification vs. Intuition”). Plannification and intuition are not always opposed, especially in a context of uncertainty; all decision makers ultimately rely on their intuition and judgement and effective forecasting helps narrowing the decision space in which to exercise intuition (Saffo, 2007) to transform a pure guess into an educated one. This said, there are two ways of starting projects and taking decisions: either by making an extensive evaluation of the possible outcomes *ex ante* (forecasting) and planning precisely each step of the process to go through to achieve the projected objective, or to start the project or taking the decision based on intuition, heuristics, imagination and beliefs. Our results suggest that ambidexterity greatly benefits from having both approaches simultaneously while the extent of

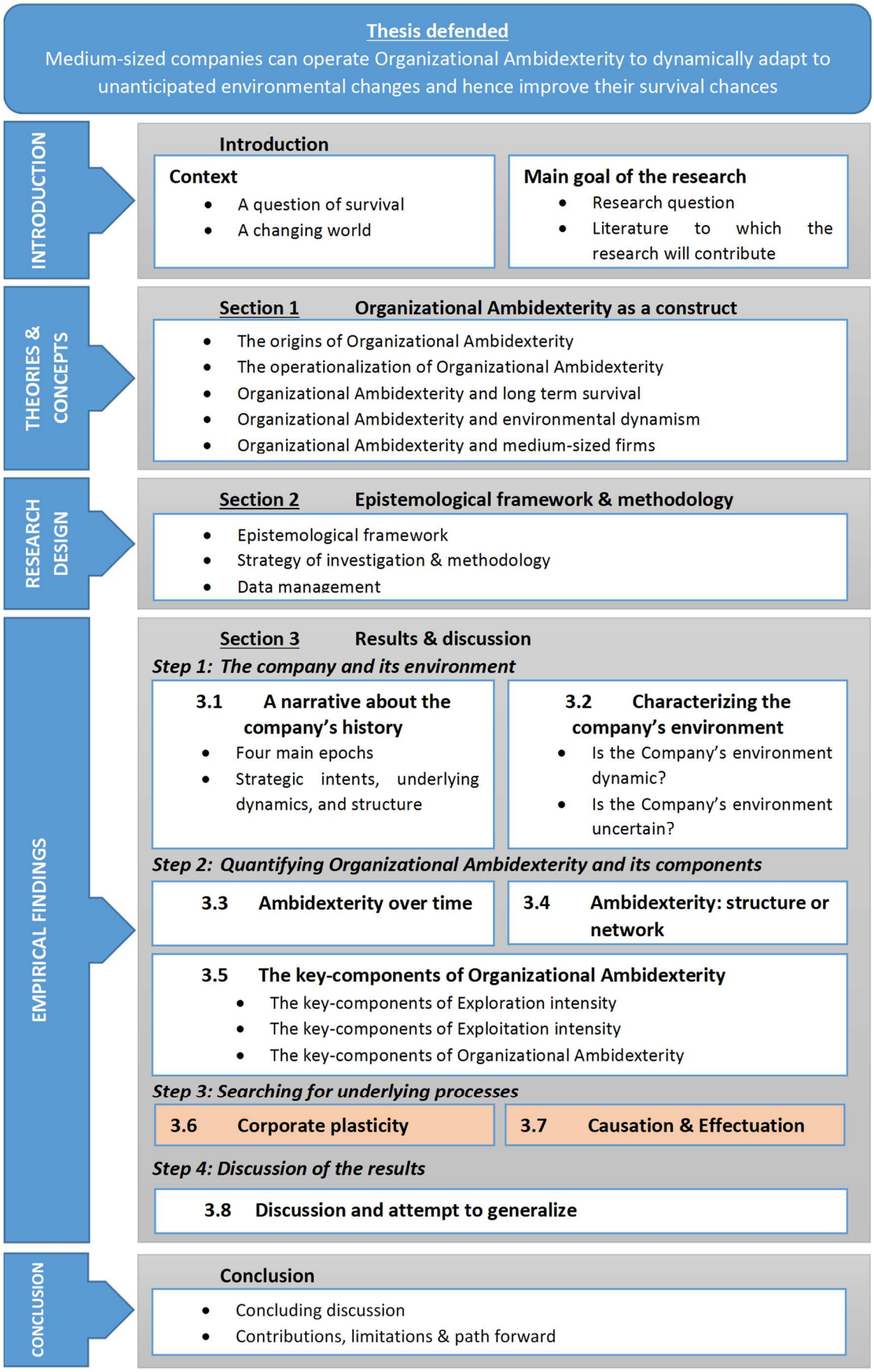
the impact on exploration and exploitation intensities separately is rather limited[51]. This point is also further discussed in our search for underlying processes (Section 3.7).

The second lever that contributes positively to organizational ambidexterity whithout strongly impacting specifically exploration or exploitation is based on **balancing attention to efficiency and to flexibility**, another tradeoff that needs to be addressed by managers as already pointed out by other authors (Adler, Goldoftas, & Levine, 1999; Ebben & Johnson, 2005; Xie, 2012).

We go further in our analysis of this in our search for underlying processes that makes the core of the third step of our methodology and which follows next.

[51] The variable "Plannification vs. Intuition" contributes for 9.07% to exploration intensity and only 3.37% to exploitation intensity.

## Step 3: Searching for underlying processes



As we have seen in Section 3.1 above, the analysis of the company's history has allowed us to delineate phases characterized by specific strategic intents which have resulted, among other things, in significant structural changes during the expansion and the progressive transformation of the company into an international group of rather small size but nevertheless settled in seven locations spread on three continents. In a second step, we have quantified different components of organizational ambidexterity and we have looked at the way they articulated over time in order to identify the levers available to managers to influence exploration and exploitation and help them balance the need for short-term incomes with the necessity of long-term development.

However, the consultation of the many documents that served as the basis for the writing of the company's history has highlighted two elements that are fundamental enough to shed light on the subject of our research and especially on possible processes underlying organizational ambidexterity. It happens that these two elements also came out of our quantitative analysis as some of the main variables influencing organizational ambidexterity without however impacting heavily either exploration or exploitation intensities. We do not pretend that these elements are entirely new to the man of art, nor that they constitute the essential part of what permited the company to be ambidextrous, but we believe that they are sufficiently obvious in the way the company operates to merit they be discussed and confronted with the existing literature on the subject.

The first element concerns the mobility and multi-disciplinarity of the management as factors of flexibility and adaptability (the variable “Efficiency vs. Flexibility” in our quantitative analysis).

The second element pertains to the variable “Plannification vs. Intuition” of our quantitative analysis and relates to the way by which the company has been able to transform its market approach to face the profound mutation that was about to threaten its very survival.

## 3.6. Corporate plasticity

> *"Chaos widens the spectrum of options and forces the organization to seek new points of view. For an organization to renew itself, it must keep itself in a non-equilibrium state at all times."*
>
> (Nonaka, 1988, p.59)

Ashby (1957) showed that, in order for a system to control another system, it is necessary and sufficient that the variety of the former be greater than, or at least equal to, that of the latter. This "law of requisite variety" implies that for an organization to successfully survive all circumstances, it needs to have at least as much variety within itself as the variety of disturbances in its external environment (Kim & Rhee, 2009)[52]. As per Volberda (1996), it is not only the variety of capabilities currently used by the organization that counts but also the collection of potential capabilities that are not yet activated and need to be developed to cope with the possible emergence of opportunities or threats. This approach is in line with March's exploitation of existing capabilities and exploration of new ones (March, 1991) as well as with O'Reilly and Tushman's description of ambidexterity as a dynamic capability (O'Reilly & Tushman, 2007) or with Birkinshaw and colleagues in their attempt to bridge dynamic capabilities and ambidexterity perspectives (Birkinshaw et al., 2016).

As highlighted by contingency theorists who believe that there is no best way to organize a company and that the optimal course of action is dependent (contingent) upon internal and external contexts (Ashby, 1962; Nonaka, 1988), nurturing existing capabilities and developing new ones ultimately aims at improving the ability of the organization to adapt to environmental changes; in other words it allows the organization to be flexible. Indeed, in a broad sense, "flexibility involves the creation or promotion of capabilities for situations of unexpected disturbance" (Volberda, 1996, p.361).

[52] Note that Ashby was particularly influencial to Herbert Simon's work on bounded rationality and its link to decision-making in organizations and artificial intelligence. Interestingly, in a letter to Simon, Ashby writes that "It is my firm belief that the principles of 'organisation' are fundamentally the same, whether the organization be of nerve cells in a brain, of persons in a society, of parts in a machine, or of workers in a factory" (Crowther-Heyck, 2005, p.190).

What is strikingly evident from the narrative of the company's history is the plasticity of its managerial team. We like to use the word “plasticity” instead of “flexibility” with reference to the concept of “phenotypic plasticity” in biology which is defined by the Oxford dictionary as the adaptability of an organism to changes in its environment. More precisely, it is the ability of an organism to change its *phenotype* in response to changes in its environment without altering its genotype. The phenotype is made of all observable attributes of the organism such as its morphology but also its developmental and behavioral characteristics; it results from the expression of its genotype, its genetic code, as well as from the influence of environmental factors and the interactions between the two. By homology, transferring the concept from organisms to organizations (McKelvey, 1999), we propose the term “corporate plasticity” to describe all types of organizational responses an organization may display to environmental changes (phenotype variations) without altering its profound makeup (its genotype, its corporate DNA: the "visions, values, and sense of purpose that bind an organization together" (Morgan, 1997, p.95)). In that sense, the idea of corporate plasticity also includes learning phenomena as there is no adaptation to environmental changes without learning (Argyris & Schön, 1978), a characteristic of “intelligent” entities such as living organisms and human organizations.

Without reducing the plasticity of a company to the sole mobility of its management, we nevertheless observe frequent changes in managerial structure during the 25 years of Galactic's history. That said, these changes have an important characteristic, that of talent retention, in that these changes are articulated for the majority around the same people. These adaptations of the managerial structure are multidimensional: they fit into time, space and the very nature of the multiple responsibilities held simultaneously by its members.

In time, because most of its members have participated in the adventure since its inception in many different job positions. A steady management team is obviously an element of stability that helps the company go through crisis and exogenous shocks but it may as well be an element of organizational inertia (Hannan & Freeman, 1984; Volberda, 1996) or cultural lock-in (Foster & Kaplan, 2001b). In the case of Galactic, the drawbacks of having a longlasting managerial structure were mitigated by changes in space and by the different responsibilities held simultaneously by the members of the management team. The need to relocate certain activities on other continents to support the growth of the company and tackle new opportunities and conquer new geographies, mainly during the decentralization phase of its decision-making structures (the period named Modernitas), has triggered the displacement of part of the top

management team to the Eastern part of the world first and to the West right after. Most of these directors were cumulating different responsibilities on different continents[53]. The essence of this observation in the frame of our research, and maybe the particularism of Galactic's organization, is not that those people were overseeing activities in different places, which is of course the case of any company active on the international scene, but precisely that the content of these responsibilities differed in the various places (see the footnote). It allowed each of the people concerned to be part of new ventures and new developments at the same time as they kept a role in the company's core activities. In this, the company follows the recommendation of O'Reilly and Tushman (2004) who proposed as "integrating mechanism" (Markides, 2013) that the parent company and the subsidiary unit share common managers.

Another point of interest is again not that people held various responsibilities in a given firm, which is very common in medium-sized companies, but that these very different responsibilities were held simultaneously; what the managers of Galactic refer themselves to as having "multiple hats". This kind of organization based on a closely intertwined set of responsibilities among the top-managers facilitates knowledge transfer from the core to newly created entities and between departments but also opens up the management to new opportunities, new perspectives and, in turn, ultimately, helps acquire new knowledge.

Paradoxically, big firms usually have slack resources[54] which are seen as advantages for the implementation of organizational ambidexterity (Atuahene-Gima, 2005; Lubatkin et al., 2006) and to buffer organizations from external shocks (Meyer, 1982) but they often lack corporate plasticity because of heavy structures and inertia-prone bureaucracy sometimes referred to as "mechanistic" structures (Burns & Stalker, 1961). Conversely, medium-sized companies have fewer hierarchical levels, their managers are more likely to play both strategic and operational roles. Hence, these companies have no choice but to concentrate different activities on few people which forces them into an "organic" mode of organization that inevitably contains the seeds of plasticity and organizational ambidexterity as the management "directly experience the added dissonance of competing knowledge demands inherent in the pursuit of an ambidextrous orientation" (Lubatkin et al., 2006, p.647). Some authors (Burns & Stalker, 1961)

[53] For instance, as described in the narrative (Appendix II.3), a general management position in Asia and R&D responsibilities in Belgium for one director; production and supply chain responsibilities in China while heading the engineering department in Belgium for another; or general management responsibilities in USA and production ones in Belgium for a third one.

[54] Nohria and Gulati (1995, p.1246) define slack as "the pool of resources in an organization that is in excess of the minimum necessary to produce a given level of organizational output. Slack resources include excess inputs such as redundant employees, unused capacity, and unnecessary capital expenditures."

have agued that such an “organic” system is more efficient in turbulent conditions whereas “mechanistic” management systems perform better in stable environment.

However, as seen in Sections 3.3.2 and 3.4.1, the company used to favor separation between the departments to conduct its exploration activities whereas exploitative ones were primarily betting on collaboration. This indicates that the organic structure held at the top of the company was partially compensated by a more mechanistic structure within and between the departments. This gives credit to Adler, Goldoftas and Levine (1999) who observed that achieving flexibility and efficiency at the same time may involve partitioning whereby one group of people adopts an organic structure to perform non-routine tasks while another takes on a mechanic structure to execute more routine tasks. Our observations also echo other researches (Tushman et al., 2011) by which managers are invited to hold at the top of the company the tensions arising from the conflicting interests of innovating and exploiting, and “foster a state of constant creative conflict” (opcit., p.76). In any case, tight coordination and integration at the senior management level are essential conditions for ambidexterity (Kauppila, 2010; Smith & Tushman, 2005).

Figure 3.26 combines our conclusions about the organic/mechanistic types of organization at different levels in the company, i.e. top management level versus department level, with our previous observations about the implementation of ambidexterity within the company.

| | TOP MANAGEMENT | |
|---|---|---|
| **Type of organization** | Organic<br>(different types of responsibilities held simultaneously in different geographies )<br>("multiple hats") | |
| **Type of ambidexterity** | Simultaneous | |

| | DEPARTMENTS | |
|---|---|---|
| **Type of organization** | Mechanistic<br>(boundaries between departments clearly defined) | |
| **Type of ambidexterity** | Structural & Network | |
| **Implementation of ambidexterity** | **Exploitation** | **Exploration** |
| Within the company | Collaboration with other departments | Separation between departments |
| Outside the company | Collaboration with external partners<br>(i.e. exploitative alliances primarily with old partners) | Collaboration with external partners<br>(i.e. exploratory alliances with old and new partners) |

*Figure 3.26: Type of organization and type of ambidexterity at top management level and department level.*

At the level of top management, we have just seen that the organic type of organization supports the ambidextrous orientation and we had seen previously that the company succeeds to simultaneously balance its exploratory and exploitative activities. However, to achieve this

result, the top management relies on subsidiaries and departments operating in silos with clearly defined responsibilities, a much more mechanistic type of organization. Although cooperation between departments seems to be always desirable and should be promoted, we have seen that the company tends to conduct its exploratory activities in a separated way, within the same department, as well as by setting up partnerships with both new and old external entities. Conversely, exploitative activities are pursued in a much more collaborative way, both internally between different departments and externally through collaborations with partners generally historical.

Duncan (1976) initially conceptualized organizational ambidexterity as alternating sequences of organic and mechanistic structures. Mechanistic structures support routine operations, functionalization and formal duties (Lavie et al., 2010), therefore being ideal to entail exploitation, whereas organic structures are much less rigid, hence facilitating search for new knowledge and exploration (Burns & Stalker, 1961). Such a temporal sequencing is probably well adapted to rather stable environmental conditions because organizations have time to manage the shifts and benefit from adaptive learning (Cyert & March, 1963), but this approach seems inappropriate under situations of swift and uncertain environmental change (Schmitt et al., 2010). According to Tushman an O'Reilly (Tushman & O'Reilly, 1996), an environmental context of punctuated discontinuities is best dealt with by separating spatially the exploration and exploitation activities (the concept of structural ambidexterity introduced in section 1.2.2. above). Conversely, Jansen *et al.* (2005) observed that organizations operating in highly dynamic competitive environments rely mostly on contextual ambidexterity instead of instating structural separation between units.

It is clear from our observations that Galactic has implemented an organization that combines the different precepts put forward by these authors:

- an "organic" type of organization at the top of the company, probably supported by elements of a contextual ambidexterity well adapted to a particularly dynamic environment as advocated by Jansen and his colleagues (2005),
- a "mechanistic" type of organization largely structural at the operational level;
- all simultaneously, which avoids the problems of "temporal sequencing" noted by Cyert & March (1963).

This type of joint organization is probably quite specific to medium-sized enterprises. Indeed, very small companies generally do not have enough hierarchic levels to allow for different

organization types between the top management and the execution level. The top managers are themselves strongly involved at the operational level and their organizations usually cannot afford creating structurally separated departments or focusing teams on exploration specifically. At the other end of the spectrum, large corporations are often mechanistically organized and their size imposes speciallization of sub-units. In this case, the challenge is to keep these multiple subunits tightly coupled internally and loosely coupled across themselves (Benner & Tushman, 2003). Medium-sized firms are at the junction of these two worlds, large enough to organize themselves structurally but small enough to have their top-management "much closer to the firm's operating core" (Lubatkin et al., 2006, p.649), playing "both strategic and operational roles" (p.647), and hence experiencing "the added dissonance of competing knowledge demands inherent in the pursuit of an ambidextrous orientation" (p.647).

In view of these elements, we argue that **medium-sized companies can nurture their corporate plasticity and become ambidextrous by adopting an organic structure of management at the top of the company** based on different sets of responsibilities held simultaneously by a limited group of flexible managers, instead of having each one in charge of a single activity as often the case, and to combine this organic structure at the top **with a mechanistic type of organization at the execution level**.

It is precisely with the level of execution that the following section deals.

## 3.7. Causation and Effectuation

> *« Human imagination and human aspirations influence each other and reshape one another continually, both directly and through economic artifacts. The swirls and eddies these interactions engender often change the shoreline and make the waters treacherous for economic ship builders and navigators. That is why destinations as well as paths are often unclear in economic decision making. And when destinations are unclear and there are no preexistent goals, causal road maps are less useful than effectual exchanges of information between all stakeholders involved in the journey. Bold expeditions and even one-eyed pirates rule such seas, and voyages to India effectually end up in the Americas.»*
>
> (Sarasvathy, 2001, p.262)

At the end of Modernitas (2010-2011), as we have seen previously, the environmental conditions surrounding the company's operations were deteriorating sharply with a gloomy macroeconomic context, extremely expensive feedstocks, rocketing oil prices, increasing competition intensity and commoditization of its flagship products. But these externalities relayed by the middle management and objective financial figures (flattening or decreasing top line, raising raw material and energy bill, squeezed margins and dropping bottom line) are in fact flashing lights on the top-management's dashboard indicating that the situation is worsening and that the very survival of the company may be sooner or later at stake[55]. At first sight though, following our line of thoughts as true believers in the power of organizational ambidexterity, the company's management was already doing the right thing: investing in R&D and developing new knowledge (in short, exploring) while maintaining a relatively high focus on improving operations (exploiting). Indeed, the firm was apparently good at balancing exploration and exploitation and maintaining an ambidexterity score under control for more than a decade by using the various levers detailed in Sections 3.4 and 3.5.

Hence it is not that the company was not innovating prior to the last strategic inflection. It is even the contrary as we have seen that the company stayed majoritary in exploratory territory almost all its life (without forsaking exploitation) and there is even an increase of exploratory focus at the end of Modernitas (see Figure 3.10 in section 3.3.1). As a matter of fact, voices

[55] A good example of Burgelman's strategic dissonance (Burgelman & Grove, 1996): when information brought up by the middle management and various objective ratios and metrics indicate a discrepancy between the strategic intent and the path really taken by the company on the field.

started to be raised as early as 2004/2005 already as it can be seen from the following abstract of the new business development plan submitted then to the board of directors.

> *« L'exercice 2004/05 sera très probablement un exercice charnière dans l'évolution de GALACTIC qui devrait voir la concrétisation de projets majeurs (B&G, GALACTIC Inc., Snoopy). Ceux-ci modifieront le positionnement de l'entreprise sur ses marchés et imposeront une modification de sa stratégie globale. Dans le contexte actuel d'expansion des activités de l'entreprise, certaines questions de fond se posent qui devront être tranchées par le management. Une de ces questions concerne la R&D au sens large, et plus particulièrement le développement de produits nouveaux : souhaitons-nous rester suiveurs ou voulons-nous tendre à moyen terme vers une situation de leader ? Si le choix du management et de l'actionnariat se porte sur la seconde alternative, des moyens devront être déployés (moyens humains et matériels). »*[56]

And the need to pursue the efforts in research and development was understood and supported up to the highest instances of the company even after the strategic inflection was initiated (abstract of the Minutes of the Board dd. Feb. 22, 2013):

> *« Combiner sur le nouveau site les commerciaux et le support technique est une excellente chose. Il faudra s'assurer que la recherche et développement contribue pleinement à la réorientation des activités. »*[57]

So, if the company succeded indeed to simultaneously explore and exploit, why was that not enough? Do we touch here the limits of organizational ambidexterity as a mean to cope with environmental changes and sourrounding volatility? Why did the management feel the need to profoundly change the company's strategy? Would the new strategy alter in any way the ambidextrous capabilities of the firm?

It was when thinking about those questions during the writing of the company's history (Appendix II) and when investigating the extant literature on the subject that we came across the concept of *effectuation*.

---

[56] "The 2004/05 financial year will most likely be a pivotal year in the evolution of GALACTIC, which should see the realization of major projects (B & G, GALACTIC Inc., Snoopy). These will modify the position of the company in its markets and will require a modification of its overall strategy. In the current context of expansion of the company's activities, certain fundamental questions arise which must be decided by the management. One of these questions concerns R & D in the broad sense, and in particular the development of new products: do we want to stay as followers or do we want to move towards a leadership position in the medium term? If the choice of management and shareholders is based on the second alternative, means must be deployed (human and material means)."

[57] "Combining on the new site the sales and technical support is an excellent thing. It will be necessary to ensure that research and development contributes fully to the reorientation of activities."

Effectuation theory discerns two logics of decision-making: causation, which assumes that the means are selected to achieve predefined goals; and effectuation, which postulates that the goals stem from the available means[58]. The decision maker decides on what logic to apply in regards to its perception of the future. If he believes that he is dealing with a measurable or relatively predictable future, he will try to gather information about this possible future and will design a strategy to address this future in order to attain his goal. Conversely, if he thinks that he is dealing with a relatively unpredictable situation, he will most likely enter in an experimental and iterative learning process (Sarasvathy, 2001a). Hence, a causal approach appears deeply rooted in plannification and forecasting which is notoriously inaccurate (Hogarth & Makridakis, 1981; Mintzberg, 1994) especially in unpredictable environment as "a prerequisite of any form of forecasting, whether judgemental or statistical, is that a pattern or relationship exists concerning the event of interest" (Makridakis, 1990). The crux of effectuation contrarily posits that one does not need to predict the future should one be in a position to control it, i.e. in position to cope with and adapt to any unexpected event that may occur.

In terms of generative mechanisms, we believe we can link the two logics to two different process theories of organizational development described by Van de Ven and Poole (1995). In our eyes, causation follows a teleological model [59] as a cycle of goal formulation, implementation, evaluation, and modification of goals based on what was learned by the entity, whereas effectuation resorts to an evolutionary model of repetitive sequences of variation, selection, and retention[60].

Figure 3.27 shows the evolution of causation and effectuation over the 25 years of the company's history as measured with the rating grid described in Section 2.4.3 (Figure 2.12). We see that Galactic started its activities with an intuition-based effectual approach, which provides support to the entrepreneurial roots of the effectuation concept (Sarasvathy, 2001), but that the company quickly had to activate causal processes based on forecasting to support its growth and development. In such a capital intensive industry characterized by long investment cycles, a certain amount of teleological plannification is mandatory. This evolution pulled the

[58] Remember the metaphor of the cook on Section 2.4.3 who is either buying ingredients needed to cook a chosen meal (a causal approach: the meal defines the recipe which imposes the ingredients) or cooking what can be done with the ingredients at hand (an effectual approach: the ingredients lead to a possible recipe which defines the meal).

[59] Teleology presupposes causality (von Mises, 1962). "*Agen autem non movet nisi ex intentione finis*" (An agent does not move without the intention of an end) – Saint Thomas Aquinas, *Summa Theologiae*.

[60] In their paper, Van de Ven and Poole (1995) position this evolutionary process at the level of a population of entities but Burgelman (1991) describe the same evolutionary process at the entity level.

resultant of causation and effectuation measures close to zero value in Figure 3.27 which indicates the coexistence of both logics.

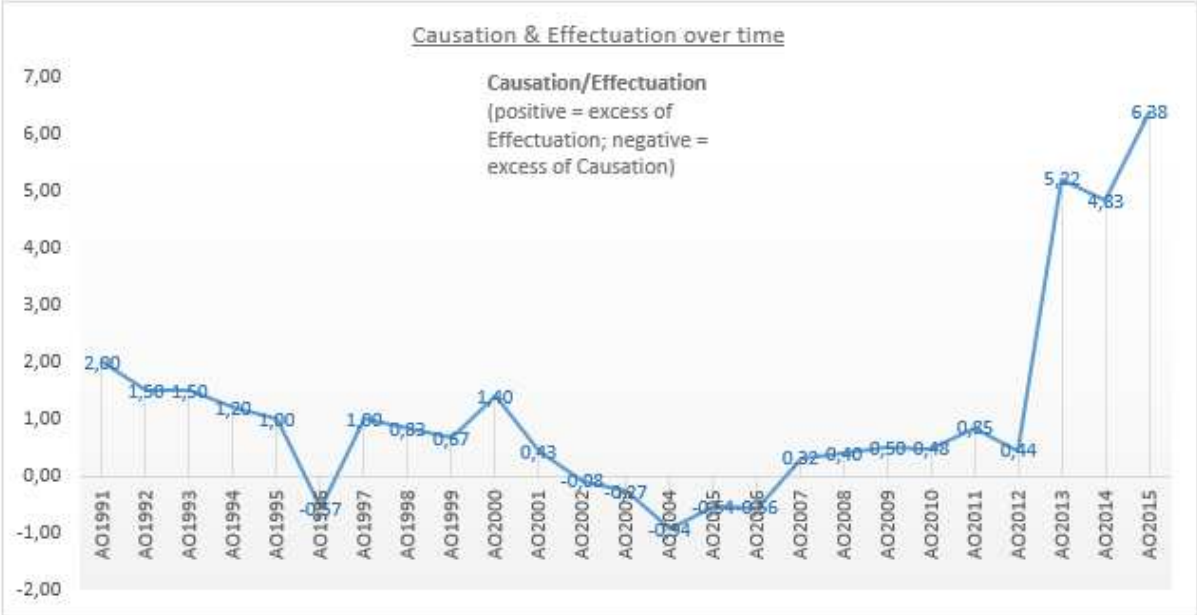



*Figure 3.27: Evolution of the Causation and Effectuation from 1991 until 2015 (a positive score means an excess of Effectuation over Causation and vice versa).*

Overall though, the Feodalis period (1994-2001) of centralization around a single production site in Belgium was outlined by an excess of effectuation. The company was then exploring its market and developing technologies, offering its customers newly developed products. A detailed analysis of the data reveals however that Galactic was not really seeking *pre*-commitment from those customers. At this point, the access channels to its market, mainly through distributors, did not allow to know well enough its final customers as acknowledged by the management in a Strategic Note to Shareholders dated October 2000.

> *« Nous vendons actuellement nos produits dans 60 pays et ce au travers de distributeurs locaux. Nous sommes reconnus et nos produits sont appréciés par nos clients. Nous ne connaissons pas bien les clients finaux. La mise au travail de notre Application Technologist nous permet cependant d'améliorer cette situation. »*[61]

[61] "We currently sell our products in 60 countries through local distributors. We are recognized and our products are appreciated by our customers. We do not know the final customers well. The implementation of our Application Technologist however allows us to improve this situation."

Obviously, the management became aware of the need to connect with its customers and not rely only on intermediaries like distributors and agents.

The approach of the next period, Modernitas (2001-2011), was more of causal nature as the company was aiming at replicating its past successes on other continents through decentralization of its decision-making structures. The second half of Modernitas showed however again a slow slide towards effectuation when the freshly incepted subsidiaries gained enough autonomy to start exploring new fields on their own. The last period, Contemporalis (as from 2011), displayed a surge of effectual logic mainly triggered by a customer-centric new strategy.

But, what means a "customer-centric new strategy" in 2011 when we have seen that the management started to take measures as early as in 2000 to jump over its distributors and connect directly with its customers? And again, why was this "customer-centric new strategy" necessary when we have seen that the company was rather good at exploring and exploiting at the same time? To which extend this "new strategy" would help survive the economic and market hurdles that were accumulating at the end of the epoch that we named Modernitas?

It is worth noting at this stage that such a demand-based perspective is rather typical of small to mid-sized companies operating in dynamic and concentrated industries (Xie, 2012) like industrial biotechnology, Galactic's market. In this type of environment, a few dominating players coexist with small competitors but, because of resource constraints, SMEs cannot outperform their competition directly; they often turn their attention to their customers with the intention to create value for them and by doing so gain competitive advantage. Customer value can be defined as the difference between the product utility perceived by the customers and the product price which is affected by the cost of production. Kim & Mauborgne (2004) have showed that competition may be irrelevant when firms offer something customers perceive to be valuable. However, customers' needs are not stable in dynamic industries, flexibility is critical for the firm to survive in this type of environment (Xie, 2012), and flexibility is precisely what differenciates small companies from larger ones. Small firms are structurally simple, agile, adaptative thanks to short decision-making circuits whereas large companies are often subject to organizational inertia (Hannan & Freeman, 1984; Volberda, 1996), convergence (Miller, 1993) or cultural lock-in (Foster & Kaplan, 2001b).

In the case of Galactic though, it is not that the company was not listening to its customers but precisely that it was listening too much to them to innovate[62]. Trapped in Christensen's "innovator's dilemma" (Christensen, 1997), Galactic was almost exclusively talking to its existing customers about slight changes to the properties and features of its existing products or about the development of new products with properties relatively close to the ones already existing. This syndrome has also been described by Hamel and Prahalad (Hamel & Prahalad, 1994) as the "tyranny of the served market", when firms limit their attention only to that of existing customers. This process led to a series of small incremental improvements to its products and to the addition of more lactic acid-based derivatives to its existing product portfolio. Indeed, if one asks a car-user what he needs, he will most likely answer that he needs a car, probably a slightly different car, maybe a bigger car or a faster one, maybe a shinier car or a car with more gadgets, but still a car. Similarly, asking a lactic acid user what he wants ends-up almost invariably with the development of new forms of lactic acid or new derivatives of it, but not with a radically different solution.

The progressive commoditization of lactic acid in the market place was also playing a role in the fact that the company was innovating but still always within a narrow space around the same subjects. All lactic acid producers were then focusing their efforts and resources on finetuning their processes and improving the existing properties of their products to keep their clientbase satisfied and gain a cost-based competitive advantage. Galactic was no exception. To escape this innovator's dilemma, Galactic had to go beyond its usual crowd of customers and start approaching new prospects, in other markets, prospects with different needs, prospects who were not using lactic derivatives and, eventually, who did not even have the need to[63]. Understanding the needs and requirements of this new genera of prospects would most probably lead to the development of other products, not slightly different but radically different from the existing ones, by leveraging on the company's skills and expertise. In short, the company had to adopt an effectual approach. It was believed that this new strategy would reduce the

[62] We insist here on the word "innovate". We consider that innovation and exploration are different notions: innovation is the product of successful exploration. Exploration or research is basically about transforming resources (human and financial) into new knowledge (technological, organizational, social). Innovation is about transforming new knowledge into products or services which respond to the need of customers, end-users or consumers. The exploitation of innovations generates new means (financial means such as profits, human means of higher expertise) which in turn become new resources for more exploration and hopefully, later, more innovations to exploit (see Figure 1.2 in Section 1.2.4).

[63] One of the hypotheses supporting the effectuation theory is that "The strategies implemented by the firm will seek to control and create the market rather than to predict and follow it" (Sarasvathy & Kotha, 2001, p.9).

company's exposure to the commoditization process at play and help it bounce back with new solutions in new markets.

The following quote from the company's CEO extracted from the minutes of a Management Meeting held in February 2012 offers an example of this new mindset.

> *« FVAN[64] indique que de plus en plus de produits seront directement conçus ou adaptés par rapport à des demandes provenant de nouveaux clients. Nous devons leur montrer que nous sommes des spécialistes dans notre domaine d'activité. »*[65]

And another example comes with a slide used to present the new strategy to the company's distributors at a Europe-wide seminar held in the city of Ghent early 2013 (Figure 3.28). This slide highlights the company's intention to move from simple supplier/customer type of relations to real partnerships in order to be able to offer innovative concepts and solutions instead of "me too" products.


*Figure 3.28: The intention of the management when enacting the 2012 strategic revolution at Galactic*
*(slide presented at a seminar bringing together all the company's European distributors in March 2013)*

[64] GALACTIC' staff members are identified in the company's organization (including all subsidiaries) since its inception by 4-letter acronyms composed with the first letter(s) of their surname and family name. We adopt the same logic in this dissertation in order to preserve the privacy of the people appearing in the narrative.
[65] "FVAN indicates that more and more products will be directly designed or adapted in response to requests from new customers. We must show them that we are specialists in our field of activity."

To do so, the company resolved to re-centralize the decision-making processes and merge the sales, marketing and R&D departments with the view to reduce the distance between its scientists and the market, better anticipate customers needs and reduce the "time-to-market" for its innovations. An ambitious program called "Competing for Growth: a new shape for a sustainable future" was designed around three pillars: exploiting the company's core competencies in product & process development; enhancing the company's market and application knowledge *through market-driven initiatives and through partnering with customers*[66]*;* and improving the company's image and notoriety through increased market presence and enhanced communication. In concrete terms, the first action was to improve what the company called "customer reach", i.e. targeting and satisfying customers' needs, by focusing on key-segments and prioritizing markets. Hence, it was decided to increase the sales force, to split them in two teams, i.e. food and non-food, to increase technical resources, and to align those on the sales teams in two teams as well. At the same time, a priority was to restructure the distribution network, not only following a geographical segmentation as it was the case formerly, but by selecting specialists of each market segment instead of generalists "one-stop-shop" type of distributor. If one aim of this set of actions was to increase the effectiveness of market prospection, a rather exploitative approach, the real objective was clearly to put in place a structure that promotes access to end-users and listening to their needs, an obviously exploratory and effectual logic.

A second set of actions was to enhance operational agility by accelerating the speed of response and promoting collaboration. For the former, the speed of response, a point of attention was brought to better anticipate and plan the sales ex-ante (before orders are coming in) so that a better execution ex-post by logistic departments would be possible. A system of key-performance indicators (KPI's) was also put in place to raise the team members' awareness towards the main business drivers and success factors. All this stem for causation-tainted exploitative logic. Conversely, to promote collaboration, the management bet on an effectual strategy straddling simultaneously on exploitation and exploration with the freshly acquired Galactic Innovation Campus that would help break the boundaries between the teams (hence improving internal communication) but also that would allow to organize product and

[66] Two other hypotheses supporting the effectuation theory are respectively that "Early decisions will involve bringing the product into customers' hands as quickly as possible without regard to detailed calculations of expected return", and that "Early customers will be chosen either randomly or through strategic partners, and not based on detailed competitive analyses" (Sarasvathy & Kotha, 2001, p.9).

application demonstrations, trainings of customers and distributors, and co-developments with them.

| Causal strategy | Effectual strategy |
|---|---|
| Push | Pull |
| Volume | Value |
| Commodity | Specialty |
| Inside-out | Outside-in |
| Fill capacity | Fulfill customers needs |
| Efficiency | Effectiveness |
| Product focus | Market focus |
| Intuition | Insight |

*Table 3.18: Descriptors of causal and effectual strategies*

A certain overlapping of causation-effectuation and exploration-exploitation frameworks seems to appear. In fact, Sarasvathy's concept of effectuation and causation has often been compared to March's concept of exploration and exploitation. Exploration contains processes of effectuation, whereas causation dominates exploitation (Sarasvathy, 2001a). Sarasvathy speculates that "the problem of allocation of resources between exploration and exploitation might itself be modeled more effectively using an effectuation rather a causation model" (opcit, p.254); and with Wittbank, she claims that without the alternative of effectuation, March's exploration-exploitation dichotomy hangs unsupported on the exploration side as it is precisely the contrast between effectual reasoning and the predictive rationality of causation that provides the underlying processes supporting exploration and exploitation (Wittbank & Sarasvathy, 2010). In other words, March's exploration of new possibilities would proceed by an effectual mechanism whereas the underlying process supporting the exploitation of old certainties would be of causal nature.

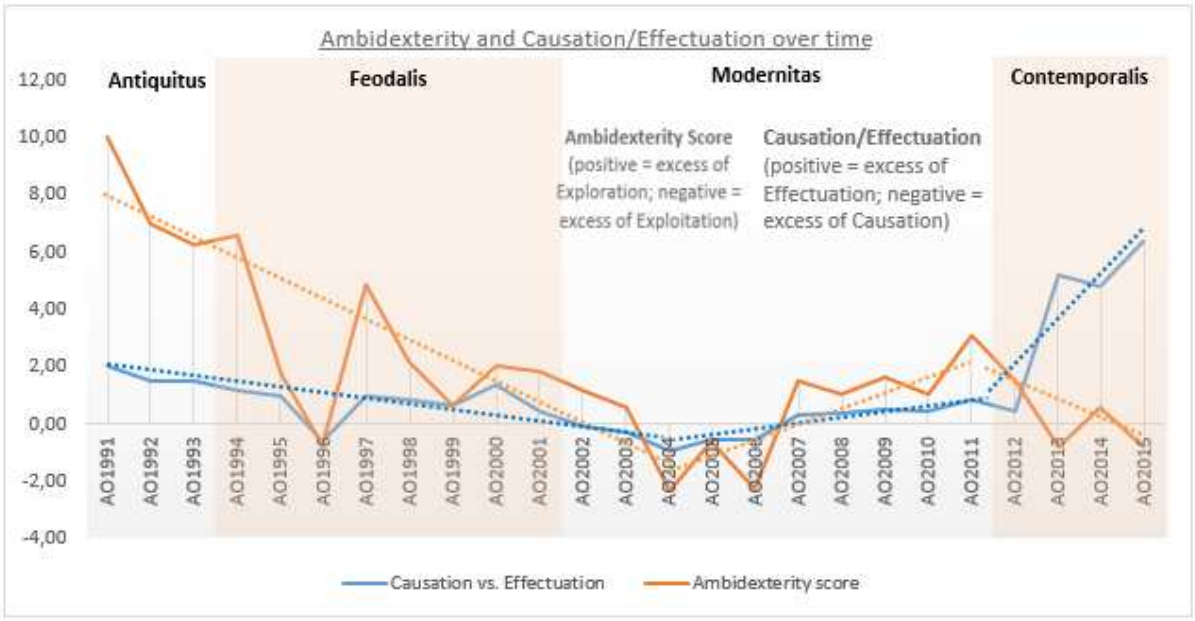



*Figure 3.29: Superposition of Ambidexterity and Causation-Effectuation patterns.*

Indeed, the comparison of the evolution over time of ambidexterity with that of effectuation brings to light obvious similarities but also, surprisingly enough, clear divergences (Figure 3.29). The two trends appear well correlated ($R^2$=0,7848; Figure 3.30), which supports the **link between ambidexterity and the effectuation framework**, until the beginning of Contemporalis (2012) when they start to part. During this phase of the company's history, Galactic recentralized its decision-making structures and changed strategic intent to escape the commoditization of its flagship products with the development of specialties and customer-driven solutions. This is precisely what explains the surge of effectuation as of 2012 when the company entered in a growing number of projects together with new prospects and customers, in fact searching for their pre-commitment as explained above. The intention of those projects was clearly to better understand their needs so that the company would be able to either propose existing solutions to new problems, which mobilizes existing knowledge, or to develop new solutions by building new knowledge. Although this approach resorts obviously from an effectual logic, it is not of exploratory nature only. As a matter of fact, the projects based on refining existing solutions, i.e. demonstration projects, were much more of exploitative nature whereas the projects aiming at developing new solutions were certainly of exploratory nature. The intensity of effectual reasoning was then distributed on both sides of the exploration – exploitation continuum which explains that organizational ambidexterity improved (orange line in Figure 3.29 approaching zero) at the same time as effectuation increases (blue line in Figure 3.29).

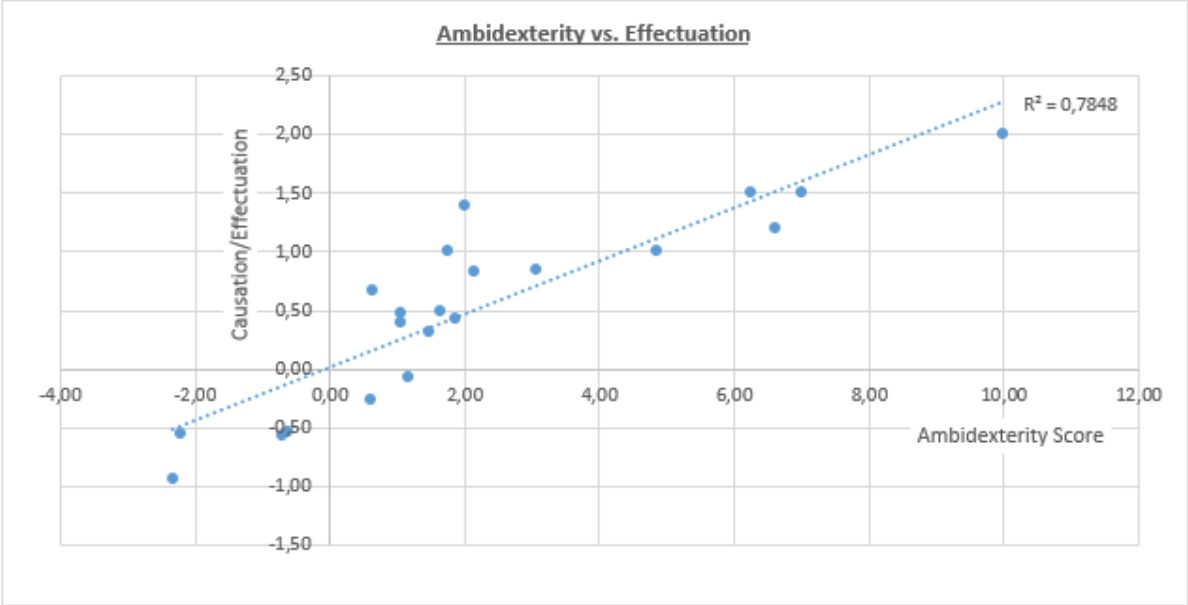



*Figure 3.30: Correlation between Ambidexterity and Causation-Effectuation patterns from 1991 to 2011.*

This divergence between the trends of effectuation-causation and exploration-exploitation during Contemporalis came as a surprise as, following Sarasvathy (Sarasvathy, 2001b), one could expect effectuation to evolve together with exploration and causation in parallel with exploitation. Our results and their explaination above show that, as close as they might seem at first sight, the two frameworks are subtly distincts. Actually, what our results show during Contemporalis is that, **in some conditions, effectuation can be of exploratory and exploitative nature at the same time**, and not as often claimed that effectuation is inevitably exploratory.

Another divergence between the two frameworks comes when we consider more precisely how some exploration activities were actually carried out by the company.

- Exploration following a causal logic: As we have seen, the company has always sustained a high level of R&D, which explains in large part that its ambidexterity score mainly remained in exploratory domain throughout its life. That said, until 2011, Galactic conducted almost exclusively its research activities on the basis of projects defined by the management of the company in relation to the offering of its competitors and the potentialities expected from existing markets. This "me too" approach was not deprived of inventiveness since the company has distinguished

itself in many respects by the development of innovative processes, as evidenced by a constantly growing patent portfolio, but often for the production of existing products marketed in existing markets. Until 2011, this approach was relatively unstructured and strongly based on the intuition of top management. In terms of processes, rapid market studies were launched to confirm these intuitions, they led to the creation of projects and to the search for financing often through the use of regional, national and supranational support systems. Projects selected and financed were then launched and regularly evaluated and, if successful, resulted in the placing on the market of the product under consideration. We find here the teleological, hence causal, model described by Van de Ven & Poole (1995) mentioned hereabove and characterized by a cycle of goal formulation, implementation and evaluation.

In 2011, the company started to better structure its product development procedure through the formal implementation of a stage-gate process[67] (Figure 3.31).


[67] A Stage-Gate process is a conceptual and operational road map for moving a new-product project from idea to launch. Stage-Gate divides the effort into distinct stages separated by management decision gates (gatekeeping). Cross-functional teams must successfully complete a prescribed set of related cross-functional activities in each stage prior to obtaining management approval to proceed to the next stage of product development. The Stage-Gate methodology was initially developed by Robert G. Cooper from McMaster University, Canada (R. G. Cooper, 2008).

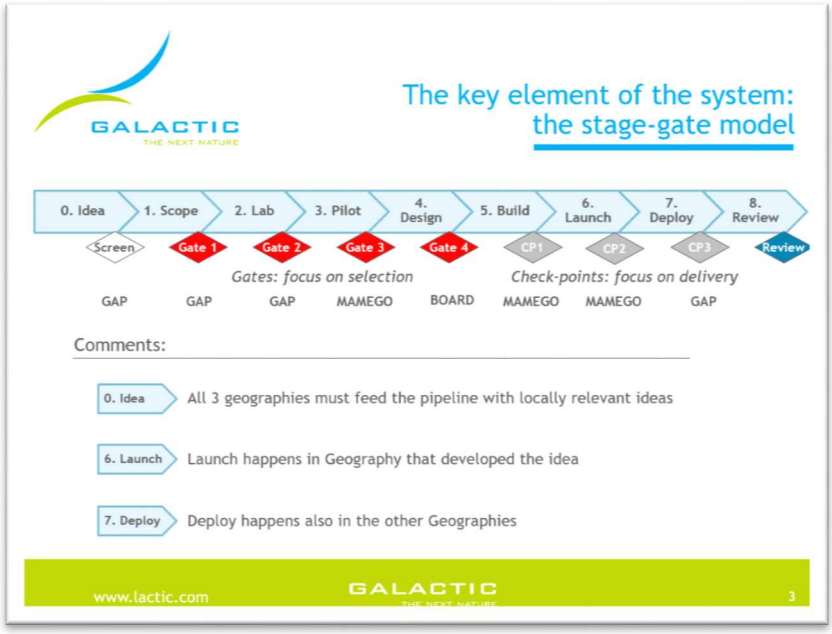
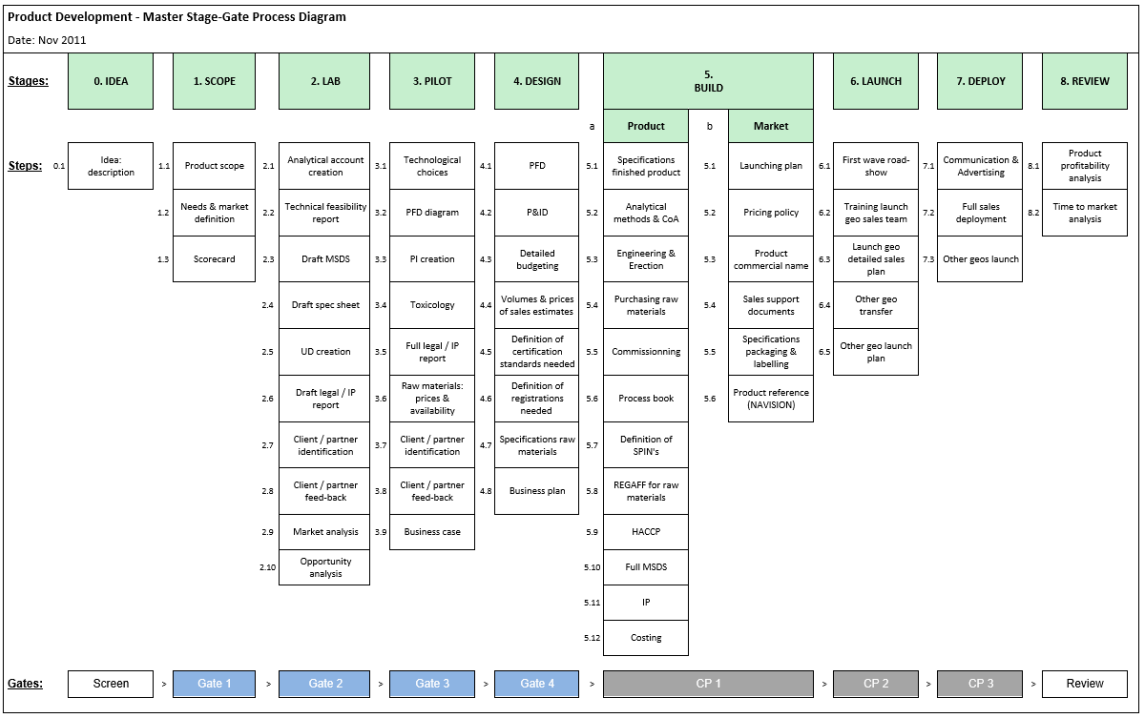



*Figure 3.31a,b: Presentation of Galactic stage-gate model for product development*
*(extract of a presentation to the middle management in November 2011)*


*Figure 3.31c: Presentation of Galactic stage-gate model for product development (continued)*
*(extract of a presentation to the middle management in November 2011)*

Although this system brings a stronger market orientation into the company's product development process (see point "C" in Figure 3.31c), it nevertheless remains highly causal in its mindset with a heavy scoping step including thorough product scoping and market definition at the very beginning (stage "1. SCOPE" on Figure 3.32), in short a goal definition which is the essence of a causation logic.




*<u>Figure 3.32:</u> Galactic master stage-gate process diagram*
*(as implemented in November 2011)*

Galactic stage-gate process also involves the establishment of a scorecard which aims at ranking and prioritizing projects by measuring product advantages (uniqueness, differenciation towards competitors, value for money), market attractiveness (market size, market growth and competitive situation), strategic fit (alignment with corporate strategy, strategic importance of the project, technology availability, availability of production assets), technical feasibility (technical easiness, technical certainty); and by assessing risk level and whether the project leverages core competencies. The scorecard also measures a "productivity index" based on NPV[68] and ECD[69] calculations. Eventhough this system allows for an efficient and mandatory selection between potential candidates, it lacks adequate sources of variation. Such a traditional inside-out methodology, as efficient as it can be when properly conducted, banks heavily on the organization's ability to identify market needs. However, by relying only on the evolutions of competition, and as we have seen, by questioning only its traditional customers, the company generates only incremental innovations which are often in the same domain. This approach

[68] NPV stands for "Net Present Value", the difference between the present (discounted) value of cash inflows and the present (discounted) value of cash outflows.
[69] ECD stands for "Expected Cost of Development", an estimate of development costs in terms of labour, chemicals and equipment.

exacerbates the risk to fall in a "competency trap" where past successes and existing technological trajectories create inertial pressures that prevents the exploration of new technological domains (Bierly & Daly, 2007).

In addition, investing resources before market approval raises the overall risk profile of the company by increasing potential losses in case of failure. It makes the company more fragile, especially in a dynamic environment and highly competitive industry as it has been proven that injecting uncertainty to a fragile system increases the likelihood of negative outcomes (Taleb, 2012). Figure 3.33 illustrates this point.

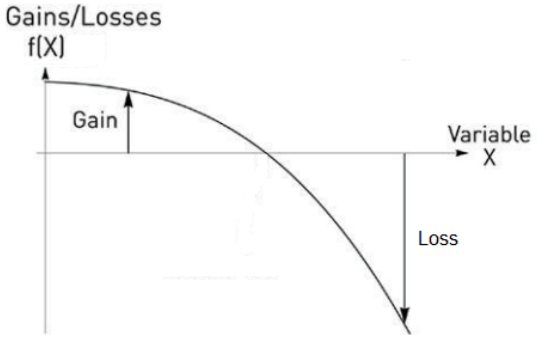



*Figure 3.33: Evolution of payoffs from exposure to a given variable for a fragile system*
*Fragile systems display a concave response to a change of variable which results in higher potential losses than potential gains (adapted from Taleb, 2012, p.273)*

The firm therefore added another dimension to its exploration activities to get out of the innovator's dilemma and the spiral of commoditization, a dimension based on a different underlying logic, a dimension based on trial and error tinkering, in short: a dimension based on effectuation.

- Exploration following an effectual logic: As of 2012, the company's top management wanted to implement a customer-centric new strategy. In concrete terms, the firm decided to improve customer reach by increasing the sales force as well as the technical resources in charge of sales support and to instate a fomalized system of Technical Support Requests (TSRs) helping the sales people delineate customers' needs or problems and leverage technical resources to work out solutions. The company also acquired at this time a research center fully equipped with applicative equipment allowing to reproduce most its customers' processes so that it could test products and develop new solutions for and with them. Finally, to

help the commercial staff prospect new markets and approach new targets, Galactic invested in a Customer Relationship System (CRM) and in a global new products database tracking trends in product innovation and retail successes in consumers packaged goods worldwide. The purpose was, after improving customer reach, to use the company's knowledge in its field of expertise to design solutions better fit to customers' needs or better adapted to new consumers trends[70]. This logic profoundly reversed the underlying dynamic of the company's exploration initiatives and called for a radical change of mindset, not only among the sales force, but within the whole company. The point was then to have the customer as the centre of attention and not only the product anymore. Of course, financial and human resources had to be committed to such a change but the risk profile was by far reduced since many more projects of smaller size were soon started with existing customers but also with new prospects (46, 53 and 87 projects respectively in 2013, 2014 and 2015 in Europe alone). So, thanks to the multiplication of projects, the investment per project became relatively low whereas the probability of having a successful one increased sharply[71]. Said differently, losses were limited and potential gains became higher which forms a positive asymmetry typical of trial-and-error tinkering and characteristic of antifragile cases (Taleb, 2012, p.236). In Taleb's framework, such an effectual logic offers optionality. With low cost mistakes, known maximum losses and large potential payoffs, the distribution of these potential payoffs forms a convex function which means that an increase of uncertainty results in a higher likelihood of positive outcomes (Figure 3.34).

[70] This initiative was resting on different pillars that the company identified as being high potential market trends in adequation with its true skills (food safety, clean labelling, health improvement, cost reduction and green chemistry).

[71] Taleb (2012, p.230) tells us that "payoffs from research (…) follow a power-law type of statistical distribution, with big, near-unlimited upside but, because of optionality, limited downside. Consequently, payoff from research should necessarily be linear to number of trials, not total funds involved in the trials. (…) It means the right policy would be what is called "one divided by n" or "1/N" style, spreading attempts in as large a number of trials as possible (…)."

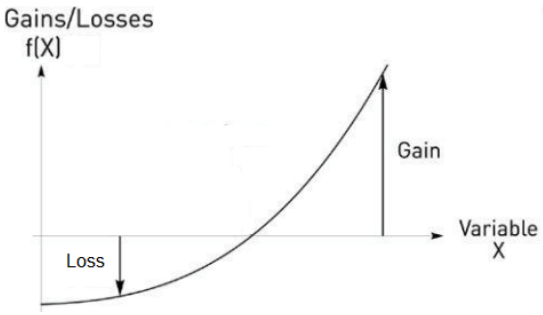
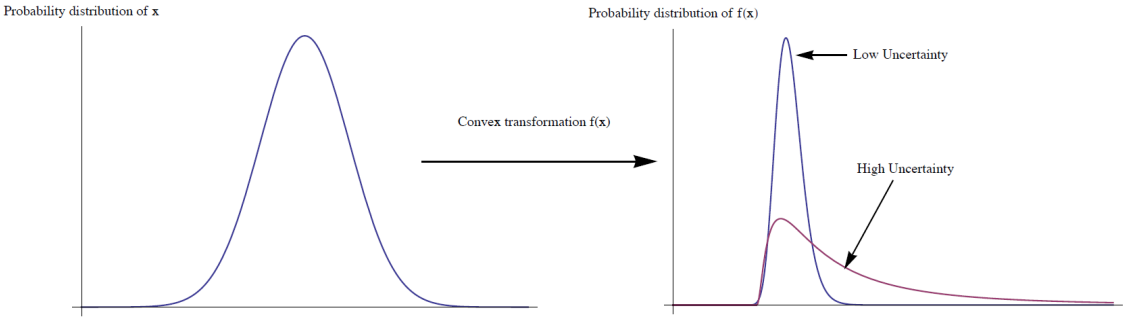



*Figure 3.34: Evolution of payoffs from exposure to a given variable for an antifragile system*
*Antifragile systems display a convex response to a change of variable which results in higher potential gains than potential losses (adapted from Taleb, 2012, p.273)*

> Another interest of this effectual approach based on multiplying trials with many prospects in many markets without preconceived goal instead of forecasting developments to be made on the basis of in-depth market surveys is precisely that one does not have to understand all characteristics of these markets *ex-ante*[72]. This is particularly useful for medium-sized companies who do not have and cannot afford marketing experts in all domains while they want or need to enter new market fields.

It is important to note however that, during the Contemporalis period, both causal and effectual logics were followed simultaneously by different teams as they require different skills but also because they address different timeframes. Indeed, customer-oriented ("outside-in") projects have to be conducted in a timely manner as, in general, customers cannot wait ages to find solutions to their problems or pressing issues. Those projects are therefore imbedded in short

[72] Here again, Taleb (2012, p.439) gives us the theoretical background behind this observation with what he calls "convex transformation" of "robustification rather than forecasting": if *f(x)* is the exposure to the variable *x* or the payoff from *x*, we can become antifragile to *x* by modifying *f(x)* without even understanding *x*. In plain English, we can benefit from the positive changes of a market (for instance) without knowing the characteristics of this market by improving our exposure to the upsides of this market and limiting our exposure to its downsides. We claim, as our results show, that this is what can be expected from an effectual approach.




The figure above indicates how an antifragile system gains from uncertainty. The distribution of *f(x)* benefits from uncertainty as the more uncertainty, the more positive outcomes (fatter tail). The negative events are of no significant harm.
[Copyright 2012 by N. N. Taleb. Retrieved from http://www.fooledbyrandomness.com/ConvexityScience.pdf]

development cycles usually focused on product/application associations and conducted by market development teams working closely with their respective sales teams. Conversely, strategic R&D projects ("inside-out") with much longer development cycles are generally oriented towards process/product associations; they form what the company calls "backbone projects", much more limited in number and conducted by autonomous R&D teams. Figure 3.35 shows a slide summarizing this dichotomous organization as presented in various conferences from 2014 to 2016.

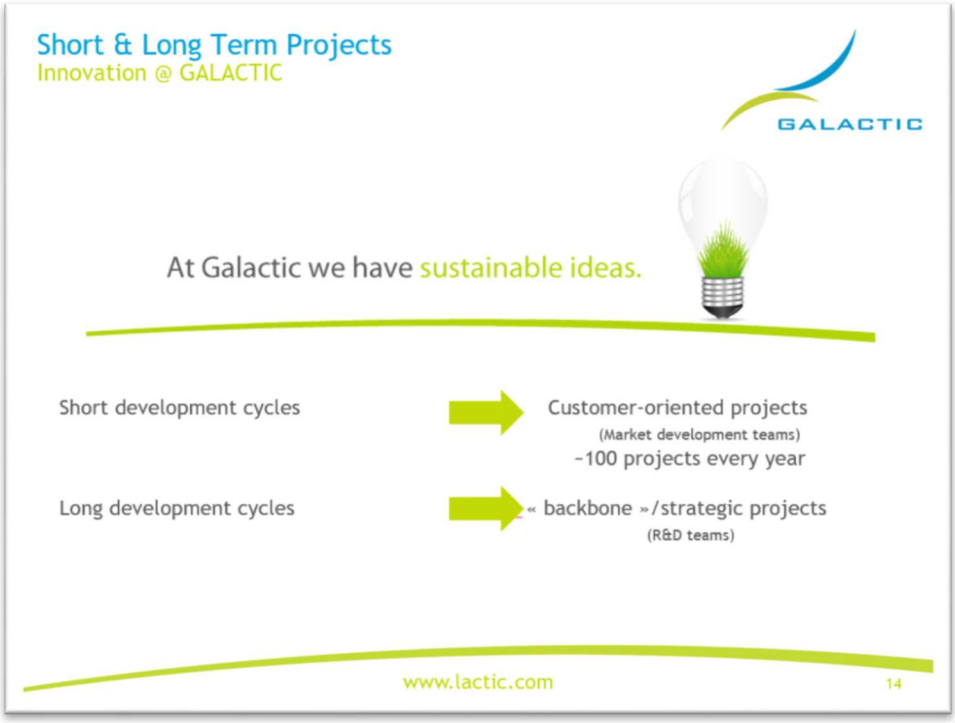



*Figure 3.35: Short and long terms projects within Galactic*
*(extract from presentations displayed in various conferences, a.o.: "20 years of bio-based innovations: an example of successful bio-business in the real economy", 5th CINBIOS Forum for Industrial Biotechnology & the Biobased Economy, Mechelen, November 7, 2014; "White Biotech and Real Economy", Gembloux, May 13, 2016)*

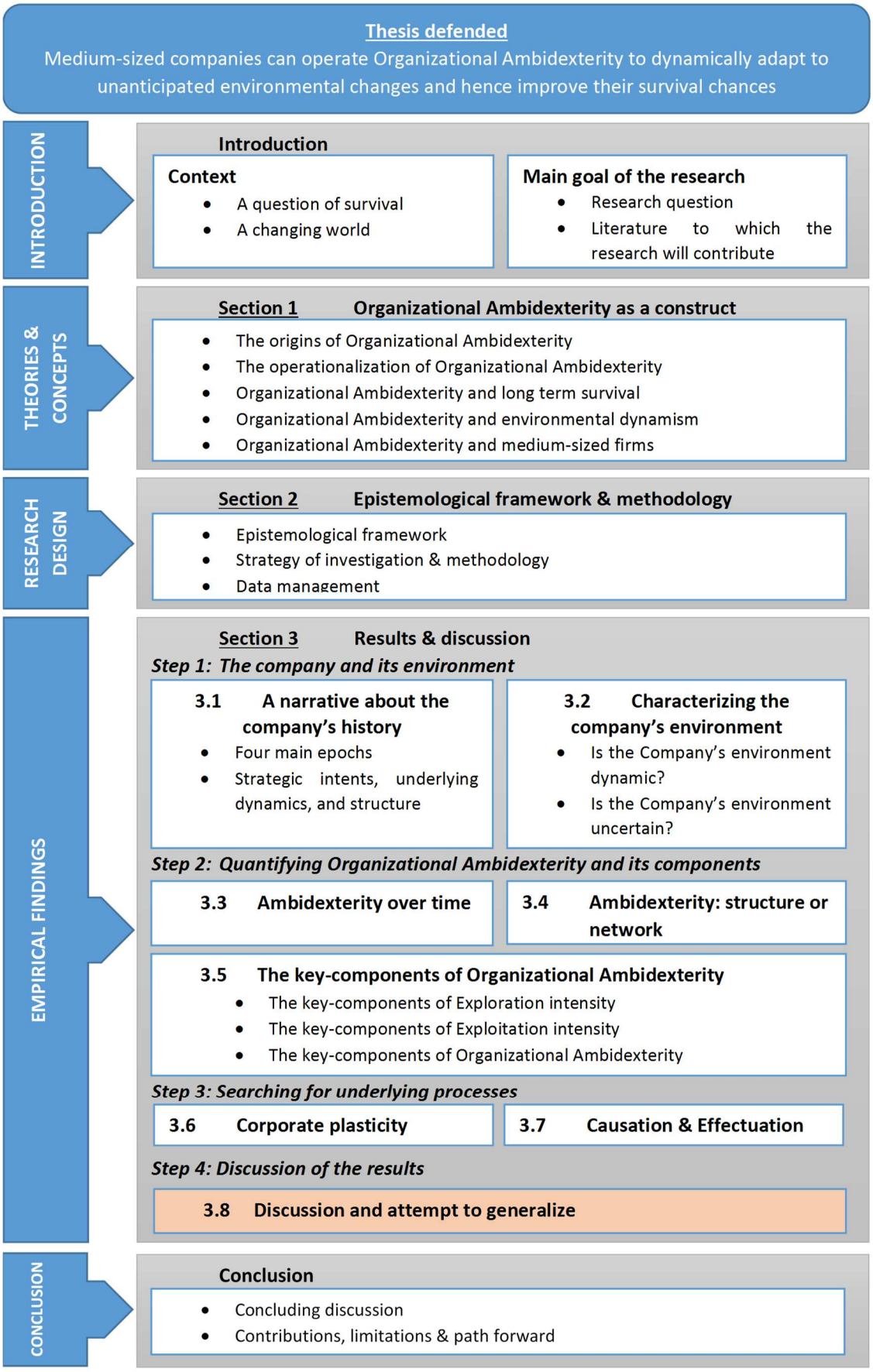
We therefore infer that exploration can be conducted in either a causal or an effectual mode.

As a conclusion of this chapter, our analysis shows that **effectuation can be of exploratory or exploitative nature**, and that **exploration may involve effectual as well as causal underlying processes**. These findings, which to our knowledge have never been formally put forward, highlight subtle differences that may exist between March's exploration-exploitation framework and Sarasvathy's effectuation-causation one.

In addition, we highlight the similarities between Sarasvathy's effectuation theory and Taleb's antifragility concept. More precisely, we underline that effectuation may be an efficient robustification method for medium sized companies evolving in highly dynamic industries and unpredictable environments.

Overall, we show in this section that **organizational ambidexterity can be achieved** in medium-sized companies **by**, among other ways, **nurturing a customer-centric effectual approach** thanks to the proper allocation of resources and the right alignment of organizational sub-structures for projects belonging to short development cycles **in combination with maintaining** a strict stage-gate system resorting to **a classical causal logic** for projects imbedded in long development cycles. We argue that the integration of an effectual logic to the company's practices creates an on-going opportunity for variation, selection and retention of new knowledge and new capabilities. The needs of financial and human resources to (partly) conduct innovation and market prospection following an effectual logic is mitigated on the longer run by the improvement (reduction) of risk profile associated with such an approach when compared to a causal one based on a limited number of pre-concieved, rather expensive, goal-minded projects.

## Step 4: Discussion



## 3.8. Discussion and attempt to generalize

> *"Since the number of organizations is limited and much smaller than the number of possible situations and outcomes, it is very unlikely that two similar situations across organizations will ever be observed. As a consequence, no cause in one organization can have a same effect in another organization."*
>
> (Forgues & Thietart, 1995, p.27)

Contingency theorists teach us that organizations are open systems evolving in environments which have their own dynamics and with which a continuous exchange of information, resources and energy takes place (Thompson, 1967). Consequently, they are not all equally affected by environmental changes. Some organizations may suffer more than others which have better capabilities to generate sufficient slack resources (financial and human) during the implementation of responses to discontinuities. At first sight, size matters in these turbulent circumstances and big corporations might be better equipped to face this challenge than medium-sized companies which are generally much more resource-constrained (Berends, Jelinek, Reymen, & Stultiëns, 2014). Conversely, medium-sized companies differentiate themselves from larger organizations by greater agility, increased flexibility, what we have called a better "plasticity".

These considerations are very general and it seems obvious that the most appropriate form of organization to deal with the volatility of the environment depends not only on the characteristics of the organization itself but also, precisely, on the multiple characteristics of this environment. However, as these characteristics are generally (and increasingly) difficult to identify (and even more to anticipate), it is advised to establish organizational forms that protect organizations from environmental changes (Nonaka, 1988). In Taleb's terminology (Taleb, 2007a, 2007b, 2012), it is about making organizations more "robust" to changes or, even better, to render them "antifragile" in the sense that they would not only resist environmental volatility but, eventually, benefit from it. Indeed, an increase in volatility widens the world of possibilities and multiplies the number of opportunities. This said, it is not only a matter of putting ourselves in a position to seize future opportunities but also to reap in the present the fruits of the past. This is precisely the object of organizational ambidexterity (March, 1991).

We recognize that the processes employed by Galactic, our unit of analysis, to build an ambidextrous company can be unique and that raises the question on how should unique

phenomena be studied and generalized. In first instance, our analysis of the Galactic case can be seen just as a passionate testimony of some "tricks" to balance the exploration and exploitation needs of a mid-sized company in an industry with a high technological content, in a particularly dynamic context, and a generally negative outlook over time. However, in single cases such as this one, it is the underlying processes that are often generalizable and not the obvious unique phenomena (Tsoukas, 1989), therefore the aim of our research to identify some processes and mechanisms underlying ambidextrous practices. In this dissertation, we put emphasis on "analytical generalization" as opposed to the traditional "statistical generalization" (Yin, 2009). According to Yin (1994) statistical generalization, often used in studies conducted from a positivist or post-positivist standpoint, is about making inferences about a population (or "universe") using empirical data collected on a sample as representative as possible of this population. This approach is generaly accepted "because research investigators have ready access to formulas for determining the confidence with which generalizations can be made, depending mostly upon the size and internal variation within the universe and sample" (Yin, 2009, p.30). In contrast, in analytic generalization, a previously developed theory (here the organizational ambidexterity framework) is used as a template with which to compare the empirical results of the case study.

We have pointed that our unit of analysis is evolving in a dynamic and unpredictable environment typical of, but obviously not limited to, high technology industries. In addition to being dynamic, the surroundings were largely negative and even worsening for most of the firm's lifetime because of the incremental evolution of some environmental caracteristics as well as the more erratic pattern (exogenous shocks) of others; and the amplitude of the cumulated changes increased over the years indicating a growing volatility around the company's activities. Farjoun (2007) distinguished two polar types of industry contexts: an *evolutionary context* where the environment is stable; and a *perpetual change context* in which the environment changes continuously. He also considered two intermediate and integrative contexts: a *punctuated equilibrium* where stable periods alternate with periods of flux and exogenous discontinuity; and a *differential change context* characterized by the coexistence of continuity and change triggered either by exogenous sources or by rapid intense rivalry. Our findings indicate that the biotechnology industry in which the company is evolving is primarily lodged in a perpetual and differential change context which is, in our eyes, the case of most industries operating at an international level in the current globalized and interconnected world. The growing uncertainty surrounding the company was not attributable solely to external

factors but also to its expansion in new domains, i.e. new geographic areas and new markets; a situation that increased dramatically its exposure to new environmental components. Logically, the more a company expands in a dynamic environment, the more it becomes exposed to the effects (positive or negative) of this uncertain environment as some environmental changes cumulate their effects whereas others, impacting the company in opposite directions, neutralize or mitigate their effects. We have posited that a growing exposure to an increasingly volatile environment make the conditions under which ambidexterity takes on its full dimension (the fourth quadrant of Figure 3.12). Indeed, in peaceful times of relative stability, companies may either opt to exploit niche markets or to explore new lines of business (Lewin, Long, & Carroll, 1999) and benefit from adaptive learning (Cyert & March, 1963), but they should instil more exploration as environmental dynamism increases, and by doing so, strive for more balance between exploration and exploitation. The more dynamically competitive the environment, the more organizations may have to pursue both activities simultaneously and become more ambidextrous (Auh & Menguc, 2005; Jansen et al., 2006, 2005; Raisch & Birkinshaw, 2008). Following this line of thinking, we can expect that infrequent environmental changes with substantial amplitude (a situation that corresponds to Tushman and Anderson's (1986) punctuated equilibrium), or even more chaotic situations owing to exogeneous shocks, equally call for ambidextrous capabilities to be developed. These conditions are however not specific of the industrial (white) biotechnology and can most probably be extended to other high technology industries such as the other fields of biotechnology (red, green and blue), pharmaceuticals, aircrafts and aeronautics, telecommunications etc… This supports the generalization of our results at least to medium-sized companies operating in high-technology industries at a global level (multiple geographies).

Despite increasing exposure to a dynamic, unpredictable and globally negative environment, the company has succeeded in developing and organizing itself, sometimes to seize new growth opportunities, sometimes to survive deep changes in the context in which it was operating. These changes have resulted in profound modifications in the company's strategy (a period of structuration followed by a period of internationalization itself followed by a period of specialization); its structure (centralized, decentralized and then re-centralized); and its underlying business dynamics (from products to customers when the products where the focus as often in engineer-driven/technology-minded organizations, until a point where customers became the focal point and the central dynamic was inversed from customers to products). Apparently, this echoes quite well what O'Reilly and Tushman (2007, p.10) described as the

conditions for survival: ”From a strategic perspective, achieving long-term success requires that firms possess not only the operational capabilities and competencies to compete in existing markets, but also the ability to recombine and reconfigure assets and organizational structures to adapt to emerging markets and technologies”. In this paper, the authors make the link between these (dynamic) capabilities and organizational ambidexterity.

Compounding an index based on 12 parameters to measure organizational ambidexterity has allowed us to track its evolution over time in a new and, to our knowledge, unprecedented fashion. There is a relative consensus among prominent scholars to seek for more qualitative, in-depth studies with a dynamic perspective and following a longitudinal survey design as time helps separe noise from real meaning. Raisch and Birkinshaw (2008) for instance have pointed the need for new research that investigates “how organizations adapt and develop ambidextrous structures, contexts, and leadership patterns over time to respond to varying boundary conditions” (p.401), and they claimed that “such a process perspective requires a methodological shift in organizational ambidexterity research”. While observing that existing empirical studies mainly rely on cross-sectional surveys measuring ambidexterity and environmental conditions with data on manager’s perceptions, they propose (p.402) to “focus on the actual realization of ambidexterity by deploying archival data on exploitative and explorative moves that have been implemented” in order to contribute to the emergence of a process perspective of organizational ambidexterity. By doing so, we saw clearly that the company, deeply rooted in exploration at the beginning of its activities, had quickly put in place exploitation activities while maintaining a high level of exploration. Ambidexterity was reached in a relatively stable manner about 5 years after the firm inception and was maintained thereafter by balancing relatively high levels of exploration and exploitation at all times, despites many environmental hurdles, which lends credence to the concept of dynamic, also called adaptive, ambidexterity (Laplume & Dass, 2009; Luger, 2014). This said, there seemed to be an excess of exploration over exploitation activities in average over the whole period. This somewhat contradicts O’Reilly and Tushman (2007) who claim that the tradeoffs necessary to balance exploration and exploitation are “most often tilted toward exploitation where positive local feedback in the form of customer demand and profits produce path dependence” (O’Reilly & Tushman, 2007, p.10). March (2003, p.14) also argued that “established organizations will always specialize in exploitation, in becoming more efficient in using what they already know”. These sources, however, are generally expressed; they don’t pinpoint particular industries or contexts. Piao (2014) is more specific in her survey of 98 firms in hard disk drive industry

(HDD). She reports a positive effect on organizational longevity of a form of skewed ambidexterity in the sense that, according to her, firms need to find the right balance between a high intensity of exploitation and a moderate intensity of exploration in order to benefit from the strong main effects of both dimensions while avoiding overly strong interactions and the tensions a high intensity of both can create. This is rather surprising for such a high-tech sector as the HDD industry. Indeed, our results also indicate a positive effect of organizational ambidexterity on the survival of the company, but with a different type of ambidextrous skewness: an overall tendency to favor a slight excess of exploration intensity over exploitation intensity (our ambidexterity score remains in exploration territory most of the time). In view of this, we would think that high-tech industries such as biotechnology but also, we believe, industries such as aeronautics or telecommunications, because of their innovation-driven culture, will naturally have a greater propensity to explore new areas, even if they nevertheless manage to pay sufficient attention to exploiting their existing ones. This is probably even more so for small or medium-sized companies active in pharmaceutical and biomedical sectors which are often the result of spinning off universities or spinning out larger companies, hence starting as pure R&D companies.

As a matter of fact, as Sidhu *et al.* (2004) pointed out, a high environmental dynamism such as in these high technology industries leads to expanded search for information in order to reduce managerial uncertainty. Our results support Keller and Weibler (2014) who showed that environmental dynamism is positively related to engagement in exploration. These results tend to support the assertion that turbulent environments favor organizations forms that are quick at taking advantage from "new opportunities and the appearance of new habitats" (Hannan & Freeman, 1984, p.163). By experimenting with different types of innovations, the firm creates a "catalogue of responses to different and, as yet, unknown demands from the competitive environment" (Forgues & Thietart, 1995, p.23). Note that in addition to promoting the engagement in exploration, environmental dynamism has been found to also impact the efficiency of the exploration initiatives by moderating positively the relationship between exploratory innovation and financial performance (Jansen et al., 2006). In other words, organizations pursuing exploration in dynamic environments see their financial performance improve, whereas organizations focusing predominantly on exploiting existing products, services and markets in such changing environmental conditions are likely to whitness a decrease of their financial performances (Jansen et al., 2006). Refining this empirical observation with an agent-based simulation model, Kim and Rhee (Kim & Rhee, 2009) predict

that “exploitative orientation would perform better when the environment changes with low frequency and small amplitude” (p. 15) and that “exploratory orientation would perform better when the environment changes either with low frequency and large amplitude or with high frequency and small amplitude” (p.16).

The fact that Galactic favors exploration (although maintaining a high intensity of exploitation) is only an average observation over its 25-year history. Looking more closely at the evolution of the exploration-exploitation mix in regards to the company's environment, we see that when the company’s environmental conditions are relaxing, the firm is progressively increasing its focus on exploiting its existing activities, heading to a good balance between exploration and exploitation. The lowest ambidexterity score, deeply ankored in exploitation, was reached a couple of years after the environmental conditions were at their best which indicates that the firm needs about this time (two years) to reorient its strategy and activate new levers. Indeed, environmental changes impact the organization in a direct way (e.g., by adapting pricing policy or shifting sourcing patterns) but also indirectly through learning (March, 1991) and experience (Tushman & Romanelli, 1985), both processes which are not immediate and which take time. Conversely, when the environment is deteriorating and margins are under pressure (rising costs, lower profitability on exports due to less favorable exchange rates), the management puts gradually the focus on exploration in a quest for new products and new markets delivering higher margins or less exposed to exchange rates. Again, this observation gives credit to Keller and Weibler (2014) as well as Sidhu *et al.* (2004) who showed that environmental dynamism is positively related to engagement in exploration, as explained above. Kauppila (2010, p.285) relayed the same: “Turbulent environments call for adaptive structures and innovation-focused strategies that contribute to increased exploration”. This is however particularly counterintuitive for most managers to proactively stress exploration in difficult economic times and declining contextual conditions as they might be tempted to emphasize exploitation in this situation to maintain liquidity and preserve financial means, eventually blaming the economic conditions to justify downsizing and lay-offs (Walrave and colleagues, 2012).

In addition to measuring ambidexterity and its evolution over the company's 25 years of existence, our research aims at identifying “how can organizational ambidexterity be operated by medium-sized companies”; hence it tries to unveil possible underlying mechanisms that support its implementation. The question can be analyzed from two angles: a perspective internal to the company, which consists of seeing how it organizes its activities in terms of *structure* to support exploratory and exploitative activities, and a perspective external to the

company, which consists in defining how it creates contacts and *partnerships* to balance its exploratory and exploitative initiatives, knowing that both perspectives are not mutually exclusive and may complement or even improve one another (Kauppila, 2010).

Duncan (1976) suggested the use of "dual structures" to accommodate simultaneously the conflicting alignments needed for efficiency and innovation. This type of organization, often named "structural ambidexterity" (Tushman & O'Reilly, 1996), calls for a structural separation between activities aiming at exploiting and exploring. The time evolution of our indicator of structural ambidexterity showed an excess of separation (managerial decisions and actions are limited to one department) over collaboration between departments throughout the whole company history. Following Schmitt, Probst and Tushman (2010, p.143), we can think that it helps "cross-fertilization between units and prevents cross-contamination, as explorative units are protected from exploitative units' routines and established processes. (…) Separation evades the impending threat of having to sacrifice efficiency for innovative activities and vice versa" (p.143). This can be seen as particularly true for high-tech firms where investment in research and development is substantial (this kind of companies display the highest R&D intensity in terms of expenses compared to sales according to OCDE) and must be kept at a high level to avoid becoming obsolete and being surpassed by contenders. Indeed, separation is particularly efficient to create new knowledge in general and promote radical innovations in particular (Benner & Tushman, 2002).

A more detailed analysis of the evolution of organizational ambidexterity during the different periods of the company's life shows fluctuations between autonomous and collaborative actions. We name "autonomous actions" the ones that are taken by one single department whereas "collaborative actions" refer to the course of actions shared between two or more departments of the company. In the early years prior to the company's inception, there was no collaboration at all as the company-to-be was actually still a separated department of another corporation. But, right after the company's creation, departments commenced to collaborate and the structural ambidexterity score started to oscillate around a zero value indicating a relative balance between autonomous and collaborative actions which gives credit to Khanagha, Volberda and Oshri (2014) who concluded that there is "a need for recursive iterations between different modes of separated and integrated structures" (p.322). The creation of autonomous subsidiaries overseas started with sharing knowledge and transferring technologies which imposed collaboration between the departments of the mother company and the newly incepted ventures. However, as the subsidiaries progressively gained operational autonomy, they started

to explore their own markets and to develop new knowledge on their own which led to a disconnection between the departments of the different entities. This movement was supported and probably even amplified by the decentralization of decision-making structures that was in place at this time, but the suddenty of this reversion must have been rooted in some external event. Indeed, when the reversion happened in 2006, there was no trace of an intended inflection of the company's strategy. It was right in the middle between the two main strategic inflection points clearly identified and acknowledged by the company's management (2001 and 2011). Therefore, the disruption in structural ambidexterity pattern seems totally disconnected from the company's strategy and independent from the overall strategic intent developed and enforced by the company's top-management at the time. The sudden bifurcation of structural ambidexterity, from mostly collaborative to mainly separated, was apparently not premedited by the management but was a spontaneous reaction to exogenous factors that were not anticipated. As a matter of fact, the change in structural ambidexterity from collaboration to separation coincides with the time when the company shifted attention from exploitation to exploration, which was an immediate reaction initiated by a rapidly worsening environmental context. We therefore infer that, at least in this case, a negative and deteriorating environmental context triggered a deep modification of the decision-making pattern in favor of more exploratory initiatives which in turn resulted in enhanced separation between departments as this is apparently the way the company conducts exploration. Indeed, our results show that, at Galactic, exploration is largely an autonomous process whereas exploitation is a collaborative one in the sense that there is a clear tendency to have a higher exploration intensity when departments are working independently while, conversely, the exploitation intensity increases when several departments are working together. Figure 3.36 summarizes the causal chains that seem to emerge from our findings.

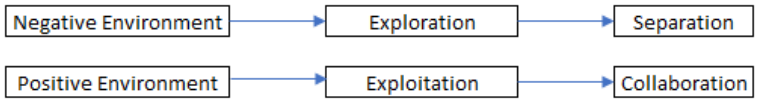



*Figure 3.36: Simplified causal chains linking the environment to the collaborative or separated nature of structural ambidexterity*

This gives credit to Walrave et al. (2012) who found that a negative environment such as a recession requires more attention to exploration, while a positive one demands more attention to exploitation.

This said, the impact we have observed of structure on exploration and exploitation intensities, although true throughout the company's history, was stronger at the beginning of the company's activities. Separation or collaboration between departments did not seem to influence largely the level of exploration and exploitation when the company reached a certain level of maturity. This observation suggests that managers who want their organization to reach a certain level of ambidexterity should pay more attention to structure in the first years of existence of their business, to allow exploratory projects to be conducted in clearly defined teams operating autonomously but, at the same time, to establish bridges between teams so that the exploitation projects can be realized in a participative way. Whether this causal chain can be generalized to all medium-sized firms operating in dynamic industries remains however to be investigated on a larger sample of companies.

While structural ambidexterity is looking at how exploration and exploitation activities are conducted from a perspective internal to the company, network ambidexterity adopts an external perspective by focusing on how the firm forges exploratory or exploitative cooperative links with its business environment. Organizational ambidexterity is likely to require interorganizational activities as they enable both exploitative and explorative knowledge processes (Raisch et al., 2009). Several studies suggest that exploitation and exploration occur both within and between organizations (Holmqvist, 2004; Raisch et al., 2009). In our terminology, exploratory partnerships are those that focus on value creation associated with upstream activities, and exploitative partnerships focus on creating value that is generally related to downstream activities in the value chain (Lavie and Rosenkopf, 2006; Rothaermel and Deeds, 2004). The link between partnerships and organizational ambidexterity, already highlighted by various authors such as Kauppila (2010) for instance, is clearly reflected in our results. As a matter of fact, increasing the number of partnerships of exploitative nature helped the company to balance the high number of exploratory alliances already in place since the beginning of its activities, as is common with high technology companies for which a high intensity of R&D is customary. The ability to form alliances of exploratory nature as well as alliances of exploitative nature is highly impacting exploration and exploitation intensities, respectively; and our results indicate that holding both simultaneously greatly improves the ambidextrous character of the company.

Our findings also indicate that small companies which are not in a position to allocate separate resources to exploration can nevertheless endeavor towards organizational ambidexterity by developing exploratory and exploitative partnerships. We show that network ambidexterity impacts organizational ambidexterity to a larger extend than structural ambidexterity. This observation may help prioritizing actions when it comes to advising managers. We think it is of particular interest for small and medium enterprises that do not necessarily have the ability, the skills or the resources to work on both aspects simultaneously. This resource-based view abounds in the direction of several authors (Lavie & Rosenkopf, 2006; Rothaermel & Deeds, 2004) who suggested externalization and outsourcing as a way of resolving the paradoxical requirements of exploration and exploitation. Especially noteworthy in this context is the study by Powell, Koput and Smith-Doerr (1996) on interorganizational collaboration in the field of biotechnology arguing that "when the knowledge base of an industry is both complex and expanding and that the sources of expertise are widely dispersed, the locus of innovation will be found in networks of learning rather that in individual firms" (p.116) because "sources of innovation do not reside exclusively inside firms; instead, they are commonly found in the interstices between firms, universities, research laboratories, suppliers, and customers" (p.118). This justifies that a medium-sized company active in a very dynamic context like Galactic turns outwards through research partnerships to support its innovation even if it encourages an exploration activity based on the autonomy of its departments (separation). And if companies look outside for new knowledge and innovation, they also engage in partnerships that are motivated by exploitation (Lavie, 2006; Lin et al., 2007) to increase the efficiency of resource utilization by means of outsourcing or contract manufacturing (Kauppila, 2010).

Eventhough the positive impact of external networking and partnering on organizational ambidexterity appears greater than the one of structural ambidexterity in our study and that resource-constrained companies may not have the luxury to conduct both at the same time, Kauppila emphasizes that making use of external partners may not be a sufficient condition for ambidexterity "because it is not the network but the firm that balances exploration and exploitation" (Kauppila, 2010, p.307). The author advises companies to be extroverted in seeking resources and knowledge outside the firm and, at the same time, to be introverted in balancing exploration and exploitation within the firm. Interestingly, our study shows that the elements most impacting exploration *or* exploitation are not necessarily the ones most influencing organizational ambidexterity which means that, in their quest for ambidexterity, managers should pay attention to different variables whether they want to promote exploration,

improve exploitation, or balance both ambidextrously. In other words, the implementation of harmonious and effective ambidextrous management should not simply focus on maximizing exploration and exploitation (the conceptualization of exploration and exploitation as orthogonal dimensions that we had called "Appolo & Dyonisos") but should also activate certain levers whose combination brings effects on ambidexterity greater than the sum of their effects on each of its components, i.e. exploration and exploitation. As a matter of fact, the analysis of the documentation that served as the basis for the writing of the company's history has highlighted two of these levers that appear fundamental enough to shed light on possible processes underlying organizational ambidexterity.

The first lever that we have identified as particularly influencial for ambidexterity is based on balancing attention to efficiency and flexibility, a tradeoff already outlined by several scholars such as Adler and colleagues (1999), Ebben & Johnson (2005) and Xie (2012). Nurturing existing capabilities and developing new ones ultimately aims at improving the ability of the organization to adapt to environmental changes; hence to be flexible (Ashby, 1962; Nonaka, 1988; Volberda, 1996) without losing on focus and efficiency. This “corporate plasticity” that we defined as the bundle of all types of organizational responses an organization may display to environmental changes (phenotype variations) without altering its profound makeup (its genotype) came out of the narrative of the company's history as a key-charasteristic of Galactic as an organization, not only by the sole geographic mobility of its management over different continents, but more specifically by the different types of responsibilities held concurrently by the senior managers across different group entities. What is interesting here is not that people held various responsibilities in a given firm, which is very common in medium-sized companies, but that these very different responsibilities were held simultaneously; what the managers of Galactic refer themselves to as having “multiple hats”. Note that the ability to be “multitasking” is an important attribute of ambidextrous managers as per some scholars (Gibson & Birkinshaw, 2004; Mom, van den Bosch, & Volberda, 2009). This kind of organization based on a closely intertwined set of responsibilities among the top-managers facilitates knowledge transfer from the core to newly created entities and between departments but also opens up the senior management to new opportunities, new perspectives and, in turn, ultimately, helps acquire new knowledge. It allowed each of the people concerned to be part of new ventures and new developments at the same time as they kept a role in the company’s core activities. In this, the company follows the recommendation of O’Reilly and Tushman (2004) who proposed as “integrating mechanism” (Markides, 2013) that the parent company and

subsidiary units share common managers. Our observation also gives credit to Mom, van den Bosch, & Volberda (2009) who found that both the participation of a manager in cross-functional interfaces and the connectedness of this manager to other organization members positively relate to ambidexterity at an individual level, and by way at the organizational level.

Large firms typically have excess resources that are seen as benefits for implementing organizational ambidexterity (Atuahene-Gima, 2005; Lubatkin et al., 2006) and to cushion organizations from external shocks (Meyer, 1982), but they often lack corporate plasticity because of heavy structures and bureaucracy (Hannan & Freeman, 1984; Miller & Friesen, 1978). They are sometimes called "mechanistic" structures (Burns & Stalker, 1961). Medium-sized firms have fewer hierarchical levels and their managers are more likely to play both strategic and operational roles (Lubatkin et al., 2006; Raisch & Birkinshaw, 2008). Consequently, these companies have no choice but to concentrate different activities on fewer people, which obliges them to an "organic" mode of operation that inevitably contains the germs of plasticity and organizational ambidexterity. Burns & Stalker (1961) have argued that such an "organic" system is more efficient when the firm is facing turbulent conditions, while a "mechanistic" management system works better when the environment is stable. Some authors argued that organic structures are associated with exploration whereas mechanistic structures are better fit to support exploitation (Brown & Eisenhardt, 1997; He & Wong, 2004; Lewin & Volberda, 1999). Our results seem to support a hybrid form that combines an organic structure at the management level with a more formal, mechanistic, structure at the execution level. Indeed, Galactic favors separation between departments to carry out its exploration activities, at least internally, while the exploitative activities are essentially conducted in a participative way which suggests that the organic structure at the top of the company was partially offset by a more mechanistic structure within and between departments. Indeed, to simultaneously balance its exploratory and exploitative activities, the top management relies on subsidiaries and departments operating in silos with clearly defined responsibilities. Adler et al. (1999) have already observed that achieving both flexibility and efficiency simultaneously calls for sharing the tasks between a group of people taking on non-routine tasks following an organic structure and another group of people performing routine tasks under a more mechanistic and streamlined structure.

As already pointed, this type of joint organization is presumably specific to medium-sized enterprises. Indeed, very small firms do not have ordinarily enough hierarchical levels to allow different types of organization between senior management and the level of execution. Senior

executives are themselves heavily involved at the operational level and their organizations can not afford to create structurally separated structures or focus their teams on exploration only. Conversely, large firms are often mechanically organized and their size requires specialization of their subunits. Medium-sized companies on their side are found at the intersection of these two extremes: they are large enough to organize themselves structurally, and small enough for their senior management to stay close to the operational core of the company (Lubatkin et al., 2006). These elements lead us to concude that medium-sized firms can nurture their corporate plasticity and become ambidextrous by adopting an organic structure of management at the top of the company based on different sets of responsibilities held simultaneously by a limited group of flexible managers, and by combining this organic structure at the top with a more structured mechanistic type of organization at the execution level.

A second lever that emerged from our study as contributing positively to organizational ambidexterity whithout strongly impacting specifically exploration or exploitation lies in the pursuit of intuitive projects in parallel of well planned ones. In making decisions, managers depend not only on pure and indisputable facts but rely also on intuition and judgment. Effective forecasting helps reduce the decision space in which to exercise intuition (Saffo, 2007). However, there are two ways to start projects and take decisions: either by conducting *ex ante* an in-depth evaluation of possible outcomes (prediction, forecast) and by precisely planning each step of the process to reach the objective , or to make the decision based on intuition, heuristics, imagination and beliefs. Our results suggest that ambidexterity benefits greatly from having both approaches simultaneously, while the magnitude of their impact on exploration and exploitation intensities separately is rather limited. The effectuation theory, initially put forward by Sarasvathy in 2001 in her analysis of entrepreneurial decision-making processes (Sarasvathy, 2001a), discerns the two logics of decision-making mentioned here above and attributes names to those two approaches: *causation*, which assumes that the means are selected to achieve predefined goals; and *effectuation*, which postulates that the goals stem from the available means.

Therefore, decision-makers decide on what logic to apply in regards to their available means and we can assume that the more constrained the resources, the more inclined decision-makers will be to adopt an effectual approach for their new projects instead of a causal one, hence our interest in this theory in our study of medium-sized enterprises. Yet, decision-makers also decide on what logic to apply in regards to their perception of the future. If they believe that they are dealing with a measurable or relatively predictable future, they try to gather

information about this possible future and they design a strategy to address it in order to reach their predefined goal (causal approach). Conversely, if they think the situation is unpredictable, they most likely start experimenting through an iterative learning process (Argyris & Schön, 1978; Sarasvathy, 2001a) (effectual approach). The causal approach appears deeply rooted in plannification and forecasting which is notoriously inaccurate (Hogarth & Makridakis, 1981; Mintzberg, 1994) especially in unpredictable environments, hence our interest in effectuation as an approach particularly well adapted to companies operating in contexts of growing uncertainty. Berends and colleagues (2014, p.619) confirm that viewpoint and write "effectuation concerns action under resource constraints, a central concern for most small firms (…); and action choice under uncertainty".

In terms of generative mechanisms, causation follows a teleological model (Van de Ven & Poole, 1995; von Mises, 1962), a cycle of goal formulation, implementation, evaluation, and modification of goals based on what was learned; whereas effectuation resorts to an evolutionary model of repetitive sequences of variation, selection, and retention (Burgelman, 1991). Indeed, as Sarasvathy (2001a) explains, Weick's theory of enactment (Weick, 1979) considers that selection in organizations is the fact of decision-makers and not only of the environment and that this process is not always "causally prescribed" but may follow an effectual logic with the actors making sense of their actions retrospectively (Weick, 1995; Weick, Sutcliffe, & Obstfeld, 2005).

Galactic started its activities with an intuition-based effectual approach, which provides support to the entrepreneurial roots of the effectuation concept (Sarasvathy, 2001), but the company quickly had to activate causal processes based on forecasting to support its growth and development. In a capital-intensive industry characterized by long investment cycles like biotechnology, a certain amount of teleological plannification is mandatory. At some point though, a profound change in the firm's market environment triggered a drastic modification of its strategy despite the fact that the company was able to keep a high level of exploration and exploitation. Actually, the progressive commoditization of the company's core products made that it was innovating but still always within a narrow space around the same subjects. All producers in the same field were then focusing their efforts and resources on finetuning their processes and improving the existing properties of their products to keep their clientbase satisfied and gain a cost-based competitive advantage. Galactic was no exception. To escape this innovator's dilemma (Christensen, 1997), Galactic had to go beyond its usual crowd of customers and start approaching new prospects, in other markets, prospects with different

needs, prospects who were not using lactic derivatives and, eventually, who did not even have the need to. Understanding the needs and requirements of this new genera of prospects would most probably lead to the development of other products, not slightly different but radically different from the existing ones, by leveraging on the company's skills and expertise. It was believed that this new strategy would reduce the company's exposure to the commoditization process at play and help it bounce back with new solutions in new markets. The management resolved therefore to re-centralize the decision-making structures and to merge the sales, marketing and R&D departments with the view to narrow down the distance between the firm's scientists and the market, to better anticipate customers needs and to reduce the "time-to-market" for its innovations. As a matter of fact, the company adopted an effectual approach by bringing the customer at the center of its development, a change of mindset that is not that obvious for a company led by engineers who like to pay more attention to processes and technologies than to their users. Such a demand-based perspective is however rather typical of small to mid-sized companies operating in dynamic and concentrated industries (Xie, 2012) like industrial biotechnology. In this type of environment, a few dominating players coexist with small competitors but, because of resource constraints, SMEs cannot outperform their competition directly; they often turn their attention to their customers with the intention to create value for these customers and by doing so gain competitive advantage. Kim & Mauborgne (2004) have showed that competition may be irrelevant when firms offer something customers perceive to be valuable. However, customers' needs are not stable in dynamic industries, flexibility is critical for the firm to survive in this type of environment (Xie, 2012), and flexibility is precisely what differenciates small companies from larger ones. We have seen that the company put in place structures, organic at the top and mechanistic at the execution level, to stay alert and sufficiently flexible to avoid organizational inertia (Hannan & Freeman, 1984; Volberda, 1996), convergence (Miller, 1993) or cultural lock-in (Foster & Kaplan, 2001b).

Some scholars (Sarasvathy, 2001a; Wittbank & Sarasvathy, 2010) argued that exploration proceeds by an effectual logic whereas exploitation does by a causal one, making the link with March's framework (1991). In our view, this is too simplistic as our results show indeed a good correlation most of the time between both frameworks, ambidexterity and effectuation, but it is not always the case and there are periods where both frameworks clearly diverge from one another. Obviously, in some conditions, effectuation is of exploratory and exploitative nature at the same time and not, as often claimed, inevitably exploratory by essence. This is due to the

high number of smaller projects that follow a trial-and-error type of process, or a variation-selection-retention process if one prefers, that an effectual logic allows in contrast with the few well-thought about projects plannified in advance that are typicial of the causal approach. Some of these multiple projects opened in the marketplace simply mobilize existing knowledge (existing solutions to be applied to existing requirements), others trigger more trials and investigations and generate new knowledge (existing solutions to new requirements, new solutions to existing requirements, or new solutions to new requirements) which will be in turn used to expand the landscape of possibilities for the company. Note that Chandler, Detienne, Mckelvie, & Mumford (2011) also claim that seeking pre-commitments of customers is a dimension shared between effectuation and causation. Berends et al. (2014), on its side, argue that the combination of effectual and causal principles is archetypal of small firms as they leverage their characteristics and resources. In their investigation of product innovation trajectories, they pointed (p.616) among others traits that small firms "scoped innovations to be realizable with available resources; used external resources whenever and wherever these became available; prioritized existing business over product innovation projects;(…) iterated the generation, selection and mofification of goals and ideas; and relied on their own customer knowledge and market probing rather than early market research"; hence a bundle of exploration, exploitation and effectuation.

Similarly, our findings indicate that exploration can take on a causal logic as well as an effectual one, especially in regards to the timeframe of the developments at play. Short development cycles call for an effectual approach while long development cycles need a stricter causal approach, especially because of the higher costs linked to long developments. Another positive effect of an effectual approach of particular interest for small or medium-sized companies operating in turbulent market conditions is that thanks to the multiplication of projects, the investment per project becomes relatively low whereas the probability of success increases sharply ("the more you seed, the more you harvest", as goes an old saying). Therefore, losses are limited whereas potential gains increase which forms a positive asymmetry typical of trial-and-error tinkering and characteristic of antifragile cases (Taleb, 2012, p.236). In Taleb's framework, such an effectual logic offers optionality. With low cost mistakes, known maximum losses and large potential payoffs, the distribution of these potential payoffs forms a convex function which means that an increase of uncertainty results in a higher likelihood of positive outcomes.

In conclusion, one way to achieve organizational ambidexterity in medium-sized companies is to nurture a customer-centric effectual approach. To do so, the firm can create sub-structures to support multiple trial-and-errors projects directly involving customers in the short run while keeping at the same time a strict stage-gate system resorting to a classical causal logic for projects imbedded in long development cycles. Although expensive, this type of long-term exploration through separated sub-structures is nevertheless needed in high technology industries to support radical innovation (Benner & Tushman, 2002) and stay at the forefront of innovation because radical innovation requires conficting mindsets and processes that the organization must be able to support (Lewis et al., 2014). We argue that the integration of an effectual logic to the company's practices creates an ongoing opportunity for variation, selection and retention of new knowledge and new capabilities that helps the company to stay ambidextrous and makes it more robust to environmental changes. It offers the remedy longed for by Goodwin and Wright (2004) to counteract the absence of efficient method to anticipate rare events when they call for a "protection for the organization to benefit from the occurrence of negatively-valenced events whilst allowing the organization to benefit from the occurrence of positively-valenced events".

Overall, the integration of our observations, as diverse as they are varied, confirms that organizational ambidexterity is a rich, complex and multilayered concept that must be dynamically analyzed in the light of the company's available resources, especially when they are limited as for the majority of mid-sized firms; but also with regards to the surrounding environmental changes, especially when these are accelerating and becoming unpredictable. According to our results, balancing exploration and exploitation by purposedly combining causal and effectual logics at the execution level while maintaining a high level of flexibility at the management level to guarantee enough plasticity for the organization may lead to nurturing a certain level of organized chaos that generates an autogeneous order (Nonaka, 1988) allowing the organization to survive turbulent times or negative contexts for relatively long periods of time.

# Conclusion

**Thesis defended**

Medium-sized companies can operate Organizational Ambidexterity to dynamically adapt to unanticipated environmental changes and hence improve their survival chances

**INTRODUCTION**

**Introduction**

**Context**
- A question of survival
- A changing world

**Main goal of the research**
- Research question
- Literature to which the research will contribute

**THEORIES & CONCEPTS**

**Section 1 Organizational Ambidexterity as a construct**
- The origins of Organizational Ambidexterity
- The operationalization of Organizational Ambidexterity
- Organizational Ambidexterity and long term survival
- Organizational Ambidexterity and environmental dynamism
- Organizational Ambidexterity and medium-sized firms

**RESEARCH DESIGN**

**Section 2 Epistemological framework & methodology**
- Epistemological framework
- Strategy of investigation & methodology
- Data management

**EMPIRICAL FINDINGS**

**Section 3 Results & discussion**

***Step 1: The company and its environment***

**3.1 A narrative about the company's history**
- Four main epochs
- Strategic intents, underlying dynamics, and structure

**3.2 Characterizing the company's environment**
- Is the Company's environment dynamic?
- Is the Company's environment uncertain?

***Step 2: Quantifying Organizational Ambidexterity and its components***

**3.3 Ambidexterity over time**

**3.4 Ambidexterity: structure or network**

**3.5 The key-components of Organizational Ambidexterity**
- The key-components of Exploration intensity
- The key-components of Exploitation intensity
- The key-components of Organizational Ambidexterity

***Step 3: Searching for underlying processes***

**3.6 Corporate plasticity**

**3.7 Causation & Effectuation**

***Step 4: Discussion of the results***

**3.8 Discussion and attempt to generalize**

**CONCLUSION**

**Conclusion**
- Concluding discussion
- Contributions, limitations & path forward

## Conclusion

> *"What looks to be conceptually simple is often extraordinary complex in execution. It requires that leaders have an understanding of both* what *to do and* how *to do it."*
>
> (O'Reilly & Tushman, 2016, Preface, emphasis original)

In real-life situations, organizational ambidexterity is more complicated that the ideal types generally described in academic literature. This is because the organizational context of development and change in which ambidexterity has to take place extends over space and time, allowing for more than one underlying mechanism to be activated. Various parameters influence organizational development, both inside and outside the boundaries of the organization. These different influences can act simultaneously on different parts of the organization, each giving its particular impetus to the ambidextrous intent. The implementation of ambidexterity also takes time. Time allows different underlying mechanisms to come into play, either simultaneously or sequentially, and the process that results therefrom is multilayered and complex. Therefore, trying to explain this process with one mechanism may oversimplify and draw too much attention to one aspect of the ambidextrous process to the detriment of others. Enlightened by our results, we argue that ambidextrous organizations display, wittingly or not, combinations of two or more types of organizational ambidexterity whose generative mechanisms interplay with each other to create complex phenomena. We saw that ambidextrous organizations may vary the intensity of exploration and exploitation in regards to internal forces (e.g. modifications of strategic intent; centralized versus decentralized structure) as well as external ones (e.g. opportunity to conquer new markets and geographies; deterioration of environmental conditions such as raw material prices and exchange rates; commoditization of flagship products). We have also seen that, counter-intuitively, organizations may chose to increase their focus on exploitation when environmental conditions are relaxing and, conversely, enhance their attention towards exploration in difficult times[73].

Indeed, organizations exchange information and resources with their environment. Yet, they are not all equally affected by environmental changes. Some organizations may suffer more than others which are better equipped to cope with turbulent circumstances and implement

[73] It should be reminded, however, that in our case these movements were parallel to major organizational changes (centralization, decentralization, recentralization).

responses to discontinuities. At first sight, large corporations may have better capabilities to face this challenge as they have generally more slack resources than medium-sized firms which are ususally more resource-constrained. Conversely, medium-sized companies differ from larger organizations by greater agility, increased flexibility, what we call a better "plasticity". We argue that SMEs operating in turbulent environments with high technological content would benefit from combining a highly flexible organic-type of structure at the decision-making level with a more mechanistic structure at the operational level. Maintaining a certain separation between departments, especially those in charge of long-term development projects, makes it possible to isolate them from the short-term pressure dampening the radical innovation so much needed by high-tech companies. This separation between departments for projects of long-term exploratory nature should however be complemented, on the one hand, by increased collaboration between departments on exploitative and short-term exploratory projects; and on the other hand, by collaborating with outside partners for both exploratory and exploitative initiatives. Such a network ambidexterity, particularly adapted to smaller companies with limited resources, has also been found to have a greater impact on organizational ambidexterity than structural effects themselves.

The most appropriate form of organization to deal with the volatility of the environment depends of course on the characteristics of the organization itself but also on the multiple environmental components which are increasingly difficult to circumbscribe and whose changes become harder to anticipate. It is therefore advisable to establish forms of organization that protect firms against environmental changes (Nonaka, 1998). The aim is to make organizations more robust to change, or even better, to make them "antifragile" in the sense that they would not only resist environmental volatility but would eventually benefit from it (Taleb, 2007a, 2007b, 2012). Uncertainty widens the world of possibilities and increases the number of opportunities. We argue that the integration of effectual logic into business practices at the execution level, especially for short term developments, creates an ongoing and affordable opportunity for the variation, selection and retention of new knowledge and capabilities that helps the company stay ambidextrous and makes it more robust in the face of environmental change. Moreover, we show that the effectuation-causation framework may diverge from the exploration-exploitation framework in some conditions. Both frameworks appear complementary instead of being exclusive from one another and they can be operationalized simultaneously which is of particular interest for resource-constrained smaller firms as effectuation constitutes a cost-effective way to increase the odds of positive outcomes in terms

of exploration and exploitation at the same time. In this sense, ambidexterity and effectuation play as negentropic forces[74] which allow companies to dynamically maintain a certain level of organization and order, hence to survive and develop, despites the entropic and even chaotic[75] evolution of the world around them.

Overall, as a final note, we like to repeat that the key to long-term survival in an increasingly changing environment is the ability of firms to dynamically adjust the balance between exploration and exploitation in response to contextual changes. To do this, companies have multiple means of operationalizing organizational ambidexterity (structural, sequential and contextual measures) and related tools (causation, effectuation), but the real world can not be satisfied with the static typologies described in the academic literature. In practice, organizational ambidexterity is a complex and evolutive process that has to adapt dynamically to internal and external factors, most often by setting up a mix or a superposition of measures, variable in intensity, simultaneous, at different levels of the company and by regularly modifying this mix in response to external stimuli and newly acquired internal capabilities.

We hope to have contributed by our work to a better understanding on how to operate organizational ambidexterity in medium-sized firms so as to better prepare for the future without losing efficiency in the present because the evolution of our economies (globalization, hyper-connectivity, etc...) gradually eliminates cases of environmental stability and predictability, and increasingly exposes companies to a context of unprecedented volatility.

## Academic contributions

Our approach based on an in-depth longitudinal case study spanning over 25 years of existence of a company is original in the sense that the literature on organizational ambidexterity has generally taken a static approach mainly relying on cross-sectional surveys and much of the work to date has consisted in empirical studies using financial performance, sales performance or eventually knowledge and innovation indicators as dependent variables. Various authors have emphasized the importance of carrying out such kind of longitudinal studies in order to see, for instance, how the relative importance of differentiation (exploration) and integration

[74] Negentropy is the entropy that a living system exports to keep its own entropy low and, by extension, it is the tendency of human organizations to become better organized, to improve or maintain their capacity and efficiency. The concept was introduced in 1944 by Schrödinger (Schrödinger, 1944) as “negative entropy”, later shortened as “negentropy” by Brilloin (1953).
[75] “Chaotic” is taken here in its thermodynamic sense.

(exploitation) evolve over time (Raisch et al., 2009) or to elucidate the short-term versus long-term implications of balancing exploration and exploitation (Lavie et al., 2010). Schmitt and colleagues (Schmitt et al., 2010) for instance consider the use of anecdotal and longitudinal case studies on the inter-firm and intra-firm level of analysis as the most promising approach for future research as these study designs provide sufficient insights into complex situations. Our study falls precisely within this framework.

In terms of **methodological contribution**, our work proposes and tests a new method of measuring organizational ambidexterity based on the rating of 12 specific parameters, identified as key-elements for ambidexterity and selected following a systematic and structured process inspired by Gioia's method for grounded theorizing (Gioia et al., 2013) that we have applied to the questionnaires of 20 different researches on organizational ambidexterity published *in extenso* in literature. We combined this rather quantitative approach with an abductive search for the underlying processes of organizational ambidexterity that are activated in regards to contextual conditions. We did that by triangulating between the narrative of the company's history, the various archival documents gathered and the measurements that emerged from the quantitative analysis of managerial decisions and contextual events mentionned above. Going back and forth between the documentary corpus and the academic literature, and refining the code-book with additional dimensions such as the ones about causation and effectuation, have made possible to complete the analysis of the underlying processes that preside over ambidexterity in the company. This combination of quantitative and qualitative methods which, according to our knowledge, has not yet been tempted in a longitudinal study on ambidexterity, is coherent with our epistemic posture as it echoes the recommendation of Mingers, Mutch and Willcocks (2013) who claim that critical realism supports mixed-method research strategies (i.e., a variety of methods in the same research study) on the ground that a particular object of research may well have different characteristics.

We applied the same systematic and structured process to develop a rating grid that could be used for measuring causation and effectuation and following their evolution over time. This method seems novel too as most publications are either conceptual (Sarasvathy, 2001a, 2001b; Sarasvathy & Kotha, 2001; Wittbank & Sarasvathy, 2010) or based on semi-structured interviews and questionnaires (Chandler et al., 2011) which differ profoundly from our approach from a methodological standpoint.

In parallel to the listing of decisions taken by the management over the years, we have recorded hundreds of contextual events that characterized the company's environment over the same period of time. These contextual events include external environmental incidents that occured beyond the control of the organization (Cheng & Van de Ven, 1996) but which were likely to influence positively or negatively its development. To search for these events, we analysed the archival sources specific to the company (memos, meeting minutes, communications etc…) and other sources external to the company such as databases. This approach helped characterize the multiple facets of environmental changes that impacted the company's development and triggered organizational adaptations within the company with regards to their incremental or erratic and disruptive nature. Although the academic literature on the interactions between companies and their environment is already rich, particularly at the theoretical and conceptual level (e.g. contingency theory, coevolution theory), our methodological approach is rather original in terms of the timeframe to which it applies (25 years) and the level of detail (fine-grained analysis) that only a single case-study allows.

We have also used mathematical tools generally mobilized for the analysis of time series to detect the presence of chaos in the direct environment of the company in order to demonstrate its complex and non-predictable nature which constitutes the initial postulate of our research question. We applied these tools, in this case an algorithm proposed by Wolf et al. (1985), to three types of variables that emerged as particularly impacting in the writing of the company's history, namely the evolution of commodity prices (sugar), energy (crude oil) and exchange rates (eur/usd). This approach is not really innovative since it has already been used by various authors in other contexts (e.g. Adrangi & Chatrath, 2003; Adrangi et al., 2001; Blank, 1991; Cheng & Van de Ven, 1996) but it has nevertheless allowed us to confirm with scientific rigor the unpredictable nature of the environment in which evolves the company rather than staying on an unverified postulate even if it seems intuitively applicable.

In terms of **conceptual contributions**, the approach outlined in this dissertation contributes to organization theory and especially to organizational ambidexterity theory in several respects.

First, it offers a parsimoniuous explanation of a dynamic view of organizational ambidexterity. The generative mechanisms supporting the ideal types of organizational ambidexterity (mainly structural, simultaneous and network) supplemented by the closely related framework of effectuation serve as theoretical building blocks, and the complexity of the survival process of

a medium-sized firm in unpredictable and largely negative environment can be analyzed as the time-dependent interplay among these building blocks. Second, our approach points out previously ill-explored explanations of organizational ambidexterity, particularly how ambidexterity can be dynamically operated in resource-constrained organizations and expecially in medium-sized companies.

In addition to refining the ambidexterity theory, this study contributes to the literature on effectuation, which is still largely conceptual, by revealing dynamics of effectual logic in the real life context of a medium-sized firm. We showed that effectual logic is not limited to entrepreneurial situations, as often claimed in literature, but may also develop long after the companies' inception. Sarasvathy tells us that "… as an entrepreneurial company grows beyond a critical size, effectual reasoning has to be supplemented with and even replaced at times by causal modes of thinking" (Sarasvathy, 2001, p.5). As such, our study supports the first point, the need to balance the two modes of thinking, but provides an example that contradicts the second one, the idea that effectuation should be literally replaced by a causal approach.

Moreover, whereas Sarasvathy's concept of effectuation and causation has often been compared to March's concept of exploration and exploitation, and we have indeed seen a strong correlation between both patterns over long periods, we showed nevetherless situations in which both frameworks diverge. In the same way that exploration and exploitation co-exist within a company and must be balanced and perpetually adjusted to adapt to internal changes and anticipate external changes (co-evolution: Lewin & Volberda, 1999; Lewin et al., 1999; Lichtenstein, 2000; McKelvey, 1999; Volberda & Lewin, 2003); causal and actual processes can also coexist and be modulated so as to dynamically adapt to contextual changes.

Finally, our work contributes to link Taleb's fragility/antifragility (concavity/convexity) theory and Sarasvathy's causation/effectuation theory. Of course, in our case, the link that we highlight between those two theories is limited to exploratory, mainly innovation-related, activities but it is probably generalizable to other domains such as entrepreneurship for instance. This assertion offers room for future studies though.

## Managerial recommendations

In addition to the theoretical contributions, this dissertation provides insights into how managers of medium-sized companies can effectively create ambidextrous organizations. However, if we recommend managers to encourage ambidexterity within their organizations, we also advise them to **constantly adjust the balance of exploration and exploitation in regards to internal and external forces at play**, especially when evolving in turbulent environments or going through critical periods, by shifting attention from one to the other in a timely manner. It may seem obvious and relatively simple to set up for companies that have the necessary resources and expertise, often large companies. On the other hand, it can be much more of a challenge for smaller companies that must make choices to ensure their short-term survival while preparing for their future.

Therefore, to help managers in this quest, we advise the following on the basis of our observations:

**Tip #1:** Constantly monitor the organization's environment and its exposure to it.

The need to combine exploration and exploitation must be reflected by decision-makers with regards to the exposure of their organization to the volatility of their environment. Some sectors are less exposed and some business environments are less volatile, they can afford higher emphasis on one dimension or the other.

- In an environment stable by nature, companies can focus on operations: the risk of failure is low and the cost of ambidexterity is not justified.
- In a turbulent environment (volatile and uncertain), companies in sectors with little exposure to changes must open to the outside by exploring new technologies and new business models to prepare for the next disruption which, despite the low exposure, is not less likely to impact it sooner or later.
- In a very uncertain environment (such as for example activities with high technological content operating in an international context), businesses will benefit from the implementation of an ambidextrous strategy. In this case, it seems justified for these organizations to trade part of their short-term productivity against their long-term survival. The key to long-term survival in an increasingly changing environment is the ability of enterprises to dynamically adjust the balance between exploration and exploitation in response to contextual changes.

**Tip #2:** Improve exploration intensity

Should there be a need to increase exploration, the managers of medium-sized companies evolving in industries with high technological content which can't afford supporting all research projects with their own financial means or which do not have enough scientific capabilities to address all possible subjects they might have the need to address in their R&D journey should prioritize long term exploratory alliances such as research programs with other companies, R&D centers and universities to maintain a good level of exploration intensity.

**Tip #3:** Keep on exploring in difficult times

When the environment is deteriorating and margins are under pressure (rising costs, lower profitability on exports due to less favorable exchange rates), managers should put the focus on exploration in pursuit of new products and new markets delivering higher margins or less exposed to exchange rates, even if this seems counterintuitive to most of them. Indeed, they usually feel inclined to emphasize exploitation in this situation so as to maintain liquidity and preserve financial means.

**Tip #4:** Improve exploitation intensity

In contrast to the above, managers who need **to improve the exploitation intensity** of their organization may focus on existing markets and customers and pay attention to improving activities, technologies, processes and products. Exploitative alliances such as sub-contracting the manufacture of some products also impact positively the exploitation intensity, as do the promotion of existing solutions and leveraging accumulated experience.

**Tip #5:** Pay attention to structure

Managers who want their organization to reach a certain level of ambidexterity should pay attention to structure, especially in the first years of existence of their business, to allow exploratory projects to be conducted in clearly defined teams operating autonomously but, at the same time, to establish bridges between teams so that the exploitation projects can be realized in a participative way.

Moreover, structure and strategic intent should be aligned. When information brought up by the middle management and various objective ratios and metrics indicate a

discrepancy between the strategic intent and the path really taken by the company on the field, managers may have to adapt their corporate strategy sometimes to seize new growth opportunities, sometimes to survive deep changes in the context in which they are operating. In this case, managers should not hesitate to drastically change the structure of their organization. There is a need for recursive iterations between different modes of separated (decentralized) and integrated (centralized) structures. Decentralizing temporarily the decision-making structures can be a way to explore new markets and dislodge the firm from its set of practices in such a way that it escapes its developmental trajectory.

**Tip #6:** Enter into partnerships

We have shown that structural ambidexterity and network ambidexterity are not exclusive of one another, and that, contrary to the generally accepted idea, medium-sized organizations can excel on both aspects concurrently. Structure and network both have high explanatory power on organizational ambidexterity which means that managers who can afford investing in both simultaneously should. However, if a choice has to be made because of limited resources, it would be more effective to prioritize network ambidexterity, that is to say, to create exploitative and exploitative partnerships, rather than to favor structural ambidexterity, namely to separate the departments in charge of exploiting existing knowledge from the ones that develop new knowledge.

In industries with high technological content, many firms are naturally involved in exploratory collaborations. Managers should balance this high focus on exploration by increasing the number of partnerships of exploitative nature in order to avoid the "failure trap" of underdeveloped ideas by which innovations are replaced by new ideas before they have had the chance to be converted into practical reality that contributes to the company's revenue stream, a state of "constant shifting in alternatives in which exploration drives out exploitation" (O'Reilly & Tushman, 2007, p.13).

Companies like to work with old well-known parters because it keeps their members in their confort zone, and sharing know-how often requires the establishment of long-term relationships in which exchange occurs in a code learned and shared. However, the company doing so exclusively somehow runs the risk to fall in a "success trap", organizational inertia, convergence and simplicity. Hence, we advise managers to

balance the types of partnerships the company is engaging into and combine collaborations with old partners and with new partners.

But still, the implementation of harmonious and effective ambidextrous management should not simply focus on maximizing exploration and exploitation but must also activate certain levers whose combination brings effects on ambidexterity greater than the sum of their effects on each of its components.
The first of these levers is based on balancing attention to efficiency and to flexibility (Tips #7 and #8 hereunder), hence:

**Tip #7:** Nurture corporate plasticity with an organic type of organization at the top level.

Finding the right balance between efficiency and flexibility emerged as an important parameter to maintain high level of ambidexterity especially in volatile context. Indeed, for an organization to successfully survive all circumstances, it needs to have at least as much variety within itself as the variety of disturbances in its external environment. Hence, the more turbulent the environment, the more variety needed within the firm. Moreover, it is not only the variety of capabilities currently used by the organization that counts but also the collection of potential capabilities that are not yet activated and need to be developed to cope with the possible emergence of opportunities or threats. Here again it is a great challenge for medium-sized companies to have such variety when resources are constrained and when their size limit the range of skills that they can enjoy internally. A way to cope with this situation is to have a stable management team whose members hold several types of responsibilities, separated in space, in different sub-units, and in a simultaneous fashion. It allows each of the people concerned to be part of new ventures and new developments at the same time as they keep a role in the company's core activities. In this, the company follows the recommendation of O'Reilly and Tushman (2004) who proposed as "integrating mechanism" (Markides, 2013) that the parent company and the subsidiary unit share common managers. This kind of "organic" mode of organization based on a closely intertwined set of responsibilities among the top-managers facilitates knowledge transfer from the core to newly created entities and between departments (exploitation) but also opens up the management to new opportunities, new perspectives and, in turn,

ultimately, helps acquire new knowledge (exploration). It therefore contains the seeds of plasticity and organizational ambidexterity.

**Tip #8:** Combine the organic type of organization at the top with a mechanistic structure at the execution level.

High-tech firms who need to constantly thrive for innovation often separate their R&D structures from the other departments with the aim to prevent cross-contamination between units and to avoid sacrificing efficiency on the altar of innovative activities (Schmitt et al., 2010). Indeed, separation is particularly efficient to create new knowledge in general and promote radical innovations in particular (Benner & Tushman, 2002). Therefore, the top management relies on subsidiaries and departments operating in silos with clearly defined responsibilities, a mechanistic type of organization. Yet, if exploratory projects are conducted in clearly defined teams operating autonomously, it is important to establish, at the same time, bridges between teams so that exploitation projects can be realized in a participative way. Moreover, as important is the need for recursive iterations between different modes of separated and integrated structures.

The second lever that contributes positively to organizational ambidexterity whithout strongly impacting specifically exploration or exploitation lies in the pursuit of intuitive projects in parallel of well planned ones (Tip#9). Our results suggest that ambidexterity greatly benefits from having both approaches simultaneously while the extent of the impact on exploration and exploitation intensities separately is rather limited, hence:

**Tip #9:** Combine an effectual approach on the short term with a causal approach for the long run.

One way to achieve organizational ambidexterity in medium-sized companies is to nurture a customer-centric effectual approach. To do so, managers can create sub-structures to support multiple trial-and-errors projects directly involving customers in the short run while keeping at the same time a strict stage-gate system resorting to a classical causal logic for projects imbedded in long development cycles. As expensive

as it may seem, this type of long-term exploration through separated sub-structures is nevertheless needed in high technology industries to support radical innovation (Benner & Tushman, 2002) and stay at the forefront of innovation because radical innovation requires conficting mindsets and processes that the organization must be able to support (Lewis et al., 2014). Conversely, the effectual approach of customer-centered projects helps contain development costs whereas the probability of success increases sharply. Even more: with low cost mistakes, known maximum losses and large potential payoffs, these projects profit from the volatility of the environment in which these firms are evolving.

The preceding advices, if successfully implemented by the company we have studied, must of course be analyzed in the light of the particular situation of each organization (the local idiosyncratic dimension we mentioned in the foreword of this thesis). They can be implemented all or only some but, once again, managers should remain attentive to the actual situations their organizations are facing and dynamically adapt the mix of measures to be taken to maintain the efficiency of their present operations while protecting themselves against the surrounding uncertainty and preparing for the future.

## Limitations

Whereas our research offers implications and contributions to existing literature on organizational ambidexetrity, it is not free from limitations.

In first instance, our study builds on an in-depth single-case longitudinal case study. As such, we need to be cautious in generalizing our results to firms of different size or operating in dissimilar industries.

A second limit comes from the rating method used in our code-book. Our rating method is actually based on positive values for exploration and negative values for exploitation (without value judgement). It does not reflect the intensity of the effect of each decision on the company's development as it was not possible to judge the quality of each decision or its consequences, especially in a context of uncertainty, inconsistency, and incomplete information

as the one in which the company evolved for most its life[76]. In addition to the difficulty of assessing the quality of a decision, our position as an actor of the company in question could have led to an endowment bias in our analysis in the sense that the qualitative evaluation of the decisions taken by the management could be tainted by our preexisting beliefs or hypotheses. From this point of view, and to avoid such endowment bias, we designed a method which is somewhat quantitative by nature. This reduces the fineness of our analysis but we mitigated the effect of this limitation by summing all the ratings of each year so that the exploratory or exploitative intensity of each year could be measured (Section 2.4.3).

Moreover, as already explained in the Section 2.4.2 about code-book design, our study could not be subjected to an independent double coding due to the limited time allowed for a DBA but also because the material analyzed, largely made of internal company documents, resorts to a specific jargon difficult to apprehend for external researchers. A deep understanding of the company, its culture and products, as well as the impediments and extraneous influences was also deemed necessary to be able to proceed to an objective, appropriate, relevant and fruitful coding. The simple coding of our data is therefore a deliberate and assumed choice.

Another limit to our study has been raised in Section 2.4.3. On the margins of a vision of ambidexterity on the scale of the organization (structural ambidexterity) and its direct entourage (network ambidexterity), our review of the extant literature had highlighted a dimension at the level of the individual called contextual ambidexterity. However, the very nature of most documents constituting the corpus of our archival sources did not permit a clear enough identification of stretch, discipline, support and trust; i.e. the attributes describing organizational context as per Ghoshal and Bartlett (1994) brought forward by Birkinshaw and Gibson (2004) as the cornerstones of contextual ambidexterity. This can be explained by the fact that our archival sources contain essentially documents made by managers and intended to managers (minutes of management meetings, minutes of board meetings, internal memos etc…) whereas contextual ambidexterity precisely displaces the decision process from a centralized management team to decentralized sub-units or even to the individual employees themselves. Consequently, in spite of an attempt to structure a coding grid using the same Gioia's type of

[76] We refer here to the *quality* and not the *correctness* of decisions. A decision can be right or correct in given circumstances but it does not mean that there is not another decision delivering better results in the same circumstances. The quality of a decision can only be judged in regards to its consequences when compared to the consequences of a different decision in the same context. This would suppose to identify all possible consequences of all possible decisions in a given situation which is imposible given the limits of rational decision making (Simon, 1976).

systematic approach as previously adopted to analyze the other aspects of organizational ambidexterity, we had to resolve to leave the analysis of individual context on the side.

At last, a limitation may come from the narrowness imparted by adherence to a simple theory of ambidexterity. As Van de Ven & Poole explain (1995, p.533, brackets added): "if it is true that the interplay of multiple forces often drives development, then conducting research with a simple a priori theory in mind actually may impede adequate explanation. The researcher may look only for indicators of that particular theory, ignoring other possible explanations. In the best case, this myopia results in an incomplete account of development and change". We tried to avoid such confirmation bias in the analysis of the source material by adopting a systematic approach in the design of our code-book and by abductively searching for underlying processes and alternative theories. This approach has led for instance to the integration of the causation and effectuation framework to our analysis.

## Hints for future research

In this dissertation, we propose a new methodology to measure organizational ambidexterity on the basis of the rating of 12 specific parameters identified as key-elements for ambidexterity and selected following a systematic and structured process inspired by Gioia's method for grounded theorizing (Gioia et al., 2013) that we have applied to the questionnaires of 25 different studies on organizational ambidexterity. This method allowed to trace the evolution of ambidexterity and its components over the 25 years of existence of our unit of analysis. It would be advantageous to apply this method to other companies, active in other fields and exposed to other contexts, so as to validate it and to compare the results with ours so as to be able to better delineate their generalizability.

We applied the same systematic approach to measure the evolution of causation and effectuation over time. As far as we could see in literature, it is a first. Testing the method with units of analysis of different sizes, activities and environments would also contribute new knowledge to this rather new field of management science.

As a further matter, the longitudinal nature of our research brings time into the ambidexterity framework, an aspect little investigated in the literature in spite of its dynamic inherent character. More work to refine the understanding of how the components of ambidexterity (exploitation and exploration intensities), and the various forms of ambidexterity (network or

structural) are articulated in different contextual situations over time could also greatly complement the theoretical corpus of ambidextrity.

Moreover, we have determined the positive effect of both exploratory and exploitative partnerships on ambidexterity. Yet, acquiring external knowledge is not sufficient to benefit from it, one has also to integrate it within the organization. This is another tensions-generating challenge that has been the subject of research on absorbtive capacity or combinative capability which Kogut and Zander (1992) describe as the organization's ability "to synthesize and apply current and acquired knowledge". This led Raisch et al. (2009, p.690) to conclude that "ambidexterity may thus imply the managerial challenge of not only balancing exploitation and exploration but also of integrating external and internal knowledge". If we addressed the former part of this statement, a detailed analysis of the latter fell beyond the limit of our research and could advantageously be the subject of further works.

Another fundamental aspect of our research that has not yet been enough studied in the extant literature is the similarities and divergences between March's theory of exploration and exploitation in relation to that of effectuation and causation dear to Sarasvathy. Here again, additional in-depth anecdotal and longitudinal studies in various contexts and domains are needed to enrich our understanding of the matter.

On the margins of a vision of ambidexterity at the level of the organization (structural ambidexterity) and its direct entourage (network ambidexterity), two forms of ambidexterity that we have investigated in our research, our review of the extant literature had highlighted a dimension on the scale of the individual named "contextual ambidexterity". The very nature of most documents constituting the corpus of our archival sources (see Section 2.4.1 Data generation) did not permit a clear enough identification of stretch, discipline, support and trust; i.e. the attributes describing organizational context as per Ghoshal and Bartlett (1994) brought forward by Birkinshaw and Gibson (2004) as the cornerstones of contextual ambidexterity. We discussed the reasons for that in Section 2.4.3. Therefore, in spite of an attempt to structure a coding grid using the same Gioia's type systematic approach as previously described, we had to resolve to leave the analysis of individual context on the side. This, however, could be the subject of a forthcoming study on the basis of a different set of archival documents, closer to the individuals instead of being of managerial nature (secondary data), or based on interviewing employees and managers at different levels in the company (primary data). In this latter case

however caution will be needed to avoid falling in the two bias typical of longitudinal studies when gathering primary data *a posteriori*: forgetting and rationalizing (Thiétart, 2014).

Finally, our work contributes to link Taleb's fragility/antifragility theory, and especially his Barbell theory[77], to Sarasvathy's causation/effectuation theory but the link that we highlight is limited to exploratory, innovation-based, activities. Future research could investigate whether our findings also apply to other domains such as entrepreneurship for instance.

[77] Taleb's barbell theory builds on a dual strategy by which a combination of two extremes, one safe and one speculative (like in our case, the combination of an effectual logic and a causal one), is more robust and eventually even antifragile than a "monomodal" strategy which is based on medium-risk ventures only (Taleb, 2007b, 2012).

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# Appendixes

## Appendix I

*Survie à long terme dans un context d'incertitude croissante : L'ambidextrie organisationnelle est-elle la réponse ?* – Article published in French in Revue Economique et Sociale, March 2016.

# Survie à long terme dans un contexte d'incertitude croissante: L'ambidextrie organisationnelle est-elle la réponse?

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> Les managers sont constamment exposés à la complexité croissante de notre monde trépidant, globalisé, interconnecté et hyperconcurrentiel. Dans un tel contexte de moins en moins prévisible, structurer une organisation et concevoir une stratégie qui équilibre les besoins de rentabilité à court terme et la survie à long terme devient de plus en plus difficile. L'ambidextrie organisationnelle a été proposée comme moyen de gérer ces objectifs contradictoires mais son effet sur la longévité des organisations reste largement non-démontré. Nous discutons cette problématique en la situant dans la littérature académique et proposons que les métiers fortement exposés à un environnement très incertain bénéficient de la mise en pratique d'une stratégie ambidextre selon un processus évolutif et dynamique superposant différentes mesures, variables en intensité, à plusieurs niveaux de l'entreprise et par la modification régulière de ce mix en réponse aux stimuli extérieurs et aux capacités internes nouvellement acquises.

Mots-clés : ambidextrie organisationnelle, incertitude, exploration, exploitation, survie à long terme.

Le monde change à un rythme toujours plus rapide et l'espérance de vie des entreprises ne cesse de se réduire. Si elle était de près de 90 ans pour une société du S&P 500 en 1935, elle n'était plus que de 15 ans en 2005 (Foster & Kaplan, 2001b). Les changements dans l'environnement

des organisations se caractérisent par deux types d'évènements: le dynamisme environnemental, lent et continu, qui présume un certain degré de prédictibilité, et les chocs exogènes qui font référence à des «rafales environnementales soudaines, inattendues et incontrôlables» (Lavie et al., 2010, p.119), des «perturbations passagères disruptives et potentiellement inamicales» (Meyer, 1982, p.515). De nombreux chercheurs ont tenté de mieux comprendre les causes organisationnelles du succès et de l'échec, et la plupart d'entre eux ont reconnu que faire face aux changements imprévisibles impose à la fois d'exploiter les compétences existantes et d'explorer de nouvelles avenues de manière à équilibrer le court terme et le long terme.

Duncan (1976) fut le premier à utiliser le terme d'«organisation ambidextre» quand il a incité les entreprises à mettre en place des «structures duales» nécessitant différentes perspectives temporelles et des capacités managériales particulières pour accueillir simultanément les alignements contradictoires nécessaires à l'efficacité (perspective à court terme) et à l'innovation (perspective à long terme). Cette idée de combiner des activités tant d'exploitation que d'exploration a été popularisée par March en 1991 (March, 1991). Au-delà du trait humain permettant aux individus d'utiliser les deux mains avec une égale dextérité, la métaphore de l'ambidextrie fait référence à la capacité d'une organisation à exploiter les compétences existantes et à explorer de nouvelles opportunités avec la même habileté. La recherche sur l'ambidextrie comme concept organisationnel a connu une fulgurante ascension au cours des 10 dernières années et est maintenant considérée comme un paradigme de recherche émergent en théorie organisationnelle (Birkinshaw & Gupta, 2013). L'hypothèse implicite que l'ambidextrie organisationnelle est nécessaire pour la performance à long terme a même été évoquée comme le "principe de l'ambidextrie" (Raisch & Birkinshaw, 2008, p.392). Cependant, alors que ces déclarations sont devenues une croyance durable parmi les chercheurs en gestion, cette hypothèse reste largement normative. En effet, comme Piao l'a observé très récemment (2014), cette proposition a, étonnamment, reçu peu d'attention et n'a jamais été réellement démontrée empiriquement. Une grande partie du travail à ce jour s'est limitée à étudier l'influence de l'ambidextrie organisationnelle sur la performance exprimée en termes financiers, commerciaux ou en termes d'innovation, mais rares sont les études consacrées à son effet sur la pérennité des entreprises. De même, les résultats empiriques sur la relation entre l'ambidextrie et l'hostilité de l'environnement restent limités et contradictoires (Schmitt et al., 2010).

Aussi, la question de savoir si l'ambidextrie organisationnelle offre un moyen d'améliorer les chances de survie à long terme dans un monde d'incertitude croissante reste largement sans

réponse, en particulier pour les entreprises de taille moyenne qui ne possèdent pas les ressources financières pour fortement diversifier leurs activités. Plusieurs voix éminentes ont plaidé pour que des études qualitatives et longitudinales soient réalisées afin de fournir une meilleure compréhension de la complexité de gérer en période de turbulences et de comprendre comment l'ambidextrie organisationnelle peut être effectivement mise en pratique (Lavie, Stettner, & Tushman, 2010; O'Reilly & Tushman, 2013; Raisch, Birkinshaw, Probst, & Tushman, 2009).

Nous cherchons à combler ce vide dans la littérature en discutant la problématique aux niveaux théorique et managérial, et en la situant dans la littérature académique. Nous proposerons pour finir des pistes de réflexions qui permettront aux managers d'appréhender la manière de mettre en place l'ambidextrie organisationnelle en vue d'améliorer les chances de survie à long terme de leur entreprise.

## L'AMBIDEXTRIE ORGANISATIONNELLE

### LA MONTEE DE LA RECHERCHE SUR L'AMBIDEXTRIE ORGANISATIONNELLE

March et Simon (1958) ont avancé que les organisations peuvent améliorer leurs performances en séparant les unités faisant usage des succès existants de celles qui cherchent à identifier de nouvelles opportunités, et Burns et Stalker (Burns & Stalker, 1961) ont fait valoir que les systèmes de gestion «mécanistiques» caractérisés par des relations hiérarchiques claires et des responsabilités bien définies sont plus efficaces dans un environnement stable, alors que les «systèmes organiques», moins formels, seraient mieux adaptés aux conditions turbulentes. De son côté, Thompson (1967) a affirmé que la force d'une organisation repose sur un compromis entre efficacité et flexibilité. Pour lui, l'efficacité des pratiques existantes est nécessaire pour que l'organisation puisse maintenir son avantage concurrentiel, alors que la flexibilité est indispensable pour éviter qu'elle ne se retrouve prise au piège de routines et de procédures obsolètes, une situation décrite comme une inertie organisationnelle (Hannan & Freeman, 1984), une simplicité organisationnelle (Miller, 1993) ou un blocage culturel (Foster & Kaplan, 2001b).

En 1991, March analyse la dualité entre efficacité et flexibilité du point de vue de l'apprentissage organisationnel. Il note que le principal défi auquel les entreprises sont confrontées en matière d'adaptation est la nécessité d'exploiter les capacités existantes tout en fournissant en même temps des efforts suffisants d'exploration pour s'adapter aux changements

technologiques et aux mutations de la demande des marchés (March, 1991). Dans la lignée de l'approche basée sur la connaissance (*Knowledge-Based View*), Levinthal et March (1993) soulignent la difficulté d'équilibrer des objectifs opposés tels que «l'exploitation des vieilles certitudes» et «l'exploration de nouvelles possibilités» face à une réalité qui pousse à favoriser l'un ou l'autre. Ils concluent que les organisations abordent ce problème par la simplification et la spécialisation, ce qui conduit à différentes formes de «myopie d'apprentissage».

Deux décennies après Duncan, Tushman et O'Reilly (1996), reprenant le concept de "structures duales", ont avancé la nécessité d'une séparation structurelle entre les activités visant à gérer de manière simultanée le changement évolutif (incrémental) d'une part, et le changement révolutionnaire (discontinu) d'autre part. Ce fut l'émergence de l'*ambidextrie* dite *structurelle* ou *simultanée*.

Dans le prolongement de leurs travaux sur les discontinuités technologiques, le design dominant et le principe d'équilibre ponctué, Tushman et ses collègues ont repris le schéma évolutif qui prévoit des périodes relativement longues de changement progressif ponctuées par de courtes rafales de changements intenses pour conclure à la nécessité d'aligner à court terme la stratégie, la structure et la culture des entreprises mais aussi de détruire périodiquement cet alignement afin de l'adapter aux changements environnementaux dans un processus séquentiel. Le temps a fait son entrée et a donné naissance à la notion d'*ambidextrie séquentielle* (Geerts et al., 2010). Dans le même esprit, les entreprises ont été décrites pour leur tendance à la «commutation rythmique» (*rythmic switching*) (Brown & Eisenhardt, 1997) ou à la «vacillation» (Boumgarden et al., 2012) dans un mouvement de va-et-vient entre des périodes d'exploration et des périodes d'exploitation. Le raisonnement qui sous-tend cet argument est qu'il est plus facile pour les entreprises d'alterner différentes structures formelles de temps à autre que de changer les fondements de leur culture. Les chercheurs ne sont cependant pas unanimes sur le concept d'ambidextrie séquentielle: Gupta, Smith et Shalley (Gupta et al., 2006), ainsi que Boumdarden et ses collègues (2012) par exemple, considèrent que l'ambidextrie se réfère à la poursuite *synchrone* de l'exploration et de l'exploitation, alors que la différenciation temporelle, telle que l'équilibre ponctué, constitue d'après eux un mécanisme radicalement différent. Pour autant, tant l'ambidextrie simultanée que l'ambidextrie séquentielle (équilibre ponctué, vacillation) s'efforcent de résoudre le dilemme exploration/exploitation par des mesures structurelles.

L'année 2004 a marqué un autre tournant dans la conceptualisation de l'ambidextrie organisationnelle avec Gibson et Birkinshaw (2004) qui s'écartent du corpus existant de l'ambidextrie structurelle pour introduire la notion d'*ambidextrie contextuelle*. Leur idée est qu'un contexte caractérisé par une combinaison d'exigence, de discipline, de soutient et de confiance (les quatre attributs décrivant le contexte organisationnel selon Ghoshal et Bartlett (1994)) permet aux individus d'utiliser leur propre jugement sur la façon de partager leur temps entre des activités d'alignement (exploitation) et des activités axées sur l'adaptation (exploration). Promouvoir l'ambidextrie dans une organisation ne se réduit pas seulement à décider de la structure organisationnelle la plus appropriée, mais devient aussi une réflexion sur la manière d'engendrer un ensemble de stimuli et de pressions pour motiver les collaborateurs à agir de la façon souhaitée, ce qui déplace le processus de décision d'une équipe dirigeante centralisée vers des sous-unités décentralisées ou même vers les employés eux-mêmes.

## NOUVELLES DIRECTIONS

Jusqu'à la fin des années 90, la plupart des travaux sur l'exploration et l'exploitation ont essentiellement porté sur le niveau de l'organisation elle-même. Alors que certains chercheurs ce sont intéressé à l'impact de l'ambidextrie au niveau des sous-unités (départements, équipes) et au niveau individuel avec l'ambidextrie contextuelle, des travaux sur le niveau inter-organisationnel ont commencé à apparaître. La formation d'alliances peut en effet être considérée comme une forme d'exploration et d'exploitation (Park et al., 2002; Rothaermel & Deeds, 2004) dans le sens où les alliances exploratoires offrent la possibilité d'accéder à de nouvelles connaissances et d'explorer de nouveaux marchés et technologies (Grant & Baden-Fuller, 2004) tandis que les alliances d'exploitation peuvent être utilisées pour tirer le meilleur parti de ressources complémentaires et des compétences existantes par-delà les frontières de l'organisation (Lin et al., 2007).

Plus récemment, des chercheurs ont aussi commencé à enquêter sur l'importance du leadership dans la gestion des contradictions et des compromis auxquels les organisations font face (Lubatkin, Simsek, Ling, & Veiga, 2006; Smith & Tushman, 2005; Vaccaro, Jansen, van den Bosch, & Volberda, 2012). Tushman et al., dans un article intitulé explicitement «Le PDG Ambidextre» (2011), font valoir que les décisions concernant le présent et l'avenir de l'entreprise doivent être prises au niveau le plus haut et ils proposent des approches différentes pour maintenir les tensions au sommet et éviter qu'elle ne percolent vers le bas de la pyramide

hiérarchique. En fait, la capacité des dirigeants à saisir les opportunités à travers l'intégration et la coordination de ressources existantes aussi bien que nouvelles pour surmonter l'inertie organisationnelle est au cœur des *capacités dynamiques*, définies comme «la capacité de l'entreprise à intégrer, construire et reconfigurer les compétences internes et externes pour répondre aux changements rapides de l'environnement» (Teece, Pisano, & Shuen, 1999, p.516). Cette capacité de l'entreprise à «synthétiser et appliquer les connaissances actuelles et acquises» a parfois été décrite comme «capacité combinatoire» (Kogut & Zander, 1992, p.384) ou «compétence architecturale» (Henderson & Cockburn, 1994). Comme l'ont souligné Raisch et ses collègues (2009), l'ambidextrie organisationnelle pose donc le défi non seulement d'équilibrer exploration et exploitation, mais aussi d'intégrer les connaissances internes et externes. Dès lors, l'ambidextrie organisationnelle vue comme une capacité dynamique au niveau de l'équipe dirigeante peut aider les organisations à substituer un environnement de sélection externe dans lequel les mauvais choix peuvent conduire à un échec fatal pour l'entreprise par un processus de sélection interne qui autorise des échecs locaux sans pour autant emporter la destruction de l'ensemble de l'organisation (Burgelman, 2002).

Toutefois, bien que ces auteurs se concentrent principalement sur le rôle des équipes dirigeantes, d'autres comme Burgelman et Grove (2007) reconnaissent que les processus autonomes d'exploration peuvent aussi être informels et décentralisés, et résulter des efforts de cadres intermédiaires. En bref, la direction pourrait être considérée comme le principal moteur d'un changement discontinu ou radical, alors que le «middle management» peut être vu comme l'acteur d'un changement progressif ou incrémental (Raisch & Birkinshaw, 2008).

Ces différentes conceptualisations illustrent le fait que les organisations sont confrontées à des situations très différentes qui ont un impact certain sur l'intensité d'exploration et d'exploitation nécessaire et sur la façon d'atteindre l'ambidextrie. Par exemple, une approche séquentielle peut être mieux adaptée à des environnements stables (Geerts et al., 2010), alors que l'ambidextrie structurelle peut être plus appropriée à un contexte turbulent (O'Reilly & Tushman, 2013). De même, une approche contextuelle est probablement bien adaptée pour soutenir et renforcer l'innovation incrémentale au niveau local, mais pourrait être difficile à gérer efficacement face à des ruptures technologiques (O'Reilly & Tushman, 2013). Les entreprises peuvent effectivement combiner différentes formes d'ambidextrie à différents niveaux organisationnels (individu, équipe, département, entreprise, collaboration/alliance) de façon concomitante (Kauppila, 2010) mais les ressources investies dans l'exploration, à quelque niveau que ce soit, ne sont alors plus disponibles pour des activités d'exploitation, et inversement. Dès lors, si

l’exploration et l’exploitation sont nécessaires, sont-elles concurrentes ou complémentaires ? Le management soucieux à la fois de la rentabilité à court terme de son organisation et de la pérennité à long terme de celle-ci se doit-il d’essayer de maximiser les efforts portés à ces deux dimensions ou doit-il plutôt essayer de trouver un juste équilibre ? Les deux points de vue se défendent comme nous le montrons ci-après.

## EXPLORATION ET EXPLOITATION : CONCURRENCE OU COMPLEMENTARITE ?

### *Apollon et Dionysos*

Chaque organisation est un faisceau de conflits, d’oppositions, de tensions, de contrastes et de contradictions, et l’étude des dualités et des paradoxes ont longtemps été d'un grand intérêt pour les théoriciens de l'organisation. Parmi les nombreuses caractéristiques ambivalentes des organisations, un thème central et récurrent est l'importance et la difficulté d’accommoder stabilité et changement (Cummings, 2013), de réconcilier ordre et chaos (Forgues & Thietart, 1995).

Dans la mythologie grecque, Apollon et Dionysos sont frères, tous deux fils de Zeus. Pour les philosophes présocratiques Apollon représente la mesure, la raison, la rationalité et l'ordre, alors que Dionysos figure l'excès, le chaos, l'irrationnel, «la force qui donne la puissance séminale à la poursuite de la vie» (Taleb, 2012, p.256). Un parallèle évident apparaît avec la définition de March de [l'apollonienne] exploitation représentée par «le raffinement, le choix, la production, l'efficacité, la sélection, la mise en œuvre et l'exécution» qui contraste avec [la dionysiaque] exploration qui implique «la recherche, la variation, la prise de risques, l'expérimentation, le jeu, la flexibilité, la découverte et l'innovation» (March, 1991, p.71, crochets ajoutés). En outre, le concept de «destruction créatrice», développé par Karl Marx et Werner Sombart (Reinert & Reinert, 2006) et popularisé par Joseph Schumpeter (1942) comme une théorie de l'innovation économique et du cycle des affaires peut être considérée soit comme un antécédent, soit comme un produit de l'exploration (Abernathy & Clark, 1985). L’exactitude historique veut toutefois que ce soit Nietzsche qui le premier inventa le terme en référence à Dionysos qu'il voyait comme «créativement destructeur» et «destructivement créateur» (Taleb, 2012, p.256).

La culture grecque antique ne considérait pas Apollon et Dionysos comme opposés ou rivaux, au moins jusqu'à l'influence du rationalisme de Socrate, mais plutôt comme deux forces entrelacées et complémentaires. Plusieurs auteurs conceptualisent l’ambidextrie

organisationnelle d'une manière similaire en considérant que l'exploitation et l'exploration ne sont pas mutuellement exclusives, mais sont plutôt des dimensions additives ou multiplicatives par nature (Gibson & Birkinshaw, 2004; He & Wong, 2004; Jansen et al., 2006; Lubatkin et al., 2006). Pour ces auteurs, l'exploration et l'exploitation sont des activités indépendantes, orthogonales l'une par rapport à l'autre (voir la figure 1a). Elles doivent toutes deux être maximisées et une organisation ambidextre est une organisation qui a la faculté de *combiner* simultanément des niveaux élevés de ces deux activités (Gupta et al., 2006; Lavie & Rosenkopf, 2006). Elle se situe dans le quadrant supérieur droit de la figure 1a.

Pour soutenir l'argument selon lequel l'exploration et l'exploitation peuvent ne pas être contradictoires, Gupta et al. (2006) indiquent par exemple qu'elles peuvent avoir lieu dans des domaines complémentaires, tels que la R&D et le marketing par exemple, qui ne se disputent pas nécessairement les mêmes ressources. Allant plus loin que de considérer que l'exploration et l'exploitation ne sont pas nécessairement en concurrence, certains auteurs de défendre que chaque dimension a en fait un effet de renforcement de l'autre, à savoir que «un haut degré d'effort d'exploitation peut souvent améliorer l'efficacité d'une entreprise dans l'exploration de nouvelles connaissances» et, d'une manière analogue, que «la maîtrise de processus exploratoires d'une entreprise peut également améliorer sa capacité à se livrer à une exploitation réussie» (Cao, Gedajlovic, & Zhang, 2009, p.784).

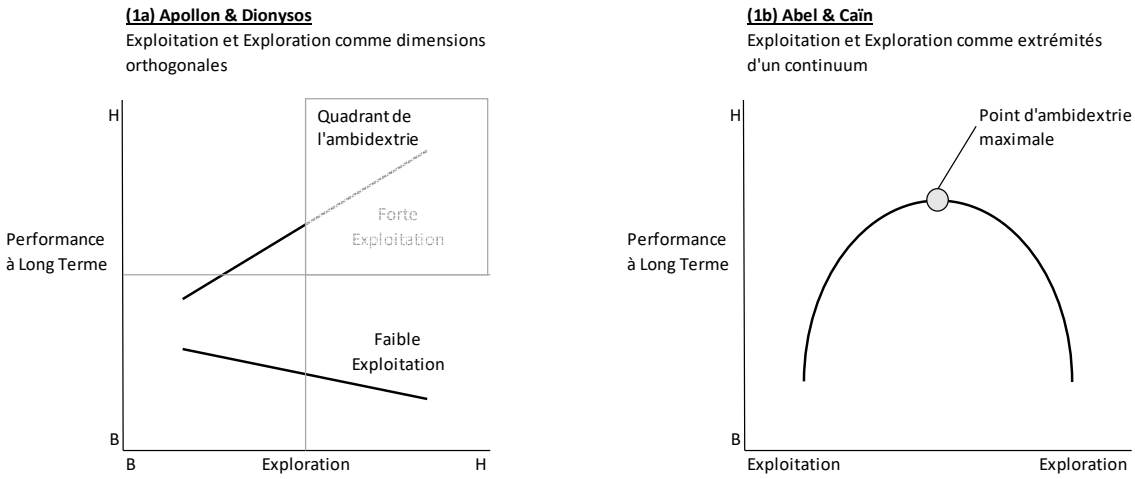


***Figure 1 :*** *Les deux conceptions de l'exploration et de l'exploitation : dimensions orthogonales ou deux extrémités d'un continuum (adapté de Gupta et al., 2006)*

*Abel et Caïn*

D'autres auteurs estiment cependant que les deux dimensions sont mutuellement exclusives (Auh & Menguc, 2005; March, 1991; Simsek, Heavey, Veiga, & Souder, 2009; Smith & Tushman, 2005) en ce qu'elles sont en concurrence pour les mêmes ressources au sein d'une organisation (ressources financières, ressources humaines), et qu'elles produisent des résultats divergents parce que les retours de l'exploration sont «systématiquement moins certains, plus éloignés dans le temps et plus éloignés du lieu de l'action» que ceux de l'exploitation (March, 1991, p.73). La métaphore mythologique ne s'applique plus et nous proposons une référence biblique avec deux autres frères, Abel et Caïn, fils d'Adam et Eve. Selon le livre de la Genèse, Caïn a tué son frère par jalousie après que Dieu ait favorisé Abel plutôt que lui.

Selon cette école de pensée, l'exploration et l'exploitation constituent les deux extrémités d'un continuum (Lavie et al., 2010) et il y a un compromis entre ces deux dimensions au sein des organisations qui peut être relié à la performance organisationnelle par une relation curviligne en forme de U inversé en fonction de la performance de l'organisation (voir la figure 1b) (Laplume & Dass, 2009). La gestion de ce compromis consiste à trouver un juste équilibre entre exploration et exploitation et une entreprise sera considérée comme ambidextre si elle parvient à maintenir cet équilibre.

Les détracteurs de ce point de vue lui opposent les coûts de coordination et de communication engendrés par la recherche d'un équilibre entre objectifs contradictoires, mais Cao et al. ont constaté empiriquement qu'un tel équilibre («Abel et Caïn») serait plus bénéfique pour les entreprises dont les ressources sont limitées, alors qu'une combinaison («Apollo et Dionysos») améliorerait les performances des entreprises ayant un meilleur accès à des ressources internes et externes (Cao et al., 2009). Ces résultats suggèrent que les gestionnaires opérant dans des contextes caractérisés par de maigres ressources peuvent bénéficier d'une gestion prioritaire des compromis entre exploration et exploitation plutôt que d'essayer de maximiser une dimension au détriment de l'autre.

## AMBIDEXTRIE ORGANISATIONNELLE ET SURVIE A LONG TERME

«Le maintien d'un équilibre approprié entre exploration et exploitation est un facteur primordial dans la survie du système» écrivait March (1991, p.71). Bien que la littérature sur le sujet soit parsemée de ce type de déclarations, cette hypothèse n'a jamais été réellement démontrée. Une

grande partie du travail à ce jour s'est limitée à des études empiriques utilisant comme variables dépendantes la performance financière (rentabilité, profits, ventes sur actifs, flux de trésorerie), la performance des ventes (croissance des ventes, croissance des parts de marché) ou éventuellement la connaissance et l'innovation (brevets, Q de Tobin), mais très peu de publications se sont penchées sur les antécédents de la longévité. L'étude récente de l'industrie des disques durs sur une période de 20 ans menée par Piao (2014) constitue une exception qui confirme l'effet positif d'une forme déséquilibrée d'ambidextrie par laquelle les entreprises doivent trouver le juste équilibre entre une haute intensité d'exploitation et une intensité modérée d'exploration de manière à bénéficier des effets principaux de ces deux dimensions tout en évitant les tensions qu'une intensité élevée des deux peut amener. On peut néanmoins lui reprocher de mesurer la longévité par le nombre d'années durant lesquelles les entreprises de son échantillon sont restées actives dans leur industrie. En considérant que la sortie d'une firme de cette industrie correspond à sa dissolution, elle néglige la possibilité que les entreprises peuvent avoir volontairement cédé leur activité disques durs ou restructuré leur portefeuille d'activités à un moment donné. Il y a de nombreux exemples d'entreprises qui se sont adaptées aux changements environnementaux en réinventant leurs modèles d'affaires et qui opèrent maintenant dans des secteurs ou des technologies totalement différents de ceux par lesquels ils avaient commencé. IBM, le fabricant de matériel informatique transformé en société de conseil, est probablement l'exemple le plus emblématique d'un tel changement révolutionnaire.

Burgelman et Grove (2007) adoptent une approche différente et originale en combinant sur une période de plus de 35 ans une recherche de terrain longitudinale et l'expérience managériale d'un des auteurs devenu directeur général de l'entreprise étudiée, Intel Corporation. Dans cette proposition, les auteurs font particulièrement valoir que la longévité des entreprises dépend de leur capacité à adapter les cycles d'exploration (assimilée à des processus autonomes) et d'exploitation (assimilée à des processus induits) aux diverses formes de dynamiques stratégiques imposées par les changements environnementaux suffisamment importants pour transformer les «règles du jeu».

Fort de cette connaissance, Laplume et Dass (2009) ont proposé le concept d'*ambidextrie adaptative*, qui se rapporte à une forme mixte d'ambidextrie structurelle et d'ambidextrie séquentielle permettant d'adapter dynamiquement l'équilibre exploration/exploitation aux circonstances organisationnelles et contextuelles. Plus récemment, Luger (2014) a présenté le même concept sous le nom d'*ambidextrie dynamique*. Si les différentes formes d'ambidextrie statique consistent à opérer sur un point donné du continuum exploration-exploitation,

l'ambidextrie dynamique permet à l'entreprise d'ajuster ce point en réponse à l'évolution des exigences environnementales et d'ainsi augmenter ses chances de survie à long terme.

## PISTES DE REFLEXION ET CONCLUSIONS

Le paradoxe d'une ambidextrie potentiellement conflictuelle à court terme mais garante de performance à long terme constitue une hypothèse généralement bien acceptée (Lavie et al., 2010). Elle permettrait aux entreprises d'absorber avec plus d'efficacité les périodes de fluctuations fortes et imprévisibles de leur environnement. Si son effet positif sur la performance (financière et commerciale) et sur l'innovation a été démontré empiriquement, il n'en va pas de même pour son impact sur la longévité des organisations qui constitue pourtant une de ses hypothèses fondatrices.

Notre analyse de la littérature académique nous permet cependant de tirer quelques conclusions intermédiaires qui revêtent une dimension pratique essentielle pour les managers.

Tout d'abord, il apparaît que les entreprises ont intérêt à maximiser autant que possible les deux composantes de l'ambidextrie, à savoir l'exploration et l'exploitation, pour autant qu'elles disposent des ressources financières et humaines nécessaires («Apollon & Dionysos»). Dans le cas contraire, il convient d'arbitrer entre ces deux dimensions («Abel & Caïn»). On peut donc considérer qu'une organisation est ambidextre si elle arrive soit à explorer et exploiter simultanément, ce qui nécessite un management capable de concilier les deux tendances et d'apaiser les conflits qui peuvent en résulter, soit à osciller entre des phases d'exploitation et des phases d'exploration, ce qui demande une flexibilité intellectuelle et une plasticité organisationnelle.

La nécessité de combiner exploration et exploitation doit cependant être réfléchie par les décisionnaires à l'aune de l'exposition de leur organisation vis-à-vis de la volatilité de leur environnement. Certains secteurs d'activité étant moins exposés et certains environnements d'affaires moins volatils, ils peuvent se contenter de porter un accent plus marqué sur l'une ou l'autre des deux dimensions. Ainsi, dans un environnement stable par nature, les entreprises peuvent se focaliser sur l'exploitation : le risque d'échec est faible et les coûts liés à l'ambidextrie ne sont pas justifiés (quadrant inférieur droit de la figure 2). Dans un environnement turbulent (volatil et incertain), les entreprises de secteurs peu exposés aux changements doivent s'ouvrir sur l'extérieur en explorant de nouvelles technologies et de

nouveaux modèles d'affaires pour se préparer à la prochaine disruption qui, malgré la faible exposition, ne risque pas moins de l'impacter tôt ou tard (quadrant supérieur gauche de la figure 2). A l'inverse, les métiers fortement exposés à un environnement très incertain (tels que par exemple les activités à haut contenu technologique évoluant dans un contexte international) bénéficieront de la mise en pratique d'une stratégie ambidextre (quadrant supérieur droit de la figure 2). Dans ce cas, il paraît justifié pour ces organisations d'échanger une partie de leur productivité à court terme contre leur survie à long terme.

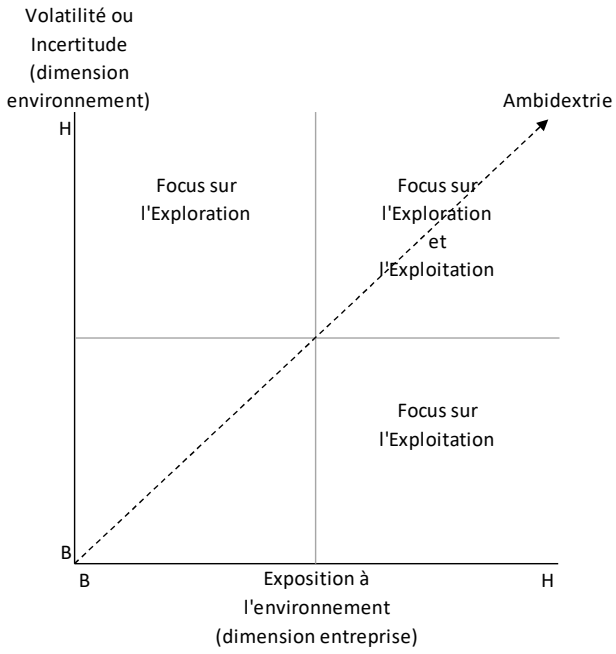


***Figure 2 :*** *Influence de la volatilité de l'environnement et de l'exposition de l'entreprise à cet environnement sur la stratégie d'Exploration-Exploitation à envisager*

Ensuite, il semble que la clef de la survie à long terme dans un environnement toujours plus changeant réside dans la capacité des entreprises d'ajuster de manière dynamique cet équilibre entre exploration et exploitation en réponses aux changements contextuels. Pour ce faire, les entreprises disposent de multiples moyens d'opérationnaliser l'ambidextrie organisationnelle (mesures structurelles, séquentielles, contextuelles) mais le monde réel ne peut se satisfaire des typologies statiques décrites dans la littérature académique. Dans la pratique, l'ambidextrie organisationnelle est un processus complexe et évolutif qui doit s'adapter de manière dynamique aux facteurs internes et externes, le plus souvent par la mise en place d'un mix ou d'une superposition de mesures simultanées, variables en intensité, à plusieurs niveaux de

l'entreprise et par la modification régulière de ce mix en réponse aux stimuli extérieurs et aux capacités internes nouvellement acquises.

L'effet de ces mesures sur la pérennité des organisations demeure toutefois une hypothèse qui demande à être vérifiée empiriquement, et au-delà de la confirmation d'un lien causal, les recherches futures devront se pencher de manière détaillée sur les méthodes de mise en pratique de l'ambidextrie organisationnelle par des études qualitatives et longitudinales afin de mieux comprendre *comment* l'opérer au quotidien car l'évolution de nos économies (globalisation, hyper-connectivité,…) fait progressivement disparaître les cas de stabilité environnementale et expose de plus en plus les entreprises à un contexte de haute volatilité.

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# Appendix II
## *The history of GALACTIC*

In this Appendix, we narrate each of the four main phases (epochs) in the company's development with some level of detail in order to reconstruct its history and identify the internal and external changes that have paved its evolution until now. To provide the reader with a better understanding of the environmental context in which the company evolved, we include here and there short vignettes describing the external factors and main events that have shaped the company's direct environment.

The text is peppered with footnotes containing details that are not essential to follow the narrative but they provide additional information useful to the reader to expand the scope of his/her understanding of the constituent elements.

## II.1. Epoch I: Antiquitus (Before 1994)

*Where it all started… and that Lactic Acid stood out from the crowd.*

FVAN[78] got a degree in electromechanical engineering as well as a post-graduate degree in biotechnology in the early nineteen-eighties. At the university, he worked on the biomethanation of industrial wastes[79] which drew his attention to different volatile fatty acids which are naturally produced as intermediates in this process. At this point, thinking that more value could be extracted from the treated wastes by harvesting, purifying and selling these intermediates instead of going down the whole degradation process until methane is produced, he got interested in their markets and he realized that while most of these acids were commodities already produced from petroleum at large industrial scale, one stood out from the crowd: lactic acid.

*But why Lactic Acid?*

Lactic acid is a small molecule with only three carbon atoms that holds simultaneously two functional groups which allow a wide variety of chemical reactions, and hence the production of a wide range of derivatives. Moreover, it is naturally present in almost all forms of organized life, playing an active role in the metabolism of carbohydrates and amino acids. Its natural occurrence, biocompatibility and biodegradability make it perfectly suited for being used in many different application fields ranging from human and animal nutrition to detergents, cosmetics, pharmaceuticals and polymers. It also forms the base of what is called "lactochemistry" that aims at developing new pathways to substitute petroleum-based products and produce new molecules with advantageous properties and reduced environmental footprint.

A lot of possibilities… and, paradoxally, a market that seemed to be underdeveloped. A niche with rather high prices and few relatively small players. FVAN smelled an opportunity but there was a lot of hurdles to pass.

*The need for an efficient purification process.*

At this time, the problem of harvesting and purifying lactic acid remained as the then-existing processes were all heavy and costly to operate or too simple and basic to reach the quality level required by the customers. FVAN started to work on the subject when he was still at the university and he came to devise an innovative purification process that would ultimately revolutionize the lactic acid industry.

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[78] GALACTIC' staff members are identified in the company's organization (including all subsidiaries) since its inception by 4-letter acronyms composed with the first letter(s) of their surname and family name. We adopt the same logic in this dissertation in order to preserve the privacy of the people appearing in this narrative.

[79] *Biomethanation*, or *methanogenesis*, is a biological process whereby anaerobic microorganisms decompose biodegradable substances into a nutrient-rich organic sludge on the one hand, and more importantly, into biogas on the other hand. The sludge is often used as fertilizer whereas biogas, a mixture of approximately 60% of methane and 40% of carbon dioxide that retains about 90% of the energy from the initial degraded organic matters, is recovered and used as source of energy in boilers and heating systems. The biological conversion of organic matter in methanogenesis proceeds in three different stages. First, a hydrolysis whereby insoluble organic material and compounds like lipids, fats, proteins, and polysaccharides are broken down into soluble monomers, such as amino acids and monosaccharides. Then, an acidogenesis which converts the soluble monomers into fatty acids such as acetic acid, propionic acid, butyric acid and lactic acid. The last stage, the methane formation, entails the conversion of these acids into biogas and organic sludge (https://sites.google.com/a/owu.edu/biogas-digesters-a-review-of-the-science-benefits-and-drawbacks/biomethanation-the-science-behind-biogas-digesters).

*1985: an attempt to offer the technology to a Spanish industrial producer.*

After having completed his studies, he went to propose his purification process to the two main producers of lactic acid of this time: a Dutch company then called CCA (*Centrale Combinatie Amsterdam*) and a Spanish one called *Luis Ayuso SA*. These companies were not producing lactic acid from industrial wastes, of course, but with the help of microorganisms with a process called "fermentation". Both were interested but the latter's proposal convinced FVAN to move to Barcelona and work as an independent researcher. The deal was simple: he was given a salary, laboratory infrastructure and time to improve his process to demonstrate its superiority over existing production methods but, for confidentiality reasons, he was not allowed to enter Luis Ayuso's production facilities. On the other hand, he would keep the full ownership of his technology which was supposed to be transferred in a later stage, provided that it was a real breakthrough, under conditions to be negotiated. As a matter of fact, the Spanish company was absorbed by the Dutch one about one year later and FVAN decided to resign as he didn't want to work for CCA who, he thought, would deprive him from his invention at the first occasion[80].

*1986: back to Brussels, the creation of ATC… in a pub.*

Back to Brussels, his hometown, FVAN didn't have the funds needed to pursue with the development of his technology. Hence, he entered a totally different field by setting up a small company with the intention to sell drainage products such as polymer concrete gutters and channels for the building industry. A friend of his established the production company, that FVAN will eventually take over a few years later, whereas his company would focus on the commercialization. Starting up this company didn't require too much money and he financed this venture with a commission on the sale of his parents' country house, the same commission as the one a real estate broker would have levied. The company, named *Advanced Technics Company* (ATC), was lodged in an old small pub.

***Environmental context:***

***[Competition]*** *In 1986, CSM expanded through the acquisition of a 75% share of Luis Ayuso SA as well as key-lactic users including the American bakery ingredients producer C.J. Patterson*[81]*. The remaining 25% of Ayuso will be bought in 1988. As a consequence about 45% of the world production of lactic acid is concentrated in the hands of CSM which is also the only producer of natural (fermentation-based) lactic acid.*

***[Competition]*** *Also in 1986, Monsanto sold its lactic acid factory in Texas City in a leveraged buyout to a group of Houston investors who foresaw that the new venture would benefit from the lower cost of petroleum feedstocks (crude oil price fell below $10 a barrel the same year) that served as raw material and from a weakening dollar. The new company, which was named Sterling Chemicals, had an anchor client in Monsanto, which was paying a fee and a share of the profits to convert its petroleum feedstocks. Shortly before October 1988 Sterling Chemicals became a publicly traded company, its stock listed on the New York Stock Exchange.*

[80] CCA was a subsidiary of CSM, a Dutch group of companies listed on Amsterdam Stock Exchange.

[81] http://www.corbion.com/about-corbion/our-history

***[Competition]*** *In 1989, Cargill[82] creates a team of scientists asked to explore new uses for corn. Cargill is looking for ways to expand the use of the billions of bushels[83] of corn and related byproducts flowing through its mills. The Cargill team makes a list of potential products and PLA[84] is on that list* (Gruber, 2004).

*1987: an attempt at selling lactic acid*

Besides the distribution of products for the building industry, FVAN thought that he could make the best of what he learned during his time at Luis Ayuso and he decided to try importing lactic acid from Chinese producers. He left for China to meet Henan Jindan. The company was small and was using an inefficient production process in a very dirty working environment[85]. FVAN bought one container to try selling the product in Europe but it will turn into a failure because of the terrible quality of the imported material.

*1990: the cellars of the pub become a research laboratory.*

In 1990, still haunted by the desire to further develop his lactic acid technology, FVAN used the first proceeds of his sales activities to revamp the basement of the pub house and convert it into a laboratory. It was a low-ceilinged dark and small room with nothing but a table and a few flasks and tubes. In parallel, he took on board a young trainee - BLED - who surveyed the lactic acid market for his master thesis. BLED will eventually become the first sales and marketing manager of GALACTIC a few years later.

*The need to find a producing microorganism.*

Having in hand a good purification technology, it was now time to work out a production process, i.e. a fermentation process, and select the right lactic acid producing microorganism. He hired a young scientist (FRON) and asked all his friends and acquaintances to bring samples of natural habitats in which lactic acid bacteria where known to grow from all over the world. In this way, he received various types of decomposing leaves, fruits and roots, animal wastes and droppings, as well as samples from sewages and animal cavities. All of them were put to the test under specific conditions in order to, hopefully, isolate the so much expected microorganism. As the story goes, after almost a year of endless cultures and subcultures, no single bacteria could be found. There was indeed lactic acid produced in a myriad of flasks and vials but the protocol used then was not efficient enough to enable the isolation of a single pure strain.

*1991: speeding up research efforts thanks to a regional grant.*

Desperate by the slow pace of this research, FVAN applied for a grant to the Brussels-City Government that made possible the recruitment of a small team of scientists and engineers and the financing of a collaborative research with the Biotechnology Unit of an engineering school nearby. In addition to human resources, it provided access to more specialized knowledge and adequate equipment and infrastructure in this engineering school. This is when the author – JCBO - embarked on this adventure as research engineer dispatched to the Biotechnology Unit with the mission to select the microorganism and develop the fermentation process. At the

[82] Cargill (USA) is a 150-years old international provider of food, agricultural and risk management products and services employing 150,000 employees in 70 countries (www.cargill.com).

[83] A bushel is a unit of weight used when buying and selling crops such as corn. A bushel of corn weighs 56 pounds (25.4 kg).

[84] "PLA" stand for Poly-Lactic Acid, a plastic made of Lactic Acid that will play an important role in GALACTIC's history later.

[85] Henan Jindan will however develop over the years and will eventually become a rather big player on the international scene as shown later in this narrative.

same time, FVAN's brother – MVAN –, who was freshly graduated in robotics from the Imperial College in London and still fulfilling his mandatory military obligations, started to work during his free time on automatizing the company's first lab-scale fermentation reactors that were build and assembled by another researcher (EMAL). That was in 1991, a time of real bootstrapping, when each and every piece of equipment was home-made and when the abyssal lack of funds could only be rivaled by the unfailing optimism of the team. Nothing seemed impossible, even if the largest supplier of this project at this moment was the do-it-yourself shop around the corner.

*1992: from a pub to a nightclub… what an improvement!*

Research on fermentation progressed rapidly despite (or thanks to?) the eviction of the first scientist who worked on bacterial selection at the very beginning (FRON). In a couple of month, a particularly efficient microorganism nicknamed "George" was identified, purified and characterized. The team then started to work on what is called "downstream processing" [86] and very soon the small and dark cellars became too small for the equipment that the team was building. FVAN acquired an old building still in the suburbs of Brussels that had been a microbrewery before being transformed into a nightclub. What was of interest for the team was the available space and ceilings' heights (and a wonderful opportunity to organize a big party before the transformation works would start). It was still bootstrapping and although the project was still in infancy, the team members, who all were spending their week-ends to revamp the place into laboratories, were getting a sense of progression, a feeling of growth, the smell of success. Doub was not an option and, as a matter of fact, it didn't even cross their minds.

*A new attempt to collaborate with an industrial company.*

In March 1992, FVAN got in contact with INPAL SA Industrias Quimicas, a Brazilian chemical company which happens to have a small factory in Aracaju, State of Sergipe. This factory, stopped since many years, had actually been erected at the same time and by the same designer than the lactic acid factory used by CCA in Campos close to Rio de Janeiro (a subsidiary named Sintheses Industria E Commercio Ltda). FVAN looked at it as a good opportunity to get some insights about their technology and, most

[86] "*Downstream processing*" refers to the recovery and purification of biosynthetic products, particularly pharmaceuticals, from natural sources such as animal or plant tissue or fermentation broth, including the recycling of salvageable components and the proper treatment and disposal of waste. It is usually considered a specialized field in biochemical engineering, itself a specialization within chemical engineering, though many of the key technologies were developed by chemists and biologists for separation of biological products.
*Removal of insolubles* is the first step and involves the capture of the product as a solute in a particulate-free liquid, for example the separation of cells, cell debris or other particulate matter from fermentation. Typical operations to achieve this are filtration, centrifugation, sedimentation, precipitation, flocculation, electro-precipitation, and gravity settling.
*Product isolation* is the removal of those components whose properties vary markedly from that of the desired product. For most products, water is the chief impurity and isolation steps are designed to remove most of it, reducing the volume of material to be handled and concentrating the product. Solvent extraction, adsorption, ultrafiltration, and precipitation are some of the unit operations involved.
*Product purification* is done to separate those contaminants that resemble the product very closely in physical and chemical properties. Consequently steps in this stage are expensive to carry out and require sensitive and sophisticated equipment. Examples of operations include affinity, size exclusion, reversed phase chromatography, ion-exchange chromatography, crystallization, fractional precipitation, and distillation (https://en.wikipedia.org/wiki/Downstream_processing).

of all, to see if this factory could be restarted and operated in partnership with its current owner. FVAN, EMAL and JCBO set off to Brazil in May where a detailed inspection of the factory took place and a business plan was tentatively established. However, no agreement could be reached and the project was abandoned in part because the factory was in a state of profound disrepair which would have required a high amount of capital expenditures, a commodity that ATC didn't have and that INPAL was not keen to invest.

***Environmental context:***
***[Society]*** *Presidents Bush and Yeltsin proclaim a formal end to the Cold War (Feb. 1). US lifts trade sanctions against China (Feb. 21).*

***[Competition]*** *CSM advances further in the bakery ingredients market with the acquisition of Westco Products (USA).*

***[Competition]*** *Archer Daniels Midland Co. (ADM)*[87]*, a major corn processor in the US, highlights a range of new developments centering on lactic acid among other products. The company has just commissioned a factory in Decatur, IL. (USA).*

***[Competition]*** *ECOCHEM, a DuPont*[88] *- ConAgra*[89] *joint venture, opens a $20 million lactic acid plant in Wisconsin, USA, using a new technology. The company will strive for two years to commission the factory to no avail before giving up and dismantling the equipment.*

*Starting a research project on PLA… already!*

At about the same time, not doubting his chances to succeed with his lactic acid project, FVAN applied for a new grant, this time to the Government of Walloon Region. This new project aimed at developing, together with the University of Liège - a revolutionary process to manufacture plastic from lactic acid. Indeed, lactic acid can be polymerized into a polyester called *Poly-Lactic Acid* or "PLA" with mechanical properties similar to common polymers such as polypropylene (PP) or poly-ethylene-terephtalate (PET). In addition to coming from renewable resources through a fermentation process instead of fossil resources such as crude oil or natural gas, PLA is biodegradable, which means that it disappears when thrown away in nature.

*1993: Time to find an investor.*

In the course of 1993, the team was progressing fast on the development of the process and FVAN started looking for investors willing to take the risk of financing its industrialization. Among other potential investors, one

[87] ADM is one of the world's largest agricultural processors and food ingredient providers, with more than 32,300 employees serving customers in more than 160 countries with a global value chain that includes 428 crop procurement locations, 280 ingredient manufacturing facilities, and 39 innovation centers (http://www.adm.com/en-US/news/_layouts/PressReleaseDetail.aspx?ID=708).

[88] The company E.I. du Pont de Nemours and Co., aka DuPont, is one of the largest chemical company in the world active in Agriculture & Nutrition (seeds and crop protection), Advanced Materials (polymers and electronics), and Bio-based industrials (enzymes). It employs about 65,000 people and records net sales of $28,4 billion (2014 data) (www.dupont.com).

[89] ConAgra Foods is one of North America's largest packaged food companies with recognized brands found in grocery, convenience, mass merchandise and club stores. The company also has a strong business-to-business presence, supplying frozen potato and sweet potato products as well as other vegetable, spice and grain products to a variety of well-known restaurants, foodservice operators and commercial customers. It has net sales of $15.8 billion with about 33,000 employees (www.conagrafoods.com/).

company finally accepted: Finasucre, a family holding company created in 1929 to bring together the assets in two sugar factories and which grew over time by acquiring other sugar factories and related businesses in Belgium and Africa. Finasucre had closed one of its sugar mills in 1990 and remained with this industrial site unoccupied and awaiting conversion. Moreover, Finasucre saw in the project a nice way to vertically diversify their activities since lactic acid is produced from sugar. The base of the deal: an industrial site and just enough capital to erect a small lactic acid factory with a yearly capacity of 1,000 tons. The aim of the game: prove that the process was working and that the product could be sold.

***Environmental context:***
***[Society]*** *British House of Commons approves European unity pact (May 20). Maastricht Treaty takes effect, creating European Union (Nov. 1).*

The year 1993 marked the end of our first epoch, a period that we have named *Antiquitus* in that it allowed the establishment of a production process and the identification of an investor willing to embark on the adventure. The foundations were in place to move ahead and to enter a new era during which a dedicated company will be set up and a business will be structured.

**1994**

*Creation of Brussels Biotech SA…*
*… and Bioprocess Technology SA.*

As a first step, Brussels Biotech SA was created just before Christmas 1993 as a spin-out of ATC to lodge all lactic acid-related R&D activities. Immediately after, in January 1994, the article of associations of a company owned by Finasucre, "Sècherie du Hainaut-Nord", were changed to allow the entry of FVAN in its capital. The "Sécherie du Hainaut-Nord" which had no activity since its closure was then renamed "Bioprocess technology" with the intention to exploit the technology in the old sugar mill closed four years before.

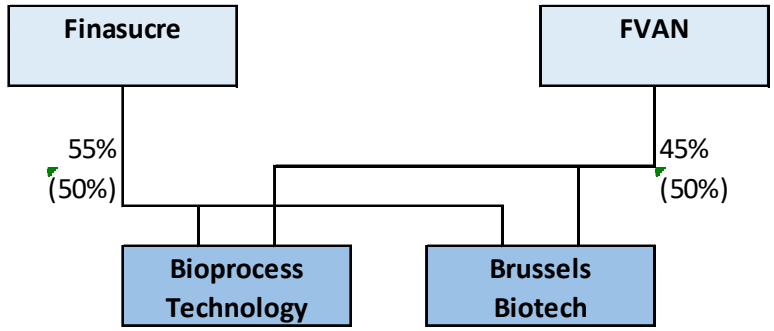


*Figure 4.2: Shareholding structure of the freshly created companies*
*(% of control in brackets)*

EMAL and MVAN started the engineering work in the factory-to-be with the help of two old engineers from Finasucre (drawing flowcharts and blueprints, sizing equipment, selecting manufacturers and service providers etc…) while JCBO pursued with the development and improvement of the various processing steps at lab and small pilot scale with a small team of technicians. At the same time, the research project on PLA was continuing in partnership with the University of Liège under the direct leadership of FVAN.

***Environmental context (year 1994):***
***[Competition]*** *Cargill builds a 4.000 tons per year PLA facility in Savage, Minnesota (USA). This plant is to be used to perfect the manufacturing technology and allow further development of a commercial market for PLA (Gruber, 2004).*

*An EU-funded research program.*

In order to help finance its continuing R&D efforts, Brussels Biotech launched a research project funded by the European Community together with the Universities of Nancy (ENSAIA - France), Liège (CERM - Belgium) and Stuttgart (IKT - Germany) and a German private company. The purpose was the "development of innovative biodegradable polylactic acids-polymers, based on agricultural raw materials for new industrial applications". The project covered the whole chain from sugar to PLA. It will last 3 years.

*First fermentation at industrial scale.*

On December 26th 1994, their minds still blurred by the haze of Christmas eve, the team members all gathered together in the coldness of the factory to put George, the microorganism previously selected, at work and launch the first industrial scale fermentation batch. It was exhilarating but soon the team disenchanted when it realized that the fermentation was producing heat and needed to be continuously cooled down while everything had been designed to heat it up. This strange but actually very logical thermodynamic behavior had not been anticipated before because of the small size of the lab-scale equipment which showed again, as if the demonstration was necessary, that scaling up industrial processes brings surprises and that much more thorough testing and measurements were needed. At this moment though, time was of essence as the cash reserves provided by Finasucre were declining fast. Short term solutions were implemented to circumvent the issue and allow the batch to proceed to its end. Meanwhile, the erection of the factory was still progressing. The team had been foolish enough to start the beginning of the process while the erection of the end part was not even completed. It was a race as the project couldn't afford wasting full batches of product. A team led by EMAL was working days and night at erecting and water-testing the new equipment while another team led by MVAN and JCBO was chasing right behind with real product. Running ahead of time, the different processing steps were started while there was not even a proper visualization of the working parameters on computer screens, only a myriad of apparently nonsensical numbers, hardcore programs and control loops coming directly from the guts of the multiple PLC's[90]. All team members were living in a small house close to the factory so that they could intervene right away in case of problem during nights and week-ends. They all knew when weeks were starting but never when they would come to an end.

**1995**

*First sale.*

By May 1995, a first order came in for a full container load to be shipped to New York. The product was far from good, it was greenish, smelly and cloudy when it's supposed to be transparent or slightly yellowish, but by chance this customer was understanding and forgiving. So, despite the many efforts already made by the team, there was no time to cheer up and JCBO was given one week-end to run trials in the lab to find a way that could be implemented in the factory to improve the product in record time so as to reach the level of quality required for expanding the sales beyond one single broad-minded and lenient customer.

***Environmental context (year 1995):***
***[Competition]*** *Cargill realizes it needs a partner with a presence in the polymer market, as it is generally thought that Cargill alone does not have the necessary credibility in the plastics industry. Cargill*

[90] A PLC, or Programmable Logic Controller, is a digital computer commonly used in chemical, pharmaceutical and refining industries for the automation of industrial process plants and control of machinery.

*subsequently assembles a list of partner attributes, and the Dow Chemical Company emerges as the best candidate (Gruber, 2004).*

***[Competition]*** *Shimadzu*[91] *builds a 100 tons/year pilot plant for its PLA in Otsu, Japan. The company has developed a fermentation process for lactic acid and has also collaborated with Mitsubishi Plastics Industries to develop poly-L-lactic acid which will be marketed under the trade name Lacty®.*

***[Competition]*** *Mitsui Toatsu Chemicals*[92] *patents a new solvent-based process to obtain high molecular-weight PLA. This process radically differs from the one studied by the other PLA-players of this time (Cargill, Brussels Biotech and other Japanese).*

*Continuous production.*

Additional equipment bought in second-hand was then temporarily installed to allow the company to produce a food grade product of a fair quality. The company was still in cash drain, by far, but there was at least some cash coming in thanks to recurring sales. The company's production department was then expanded to help produce in shifts on a 24/7 mode and the production capacity increased mechanically to 3,000 tons per year.

The company's structure was still very simple as shown in the figure below.

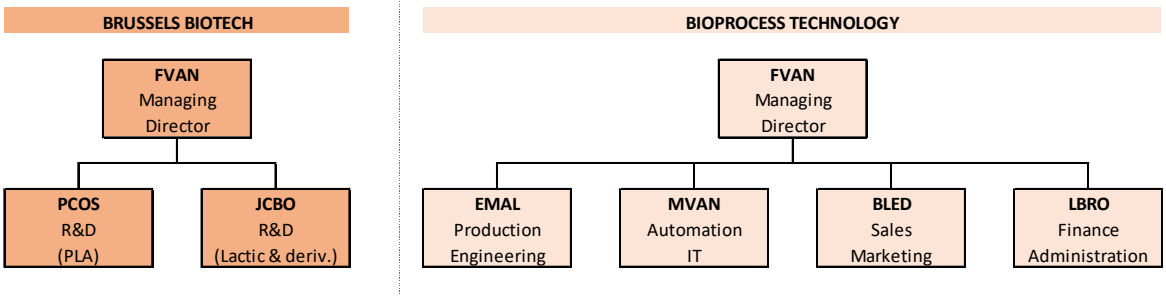


*Figure 4.3: Organizational chart of the management team in 1994-1995*

*The need for more improvements to reach higher quality levels.*

FVAN's revolutionary purification process developed about 10 years before couldn't yet be run at industrial scale though. More improvements were needed to achieve the good yields, low costs and high quality that it was supposed to offer. To this end, the team worked on adding a pre-purification step using a technology widely used in the treatment of sweeteners but never tested on organic acids. Although the basic principle of this existing technology seemed to be workable for lactic acid, it had to be adapted to this specific case. The team

[91] Shimadzu is a Japanese science and technology-driven company whose core businesses lies in developing, producing and selling precision analytical instruments, medical systems and aircraft equipment. It is listed on the Tokyo Stock Exchange and has net sales of about ¥315 billion (€2.5 billion, 2014)(www.shimadzu.com).

[92] Mitsui Chemicals, which was formed by the merger of Mitsui Toatsu Chemical and Mitsui Petrochemicals in October 1997, is a major chemical company in Japan. It is one of the 225 companies making the Nikkei index at the Tokyo Stock Exchange and employs about 13,000 people worldwide. The company mainly deals in performance materials, petro and basic chemicals and functional polymeric materials with net sales of ¥1410 billion (€11.3 billion, 2015)(www.mitsuichem.com).

therefor eworked in tandem with a French leading provider of services in the field of molecule production and purification for the life science and chemical industries. Pilot tests were conducted and an industrial fully-automated piece of equipment was designed.

**1996**

*1996: Capacity extension and launch of a first wave of derivatives.*

Thanks to the implementation of the pre-purification unit, the company was able to increase its production capacity to 6,000 tons per year and to successfully start FVAN's purification process, hence guaranteeing previously unmet purity levels at highly competitive costs. The sales of lactic acid could be extended from low-end applications in the food and animal feed industries to high-end chemical markets and much more demanding food applications like the manufacture of bakery emulsifiers.

The access to this higher quality of lactic acid, called "heat-stable", also allowed the company to start developing derivatives such as sodium lactate and potassium lactate of equally high quality, thus opening up new markets in food preservation.

*One of the key-people quits*

EMAL who was in charge of the production department as well as a part of the engineering resigned precisely when the business seemed to take off. After a moment of stress, his responsibilities were reassigned: production went to JCBO (in addition to R&D) whereas MVAN took over the engineering (in addition to IT), as shown hereunder.

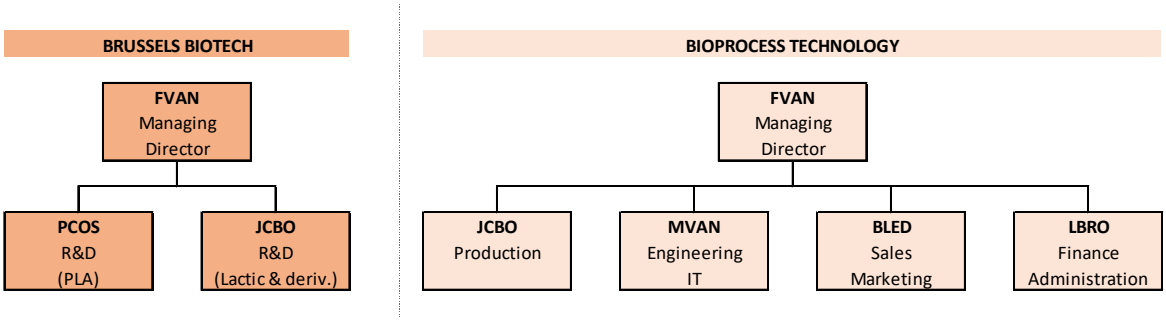


*Figure 4.4: Organizational chart of the management team in 1996*

***Environmental context (year 1996):***

***[Competition]*** *Archer Daniels Midland Co. is doubling the size of its Decatur, IL., lactic-acid plant. Their market approach is typical of a multinational commodity player: targeting key-accounts in order to move big volumes with limited marketing efforts. ADM offers few lactic acid derivatives whose production is sub-contracted. They are mainly active on the North American market and almost absent from the European market.*

***[Competition]*** *Chronopol Inc.*[93] *plans to construct a $4 million plant in Golden, Colorado, to produce about 1000 tons per year of Chronopol-brand PLA resin.*

***[Competition]*** *Sterling Chemicals decides to exit the synthetic lactic acid business because of the "significant" capital outlay required to upgrade the 19-million lbs/year plant at Texas City, USA. The company would not be able to recoup the high cost of the upgrade and it would make the price noncompetitive with fermentation processes.*

***[Competition]*** *Mitsui starts up a 500 tons/year semi-commercial plant for its PLA at its factory in Omuta, Japan. The product will be commercialized under the brand name LACEA® but it will never reach substantial volumes.*

**1997**

*1997: A new name.*

As sales progressed, it was deemed necessary to change the company's image and Bioprocess Technology was then renamed into GALACTIC SA. The link with its core product, lactic acid, was obvious but the new name translated also a certain mindset in the management team: the sky is the limit! A baseline was attached to the company name: "*GALACTIC, the lactic acid universe*". This somewhat snooty baseline will be abandoned about 15 years later when the company will start adding non-lactic products to its portfolio in an attempt to reposition itself as a solutions provider instead of being only a lactic acid producer.

*Capacity expansion, again.*

As soon as the most stringent quality requirements could be met, market demand increased fast as the main customers were seeking for an alternative to CCA who was in a quasi-monopolistic situation since it had taken over about all lactic acid producers at that time. GALACTIC was then seen as THE alternative, especially for big users who wanted to split their purchases and reduce their dependency towards one single supplier. The decision was taken to increase again the production capacity and reach 15,000 tons per year which was believed to be the maximum the main pieces of equipment would sustain. One step was limiting this expansion though, the concentration step. Because of limited financial resources and time constraints, the company decided to buy some parts of an old multiple-effect falling-film evaporator that was staying unused in one of Finasucre's sugar factory, which was then revamped, transformed and customized for a new life. It was nothing but a big scale makeshift job but it was quickly up and running.

*Development of a production process for calcium lactate.*

In its quest to expand its product portfolio, Galactic decided to start working out a process to produce calcium lactate[94]. The company had built some expertise at producing liquid products but calcium lactate is

[93] Chronopol Inc. is a subsidiary of Golden Technologies Co. Inc., member of ACX Technologies Inc., itself owned by CoorsTek, an American manufacturer of engineered ceramics, semiconductor tooling, plastic tubing, medical devices and other industrial products. Coorstek posted revenues of $1.25 billion with 5,900 employees (2015) (www.coorstek.com).

[94] Calcium lactate is a salt of lactic acid extensively used, among others, for increasing the calcium level of food and beverages in order to prevent calcium deficiencies especially among some target groups such as children and teenagers, pregnant and lactating women, women experiencing menopause, and elderly people. Calcium lactate displays properties superior to most other calcium sources in terms of solubility and bioavailability.

a powder product posing new difficulties to which the company was not accustomed. Here again the budget allocated to the R&D team to develop a product as close as possible to the competition one was scarce. Hence, the process obtained was not optimum but it helped the company to enter this new market and learn about the customers' requirements. Incidentally, the company will continue to work on the subject even after market launch and will ultimately end up with an innovative method for the production of a new shape of particles bringing real benefits to the customers. But back then, in 1997, Galactic was still far from being inventive with this product as very soon after the launch, Purac[95], Galactic's main competitor and worldwide market leader, came to offer a superior product in terms of particle size distribution.

*A new EC-funded project from lactic acid to PLA-based end-products.*

At about the same time, Galactic started a new research project (PL97-3070) funded by the European Community in continuity with the AIR project that spun from 1994 to 1997. The purpose was to scale up the production of biodegradable films and bottles made of PLA. The project associated Galactic, Brussels Biotech, the University of Stuttgart and two Belgian industrial companies interested in evaluating these polymers for their own use as potential customers. The project lasted for another 3 years and allowed Galactic to build a production line for lactic acid esters which were intermediates in this new process but one of them, ethyl lactate, was also an interesting product to be sold as bio-based solvent.

*Brussels Biotech acquires a patent on PLA*

Brussels Biotech acquired the protective rights on the patent filed in 1996 by the universities of Stuttgart and Liège on the PLA production process developed during the EC-funded research project AIR3-CT94-2285 that was coordinated by Brussels Biotech.

*Galactic announces new derivatives to be launched in the next year.*

Having developed production processes for both products, Galactic announced publicly in October 1997 its plans to launch its own production of solid Lactate Salts (Calcium Lactate) and Lactic Esters (Ethyl Lactate) with a total capacity of several thousand tons. Inasmuch as it materialized in 1998 for the former, the company was not able to reach the right quality requirements for the latter, and it decided to focus on other priorities.

***Environmental context (year 1997):***
***[Competition]*** *Cargill and The Dow Chemical Company[96] decide to join forces by creating a 50:50 joint venture aimed at developing and producing PLA. The company is named Cargill Dow Polymers LLC. Dow will dramatically change the positioning of the polymer by putting*

[95] Purac was the name of CCA's lactic acid division. CCA will change name to become CSM (*Centrale Suiker Maatschappij*) and Purac will be referred to as CSM's biochemicals division. CSM will go through a profound restructuring during the first decade of the 21st century with the progressive divestment of several divisions (the food division, the sugar division, and the confectionery division) before the remaining activities, the bakery division and the biochemicals, be separated for good in 2012. CSM's bakery operations (€2.7 billion turnover) will then be acquired by Rhone Capital, keeping the name, whereas the ingredients and biochemicals will be combined under the name Corbion and stay listed in Amsterdam Stock Exchange.

[96] The Dow Chemical Company is an American multinational chemical corporation founded in 1897. It provides chemical, plastic, and agricultural products and services to consumer markets and operates in approximately 180 countries. Dow is the third largest chemical company in the world by revenue. It employs approximately 53,000 people worldwide and totals sales of about $58.2 billion (data of 2014) (www.dow.com/).

*the emphasis on its natural origin and its technical properties more than on biodegradability.*

***[Competition]*** *Shimadzu and Kobe Steel bring on stream a semi-commercial plant with a capacity of about 1000 tons/year to carry out a continuous polymerization process for their PLA (Lacty®).*

**1998**

*In 1998, Galactic becomes the second largest lactic acid producer worldwide*

In 1998, Galactic was already serving customers through a distribution network spanning over more than 40 countries, exporting about 80% of its production. It received an Export Award at the World Expo in Lisbon, Portugal, and became *de facto* the world second largest producer of lactic acid and lactates thanks to the capacity expansion made the year before and the wave of new derivatives introduced in the previous three years. At this point in time, the company that started a few years before with a staff of 4 was employing about 40 people.

*A patent that will change the company's future*

In June, Galactic filed for a patent on "a method for recuperating and purifying a lactic acid solution", a real breakthrough in the lactic acid industry (hereinafter referred to as "LA I"). It is the technology initially developed by FVAN which was exploited by the company and which would now be protected. The decision was taken not only to protect the technology but also to prevent other companies to patent it and, by doing so, to preclude Galactic from exploiting it in other countries one day. It was the first time in its history that Galactic filed for a patent but, as we will see later, it would play a crucial role in the company's development.

*A byproduct-free production process*

The production of lactic acid by fermentation generates a byproduct generally called gypsum (calcium sulfate), itself sold as raw material for the manufacture of products for the building industry (cement and plaster). Galactic had imagined a different process that would not entail such byproduct and received a grant from the regional government to research on the development of this new production process. This project will last for 3 years. About twenty years later, this process is still not exploited but forms the base of a broader manufacturing method on which the company is putting high hopes to revolutionize the lactic industry when production capacities will expand beyond the possibility for the market to absorb the amount of gypsum generated.

*Discussions for an industrial partnership with Roquette…*

Galactic discussed with the French company Roquette Frères[97], a major producer of starches and glucose, a common project for the production of 30.000 tons per year of lactic acid to be in turn transformed into 25.000 tons per year of PLA. They conducted a joint cost evaluation to compare 3 production sites (Belgium, France and USA) and 2 different raw materials (sucrose and glucose). The parties will stay in contact about this project for two years before the project be ultimately abandoned. As a starch producing and crop processing company, Roquette has had an eye on lactic acid since many years; it has even been on the verge of taking over Purac in the early nineties when the

[97] Roquette Frères ranks in 5th position worldwide for starch production and in pole position for the production of polyols with a global turnover of €3.1 billion and about 8,000 employees in 2014 (www.roquette.fr).

investment decision was rejected by the board of directors to a one-vote majority[98].

***Environmental context (year 1998):***
***[Competition]*** *Purac and Cargill announce a joint-venture for the production of 35.000 tons per year of lactic acid in Blair, Nebraska (USA). Half the production will be dedicated to Cargill for its future production of PLA, the other half being for Purac's classical market. The company is called PGLA-1: Polymer Grade Lactic Acid - plant 1. Both shareholders intend to double the production capacity at short-to-mid term.*

***[Competition]*** *Chronopol discontinues its PLA-development activities. The owners put the patent portfolio (163 references!) and tangible assets (pilot plant with an annual capacity of 1,000 tons) up for sale. Most patents will be bought by Dupont but will ultimately end up in Cargill's hands.*

*… or to buy Chronopol's assets*

Galactic was invited to assess Chronopol's patent portfolio and its assets but Galactic pulled out from the negotiation when the due diligence revealed that Chronopol's process used noxious solvents which Galactic rejected by principle for the manufacture of an environmentally-friendly polymer.

**1999**

*1999: a change in Galactic's shareholding structure*

Since its inception, Galactic's shareholding was divided between Finasucre (55% of shares, 50% of control) and FVAN (45% of shares, 50% of control). To further support its development, the company needed fresh funds but the capital intensiveness of its activities call for increasing equities to an extent that cannot be sustained by a single individual. FVAN's shareholding position would be diluted if he would not inject money in proportion and the decision power not not be shared equally anymore which meant that Finasucre might take full control over the company's destiny. To avoid this, FVAN decided to create an investment vehicle, named Serendip[99], to which he brought his 45% of Galactic and in which Compagnie du Bois Sauvage (CBS)[100] took 25%. The funds invested by the latter will allow Serendip to follow Finasucre so as to increase Galactic's equity and maintain a balanced control. The figure below shows the final shareholding structure.

[98] Personal communication.
[99] The name *Serendip* was chosen in reference to the Persian fairy tale *The Three Princes of Serendip*, whose heroes "were always making discoveries, by accidents and sagacity, of things they were not in quest of" as Horace Walpole wrote in a letter to his friend Horace Mann in 1754. He coined the term *Serendipity* which refers to accidental discovery. Common examples of serendipity in scientific innovation are Alexander Fleming's accidental discovery of penicillin in 1928, the invention of the microwave oven by Percy Spencer in 1945, and the invention of the Post-it note by Spencer Silver in 1968.
[100] Compagnie du Bois Sauvage (CBS) is an investment holding company, quoted on NYSE Euronext Brussels, with a stable 'family' principal shareholder. The Company aims to focus on a limited number of holdings, whether listed on the stock exchange or not, mainly in the industrial sector. CBS totaled a market capitalization of about €333 million for an intrinsic value (in-the-money) of €459 million at the end of 2014 (www.bois-sauvage.be).

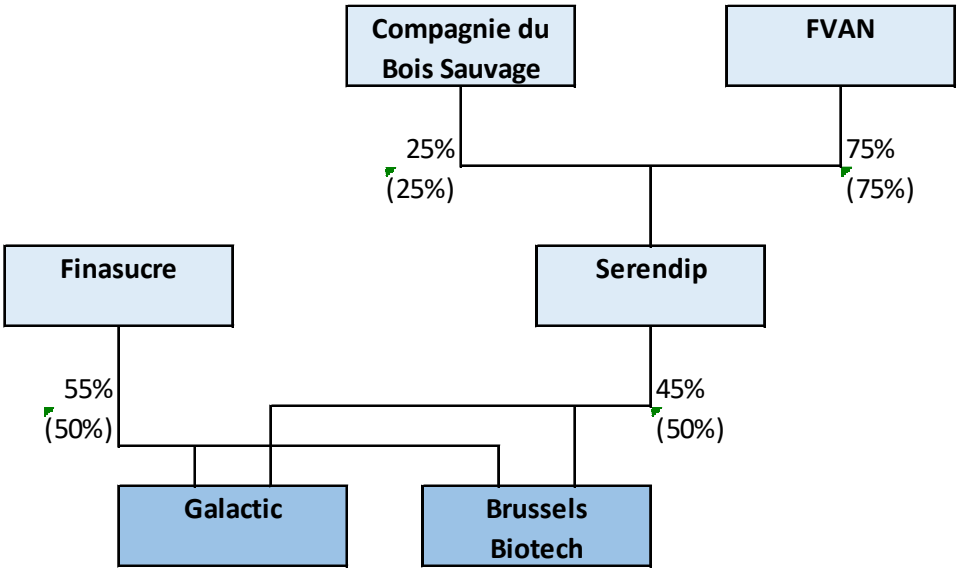


*Figure 4.5: Shareholding structure after the change of 1999*
*(% of control in brackets)*

*A newcomer in production*

A young production engineer joined the company (EBIE). About a year later, he would enter the management team as Production Manager and eventually play a larger role in the company's international development later.

*Galactic starts going deeper in the market*

By the end of the millennium, Galactic's products had become well known and accepted in the market and the company was selling in about 60 countries around the world, but mainly through local distributors. As a consequence, Galactic didn't know well enough the end-users nor the applications of its products. Galactic decided to recruit an Application Technologist to start going further down the value chain and deeper in the market, meeting end-users, understanding better the usage of the products and providing support for developing new applications.

This Application Technologist was reporting to a newly created position of Business Development Manager which itself was reporting directly to the CEO. This function aimed at coordinating the company's research and development efforts, providing scientific support to production teams so as to improve processes, protecting the company's intellectual property, supervising quality control and assisting the CEO to assess new projects.

***Environmental context (year 1999):***

***[Competition]*** *Musashino*[101]*, a Japanese producer of synthetic lactic acid, works on developing a fermentation-based (natural) production process with the financial support of MITI*[102].

**2000**

*Finally profitable!*

For the first time in its history, about six years after its operations started, Galactic turned profitable.

*Galactic in need of a strategy…*

By the year 2000, in addition to realizing the need to jump over distributors in order to access end-users, Galactic's management started to perceive a profound mutation in the market structure. Indeed, thanks to the expansion of the processed food industry consecutive to the urbanization of the world population, to changing eating diets in developing countries towards the rising consumption of meat and dairy products, and to the spreading of new applications for lactic acid and lactates, demand was growing exponentially and the offer would need to follow with ever larger production units. In addition to size, lowering production costs was calling for the integration of lactic production units to existing massive crop-processing sites[103]. At the same time, the company was facing organizational difficulties due to its fast growth: the company was employing more than 70 people and its turnover had grown from 380 million Belgian francs to 635 million[104] in one year. It suffered for instance pressures from trade unions who wanted to be represented among the company's workers, unproductive administrative departments, an understaffed engineering department, and a lack of financial resources to support R&D activities.

A comprehensive strategic analysis was launched that concluded on the need to increase production capacity in Belgium or settle down closer to fast-growing foreign markets (Asia, United States), to reduce dependency to beet sugar as single raw material and to diversify the product offering with the launch of additional margin contributors. Substantial financial means were needed and several growth scenarios were proposed to the shareholders including a possible takeover by Purac (who had recently made an offer) or opening up the capital to Roquette (who had recently indicated its interest in doing so).

*… and Brussels Biotech in need of a partner*

Brussels Biotech also realized that its would need to team up with a major polymer manufacturer if it wanted to succeed in the PLA arena. Brussels Biotech and its sister company Galactic were biotech companies, not plastic producers, and they had neither the internal

[101] Musashino Chemical Laboratory, Ltd. is a Japanese producer of synthetic lactic acid. Synthetic lactic acid is produced from fossil resources through a chemical synthesis process (as opposed to a natural fermentation-based process). In addition to lactic acid, Musashino produces alanine and pyruvic acid (www.musashino.com/english/).

[102] Tsūshō-sangyō-shō or MITI was one of the most powerful agencies of the Government of Japan that ran much of Japanese industrial policy, funding research and directing investment. In 2001, its role was taken over by the newly created Ministry of Economy, Trade and Industry (METI).

[103] This approach is commonly referred to as the biorefinery concept. A biorefinery is a facility that integrates biomass conversion processes and equipment to produce fuels, power, and chemicals from biomass. The biorefinery concept is analogous to today's petroleum refineries, which produce multiple fuels and products from petroleum. Industrial biorefineries have been identified as the most promising route to the creation of a new domestic biobased industry (http://www.nrel.gov/biomass/biorefinery.html).

[104] From € 9.4 million to € 15.7 million.

capabilities nor the human and financial resources to break through in this market.

*A partnership in India?*

Galactic investigated the setting up of a joint venture for lactic acid production in Tamil Nadu state, India, together with a local partner (Interspice/BK Group). The production capacity would be 3,000 mT/yr in a first step. A detailed business plan was made and a prospective trip was organized concluding that the lack of infrastructure and the local conditions were absolutely not met to support this type of activity.

*ADM wants Galactic product*

ADM approached Galactic to buy about 1,500 tons of lactic acid per year to supply their European customers active in the food industry. Their use of GMO-corn as raw material was confering a GMO-status to their lactic acid[105]. A few years before, in 1997, the European Union had started to establish a legal framework [106] to ensure that the development of modern biotechnology, and more specifically the use of genetically modified food and feed, took place in safe conditions thereby hindering the sales of American lactic acid in Europe for this type of applications. Galactic saw this request as an opportunity to secure the sales of a rather large volume at a good price. The deal would last for a few years until ADM decided to pull out of Europe with this range of products.

***Environmental context (year 2000):***

***[Society]*** *At the end of the year, mad cow disease alarms Europe.*

***[Shareholders]*** *Finasucre, Galactic's main shareholder, acquires Bundaberg Sugar from Tate & Lyle Plc.*[107] *Bundaberg Sugar is a grower, miller, refiner, and marketer of sugar and related products in Australia. The company is one of Australia's largest cane growers and owns and operates sugar mills in Queensland.*

***[Competition]*** *PGLA-1, the production join-venture between Purac and Cargill finally starts up after having been delayed several times. The initial process intended was supposed to avoid the production of gypsum as by-product. This was a complete failure and the engineers have had to come back to the classical gypsum-based process.*

***[Competition]*** *Purac opens a sales office in China.*

***[Competition]*** *Roquette Frères starts up a pilot plant for the production of lactic acid. The capacity is 1.000 tons per year.*

***[Competition]*** *Cargill and Dow are convinced of the commercial viability of their PLA technology and they agree to invest $300 million to fund the building of a commercial scale facility for PLA manufacturing in Blair, Nebraska (USA).*

[105] *Genetically modified organism* (GMO) means an organism, with the exception of human beings, in which the genetic material has been altered in a way that does not occur naturally by mating and/or natural recombination (Directive 2001/18/EC, art. 2[2]).

[106] Regulation (EC) No 258/97 later amended and strengthened in Regulation (EC) No 1829/2003.

[107] Tate & Lyle is a global provider of ingredients and solutions to the food, beverage and other industries, with operations in over 30 locations worldwide. The product portfolio consists of texturants, sweeteners, specialty fibers, and fermentation products (primarily acidulants). Tate & Lyle is listed on the London Stock Exchange and totaled £2.4 billion in sales in the year to 31 march 2015 (www.tateandlyle.com).

***[Competition]*** *Musashino establishes a joint venture to produce natural lactic acid by fermentation together with a Chinese partner, Keyuan Biotech Co., Ltd. The newly created company named Jiangxi Musashino Bio-Chem Co. plans to set up a 5,000 tons per year production unit in China.*

**2001**

*Go East!*

Following the strategic analysis conducted the year before, Galactic kept its eyes on Asia despites the failure of the Indian project. This decision was supported by the growth potential, particularly pulled by China's rocketing development, and by the competitive environment in this area. This was the only continent where Purac, the world leader, did not have a factory. Moreover, In Japan, Musashino's production process was extremely costly therefore limiting the company in a few niche markets, whereas the dozen of Chinese producers were manufacturing low quality products which were also poorly marketed. China looked attractive because the Central Government had decided to list lactic acid production amongst the priorities of its newly adopted five-year plan. JCBO was asked to organize an exploratory trip so as to visit some of these Chinese companies, and primarily the largest of them, a company named Henan Jindan (the same company FVAN imported a couple of containers from in the late nineteen eighties). Coincidentally, in May of the same year 2001, one of Galactic's equipment supplier asked for a license on Galactic's patented purification technology (LA I) for one of its Chinese prospects. Galactic management was not in favor of granting such a license which would have ended up in creating a new competitor with a similar technology as the one Galactic was using but it was agreed that JCBO would take the opportunity of its trip in July to China to pay a visit to this company by the name of BBCA Biochemicals.

*An efficient CFO… finally!*

After several unsuccessful attempts, Galactic's management team was joined by an experienced CFO. It was time as the business was getting more sophisticated and the company would have to keep on investing relatively large amounts of money to support its growth.

*And the departure of another of the pioneers*

BLED who had started as thesis student before the company was even created and led the sales and marketing activities since then decided to leave the company to pursue new opportunities. One of the area sales managers who was in the team for three years took over the position as Sales Manager while BLED's marketing assistant became Marketing Manager.

*Brussels biotech and Purac sign an agreement*

In June, Brussels Biotech and Purac signed a co-ownership agreement concerning the patent on lactic acid purification (LA I). In fact, about a year before, Purac had launched a legal action against the inventors of this technology in an attempt to gain its ownership by claiming that they were using it before the filing date. Brussels Biotech finally agreed to settle the dispute by sharing the ownership together with Purac because it did not want to enter a lengthy and expensive procedure against a much larger and wealthier organization at a moment when it felt possible to use this technology in the frame of other ventures on other continents.

*Exploring options in the Middle Kingdom*

In China, the visit to Henan Jindan had proved a fiasco, while that of BBCA Biochemicals[108] seemed promising from the outset. A meeting in Brussels was organized in early October in the presence of a delegation headed by BBCA's chairman and some representative of the government of the city where BBCA was headquartered. This was immediately followed by a new mission to China to set up a workable business case and to discuss in depth the terms of a potential partnership. Late October, a Letter of Intent was signed to outline the creation of a first joint venture for the production of 30,000 tons per year of lactic acid followed by, eventually, a second joint venture to build and operate a pilot-scale production facility for PLA. As a matter of fact, China's Central Government was encouraging companies such as BBCA to start producing biopolymers, namely PLA, to help solve what they call "white pollution", a term coined to describe the unsightly accumulation of plastic wastes in the environment.

A deal with BBCA was seen as much as an opportunity to advance with a strong foot in the world's fastest growing market than the occasion to turn a powerful competitor-to-be into a robust ally.

***Environmental context (year 2001):***

***[Society]*** *Without U.S., 178 nations reach agreement on climate accord, which rescues, though dilutes, 1997 Kyoto Protocol (July 23).*

***[Society]*** *Four coordinated terrorist attacks by the Islamic terrorist group Al-Qaeda hit the United States (September 11). As a result, the global economy underwent a difficult period. Drastic cuts in US and European interest rates and stimulatory measures for the US economy were taken to contain the slowdown in economic growth.*

***[Society]*** *On December 11, 2001, China officially became the World Trade Organization's 143rd member, 5 years after having submitted its request to accede WTO and 15 years after having requested the status of contracting party to the GATT (General Agreement on Tariffs and Trade).*

***[Competition]*** *CSM acquires Unilever's European bakery suppliers business and sells its Food Division to H.J. Heinz Company, a leading and worldwide player in the food market.*

[108] Five years before, BBCA Biochemicals was still a small company merely producing 3,000 tons of citric acid per year. As often in China at this time, the only shareholder was the city of Bengbu and the company was continuously losing money when a new General Manager was appointed who totally reshuffled the management team, a bold and hardy posture in this context, and modernized their production technology. He then conducted the company to an IPO on the Shenzhen stock exchange seeking for a listing with type-A shares reserved to Chinese investors only in order to stay independent from foreign competitors. The enthusiasm of the Chinese population for the stock exchange made it easy to complete the transaction by privatizing a first part of the business and thus raise large sums of money. In five years, BBCA increased its production of citric acid from 3,000 to 130,000 tons/year and became the second largest producer worldwide after Tate & Lyle by offering a product of equivalent quality at a lower price. Building on its success, BBCA started to diversify its operations by entering fuel ethanol, amino acids, vegetable oils, and vitamin C businesses. A fully integrated production site was erected to this end in Bengbu City (500 km from Shanghai) that was already processing each year about 600,000 tons of corn, the raw material common to all these products, by 2000 with the intention to double in size by 2002.

***[Competition]*** *G. van Nieuwenhuyzen replaces P.G. Stoutjesdijk as CEO of Purac.*

***[Competition]*** *Purac increases production capacity for lactic acid in its plants in Brazil and in The Netherlands.*

***[Competition]*** *Roquette submits authorizations to build and operate a 10.000 mT facility for lactic acid in France.*

***[Competition]*** *Cargill Dow LLC and Mitsui Chemicals, Inc. announce a collaboration for business development of PLA. They have signed a collaboration agreement to accelerate market development for PLA in Japan and the rest of the world. Under the terms of the agreement, there will be an exchange of intellectual property and technical information relating to PLA application development. Through this arrangement, customers for both parties will be in a position to proceed with business development without concerns of potential intellectual property restrictions from Cargill Dow or Mitsui Chemicals portfolios. Mitsui Chemicals will receive exclusive business development rights to sell PLA resin in Japan.*

The year 2001 marked the end of our second epoch. The business had been structured around a single production site in Belgium, and the company had gained a reputation as second producer worldwide. Global market demand was growing steadily in spite of the slowdown of economic growth subsequent to September 11th terrorist attacks. Among other factors, the growth of Galactic, essentially oriented towards exports from Belgium, was supported since its inception by an ever stronger US dollar[109], as well as by a downward trend of sugar prices from 1995 to 2001.

The company's product portfolio was however still relatively limited, as was the production capacity, and the sales were exclusively conducted from Belgium through a network of distributors. It was time for the company to enter a new era, shift up and execute the growth strategy elected by the shareholders.

By this time, the management structure had evolved as follows:

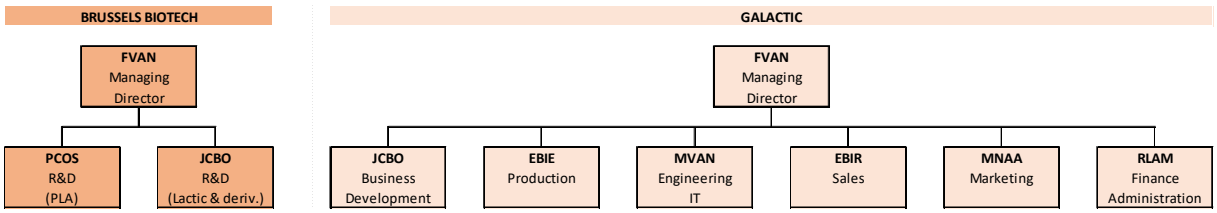


*Figure 4.6: Organizational chart of the management team in 2001*

[109] Between 1996 and 2001, the US dollar appreciated in a relatively regular fashion against the Euro (not yet in circulation) by more than 35% (from 0.74 €/$ to 1.19 €/$).

## II.3. Epoch III: Modernitas (2002 – 2011)

**2002**

*The urgency of a new process*

As the negotiations with BBCA were progressing, certainly with ups, downs and other hiccups, Galactic had to urgently design a production process able to reach the same quality levels in an economical way with a substantially different raw material. In Belgium, Galactic uses refined beet sugar (white sugar), an extremely pure carbon source. In China, the only option is corn syrup[110], a product that contains non-fermentable sugars which greatly disturb the manufacturing process. And, similarly to computer science or information technology, in chemistry the quality of the output is largely determined by the quality of the input: garbage in, garbage out! Galactic's R&D team had only a few months to come up with a new process. With such short notice, only a few pilot trials could be made together with the same French leading provider of services in the field of molecule purification for the life science industry as 6 years before, but the management trusted the team's almost 10 years of experience enough to dare committing the company's credibility and a few millions to this venture.

*A failed attempt with Toyota in Australia…*

Galactic and Toyota Tsusho [111] entered into discussion about a partnership for the production of 50.000 mT of lactic acid exclusively dedicated to the manufacture of PLA by Toyota Motor Co. Australia, where Galactic's parent company operates several sugar mills, was seen as a possible location so as to be close to the raw material (sugar cane). The aim was to have the factory started by 2004. Purac was seen as another possible partner by Toyota Tsusho but they had no privileged access to raw material. Finasucre, Galactic and Toyota would keep on talking and exchanging data until 2004 when the latter finally decided to disregard Australia as a production place. As we will see later, Purac will propose Thailand as a place but the project will ultimately be abandoned by Toyota.

*…a research project in Cuba…*

Galactic launched a 3 years research project with the financial support of the Walloon Region (project n°4712) in partnership with ICIDCA, a Cuban research center. The aim was to isolate and characterize a bacterial strain able to produce D(-) lactic acid[112] with a high optical purity.

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[110] Corn syrup is a thick, viscous liquid made from the enzymatic hydrolysis of starch and consisting primarily of a solution of glucose in water. Starch is a polysaccharide composed of glucose units that occurs widely in plant tissues in the form of granules to store energy.

[111] Toyota Tsusho Corporation is a sōgō shōsha (trading company) member of the Toyota Group. Toyota Tsusho has a worldwide presence through its many subsidiaries and operating divisions, including over 150 offices, and 900 subsidiaries and affiliates around the world. Its main business is supporting Toyota Motor's automobile business and other Toyota Group companies, but Toyota Tsusho's business is very diverse, spanning industrial, commercial, and consumer sectors, with metals, automotive parts, logistics services, machinery, chemicals, electronics, and food products. It employs globally 33,845 people for $71.9 billion of revenues (2012) (www.toyota-tsusho.com).

[112] Lactic acid is chiral and therefore exists in nature in two forms, two optical isomers called enantiomers. One is known as L(+) lactic acid or (S)-lactic acid and the other, its mirror image, is D(−) lactic acid or (R)-lactic acid. The L form is by far predominant in nature and hence it is the isomer the most produced industrially. The D form is dedicated to niche markets in chemical synthesis and polymers.

*…and a creative joint venture structure in China.*

Galactic and BBCA Biochemicals ultimately reached agreement and sat up a joint venture for the production of 25,000 tons of lactic acid and some derivatives in September 2002. The total cost of the project was provisionally estimated to $42 million. A smart but unusual company structure was imagined with the help of lawyers specialized in the matter so as to best combine both Parties demands. The newly created company was a contractual joint venture with 51% of the shares in Chinese hands but 60% of the control in Belgian ones. Indeed BBCA being a stock listed company needed to have a majority stake in order to be able to offer its public shareholders with consolidated financial reporting, whereas Galactic wanted to retain the control of the company, especially the accounting department and the sales activities, to avoid internal competition with its own presence in the marketplace. In addition, the company would be renting tangible assets, mainly production equipment and buildings, to BBCA while the technology and market knowledge would be licensed from Galactic. Capital expenditures on the one hand, and technology valuation on the other hand, were aligned so that renting fees and technology license fees would be paid to the assets' owners in equal amounts as soon as the company would generate revenues until a predefined amount corresponding the total investment would be reached.

The joint venture's full name was *Anhui BBCA & Galactic Lactic Acid Co., Ltd.*, in short "B&G".

The project was ambitious and, as always, became an urgent imperative for the partners before the ink on the contract was even dry, but the resources of Galactic, a small company, were scarce in terms of staff experienced enough to handle a task like this. It was decided that JCBO would be responsible for setting up the company, the sales network and the administrative organization when MVAN would be in charge of designing the factory, selecting equipment providers, erecting and commissioning the plant. It turned out later that after having built it, he was asked to operate it. RLAM, in his quality of group CFO, would naturally take the helm of accounting and finance. Because of the limitations of Galactic's management resources, they all three would at the same time keep their responsibilities in Belgium, commuting on a monthly basis between Belgium and China.

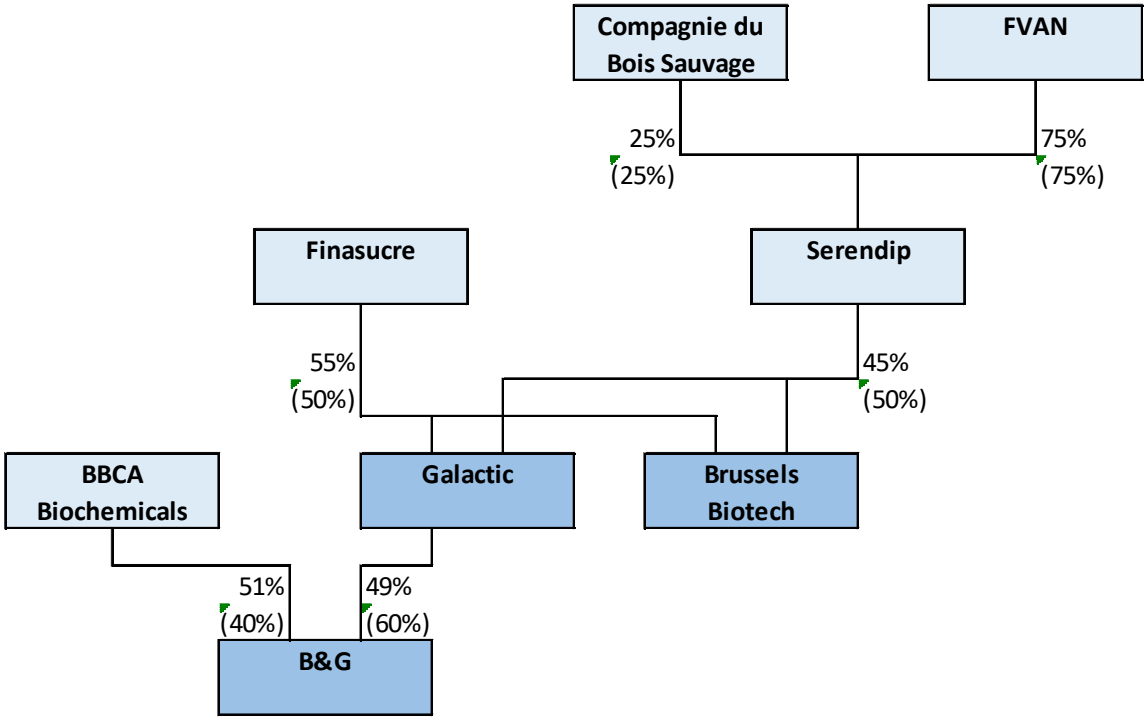


*Figure 4.7: Shareholding structure after the creation of B&G*
*(% of control in brackets)*

In September, the newly created company received its business license and was officially incorporated. A first board of directors was held in October which formally appointed the company's general manager and deputy general managers. A launch of B&G's first food grade product was optimistically planned for November 2003 but, as we will see, it will come to life only about 6 months later.

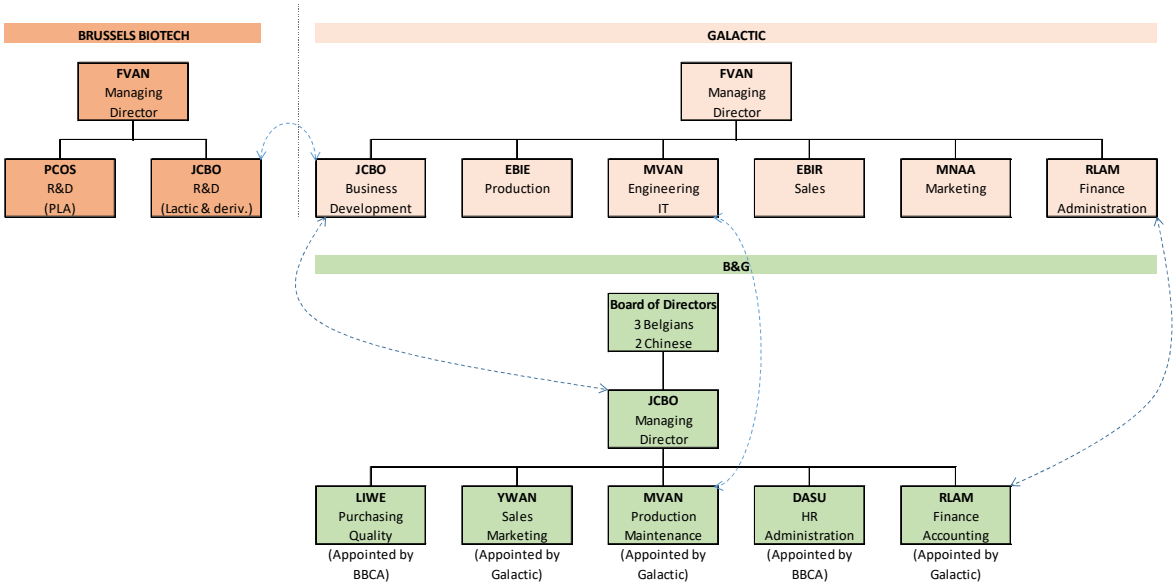


*Figure 4.8: Organizational chart of Galactic's and B&G's top management when the latter was created*

*Galactic buys its production site from its shareholder.*

Galactic acquired the land and buildings it was renting until this time from Finasucre. This covered about 20 hectares of industrial land, production buildings, offices and lab space.

***Environmental context (year 2002):***

***[Currencies]*** *The first of January, the currency Euro enters circulation.*

***[Competition]*** *Henan Jindan who was primarily controlled by the City of Dansheng in China completes its privatization process.*

***[Competition]*** *Toyota Motor*[113] *acquires Shimadzu's PLA assets (pilot plant, patents and team of engineers). The pilot plant is relocated to Toyota-shi (Toyota City) where the group has its headquarters. Toyota's intension is to include bio-based polymers in its cars, especially the Prius, to reduce their environmental footprint. The ES3 concept car displayed at motor shows in 2001 was fitted with automotive parts made of bioplastics. Competitors and critics however call these claims "greenwash." They are skeptical of Toyota's real intention to produce its own plastic resins, a vertical integration step atypical of the auto company. Bioplastics among which PLA will nevertheless be used for the first time on a vehicle for the commercial market with the launching of the new Raum in May 2003.*

***[Competition]*** *Cargill Dow LLC opens the world's first global scale manufacturing facility to make commercial-grade plastic resins (i.e. PLA) from an annually renewable resource. The facility, which represents nearly $750 million in investments, is capable of producing about 140.000 mT of NatureWorks® PLA per year. The resin is being shipped around the globe for use in producing food and nonfood packaging, disposable cups and utensils, comforters, pillows, carpet tiles, and apparel.*

***[Competition]*** *CSM sells its coffee and tea operations that were part of CSM Sugar Confectionery in an attempt to concentrate maximally on brand positions in the European confectionery market. At the same time, CSM divests its unprofitable confectionery operations in China through a management buy-out.*

**2003**

*2003: a price war and two difficult years ahead…*

In 2003, Purac initiated a price war in reaction to Galactic's announcement to build and operate a lactic acid factory in China. It seemed nothing but an emotional reaction. Interestingly, CSM's management publicly hinted that there was price pressure because of new entrants lowering their prices in order to increase utilization rates in their factories[114]. It was one year before B&G had even started to operate! As a consequence of this nonsensical response, in the two years from 2003 to 2005, Purac would see its operating result cut by

[113] Toyota Motor Corporation (TMC) is a Japanese automotive manufacturer that generated $243 billion of revenues (2015) with 338,875 employees worldwide (2014). TMC is member of the Toyota Group.

[114] ING Financial Markets, report on CSM shares, September 7th, 2004.

77%, its return on sales (ROS[115]) fall from 28.4% to 6.5%, and its return of capital employed (ROCE[116]) plunge from 32.7% to 6.6%. Galactic's operations were of course also deeply impacted but to a lesser extent thanks to its relatively small size and to its position of second supplier. At the same, rumors start spreading that Purac would be seeking to reach a pan-European distributorship agreement with Brenntag[117]; an additional concern for Galactic who was then working with Brenntag in several countries.

*Galactic cooperates with a major US company*

Galactic reached an agreement with an American company[118] for the purchase by the former of a byproduct of the latter (a project called "Snoopy" internally). This product would be transferred to Belgium and transformed into lactic acid with Galactic's proprietary technology. Thanks to this cheap product, Galactic would then be in a position to take a major stake in the animal feed segment in Europe[119] and would generate substantial profits in the following years thanks to the sales of about 7.500 mT of these products each year. Irony wants that this US company belonged to one of the world leaders in feed ingredients… Galactic had to invest in large storage tanks dating from the old sugar mill and in processing reactors, as well as in the immobilization of large sums in its inventory; expenditures to which was added a significant currency risk in a time were prices were under pressure and resources had been vastly pledged in the Chinese venture. The situation had everything of a headlong rush.

*Galactic plants a seed for future collaboration on PLA*

In June of the same year, Galactic was invited to present PLA to ATOFINA, soon to become Total Petrochemicals[120], at the occasion of a two days R&D seminar organized by the latter. Galactic had continued over the last 10 years to invest R&D efforts on the subject, to grow its patent portfolio, and to start crunching some numbers to assess the economic feasibility of an industrial production of this new material. This seminar gave Galactic the opportunity to plant the seed

[115] ROS is calculated here as the Earnings Before Interests, Taxes and Amortization (EBITA) divided by the net turnover.

[116] ROCE is calculated here as the EBITA divided by the average capital employed (fixed assets plus working capital) in the period considered including goodwill.

[117] Brenntag AG is a German chemical distribution company which was founded in 1874 in Berlin, and which currently operates in more than 70 countries worldwide. It is the global market leader in full-line chemical distribution. It employs about 13,000 people for revenues of €9.7 billion (2012).

[118] A Non-Disclosure Agreement between the parties involved prevent us from disclosing the name of this company.

[119] An EU-wide progressive ban on the use of antibiotics as growth promoters in animal feed has been initiated by the European Community a few years before. Their use will be totally prohibited in 2006. The ban is the final step in the phasing out of antibiotics used for non-medicinal purposes. It is part of the Commission's overall strategy to tackle the emergence of bacteria and other microbes resistant to antibiotics, due to their overexploitation or misuse. Organic acids such help improve animal digestion and hence the daily weight gain in a natural way without imparting any resistance. This regulatory initiative opens a huge market potential for lactic acid.

[120] Total Petrochemicals, the petrochemicals activities of Total Group, includes base chemicals from steam crackers and refinery processing plants – olefins (ethylene, propylene), C4 fractions and aromatics (benzene, toluene, xylene and styrene) -, as well as the commodity polymers they derive from (polyethylene, polypropylene, polystyrene). With over 7,000 persons, the company is active in Europe, the United-States, the Middle-East and Asia. Its products are used in many consumer and industrial markets, including packaging, construction and automotive. The petrochemicals activities have been grouped in 2015 with refining operations and specialty chemicals activities in Total's Refining & Chemicals business segment.

of a future collaboration in the field with one of the world's largest polymer company but it would still take another 4 years to materialize.

*More complexity…*

In the meantime, B&G started setting up a new distribution network in Asia-Pacific while working on the erection of its manufacturing plant in China, Galactic got prepared for a business model that gained in complexity with two factories, different cost structures, intercompany sales, new markets to penetrate (e.g. animal feed market in Europe), and last but not least with more than twice the volume to be sold. The erection of B&G's factory, initially too-optimistically scheduled for end of 2003, was delayed to a more realistic June 2004. The SARS outbreak in China for sure did not facilitate the numerous travels of Galactic engineers, nor the delivery of key-equipment from Europe.

*… and turmoil ahead.*

At the end of 2003, the management team was increasingly concerned about the evolution of the company's sales. Large sales volumes were lost because of Purac's aggressiveness. Decision was therefore taken to take contracts for about 2500 tons at much lower prices in Europe to avoid slowing down the production speed. In a context like Europe characterized by high fixed costs, reducing production throughput is a killer. Luckily, the year 2003 saw lower prices of raw materials, especially sugar, which helped mitigate the effect of lower sales prices, but inventories increased sharply due to low sales volumes and the company's cash situation tightened even further.

***Environmental context (year 2003):***

***[Society]*** *The epidemic of SARS (Severe Acute Respiratory Syndrome) appears to have started in Guangdong Province, China in November 2002 but reaches the public spotlight only in February 2003. It will last until July 2003.*

***[Industry]*** *China establishes a professional organization of lactic acid producers under the Association of Chinese Fermentation Industry.*

***[Regulatory]*** *On October 6, the public health agency within the USDA (Food Safety and Inspection Service) issues a new regulation by which meat processors must take actions to protect Ready-to-Eat Meat and Poultry products against the growth of a foodborne pathogen called* Listeria monocytogenes[121]*. This "Listeria Rule" will boost by tenths of thousands tons the North-American market for lactate-based blends.*

***[Currencies]*** *The US dollar that was at its strongest in 2001 starts loosing traction against the Euro which appreciated by 38% over the two last years. The world does not know it yet but this strengthening movement of the Euro will continue almost interrupted until 2008 (with only a short limited drop in 2005). This situation will profoundly change the respective competitiveness of the market players.*

[121] *Lysteria monocytogenes* is a Gram-positive rod shaped bacterium responsible for listeriosis. In 1999, it was estimated that this bacterium was responsible for 2,493 cases per year among which 20%, i.e. 499, fatalities (http://www.aphl.org/conferences/proceedings/Documents/2007_ISOPOL/FSIS%20Regulations_to_Control_Listeria.pdf).

***[Competition]*** *Purac receives a one-time payment of € 13.6 million in connection with the PGLA lactic acid joint venture with Cargill, including license rights that were granted to Cargill Dow with respect to certain technologies for possible future use for the production of lactic acid for poly-lactic acid. In fact, this payment comes to settle a lawsuit initiated by Purac against Cargill for alleged stealing of technology from PGLA-1 when the latter erected its new lactic acid plant aimed at supplying Cargill Dow's PLA production.*

***[Competition]*** *CSM acquires Glucona from Avebe*[122] *for $35 million. Glucona is producing gluconic acid and gluconates (derivatives) with a turnover of about $30 million. Gluconates are seen as being sold in the same market segments than the lactates and the company expects synergies to be generated with the integration of the gluconic business into the lactic one. This will prove a wrong move: Glucona's production assets in The Netherlands will be sold back to Avebe in 2008, whereas the US operations will be sold to Fuso America*[123] *already in 2007.*

***[Competition]*** *CSM completes the acquisition of Carpro, a leading manufacturer of bakery supplies in the United States. The total acquisition price is US$ 302 million. The two main operating companies of Carpro are H.C. Brill Company, Inc. and Caravan Products Company, Inc. with total annual sales of approximately US$ 300 million for a combined staff of about 950. In the same year, CSM has reached agreement with Unilever on the acquisition of their bakery ingredients business in Hungary. The acquisition of part of the Friesland Coberco bakery activities outside the Netherlands followed, as well as the acquisition of Readi-Bake in the United Kingdom.*

**2004**

*Expansion in North America…*

In spite of the difficult competitive situation, Galactic decided to continue its expansion by setting up a subsidiary in Milwaukee, Wisconsin (USA) in 2004. This move, which was following the strategic path indicated by the board, was made even more appropriate because of the extremely small presence of Galactic on this market, huge by the size, and because of the large volumes of product that would be manufactured in its soon-to-be-started Chinese plant. The recent appreciation of the Euro against the dollar was making exports from Belgium more difficult whereas, to the reverse, the Chinese currency was remarkably stable against the dollar thanks to the Chinese decision to peg the yuan to the greenback, therefore allowing only very small exchange rate fluctuations. The company, Galactic Inc., would shelter a sales office for North-America and a transformation unit importing lactic acid either from Galactic Belgium or from B&G,

[122] Avebe is a Dutch cooperative company focused on extracting value from potatoes with sales of proteins, fibers, starch, and starch derivatives. Employing about 1300 people, Avebe posted revenues of € 580 million in 2014.

[123] Fuso Chemical Co., Ltd., is a Japanese company listed in the First Section of the Tokyo Stock Exchange and offering electronics materials, functional chemicals and organic acids. Fuso posted a turnover of about $265 million in 2015. Fuso's American subsidiary operates under the name PMP Fermentation Products Inc. and produces gluconic acid and sodium gluconate by fermentation of liquid sugar in Peoria, IL (USA).

for resale or transformation into liquid derivatives (salts) such as sodium lactate, potassium lactate, and blends with other ingredients.

*… more investments in Belgium…*

The Belgian factory was not forgotten though and the company invested heavily in a new wastewater treatment plant and in new warehousing facilities.

*… and more structural changes.*

The same year, Galactic absorbed Brussels Biotech. In this merger by dissolution without liquidation, all tangible and intangible assets as well as all liabilities of Brussels Biotech were transferred to Galactic, including the rights to keep using Brussels Biotech name for IP-related matters for instance. All Brussels Biotech staff was moved to Galactic and the R&D team led by PCOS was transferred under JCBO. The purpose was on the one hand to simplify the structure and, on the other hand, to reduce Galactic's taxable income by incorporating Brussels Biotech's losses accumulated over time as it is often the case for pure R&D organizations.

Galactic became a small group of companies which structure is shown below.

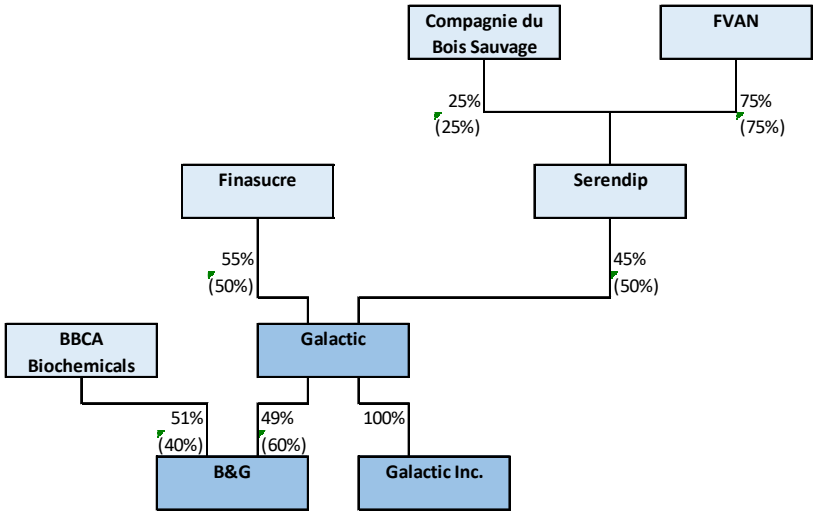


*Figure 4.9: Shareholding structure after the creation of Galactic Inc. and the absorption of Brussels Biotech in 2004.*

*(% of control in brackets)*

*Intellectual property rights are also worth fighting*

In 1997, Brussels Biotech had acquired the rights on a patent about PLA production from the Universities of Stuttgart and Liège. This agreement contained a reassignment clause that forced the parties to find a new agreement for Galactic to purchase definitely and without reassignment all the rights on this patent. That was done in 2004 as the company believed at this time that this technology could be central for its future in the PLA arena.

A few months after, Galactic was informed of an action launched by an Italian attorney to oppose Brussels Biotech's patent on lactic acid purification (LA I). Galactic suspects Roquette to be behind this. The patent will finally be maintained and all claims kept unchanged after a one year litigation procedure and an oral hearing at the European Patent Office.

*China: the big start…*

In China, the project reached a key-milestone in April/May with the commissioning of the newly-built plant. Galactic's technology that had been adapted to the different raw material in a rush would be put to the test. Failure was of course not an option. The commissioning was actually a success as the factory was up-and-running in June already with the first customers supplied in the wake.

At the same moment, in June 2004, Galactic signed at the Great Hall of the People in Beijing, in the presence of Mr Hu Jintao, President of the People's Republic of China and His Royal Highness, King Albert II of Belgium a Memorandum of Understanding which dealt with the erection of the first industrial production unit in Asia to produce PLA (Polylactic acid). However, in spite of a signature under such beautiful auspices, the deal will not materialize in part because BBCA Biochemicals will enter difficult times.

*… and a grand inauguration ceremony*

On November 25th, B&G factory was inaugurated in the presence of His Royal Highness the Prince Philippe of Belgium and a delegation of more than 100 Belgian businessmen, members of diplomatic corps and the press. A private aircraft was specially rented to bring the delegation from Shanghai and the Chinese air force authorized the landing on the military airport of Bengbu city. The weather was however so bad that the flight had to be rerouted by about 170 km and limousines and buses for such a crowd had to be found in less than two hours. A hectic travel that all attendees will remember, more than the visit itself probably.

*A recognition by the main competitor … for what it matters*

Interestingly, Purac acknowledged that he has only one real competitor, Galactic/B&G, because this is the only company that offers a complete range of products with an equivalent quality as theirs and the only company working on market development. For Purac, the other players are opportunistic companies (ADM, Jindan) or sentenced to death at mid or long term (Musashino)[124].

***Environmental context (year 2004):***

***[Shareholders]*** *FVAN sells ATC, Galactic's former mother-company, to a German group (AKO).*

***[Society]*** *IBM sells its PC business to China's Lenovo. A sign of the times. Facebook launches and Google releases Gmail. Another sign of the times.*

***[Society]*** *The largest expansion to date of the European Union takes place, extending the Union by 10 member-states: Poland, Lithuania, Latvia, Estonia, the Czech Republic, Slovakia, Slovenia, Hungary, Malta and Cyprus.*

***[Competition]*** *Purac increases its production capacity in Brazil to profit from the drop of production costs resulting from the devaluation of the Real against the Dollar (from 1:1 to 1:3).*

[124] Personal communication, Gert-Jan Bening, Purac's Director Marketing & Sales.

***[Competition]*** *CSM and Royal Cosun*[125] *completed the transfer of CSM's shares in Koninklijke Nedalco, one of Europe's main producers of grain-distilled alcohol. CSM has now entered a phase of restructuring and streamlining of its portfolio as the basis for further growth. Its intention is to transform into a global bakery supplies and food ingredients company. Consistent with this, CSM restructure its BakeMark organization in Germany which results in the loss of approximately 100 jobs, and finds an agreement to divest its Confectionery Division for € 850 million. This last move is not applauded by the financial community and adds to the disappointment due to poor results of CSM's European bakery and Purac businesses. Purac's results were negatively affected by currency effects and price pressure. CSM shares are downgraded by most financial analysts to "Sell" (ING), "Underperform" (Crédit Agricole Cheuvreux) or equivalent recommendations.*

***[Competition]*** *The Netherlands Competition Authority (NMa) starts an investigation at CSM's Sugar Division on possible price arrangements with its competitors and customers.*

***[Competition]*** *CSM's chairman steps down to leave place for a management more closely involved in the actual management of the company's activities.*

**2005**

*2005: Galactic employees are worried*

Several press articles relay the worries of Galactic employees following a declaration from one of the trade unions represented in the company. These worries come after the workers noticed a slowing down of the sales ex-Belgium. The trade union erroneously claimed that Galactic management was progressively phasing out the sales to the production plant that was starting operations in China, whereas the company was actually struggling with falling prices on the market place.

*The Chinese currency de-pegged from the dollar*

In July, China's Central Government revalued its currency, the Renminbi[126], and said it would no longer have it tied to a fixed rate against the US dollar. As the Chinese currency was reportedly largely undervalued, this decision to un-peg the yuan signals a period of gradual appreciation that will result in higher export costs from China and hence, a progressive reduction of competitiveness for Chinese exporters. Clearly, not a good news for B&G that was just starting its international operations!

[125] Royal Cosun is an international company specializing in the development, production and sale of natural food and ingredients. Its product range varies from sugar, fructose & inuline and potato specialties to combined ingredients for, amongst other things, snacks, patisserie and dairy products, soft drinks, and the food service sector. Royal Cosun is a cooperative with some 11,500 members/shareholders. It operates mainly in Europe and employs 4,325 people. It has a corporate turnover of around EUR 1.3 billion (2004). (www.cosun.nl)

[126] The renminbi is the official currency of the People's Republic of China. The name literally means "people's currency". The yuan is the basic unit of the renminbi, but is also used to refer to the Chinese currency generally, especially in international contexts. The ISO code for renminbi is CNY but the currency is often abbreviated RMB, or indicated by the yuan sign ¥. Until 2005, the value of the renminbi was pegged to the US dollar at a value of around 8.28 renminbi for one US dollar. The renminbi exchange rate was after that allowed to float around a fixed base rate determined with reference to a basket of world (undisclosed) currencies.

*A most needed price increase*

In November, Galactic entered a new Sales Director (RPEE) and announced in the press a substantial price increase on the back of rocketing energy costs. The increase, which will come into effect in January 2006, would vary from 5 to 15 per cent, depending on the product. Exposed to the same worsening conditions, several other food ingredient companies have announced the same (Purac, Jungbunzlauer, Tate & Lyle, Lonza, ISP...).

***Environmental context (year 2005):***

***[Economy]*** *With the constant increase of crude oil prices since more than a year, the specter of inflation resurfaces but, at the same time, supports a growing interest for new energy sources and non-fossil technologies.*

***[Competition]*** *Cargill buys back The Dow Chemical Company's interest in Cargill Dow LLC and decides to rename the company "NatureWorks LLC" as per the brand name of its PLA range. The company employs about 230 people. As a joint venture, the enterprise consumed close to $750 million dollars in capital and was not yet profitable.*

***[Competition]*** *Roquette stops producing lactic acid and pulls out of this market.*

***[Competition]*** *CSM also restructures much its bakery business as it aims to bounce back from poor results the year before and announces plans to restructure its sugar activity in Holland, as the dreaded EU sugar reforms come through. CSM announces further restructuring at its Purac division and anticipates the loss of approximately 65 jobs out of a current 380. In March, G. Hoetmer, a former Unilever executive, succeeds J. Vink as Chairman and CEO of CSM.*

***[Competition]*** *Sinolac, a 50% subsidiary of Hyflux (Singapore), announces its intention to invest $37 million in a 20,000 tons/year lactic acid production plant in Liaoning province (North-East China). The product will come on the market in 2007 only for a few months. Quality is good but production costs are obviously too high to sustain any sales activity and the factory will be closed in 2008.*

**2006**

*Galactic licenses its production microorganism*

In 2006, Galactic was approached by a large American corn processor to discuss a possible license for its producing microorganism. Since its lactic acid factory started, this company was suffering from a rather inefficient fermentation. The situation became unbearable as production volumes were progressing. The parties found an agreement by which the company would be entitled to use Galactic' strain within a strictly limited frame in terms of duration, place and purpose. This move, that will yield several million euros to the company in the next three years, was a recognition for the quality of Galactic's researches.

*B&G expands…*

Hardly two years after starting production, B&G announced a capacity expansion. Along with it, the company launched a whole range of feed acidifiers in powder form based on the results of a one year study on

piglets made by B&G together with the Anhui Agriculture University, as well as new grades of sodium lactate and new types of packaging specially designed for the Japanese market. Japan was the second largest market in volume in Asia and the first one in value. Sales prices were the highest in the area but so were the requirements as far as quality and customer service were concerned. Japan therefore soon became a prerequisite and an important target for B&G.

*… applies a new remuneration system…*

In 2006, the management of B&G decided to implement a new remuneration system based on individual KPI's (Key Performance Indicators) as a tool for evaluating, motivating, rewarding or sanctioning all staff members (employees and managers). It was a first time in Galactic group and it will serve as a test before generalizing the system to the whole group several years later (in a modified way to adjust to local conditions).

*… and becomes part of one of the biggest Chinese conglomerate*

In November, COFCO announced its intention to buy 20.73% of BBCA Biochemical and, hence, to become BBCA's (and by extension B&G's) main shareholder. COFCO, China's largest grain trader and processor [127], was particularly interested in BBCA's 320,000 tons production of alcohol as the country introduced ethanol in 2002 as fuel blend to help cut pollution[128]. The operation was completed in April of the next year. COFCO was so influential that it took immediately the full control of the former BBCA in spite of their owning far less than 50% of the shares. In no time, logos were changed, as was the company culture, and even the street in front of the head office was renamed "Cofco Road". As for B&G, the least to say is that COFCO's management did not like at all the fact that they were not in full control of the joint venture despite their 51% ownership, but they were straight enough to respect the contract signed.

*A missed opportunity*

In fact, COFCO had the opportunity to acquire a sizable share of BBCA Biochemical from BBCA Group because the latter was in difficult financial situation. The group was committed in too many large projects at the same time betting on leveraging easily big amounts of money from the stock exchange as it did before when financial markets were bullish [129]. But in 2006, China stock exchange was heading down since five years already[130] and Chinese investors were becoming much pickier in their investment decisions. At about the

[127] China National Cereals, Oil and Foodstuffs Import and Export Corp (COFCO) is China's largest grain trader and processor, and largest producer of edible oils and soybean meal as well as a major wine and confectionery maker. Besides the foodstuff business, COFCO has developed itself into a diversified conglomerate, involving planting, cultivation, food-processing, finance, insurance, warehouse, transportation, port facilities, hotels and real estate. COFCO is a state-owned company in the PRC which commenced business in 1952 and is one of the 159 enterprises under the direct purview of the State-owned Assets Supervision and Administration Commission of the State Council of the PRC. Since 1994, Fortune magazine has ranked COFCO among the Global Top 500 Companies. In 2007, COFCO had just over 60,000 employees in multiple locations in China as well as overseas operations in countries such as the US, UK, Japan, Australia, and Canada.

[128] The mainland government mandated five provinces and 27 cities in another four provinces to blend at least 10 per cent ethanol into petrol. At this time, COFCO owned already a plant with a 250,000-tons output a year in Heilongjiang province and had a 20% stake in another plant with 400,000 tons of annual capacity in nearby Jilin province. It was also planning to build two other factories, in Hebei province and Inner Mongolia Autonomous Region, each with a 300,000-tons annual capacity.

[129] For instance, the Shanghai Composite Stock Market Index grew up by 300% between 1996 and 2001.

[130] Between 2001 and 2006, the Shanghai Composite Stock Market Index lost about half its value.

same moment COFCO appeared as a potential buyer, Galactic teamed up with a group of investors mainly supported by a hedge fund from Hong Kong to negotiate a deal with BBCA Group by which Galactic's lactic acid operations and BBCA's citric acid operations would be combined on a global level. Unfortunately, the parties did not reach agreement and BBCA went on with COFCO. Of course, COFCO being a large state-owned organization, we can think that their proposal gathered more support from the central and the local authorities.

*Galactic selling citric acid…*

BBCA Biochemical, soon to become COFCO, was then the largest producer of citric acid worldwide. As often with large commodity-oriented Chinese companies, they were focusing primarily on production output with little attention to sales channels and end-users. Exports were for a big part in the hands of western distributors negotiating every year bigger contracts at always lower prices. Galactic ceased this opportunity to discuss advantageous prices from its Chinese partner and start promoting the product in Europe with a western image and better service. For Galactic it was a good way to better use its rather expensive sales team over a higher sales volume.

*… a bad idea!*

This activity started rapidly as many lactic acid users also buy citric acid but, unfortunately, it ran as quickly out of gas because of unreliable logistic from China. Galactic generated frustrations and discontent among its lactic acid customers which negatively impacted its reputation; a situation that could not be sustained any longer and the company decided to stop doing it as fast as it had decided to start it.

*The need for a new price hike…*

During 2006, all production costs related to the fermentation industry had significantly increased. Energy costs and specifically oil costs almost doubled with a direct impact on processing, packaging and transporting. Sugar prices in Europe increased due to the new sugar regime[131] thus pushing down local sugar production and pushing up prices of carbohydrate raw materials. An important demand for ethanol production also induced a price increase on sugar, corn and wheat in the rest of the world. The strong impact of these events on production costs had resulted in an immediate need for Galactic to announce again a price increase to be implemented on January 1st, 2007 or as contracts expired. The price adjustment was applied throughout the world except in China where prices had already been increased by 10% during the month of August. Despite this situation, Galactic maintained the primary objective of continuously working on the improvement of its lactic acid and lactate production processes to offer the highest quality standards at competitive prices. At the same time, most food companies, including CSM, had been trying to pass on rising costs for commodities such as grains, sugar and edible oils, as well as increasing plastics and packaging costs, with mixed success as price hikes put their market share at risk.

*…and costs reductions.*

As a result of the combination of rocketing raw material prices and the price war triggered a few years before by Purac (average sales prices dropped by 27% between 2003 and 2006), Galactic's EBITDA/Sales ratio dropped by 10 percentage points in the same period. As a reaction, in addition to increasing prices, Galactic put all capital

[131] EU sugar policy was first established in 1968 and regulates all aspects of the industry, ranging from production quotas and guaranteed prices, to exports subsidies and import restrictions.

investment programs on hold and launched a cost reduction program to lower the company's fixed expenses, especially general, administrative and labor costs. The company also accelerated its research efforts towards an improvement of its production processes mainly focused on lowering consumptions and improving yields. A special program was launched in a newly created R&D team at B&G to develop a cheaper fermentation medium, what is called a minimum defined medium (as opposed to a rich complex medium), whereas the Belgian team actively worked on reducing energy consumptions.
A spark of light in this gloomy landscape: by the end of the year, the royalties paid by B&G were higher than initially expected thanks to a faster take off of B&G sales who reached already a market share of about 20% on the domestic market after only 18 months of operations. Between its first sales and 2006, B&G's EBITDA on Sales ratio gained 10 percentage points and the objective was to gain another 10% for the end of 2007 by increasing capacity and focusing on more lucrative export markets while keeping its hardly gained positions in mainland China.

***Environmental context (year 2006):***

***[Regulatory]*** *An EU-wide ban on the use of antibiotics as growth promoters in animal feed takes effect. The last 4 antibiotics which have been permitted as feed additives to help fatten livestock will no longer be allowed to be marketed or used. The ban is the final step in the phasing out of antibiotics used for non-medicinal purposes. It is part of the Commission's overall strategy to tackle the emergence of bacteria and other microbes resistant to antibiotics, due to their overexploitation or misuse. This ban opens an extremely large new market to organic acids, including lactic acid, because they are the best harmless growth promoting alternative.*

***[Regulatory]*** *In a case brought by Australia, Thailand and Brazil against EU, a WTO panel finds EU sugar policy not compliant with international trade rules. The EU undertakes an extensive reform in 2006 that will substantially reshape its sugar market. In the few years that will follow, the EU will change from being the world's second largest sugar exporter to a net sugar importer.*

***[Partners]*** *Cofco International, Cofco's parent company, announces its intention to spin off its grain-processing units and have them listed separately on the main board of the Hong Kong stock exchangewith the name China Agri Group.*

***[Industry]*** *As part of the Marshall Plan, the Walloon Region defines 5 priority areas in order to improve competitiveness in the region and creates WagrALIM, a center of excellence dedicated to the food industry, which bring together businesses, training centers and public and private research organizations who are keen to get involved in collaborative high added value projects.*

***[Competition]*** *CSM merges two of its subsidiaries, American Ingredients Company and Caravan Products, into one single entity*

*called Caravan Ingredients, selling lactic-acid-based emulsifiers, functional blends and fortification ingredients. CSM also restructures its bakery activities in UK and Italy, and announces its intention to sell its historical Sugar Division to Royal Cosun in response to the rapidly changing European sugar market. The new management announces a tighter strategic focus, geared at product innovation and new applications to drive sales volume growth close to historical growth rates in combination with price increases and aggressive cost cutting measures. As a result, the company regains the favors of the financial community.*

***[Competition]** PURAC improves operating result before exceptional items by 6%, breaking the 3-year trend of declining results.*

***[Competition]** Henan Jindan sets up a trading company in China to allow exporting products that are not manufactured directly by the company. The company is named Henan Jindan Import & Export Trading Co. Ltd. and has a registered capital of 2 million Renminbi (€ 0.2 million at 2006 exchange rate).*

***[Competition]** Sinolac, a 50% subsidiary of Hyflux (Singapore)*[132]*, announces its intention to commission a 30,000 mT/yr lactic acid production plant in Ningxia province (North of China, near Inner Mongolia) in partnership with a local electricity provider and a local venture capital. The company is called Ningxia Haokai Company.*

**2007**

*More ambitious targets to improve the short term and survive in the long run.*

In 2007, price erosion had stopped and prices had stabilized in the marketplace, the end of the EU sugar regime gave way to higher sugar prices (at least this is what was expected), and energy prices were again inflating. The management decided to reorganize some departments to tackle 4 main objectives:

- Improve the company's added value
- Increase sales volume
- Raise production capacity
- Maintain the company's technological leadership

To improve the value added, the management resolved to intensify its research efforts by working not only on improving existing processes, as it had been already decided the year before, but also by developing totally new processes for ethyl lactate and calcium lactate, two products that the company was already producing. In spite of the years that had lasted since ethyl lactate production had been launched, the product had never been produced in a very efficient way and the production had even been stopped a couple of years before. It was believed that restarting the development from the very beginning with the help of an external consultant might lead to a more efficient process. The situation was different for calcium lactate: the product was well accepted by the market but customer requirements were

[132] Hyflux is considered in Singapore as one of the industrial jewels in the sector of "high technologies" and, as such, Singapore's government was injecting a lot of money in the company through grants and subsidies.

gradually evolving towards new specifications that the old process did not permit.

On the sidelines of the development of new products, the company decided to continue its application development efforts so as to offer more and more new formulations based on mixtures of its products with other ingredients and thereby better address its customers' needs and diversify its offer. Other measures were also taken such as reinforcing the marketing team so as to improve market knowledge and to upgrade the company's image and visibility. The GAG (Galactic Application Group) was created gathering together the directors of R&D, Marketing and Sales every month in order to better link market needs and new developments.

In order to increase sales volumes, the company decided to completely reshuffle the sales team by replacing most sales people with a focus on Asia and North America, and the production capacity was increased in China by 20%, this investment being integrally self-financed by the joint-venture.

All this was intended to have an impact at relatively short term but the management was well aware of the threats to its technological lead that could put the company at risk on the longer term. Its technology, taken in a broad sense, was indeed recognized by the market: as we have seen, Purac, the market leader, had adopted the same purification technology; a large corn producer had licensed its production microorganism; and BBCA/COFCO had heavily invested in a partnership. However, at the same time, Purac's freshly appointed new CEO unveiled its plans to profoundly reshape Purac's business with the aim to drive it from volume to value (see the vignette on environmental context) which assumes a stronger focus on innovation; and the quality gap that had always existed between western products and Jindan's was gradually narrowing with the latter constantly raising the quality of its products. With this in mind, it became clear that Galactic had to redouble its endeavors to stay at the forefront: partnerships with research centers and universities were multiplied, a team in charge of Intellectual Property was set up under PCOS leadership and new pilot scale equipment was bought with the financial support of the regional government. Finally, the R&D department, named New Business Development, was reorganized as a network of competencies gathering around projects instead of a hierarchical pyramid.

*A creativity contest.*

The company invited all employees to participate to a creativity contest on the theme "Be creative to push your limits" with the intention to federate and emulate all the resources around the identification of possible improvements in the company's organization at all levels and in all departments. The idea was to change the mindset which was too much in a "problem pointing" fashion and not enough in a "problem solving" mode.

*A new attempt with genetic engineering.*

Galactic launched a 3-years research project together with the Catholic University of Louvain-La-Neuve aiming at developing a transformation protocol to genetically modify its production strain. A similar program had been in place about 10 years before with unsuccessful results. New genetic tools had emerged that made the company think that it might succeed this time. The purpose of such a

project was to better understand how Galactic's production strain is organized at the genome level, which metabolic pathways the bug is equipped with, and which modification strategy could be imagined to tune it.

*Headwinds in China.*

In China, the situation deteriorated unexpectedly. The Central Government had suddenly decided to reduce the export tax refund[133] for lactic acid and its derivatives from 13% to 5%[134] which implied an immediate and unforeseen drop of 8% in sales margin for all the company's exports. Announced mid of June, this new measure was enforced on July 1st, leaving no time for companies to adjust their sales prices and cope with this situation. Due to that, B&G anticipated a 28% reduction of its profits in 2007 and up to 56% reduction in 2008.

B&G margins on exports were even further reduced by surging transportation costs that hit international trade the same year as a result of rising oil prices and a booming Chinese economy[135], as well as by a local currency constantly appreciating against the US dollar, a currency to which the company is highly exposed (44% of its total turnover was made in US dollar in 2007). B&G had signed hedging contracts with Bank of China to help mitigate the effect though.

As a problem never comes alone, the factory experienced a lot of technical issues (especially due to microbial infections) between May and September, and production costs escalated tremendously because of sharp raw materials price increase and general inflation of fixed costs (i.e. salaries[136]). In average, production costs were almost 11% higher than the year before with a peak of more than 22% in December auguring high costs for the next year.

As a result, the company had no choice but to increase its sales prices twice in the same year. The production department was actively working with the R&D to continue improve products' quality. To rapidly penetrate the domestic market, B&G had launched its products at the same prices as local competitors in spite of their higher quality.

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[133] China began to implement its export tax rebate policy in April 1985 as a way to enhance the country's competitiveness in foreign markets by eliminating double taxation on exported goods. Export tax rebates refer to refunds of indirect taxes paid by exporting enterprises in the production and distribution process. Contrary to most countries, Chinese production companies have to pay value-added tax (VAT) on the materials purchased for production ("input VAT") and they include VAT in the amounts invoiced to their Chinese customers ("output VAT"). When goods are exported, the Chinese production companies cannot include VAT in their invoices to foreign companies and the tax authorities refund all or part of the input VAT paid up. Chinese authorities use this tool to favor key-economic segments (full refund) and hinder other segments (partial or zero refund). The portion which is not refunded acts as an export tax levied on the economic segments for which the government does not want to promote the exports (e.g. agriculture-based products that the authorities want to keep on the domestic market to the benefit of the Chinese population). This mechanism, called ECR method (Exemption, Credit and Refund) is generally applicable only to production enterprises qualified as general taxpayers. A different mechanism, the ER method (Exemption and Refund) is applied to the export of goods or services by export enterprises or other enterprises with no manufacturing capabilities.

[134] The standard value-added tax rate applied to most materials purchased for production is 17% which means that B&G had to support an "export tax" (i.e. input tax minus refund) of 4% on all goods exported when the refund rate was 13% (i.e. 17% - 4%), increasing to 12% with the new refund rate of 5% (i.e. 17% - 5%).

[135] China posted a GDP growth rate of 14.2% that year, the highest since 1992 (http://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG?page=1).

[136] Average labor costs increased by 18% in 2007, the highest increase in the 2001-2011 period http://www.chinadaily.com.cn/business/2012-09/26/content_15783913.htm).

Luckily, in 2007, domestic customers started to accept a "premium" for quality allowing B&G to price its products higher than local (low quality) competitors. An aggressive cost reduction plan was also designed for the next year (2008).

Despite these headwinds, B&G ended 2007 with a profit and the year marked a turning point as the reported losses accumulated over the very first years before the company started operating were now entirely reversed which also meant that the company initiated its tax holiday period[137].

*A major leap forward in the PLA arena.*

Galactic had never stopped working on the development of PLA in the past 15 years, although at varying speed from year to year depending on its resources and priorities. Even after the company had absorbed Brussels Biotech, the project had always been handled separately from the company's core activities. Albeit the conviction of the shareholders towards the long term potential of this material and the prominent role that Galactic could play in this field, it had always been considered as the company's "dancer", a sort of extravagant mistress that one keeps for pleasure, a costly venture with very hypothetical outcome. However, the seed planted by Galactic when presenting PLA to Total Petrochemicals in 2003 had grown to a genuine interest as Total was seeing a raising demand for plastics of renewable origin. After Total had conducted a rather long and in depth evaluation of Galactic patents, both companies announced in September 2007 the signature of an agreement for the creation of a joint-venture. The project entailed the construction of a pilot plant capable of producing 1,500 tons per year of PLA. Based on Galactic site, the plant was scheduled to come on stream in 2009. A research and development phase aiming at fine tuning the production technology would be conducted during 4 to 5 years at the same time as the plant would be constructed. Named "Futerro", the new company was benefiting from the scientific support of the Total Petrochemical Research Centre nearby as well as from the financial support of the Walloon Region within the framework of the competitive hubs of the Walloon Marshall Plan[138].

***Environmental context (year 2007):***

***[Partners]*** *Alfa Drain, the factory producing channels in polymer concrete that ATC had moved to Escanaffles and that had been sold to the German AKO by FVAN in 2004 closes its doors. 50 workers lose their jobs.*

***[Partners]*** *COFCO, Galactic's partner in B&G, launches an Initial Public Offering on the Hong Kong Stock Exchange for a company in which*

[137] China was then offering tax incentives to foreign investors. In our case, a total exemption for the first two years of accumulated profits followed by 3 years with a 50% reduction of corporate income tax.

[138] In an effort to boost the competitiveness of the Walloon Region in sectors where it already had potential, the Walloon government adopted the Marshall Plan in September 2005. The plan is based on five aspects: centres of competitiveness; development of activities; cutting corporate taxation; encouraging research and development; and enhancing vocational skills. As part of the green version of the Marshall Plan (Marshall Plan 2.0), the Walloon government decided to expand the clusters/centres of competitiveness policy. To this end, a budget of €388 million was provided to implement research, investment and training projects.

*COFCO lodges all its agro-industrial businesses, i.e. biofuel and biochemical, oilseed processing, rice trading and processing, brewing materials, and wheat processing. The company will operate under the name "China-Agri". The newly listed company has revenues of about 18.7 billion HK dollars (about € 2 billion). COFCO Group retains 59,4% of China-Agri. The shares of BBCA Biochemical owned by COFCO (20,74%) are however not transferred to China-Agri because the company is already listed on the Stock Exchange in Shenzhen.*

***[Raw materials]** Sulfur prices rocket because of strong international demand and lower than expected production in some regions that resulted in a perceived shortage in the global market. Booming demand for sulfur for fertilizer manufacturing around the world, with especially strong demand in China and India, resulted in the continued run-up in prices that will last until mid-2008. Sufur is the base material for manufacturing sulfuric acid, a key raw material in lactic acid making. The impact hit Galactic on a global level as well. In China for instance, sulfuric acid price multiplied by 4 between March and December 2007, accounting for 2/3 of the global cost increase incurred this year.*

***[Competition]** In June, CSM announces the sale of the customer base of the gluconic acid business of its subsidiary Purac America to Fuso America.*

***[Competition]** In September, CSM subsidiary Purac intends to restructure its operations by integrating the new lactic acid production plant in Thailand (capacity 100,000 mT/yr) into the overall production capacity and by discontinuing lactic acid production in the Netherlands and Spain as a result of a strategic review.*

***[Competition]** G. Van Nieuwenhuyzen is replaced as CEO of Purac by F. Rampinelli, a former Unilever executive. The rumor wants that CSM's board had van Nieuwenhuyzen's head because of the huge investment in Thailand that appeared to be more of a desperate bet at convincing Toyota to pursue with Purac than a rational and sound growth decision. A bad move that caused a costly mothballing of Purac's European facilities.*

***[Competition]** In October, Japan's Teijin*[139] *acquires 50% stake in NatureWorks.*

***[Competition]** Wuhan Sanjiang Space Gude Biotech Co., Ltd., is created in China with the purpose of producing and selling lactic acid and lactates. The company claims a capacity of 20,000 mT/year but it will actually buy food grade lactic acid on the local market and transform it into lactic acid derivatives with higher profit margins (primarily*

[139] Teijin is a global technology-driven group operating in five main fields: synthetic fibers; films and plastics; pharmaceuticals and home health care; trading and retail; and IT and new products. Teijin Limited is listed on the Tokyo and Osaka stock exchanges and has a market capitalization of USD 5.2 billion. The company had consolidated sales of USD 8.5 billion in fiscal 2006 and employs approximately 19,000 people worldwide.

*calcium lactate). Sanjiang's shareholders are Guangshui National Chemical (which was already distributing lactic acid, including B&G's, in China for about 10 years) and Sanjiang Space Group, a financially strong government-backed-up aeronautical and aerospace corporation.*

***[Currencies]** The THB appreciates sharply against most international currencies (from 2006 to 2007: +14% against CNY, + 24% against JPY, and +21% against USD), putting Purac's Thai plant under pressure.*

**2008**

*Galactic commissions a new production line for calcium lactate…*

Following more than a year of intensive research and development, Galactic hit the market with a new grade of calcium lactate. The technology was totally new and led to innovative particles shape, therefore the commercial name "Calcium Pearls", and unrivalled properties. The production method will be patented the same year. The production unit was more than twice as big as the former one which will no longer be utilized. The product will soon become a reliable cash cow for the company.

*…builds a pilot unit for D(-) lactic acid…*

At the same time, Galactic started the erection of a pilot unit for the development of a new technology aiming at producing D(-) lactic acid based on the bacterial strain successfully isolated in the frame of the collaboration program in Cuba that lasted from 2002 till 2005.

*…and continues to patent new processes.*

The company's R&D department did not rest on its laurels. The same year, it filed for a patent on the preparation of lactic acid by fermentation of sugar cane extract, as well as one about a continuous process to obtain lactic esters. The former patent will never been exploited, but the latter will allow the company to efficiently penetrate the ethyl lactate market with a product of good quality and competitive price. As a matter of fact, the company had worked for a couple of years on such a process, even hiring an expert as a consultant, with disappointing results until it came across an American specialist who could help solve the main issues and make this innovative process run satisfactorily.

Therewith, Galactic filed for one more patent, this time on the purification of lactic acid by crystallization. This new process allows to reach a higher quality level than previously possible, especially suited for use in cosmetics and personal care products. Substantial sales will be possible as from 2013 in Asia and 2014 in Europe thanks to this new process.

*A subsidiary in Hong Kong.*

With a company in China and a growing business in the whole Asian area, Galactic was witnessing from the inside the tremendous growth of this part of the world. The management was then convinced that more opportunities might come and it was decided to incorporate a fully owned subsidiary in Hong Kong - Galactic HK Limited – in preparation for the future.

*B&G creates a subsidiary to support trading activities…*

In China, B&G's operations are limited by its status of production company which forbids the company to conduct trading activities because of the VAT regime imposed to companies with manufacturing activities. B&G's board therefore approved the management's proposal to create a fully-owned subsidiary to take care of importing

and exporting chemicals and ingredients, and extend the company's offering. B&G Import and Export Co., Ltd. was born.

*…but the environmental situation degrades terribly in China…*

The headwinds encountered the year before gained in intensity and the situation worsened dramatically in 2008 which turned out to be B&G's "annus horribilis". China, which had for a long time been considered as a cheap manufacturing location, was suddenly losing its competitive advantage on the international scene: in 2008, Chinese corn was 35% more expensive than US corn, dextrose[140] price was 56% higher in China than the Sugar No. 11[141], most chemicals increased by 20 to 25% in a few months and utilities such as steam and electricity nearly doubled. Moreover, in addition to the reduction of export tax refund mentioned earlier, the Chinese renminbi continued to appreciate against most foreign currencies[142], and the China Marine Bureau declared absurdly lactic acid as hazardous material when it was not so by the United Nations nor in any other country. This measure resulted in a sharp increase of transportation costs for all B&G's exports[143]. As if it was not enough, the outbreak of a major long-lasting strike in North American potassium mines plunged the world in terrible lack of potassium hydroxide (a key raw material for the manufacture of potassium lactate-based blends, very important specialties for Galactic and its subsidiaries). All continents were impacted.

In 2007, China's General Administration of Quality Supervision, Inspection and Quarantine had issued a new regulation setting tighter controls on exports of certain goods including lactic acid and lactates. In 2008, even stricter control procedures have been implemented by the Authorities in reaction to several scandals about food safety in China (i.e. melamine-tainted milk). In the case of B&G, these controls and procedures implied an increase of about +0.5% of the value of the goods exported.

On the 1st of January 2008, China's new Labor Contract Law (LCL) went into effect. B&G saluted this new regulation as a positive step forward in the protection of employees' interests. As all B&G employees benefited already from exhaustive working contracts, this new law didn't impact seriously the company's administration. However, new rules for calculation of social security payments have been implemented at the local level ending up with a sensible increase of expenses for human resources. In addition to this, in 2008 China recorded the highest inflation rates of the last 10 years (especially on primary goods like food products) putting high pressure on companies to increase salaries accordingly.

[140] Dextrose is the name given to glucose obtained by complete hydrolysis of starch. In China, B&G uses corn dextrose as main source of carbon in its manufacturing process.

[141] The Sugar No. 11 contract, traded on the New York Board of trade renamed IntercontinentalExchange (ICE), is the world benchmark contract for raw sugar trading. It is traded in USc/lb. White (refined) sugar is traded in London at the London Futures Exchange (LIFFE). The contract is known as the No 5 contract and is traded in US$/metric ton.

[142] By 2008, the Chinese renminbi had already increased by 17% since it had been de-pegged from the USD in 2005, with a 6% increase in 2008 alone. B&G was losing about 1 million renminbi of EBIT for each 1% increase against the USD. In this year, it also took about 20% against the EUR and up to 30% against the Australian dollar.

[143] This decision will luckily be reverted about one year later thanks to B&G's lobbying efforts together with China fermentation Association and other lactic acid producers.

To cope with this difficult situation, the management started implementing a cost saving plan involving all departments and decided a new price increase to all customers.

*…with effects in the US.*

Galactic Inc., Galactic's arm in the US, was relying on B&G for its supplies of lactic acid to be transformed locally into derivatives but the extend of cost increases in China made impossible to sustain this business any further. Consequently, Galactic stopped producing in the US, mothballing its production facility in Milwaukee and reducing the staff. The American subsidiary was converted into being only a sales office in an attempt to keep a foothold there, but also to avoid having to take a loss of $1 million in its balance sheet that would have resulted from totally disbanding Galactic Inc.

*A rescue plan for Galactic Inc.*

Galactic decided to adapt its sales strategy by moving the existing sales on the west coast from B&G to Galactic Inc., expending prospection on the west coast with new distributors, and transferring South American sales from Galactic SA to Galactic Inc.

*An attempt to acquire B&G's biggest customer.*

In these difficult times, B&G management started to think that a new business model might be needed: a broader and richer product portfolio, focused on specialties rather than commodities, and a reinforced presence on the domestic market in order to reduce its exposure to export markets. B&G initiated negotiations with its biggest customer in China, a private company producing derivatives of lactic acid for the flavoring industry as well as fine chemicals. This enterprise had to move because of local real estate project and lack of available room to increase production capacity and sustain its growth. The idea was then to relocate its assets on B&G site in Bengbu. After the integration of this company, B&G would have doubled its sales turnover and improved profitably thanks to upstream and downstream synergies. The parties however could not agree on a value for the deal and, above all, on the payment scheme[144].

*A small rift in China clouds…*

At the end of the year, China's fiscal policy relaxed a bit. The Export Tax Refund on exports was increased from 5% to 9%.

*…but bad weather in Europe.*

In Belgium, the factory had run at full capacity every single month of the year except in November when a technical problem occurred in the evaporation unit. The new production unit for calcium lactate had been successfully started but it had still to be improved to reach a steady state in terms of quality and throughput, and the facility for ethyl lactate that had been adapted to the new process recently developed was still operated by the R&D team before to be handed over to the production department in 2009. The sales of these two products had started but too slowly. The worldwide shortage of potassium hydroxide has led to an increase of production costs that could not been passed onto customers immediately, a situation that further eroded the profitability of some of Galactic's specialties while the global financial and economic crisis did not create a favorable climate to consider price increases.

Moreover, whereas the collection of royalties from B&G had increased, the Technology License Agreement with the corn processor

[144] The owners of the target company wanted a full payment in cash at the time of the transfer whereas B&G proposed a lump sum followed by performance-based earn-out after 4 years in order to retain the key-people, make sure there was no "skeletons in the closet", and increase the chances of success.

in the US ceased to have effect in late September, hence no longer impacting favorably the company's P&L. The economic turmoil was also reflected in another way with strong social discontent and, after 15 year of social peace, two strikes in Belgium.

***Environmental context (year 2008):***

***[Economy]*** *On the 2nd of January, the price of petroleum hits $100 for the first time in history and the monthly average even peaked up at $140 in the month of June to fall down to $40 in the second half of the year.*

***[Economy]*** *On the 21st of January, stock markets around the world plunge amid growing fears of a U.S. recession, fueled by the 2007 subprime mortgage crisis. In February, Northern Rock is the first bank in Europe to be taken into state control, due to the subprime mortgage crisis. In September, Lehman Brothers, the fourth largest investment bank in the US files for bankruptcy, the largest in the US ever. In October, U.S. President George W. Bush signs the revised Emergency Economic Stabilization Act into law, creating a 700 billion dollar Treasury fund to purchase failing bank assets.*
*All in all, 2008 was a traumatic year for the global economy. A decade of global economic growth has come to a sudden, grinding halt. The financial services sector has been forever transformed through collapse, write downs and forced government intervention.*

***[Society]*** *The 2008 Summer Olympics take place in Beijing, China.*

***[Partners]*** *On May 6th, FVAN creates a new company called "Man-To-Tree" (MTT) with the view to import, distribute and install solar panels in Belgium, an activity that will be divested a few years later because of the escalation of competition on such a small market. In the same year, MTT signed a deal with Air Energy*[145] *to launch a project of 5 wind mills very close to Galactic's production site. The project will be delayed because of oppositions from neighbors.*

***[Competition]*** *The shareholders of Henan Jindan Import Export decide to change the name of the company to Henan Jindan Lactic Acid Co. Ltd., enlarge its business scope to allow for the production and sales of lactic acid and several derivatives. They increase the registered capital of the company three times in the same year.*

***[Competition]*** *Minneapolis-based chemical products firm Hawkin's Inc. has acquired a 77,000 square foot facility in Centralia, Illinois. Hawkins is one of the largest buyers of lactic acid for transformation into lactates in the American market. The facility will be mainly used for expanding its lactate and other food ingredient manufacturing capacity. It is expected that the facility will be fully operational in the summer of 2009.*

[145] Air Energy was one of the largest companies in the field of wind energy in Belgium with both onshore and offshore activities. It was acquired in 2011 by Eneco, a large Dutch producer and distributor of electricity totaling revenues of €4.3 billion in 2015.

***[Competition]*** *CSM announces the completion of the sale of the small scale gluconic acid and gluconates production plant of its subsidiary PURAC biochem in the Netherlands to AVEBE. The transaction does not comprise the marketing and sales activities for gluconic acid and gluconates, which activities will be continued by PURAC. The agreement also includes a tolling contract. AVEBE will continue to operate the gluconic acid and gluconates production plant exclusively for PURAC. The sale of the production plant is part of the strategic restructuring of PURAC's manufacturing footprint, announced in September 2007.*

***[Competition]*** *PURAC and Sulzer Chemtech*[146] *announce having jointly developed a new cost effective polymerization process to produce PLA. They announce at the same time the erection of a first plant to use this new technology. The plant will be built by Synbra*[147] *in the Netherlands for the production of BIOFOAM®, a foamed product made from this PLA, complementary to their wide range of polystyrene foam products of. The new plant with a capacity of 5,000 ton/year is targeted to be operational by the end of 2009.*

**2009**

*More R&D, more patents*

Galactic continued its efforts in R&D, with various projects mainly focused on the development of innovative production processes for specialty derivatives. A new patent on the production of esters was filed in July. Quality improvement was still needed for calcium lactate. As a matter of fact, Galactic's product would greatly benefit from a lower iron content to extend its market reach and better satisfy some customers' demand. The newly started production unit was lagging behind forecasts and had to be stopped for one month because of high inventories. Solving this issue implied the development of dedicated de-ironing system that did not exist yet for this type of product. The company was also working on applications and filed for a patent on a new technology for the bioremediation of polluted soils [148] in partnership with one its customers. R&D resources were also committed to the design and validation of an innovative process to recycle PLA wastes in a clean and profitable way. This process, named

[146] Sulzer Chemtec is a technology company in the area of Static Mixing and Reaction Technology with some 100,000 references over a wide range of applications such as polymer production, polymer finishing, plastics processing and broader chemical process industries. With global footprint related to sales, engineering, fabrication and customer services Sulzer Chemtech serves the segments in the oil and gas, hydrocarbon processing, petrochemicals and polymer production industries. Sulzer Chemtech is a division of Sulzer Corporation with annual sales of CHF 760 million and over 2,400 people worldwide (www.sulzerchemtech.com).

[147] Synbra has a leading position in Europe regarding Expandable Polystyrene EPS for Sustainable Insulation Systems and Industrial Products & Solutions for a wide diversity of markets. Synbra achieves a turnover of € 330 million with about 1,600 employees in the Netherlands, Germany, France, Denmark, the United Kingdom and Portugal.

[148] According to the EPA (United States Environmental Protection Agency), bioremediation is a "treatment that uses naturally occurring organisms to break down hazardous substances into less toxic or nontoxic substances", or more specifically, a waste management technique that involves the use of organisms to remove or neutralize pollutants from a contaminated site.

LooPLA®[149], gave way to two more patents in the same year. Decision was taken to bring this new technology to industrial level as it was deemed to be a key-element for the future development of PLA. Indeed, this biopolymer degrades naturally in industrial composting conditions but not everywhere in nature and there were more and more interest towards the development of non-degradable PLA for durable applications such as computer casings and automotive parts. An economically-sound "end-of-life" solution had to be found and Galactic was confident that its process was the most elegant one.

*The recovery after the meltdown.*

Sales volumes from Belgium increased especially in direction to the US. Since Galactic Inc. stopped producing locally, it started to import more from Belgium to honor some contracts of special blends for the preservation of food products. The strengthening of the Euro against the dollar made these sales less profitable than initially expected but the gain in volume helped the Belgian factory to run smoothly at full capacity and hence to better control its fixed costs. Overall, sales prices had successfully been raised to mitigate the effect of raw material costs increases, especially in China, and could be maintained at this higher level when direct costs relaxed. The profitability of the Chinese joint venture improved healthily as a consequence and the royalties to Belgium could be increased in proportion. The same positive evolution was true in North and South America in the second half of the year and all group companies closed the year with a strong growth in profit over the previous one despite that Belgium still lagged behind compared to its budget.

*Some organizational changes.*

With B&G back on tracks and several new development projects in Belgium, it was decided to bring MVAN and JCBO back. B&G production, engineering and maintenance departments where taken over by MVAN's Chinese counterpart (LIWE), a brilliant and trustable engineer who had participated to the project since the beginning and was already overseeing supply chain management (purchasing, packaging and logistics) as well as the quality assurance department. The company's general management was given to a new recruit (HPEN), a Swiss citizen who had already spent several years managing companies for a major Swiss chemical group in China. JCBO would however stay member of the board to guarantee a certain continuity. In addition, as Environment, Health and Safety become increasingly critical issues in modern corporations and more and more in the eye of the Chinese Authorities, a new key-position was created in B&G by merging this responsibility with the quality assurance and create therefore a new position of Assistant General Manager. This position was to be viewed as hierarchically below the Deputy General Managers but above the Manager level. The sales and marketing operations had already been transferred a couple of years before to a Chinese sales manager (CHHU) who had started as simple sales person and had climbed the ladder thanks to his sales performances in a difficult context.

[149] A short movie about "LooPLA by Galactic" can be seen on YouTube at: https://www.youtube.com/watch?v=dJEUf_mINxY

The structure was also adjusted in Belgium with the departure of the marketing director and the decision to merge the marketing and the sales departments under the same leadership (RPEE).
In the US, the team was expanded to develop direct sales, reduce dependency towards local distributors, and take over the sales to Latin America that have been transferred the year before.

*All ideas are worth a look.*

A new project came to mind because of the high price of energy in Europe. This project, nicknamed "Xylox", was aiming at the production of energy (steam and electricity) from wood and wooden wastes. As strange as it sounds, it was not complete nonsense as such industrial units do exist already and it would have helped the company to stay tuned with its image of environmentally-responsible company. However, this investment was not followed by banks and the company had to keep its re-investment capacity for other, more sales-oriented, productive projects.

*Futerro's demonstration unit started up.*

Activities were also progressing at Futerro whose capital had to be increased. Both Galactic and Total teams were working actively together on the PLA production process and the erection of the 1500 tons/year pilot unit which was started up end of 2009 and officially inaugurated in the presence of important representatives of the political and industrial world in April 2010. It was the first of the kind in Europe.

*COFCO wants PLA…*

COFCO, co-owner of B&G together with Galactic and major corn producer and trader in China, was also particularly interested in PLA. It was planning to start the production of PLA, probably on one of its large corn processing sites in northeast China although the choice of the location was not yet finally settled. The project had already been the subject of announcements in the stock market listing prospectus of China-Agri (agrochemical division of COFCO) in 2007 and in the financial statements of the latter in 2008. In this context, COFCO began to search for the technology worldwide and visited Futerro's demonstration unit in Belgium.

*…and to change B&G's structure.*

COFCO's management was pretty upset about the structure of B&G since the very first day it had taken over the control of BBCA Biochemical in 2006. They could not accept not to have the decision power of a company they own 51% of. In practice, the idea was to change B&G from being a CJV (Contractual Joint Venture) into an EJV (Equity Joint Venture), meaning that the control is not defined by contract anymore but simply proportional to the equity repartition between shareholders. In this context, COFCO wanted to keep the distribution of existing capital (51:49) and hence take the management control, a proposal that Galactic could not agree with. Despite all of COFCO's arguments and barely disguised threats, Galactic held well thanks to a burly joint venture contract firmly rooted in Chinese law. COFCO will however not admit defeat and will put the issue on the agenda whenever possible.

*Time to conquer Japan.*

The Japanese market is the largest in Asia for lactic acid and derivatives. It was by then already mature and was growing slowly with a single digit growth rate. Thus, growth for a company had to be achieved by taking market shares from competition. B&G was unable to build sustainable customer relationship because the Japanese business was essentially managed via distributors shielding the

company from its customers so as to keep their margins and avoid customers moving to direct sales. Moreover, some of B&G products had started to commoditize, the costs for customers to change suppliers therefore became relatively low, and the protective mechanism to keep the business under these circumstances was traditionally based on customer relationship. The language barrier, the Japanese business culture and the sometimes difficult relations between Japan and China finished to convince B&G management of the need to set up a sales office and recruit nationals in Tokyo. The subsidiary company named "B&G Natural Ingredients and Chemicals K.K." (in short "B&G Japan") was officially incorporated on the 30th of October 2009.

***Environmental context (year 2009):***

***[Economy]*** *The world economy tries to recover from the aftermath of the global financial crisis. The crisis, as well as house price declines, have delivered a shock to consumer confidence and sparked capital flight from emerging markets, raising the specter of a retraction in developed economies becoming a truly global recession. The credit crunch and its aftershocks pose existential threats to leading global financial firms while capital-intensive sectors such as life sciences and biotech are under pressure from a tighter credit environment*[150]*.*

***[Society]*** *The outbreak of the H1N1 influenza strain, commonly referred to as "swine flu", is deemed a global pandemic.*

***[Competition]*** *CSM announces that its subsidiary Purac will start with the construction of a lactide*[151] *plant in Thailand. The investment for this new plant will be €45 million. The new plant will be ready for startup in the second half of 2011 to meet current level of demand and to accelerate market development*[152]*.*

***[Competition]*** *PURAC and TOYOBO*[153]*, a Japanese specialty chemicals, film & fiber company, announce that they have formed a strategic partnership for the production of PLA that will be broadly introduced*

[150] *The 2009 Ernst & Young business risk report*, 2009, p.5

[151] Lactide, also often called dilactide, is a cyclic dimer of lactic acid. One method to produce PLA consists of polymerizing lactide, instead of directly lactic acid, with a catalytic process called "ring opening polymerization".

[152] As a matter of fact, Purac's business model for PLA aimed at offering lactide to third parties who would have to invest in polymerization units. This model will prove inefficient as most industrial players do not want to rely on a single supplier of a key raw material. Moreover, the need to recycle some residual fractions during the polymerization process call for the integration of this step together with the lactide manufacturing units. Purac will later change its approach and announce plans to erect a polymerization unit in Thailand as well.

[153] Toyobo was founded in 1882 as a textile company, when it began its spinning and textile business. Over the next 125 years Toyobo continued to adapt to the changing needs of the times, drawing on their core technologies in polymerization, modification, processing and biotechnology to expand business fields and develop high-performance products; Films and Functional Polymers, Industrial Materials, and Life Science. Toyobo operates in Asia, North America & Europe, and generates €3.3 billion with a workforce of around 3300 employees. Toyobo is listed on Tokyo Exchange market (www.toyobo.co.jp).

*into the European market by TOYOBO under the brand name VYLOECOL®.*

***[Competition]*** *BASF[154] and CSM announced the cooperation between their respective subsidiaries BASF Future Business GmbH[155] and PURAC for the development of the production of biobased succinic acid. The intention is to start production of commercial quality and volumes in the second quarter of 2010.*

***[Competition]*** *Musashino Chemical Laboratory (Japan) acquires full ownership of Jiangxi Musashino Bio-Chem Co., Ltd.*

***[Competition]*** *Teijin Fibers Limited, the Teijin group's core polyester fiber company, announces that a car seat fabric made 100% of BIOFRONT, a green PLA-based bioplastic, is being used in the Mazda Premacy Hydrogen RE Hybrid vehicle that the Mazda Motor Corporation began to manufacture.*

***[Competition]*** *Teijin, facing corporate restructuring in the wake of the Great Recession[156], steps down from NatureWorks.*

Over the last five years, Galactic' structure had continued to develop into a small international group of companies. The figure below shows how it looked like at the end of the year 2009.

[154] BASF is the world's leading chemical company: The Chemical Company. Its portfolio ranges from chemicals, plastics and performance products to agricultural products, fine chemicals as well as oil and gas. BASF has approximately 97,000 employees and posted sales of more than €62 billion in 2008. BASF shares are traded on the stock exchanges in Frankfurt (BAS), London (BFA) and Zurich (AN) (www.basf.com).

[155] BASF Future Business GmbH, a 100 percent subsidiary of BASF SE, was founded in April 2001. It aims to open up business areas with above-average growth rates that lie outside BASF's mainstream activities. The company focuses on chemistry-based new materials, technologies and system solutions.

[156] The Great Recession was a period of general economic decline observed in world markets during the late 2000's. Japan, whose economy was already weakened by several years of turmoil, fell into recession as early as the third quarter of 2008 when businesses sharply cut back on spending and as net exports made a negative contribution to growth (http://www.economist.com/node/12627563).

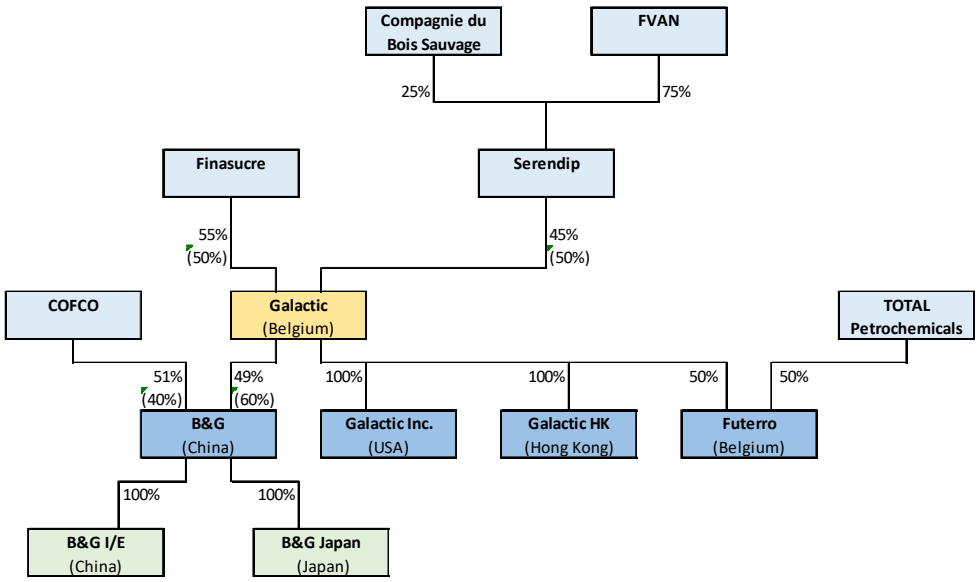


*Figure 4.10: Group structure at the end of 2009*
*(% of control in brackets)*

**2010**

*Galactic further improves its processes…*

In 2010, Galactic implemented an automated warehouse management system (WMS) and invested in a co-generation unit in its Belgian factory to reduce its exposure to high energy prices as well as its environmental footprint. At the same time, the company commissioned a new pretreatment unit for its calcium lactate process allowing to sharply improve the quality of this product and hence target new markets (a process internally nicknamed "Tornado"). This innovative pretreatment was the result of several months of research and pilot trials conducted in a climate of urgency since the sales of this product, which had been subject of a multi-million investment a couple of years before, were by far hindered by the still sub-optimal quality of the product in terms of iron content despite unrivalled novel features in terms of dissolution rate (an important property for a product essentially dedicated to the beverage industry).

*…continues to prepare for the future…*

On the research and development side, the company went on with the prolongation for three years of its ongoing partnership with the Catholic University of Louvain on genetic transformation of lactic bacterial strains, and with the filing of two more patents on esterification of lactic acid. These patents relates to a process (named “Dumbledore”) that formed the first step of a broader process aiming at manufacturing lactic acid without producing gypsum as by-product. The company trusted that this new perspective could become a real breakthrough for the whole industry but many more years of development will be needed to bring it to full industrial scale.

*…and extends its network of potential partners (with little to no success).*

In the US, Galactic and Total Petrochemicals started discussions with Cargill to assess the possibility of acquiring NatureWorks after Teijin stepped down as shareholder. This project nicknamed "Cachalot" will not go through.

In Thailand, Galactic and Futerro discussed a possible collaboration about PLA with PTT[157], the country's largest petrochemical company. The parties will stop talking when PTT will announce taking a 50% stake in NatureWorks the year after.

In China, Galactic met Hyflux-Sinolac's top management in the frame of a potential collaboration to restart their lactic acid factory in HuLuDao, China. This project will be abandoned. Galactic was also looking at a possible partnership in PLA with APC[158] in China, to no avail, as well as at a possible alliance to produce lactic acid in China together with Hisun[159]. Hisun was in fact already buying lactic acid from B&G since a while to feed its 5,000 tons/year PLA pilot plant. Hisun had the intention to build a 50,000 tons/year industrial facility for which he would have to build a fully-dedicated lactic acid factory. Having no experience in producing lactic acid, Hisun decided to initiate discussions with its largest local supplier. The talks were halted when Hisun realized that it would not get the approval from the Authorities to produce on the site they wanted to use.

In Europe, Galactic and a French company K&Co signed a Memorandum of Understanding to explore the possibility of setting up a joint-venture whose purpose would be to jointly build and operate an industrial plant on Galactic industrial site using K&Co's technology for drying and transforming gypsum, a by-product of the lactic acid production, into Kerysten©, a valuable form of anhydrous calcium sulfate usable for various applications in the building industry such as binders and self-leveling screeds. This partnership will however never materialize.

*Loopla® goes live!*

After the inauguration in great pomp and ceremony of Futerro's demonstration unit, Galactic commissioned the first chemical-recycling unit for PLA in the world operating with its proprietary patented process called Loopla®. The company will start to collect and recycle PLA wastes all around Europe, including the PLA-based carpets used for the climate summit in Copenhagen in November 2009.

The basic idea was quite counter-intuitive, and hence truly original, for a biodegradable polymer. Until then, scientists and engineers working on the lifecycle management[160] of biodegradable polymers were only

[157] PTT Public Company Limited or simply PTT is a Thai state-owned SET-listed oil and gas company. Formerly known as the Petroleum AuThority of Thailand, it owns extensive submarine gas pipelines in the Gulf of Thailand, a network of LPG terminals throughout the Kingdom, and is involved in electricity generation, petrochemical products, oil and gas exploration and production, and gasoline retailing businesses. PTT posted revenues of $94.55 billion in 2014 with a workforce of 9,015 people (www.pttplc.com).

[158] APC, Action Perfect Engineering (Xiamen) Co., Ltd., is a subsidiary of Xiang Lu Group and Dragon Group. APC produces paraxylene and pure terephtalic acid from aromatics issued from naphtha refining. Their terephtalic acid serves to produce poly-ethylene terephthalate (PET) which is then transformed into polyesters for textiles and bottles.

[159] Zhejiang Hisun Pharmaceutical Co.,Ltd. ("Hisun") is a Chinese company producing pharmaceuticals and agrochemicals such as pesticides, herbicides and fungicides. It is ranked in the top 520 key enterprises in China and listed on the Stock Exchange in Shanghai.

[160] Product lifecycle management (PLM) is a systematic approach to managing the series of changes a product goes through, from its design and development to its ultimate retirement or disposal.

considering three main end-of-life [161] options, i.e. composting, landfilling and incineration. Galactic's ingenuity was to think about recycling. As silly as it may sound for a polymer that is supposed to degrade spontaneously when disposed of in nature, recycling, when properly conducted, presents real economic and even environmental advantages[162] over the other end-of-life solutions as it allows for much shorter cycles (see figure below). With this process, Galactic turns PLA back into pure lactic acid that can be re-used for making PLA anew without compromising the technical properties of the polymer.

But chemical recycling is nevertheless relatively heavy to conduct and therefore must be kept for PLA-containing wastes of low purity. For PLA scraps and scums of high purity, an even shorter cycle can be envisioned which consists to simply clean, melt and re-pelletize the PLA. This recycled PLA ("r-PLA") can then be sold at favorable price for making lower quality products. Galactic will decide in the same year to also invest in this activity and to recruit a dedicated project manager (SDEJ).

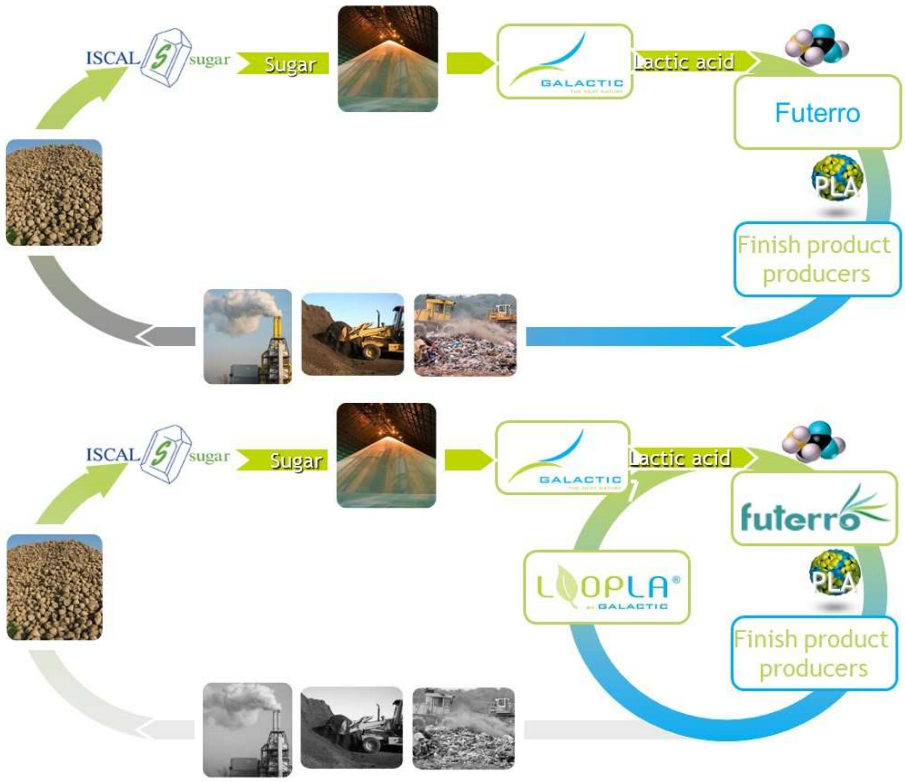


*Figure 4.11: Illustration of Galactic's concept of chemical recycling transforming PLA back into lactic acid to be re-used for making PLA again.*
*(top: normal lifecycle of PLA; bottom: Loopla®)*

[161] End of life (EOL), in the context of manufacturing and product lifecycles, is the final stages of a product's existence. In our case, EOL concerns include disposing of the existing product responsibly, transitioning to a different product and ensuring that disruption will be minimal.

[162] It has been demonstrated by an independent organism, the VITO, in a study based on data provided by NatureWorks and Galactic in 2009.

*Bouncing back in the US!*

With a recovery as fast as the fall, and thanks to Chinese production costs coming back to normal, Galactic came back in a position to resume its local production in Milwaukee. The project was called "Victor", a name fraught with meaning. In the wake, Galactic had the opportunity to acquire the building where it was established and that was rented until this moment. It was the perfect occasion for the company to fully own its infrastructure and, as it seemed, to make a nice investment in real estate terms as well.

***Environmental context (year 2010):***

***[Society]*** *Expo 2010, officially the Expo 2010 Shanghai China, was held in Shanghai, China, from 1 May to 31 October 2010. It had the largest number of countries participating and was the most expensive Expo in the history of the world's fairs. By the end of the expo, over 73 million people had visited – a record attendance – and 246 countries and international organizations had participated. Futerro had taken this opportunity to present PLA in the Belgian pavilion.*

***[Competition]*** *Jungbunzlauer, an Austrian producer of citric and gluconic acids, announces an investment of €25 million to erect a lactic acid production line on its site of Marckolsheim, France. The capacity has not been disclosed but is estimated to be between 10 and 15,000 tons/year.*

***[Competition]*** *The shareholders of Henan Jindan increase the registered capital of the company again twice in the same year to reach 82.6 million Renminbi (€9.5 million at 2010/06 exchange rate). This operation organizes the entry of new shareholders, mainly venture capitalists and investment funds, in the company's capital for a total amount invested of 130 million Renminbi (€ 14.9 million at 2010/09 exchange rate).*

***[Partners]*** *FVAN succeed in attracting new investors and subsidies in Man-To-Tree to help finance a research project on the production of succinic acid by fermentation.*

**2011**

*A first real market-pulled radical innovation…*

In 2011, Galactic started the production of a totally new derivative of lactic acid, a product called “Adagio” because it allows for a slow acidification as opposed to the immediate release of acidity classically obtained with acids[163].

The development of this product had actually started two years before when a customer had come to Galactic with a very special request that apparently no product available on the market could satisfy. A series of trials and errors followed, back and forth between Galactic and the customer, with the former developing the product and adjusting its features and the latter reporting on the shortcomings after having it

[163] The word “Adagio” comes from the Italian expression ‘*ad agio*’, literally 'at ease', indicating a relatively slow pace. In music, adagio is usually considered to be a tempo slower than andante but faster than lento or larghetto.

tested in its factory, until the right product behavior and dosage were reached.

Although Galactic had always been striving at innovating, this was the first user-centered *radical innovation* [164] of the company really triggered by the clearly identified need of a customer, and developed in the frame of a real technical partnership together with the customer. And even if the client, who will later start consuming the product on a regular basis, will never buy as much as originally envisaged, this will give Galactic the opportunity to extend the innovative properties of the product to a variety of other applications, not alone in various types of bakery products but also in meat, dairy and even in hygiene and personal care. What started as one product for one customer slowly became a full range of products in different market segments.

This experience showed Galactic the power of intertwining the customer directly inside its product development cycles, as the company would otherwise never have thought about this application and it would never had the applicative knowledge needed to complete its development; but it will also show, in the years that will follow, how long, difficult and riddled with pitfalls can be the launch of a radically different unique product. It will not only be a question of informing and educating the market about this new option but it will also need to break the users' preconceptions, doubts and reservations. It will take more than another five years to attain satisfactory sales quantities for this new Adagio-type of product...

*… and still a lot of company-pushed innovations.*

Galactic of course continued to be active in traditional "inside-out" research and development and filed for four new patents in the same year: one on the production of ultra-concentrated forms of potassium lactate that will put into production and allow the company to enlarge its product portfolio, a patent on a method to prolong the shelf-life of food products with a microbial composition made by natural fermentation that will later form the base of a whole range of new products for the company, and two patents on the separation of the two isomers of lactic acid which will actually not be exploited.

*Galactic tries a new type of research partnership.*

What's more, Galactic applied together with another Belgian company for a patent about a combination of antibacterial and antioxidant natural agents to better preserve food products. This marks a new type of partnership for the company: a research cooperation, not with traditional research centers or universities, not with a customer (as for the development of Adagio), not with a company further down in the value chain (as with Total in the development of PLA), but with another company which is offering products different from those of Galactic but whose properties can be synergistically combined with Galactic products in order to offer "2 in 1" superior solutions to customers. These products will however struggle to break into the market, and

[164] "*Incremental innovations* are product improvements and line extensions that are usually aimed at satisfying the needs of existing customers. They involve small changes in technology and little deviation from the current product-market experiences of the firm. In contrast, *radical innovations* involve fundamental changes in technology for the firm, typically address the needs of emerging customers, are new to the firm and/or industry, and offer substantial new benefits to customers" (Atuahene-Gima, 2005, p.65)

here again several years will be needed to see substantial sales materialize.

*Managing taxes at international level is an art… and B&G get to learn it the hard way.*

In China, B&G had the visit of the Chinese State Tax Inspection Bureau with regards to its Transfer Pricing Policy (prices at which products are sold to affiliated companies, i.e. to Galactic and Galactic subsidiaries) and to its royalty fees amortization rules. An extensive and detailed audit lasting several weeks covering 5 years of operations was conducted. This followed a tightening of the rules towards foreign invested companies which were put under reinforced scrutiny by the Chinese authorities. After long-drawn negotiations, and thanks to the help of a law firm specialized in these matters, a settlement was found with the Chinese authorities and a tax adjustment of more than EUR 1 million was agreed upon. Despite no illegal action has been brought, B&G had discovered the joys and difficulties of different tax systems guided by divergent national interests coexisting on the international stage.

*More growth opportunities that will not go through.*

Hyflux (Singapore) put to sale its participations in Sinolac's two lactic acid factories in China (Hu Lu Dao and Ningxia). Both factories had had to stop their operations only a few months after commissioning mainly because of wrong technological choices leading to high production costs. B&G investigated but ultimately declined. At about the same time, Teijin approached Galactic for the production of 5,000 tons per year of D(-) Lactic Acid. A business case was established to estimate production costs but the parties will not reach an agreement as Teijin got a cheaper offer from Musashino Jiangxi who saw an opportunity to fill up its under-utilized production capacity in China.

*One of the top-managers dispatched to the US.*

In the US, the business was taking off again and the manufacturing part gained in importance. It was decided to send Galactic's industrial director (EBIE) as general manager there to take over and streamline the operations. EBIE will be going back and forth between Milwaukee and Belgium for a while but soon the management of the Belgian factory will be transferred to MVAN who was already in charge of Engineering and IT so that EBIE would settled in Milwaukee with his family and focus his time and effort on the American venture.

*Headwinds and dark clouds ahead … again!*

In Belgium, production costs started to rocket again, with an increase of 44% year-on-year, mainly driven by historically high sugar prices[165] as well as high prices for the other raw materials. Crude oil was again above 100 USD per barrel, dragging energy prices including natural gas to high levels also, but luckily the impact could be mitigated thanks to the cogeneration unit installed the year before. Labor costs were also increasing despite a stable workforce because of a double indexation

[165] In January2011, the sugar monthly price peaked at 29.74 US cents per pound in New York (contracts No 11), and again it went over 29 US cents per pound at 29.47 in July of the same year, a situation unseen since May/June 1980. As a reference, the average monthly price in the last 20 years was 10.84 US cents per pound (source: International Monetary Fund, http://www.imf.org/external/np/res/commod/index.aspx).

of wages[166] and the conclusion of two collective labor agreements[167]. In this situation, the company had no other choice but to not renew some of the working contracts coming to an end and to delay some recruitments.

In China as well B&G had lost significant profitability in comparison to previous years, here again improvements in areas such as production utilization and production yield were not high enough to offset raw materials and utility costs.

What's worse, in spite of Corbion's announcement in the press of their intention to increase sales prices, nothing really happened because of the threats paused by the Chinese attracted by the strength of the Euro[168] and because of the specter of Jungbunzlauer's arrival on the market predicated for the beginning of 2012.

*An organizational change that marks the inception of a new strategy and the need to change mindset.*

In the midst of these market tensions, and after 6 years in the job, Galactic's sales and marketing director (RPEE) resigned and went to work for one of Galactic's major customers. It offered the occasion for the management to step back and reflect about the recent evolution of the company's market environment and the changes eventually needed to best tackle new challenges. Among these, the main concern was the commoditization of lactic acid and some straight lactates (such as sodium and potassium lactates) triggered by, on the one hand, an intensification of competition pulling down prices, and on the other hand, by the emergence of some big scale applications requiring high quality products at low prices hence pulling those even further down (i.e. PLA). Because of its structure and size, Galactic was not in a position to become a low cost champion. The company's management then decided to reorient its strategy to focus on growing its portfolio of specialty products. However, selling specialties is very different from selling commodities as it requires a deeper understanding of markets and applications, a much more technical approach to customers, and much longer sales cycles. The company's prime interlocutors among customers would therefore no longer be purchasers but more R&D people (for new products with new properties for new applications, in short new "unique selling propositions" [169]), marketing people (for new marketing claims or "clean labelling"[170] alternatives) or even people in charge of regulatory affairs (in case of new regulations).

[166] In Belgium, wages and salaries are automatically adjusted according to an index which reflects the evolution of a basket of goods and services. When prices increase, the index follows the increase. When the index exceeds a certain threshold, social benefits and civil servants' salaries are adjusted 2% in stride. In the private sector, the moment when wages are indexed is negotiated and defined by collective agreements.

[167] In Belgium, the collective labor agreements ("Conventions Collectives de Travail", CCT) are agreements between one or more workers 'organizations and one or more employers or one or more employers' organizations. These agreements cover individual and collective relations between employers and workers in companies or an industry.

[168] The USD was still traded close to 1.50 against the EUR in January 2011.

[169] The Unique Selling Proposition or Unique Selling Point (USP) "contains the one feature of the product that most stands out as different from the competition, and is usually a feature that conveys unique benefits to the consumer." (Blythe, 2005, p.250).

[170] "Clean label" has become a buzzword in the food industry but there is actually no clear official definition yet. There is some confusion over what a clean label is and what it means for businesses and consumers. In effect,

Beyond the need for a profound organizational change, a change of mindset was needed at all levels in the company. To support this transition, the company decided to merge its corporate R&D and European sales/marketing departments, both in management terms (same leadership) and in organizational terms (same building infrastructure). The intention was to reduce the distance between the company scientists and the market and hence improve the time-to-market for its new developments.

In fact, it happened that Galactic had already decided to invest in a new building to shelter its R&D activities on its manufacturing site in Escanaffles when it had been made aware of the discontinuation of a research institute in Brussels. It was actually a business incubator funded by the regional government to help start-up companies and spinoffs active in biotechnology to develop in their early-stages by providing access to fully-equipped laboratory infrastructures and services. But, after only a couple of years of activity and despite the presence of a few companies already taking advantage of those, decision was taken at a political level to close the center and convert the place into offices. Galactic saw an opportunity there to save time over the building of new R&D infrastructures in Escanaffles but, more importantly, to lodge its R&D teams and its sales and marketing teams under the same roof. Galactic reached an agreement with the organism managing the assets of the regional government and, by the end of 2011, completed the acquisition of the center that was renamed "Galactic Innovation Campus"[171].

As for the management, it was decided that JCBO would take the lead of the newly created entity combining scientists, marketers and sales people in order to unfold the company's new strategy at a regional and later global level. In the wake of this reorganization, the company decided to reinforce its marketing team and to better structure its New Product Development procedures through a stage-gate process[172] that allowed the integration of customers and interactions with the market much earlier in the development cycle.

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clean labelling is essentially the same process as marking a food or item as natural or organic. It means providing security to consumers regarding the friendliness of an item on the label itself. The entities responsible for managing and monitoring food safety in several countries have left an ambiguous air surrounding the common terms "natural" and "organic"; in response the consumer is now taking responsibility to inspect the ingredients labels of their favorite products and decide for themselves whether they trust the item. To assist in this process, companies have taken to making their labels more easily understandable, providing a new level of transparency when referring to the ingredients and processes used in the production of their items. Basically, it comes down to replacing additives by natural ingredients in order to reduce or suppress the number of chemical names and/or E-numbers (in Europe) from the label of common food products.

[171] Galactic humorously renamed the center "GIC", pronounced « geek » with reference to a group of people passionate by one or more specific areas, most often related to science and technology. Interestingly, the dutch word "gek", as the German one "geck", can be translated by "fool" or "crazy". GIC actually stands for "Galactic Innovation Campus" in which "campus" refers to the fact that the company kept the incubation business of the former center, hence adding a new feather in its cap, and the place stayed one where scientists of different disciplines can meet, discuss, exchange and cross-fertilize openly.

[172] A Stage-Gate process is a conceptual and operational road map for moving a new-product project from idea to launch. Stage-Gate divides the effort into distinct stages separated by management decision gates (gatekeeping). Cross-functional teams must successfully complete a prescribed set of related cross-functional

***Environmental context (year 2011):***

***[Society]*** *March: Fukushima Daiichi nuclear disaster. The standstill of the Japanese economy hits B&G Japan and hinders its growth only 2 years after its inception.*

***[Shareholders]*** *Finasucre takes a participating interest in the Holding S.G.D. that owns 20,8% of Naturex*[173]*. In 2013, Finasucre will take over S.G.D. completely. Naturex and Galactic will cooperate on different projects in the following years.*

***[Competition]*** *Thailand's largest chemical producer, PTT Chemical Public Company Limited (PTT Chemical) is investing US$150 million in NatureWorks for 50% of its shares.*

***[Competition]*** *Myriant (US) launches an Initial Public Offer and goes public. Myriant is a R&D company that has developed a proprietary platform (i.e., a genetically modified microorganism) for the production of bio-based chemicals including, among others, D(-) lactic acid and bio-succinic acid. Myriant is an affiliate of PTT Global Chemical.*

***[Competition]*** *CSM is executing a restructuring program to re-position the organization to the changing consumer environment. It announces a plan to reduce its workforce by 330, a move that impacts mainly its bakery business.*

***[Competition]*** *Bofei Biochemical commissions a new plant in 2011 in Chongjing, China, with a yearly capacity of 10 to 15 thousand tons.*

***[Competition]*** *Sanjiang Gude commissioned a new production plant with a yearly capacity of 15 to 20 thousand tons in late 2011. Gude did however stop the production as for a while just after the startup due to production cost issues. It was expected that Gude would restart the production in 2013.*

***[Competition]*** *Indorama Ventures PLC*[174] *and CSM subsidiary Purac are in discussions to set up a Polylactic acid (PLA) manufacturing facility in Thailand, with an initial capacity of 10,000 tons per annum being*

activities in each stage prior to obtaining management approval to proceed to the next stage of product development. The Stage-Gate methodology was initially developed by Robert G. Cooper from McMaster University, Canada (R. G. Cooper, 2008).

[173] Naturex is a French manufacturer of natural specialty ingredients (mainly plant extracts) for the Food & Beverage, Nutrition & Health and Personal Care. The company employs 1700 people and posted revenues of €253.9 million and €397.8 million, respectively in 2011 and 2015. It is listed on the Paris Stock Exchange since 1996.

[174] With US$6.8 billion in revenues and about 14,000 employees, Indorama Ventures Public Company Limited is one of the world's leading petrochemical producers, the largest PET producer globally, and a leading global manufacturer of wool yarns. Indorama is headquartered in Bangkok, Thailand, and its shares are traded on the Bangkok stock exchange (www.indoramaventures.com).

*raised to 100,000 tons per annum after developing application specific grades*

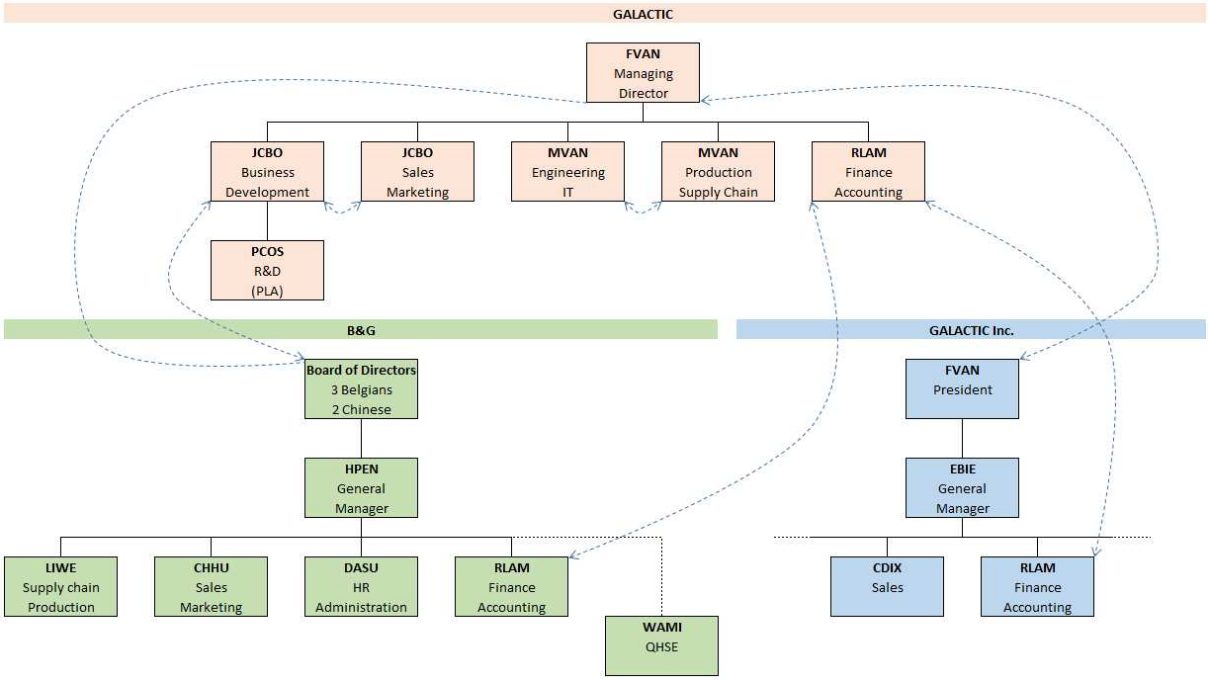
***[Competition]*** *On 9 January 2011, DuPont announces that it had reached agreement to buy Danisco[175] for US$6.3 billion ($5.8 billion in cash and assumption of $500 million of Danisco net debt). The acquisition is motivated by a desire by DuPont "to gain production of food additives and enzymes used in biofuels." On May 16, 2011, DuPont announces that its tender offer for Danisco had been successful and that it would proceed to redeem the remaining shares and delist the company. Danisco is one of Galactic's largest regular customers but it will also become a competitor when Galactic will expand its activities in the field of bacteriocins and other natural preservatives (see further)*

The year 2011 marked the end of our third epoch, the one that we named "Modernitas". A period characterized for the company by a fast growth, many organizational and structural changes, heightened competition and price wars. A period of rapid internationalization by which the company succeeded to set up factories and trading posts on three continents, hence becoming a small group with fully-owned companies and joint-ventures with external partners. A period also of instability and economic turmoil which has seen, among many other environmental changes: a global crisis, crude oil prices multiplied by a factor 5, sugar prices rising by almost 400%, and the Euro gaining more than 60% on the dollar. Finally, a period during which lactic acid had evolved more and more towards a commodity status.

As its structure and size do not allow Galactic to become a low cost champion, coping easily with raw materials volatility and defeating the competition directly, the company needed to respond and adapt quickly to the new environmental situation. It was time for Galactic to inflect its market strategy, focus on specialties and turn attention to its customers.

By this time, the management structure had evolved as follows:

[175] Danisco A/S is a Danish bio-based company with activities in food production, enzymes and other bio-products as well as a wide variety of pharmaceutical grade excipients. It was formed in 1989 from the largest Danish industrial merger ever of Danish Sugar and Dansk Handels- og Industri Company (Danisco A/S). Danisco was one of the world's leading producers of ingredients for food and other consumer products and was also one of the biggest sugar producers in Europe until the divestment of its sugar division to Nordzucker in 2009. Headquartered in Copenhagen, the group has approximately 6,800 employees in more than 80 locations in 40 countries and revenues of about DKK 13.7 billion (2010). Danisco shares were listed on the Copenhagen Stock Exchange and a member of the blue chip OMX Copenhagen 20 index until June 2011, when DuPont completed a US$6.3 billion acquisition of the company (www.danisco.com).




*<u>Figure 4.12:</u> Organizational chart of the main entities' top management at the end of 2011*
*(The structure of Galactic Inc is truncated and the other entities such as B&G Japan, B&G Import & Export and Futerro are not shown to preserve readability)*

## 2012

*A gloomy macroeconomic context…*

In 2012, there was a relative consensus among experts and analysts of all sorts to forecast a gloomy macroeconomic context with a moderate recession in Western Europe (-0.2% of GDP growth, no growth of enterprises' investments and industrial production, a very limited growth of household consumption, and an increase of unemployment). The situation was supposed to be slightly better in North America (+0.4% of GDP growth), which led to hope for the Euro to relax against the dollar.

*…but growth driven by emerging economies…*

All attentions were then on emerging markets: Asia (+6.5% without Japan), Latin America (+3.5%), and Eastern Europe (+3.4%).

*…and Galactic opens an office in Brazil.*

Galactic was already well set in Asia which B&G China and B&G Japan, and Western Europe was to be served from Belgium. The company therefore decided to put a foot on the South American continent where it was selling already substantial quantities through distributors since several years. It opened a sales office in Curitiba, Brazil. Galactic Bioquimicos Ltda was born and the group structure became as shown below.

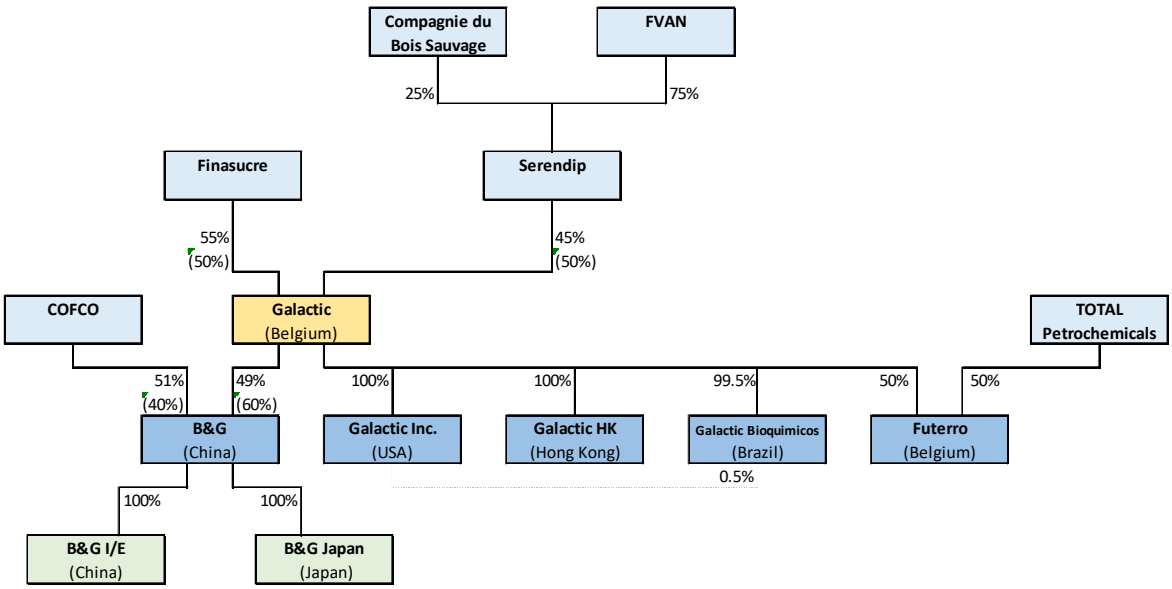



*Figure 4.13: Group structure in 2012*
*(% of control in brackets)*

*Strategy: from design to implementation.*

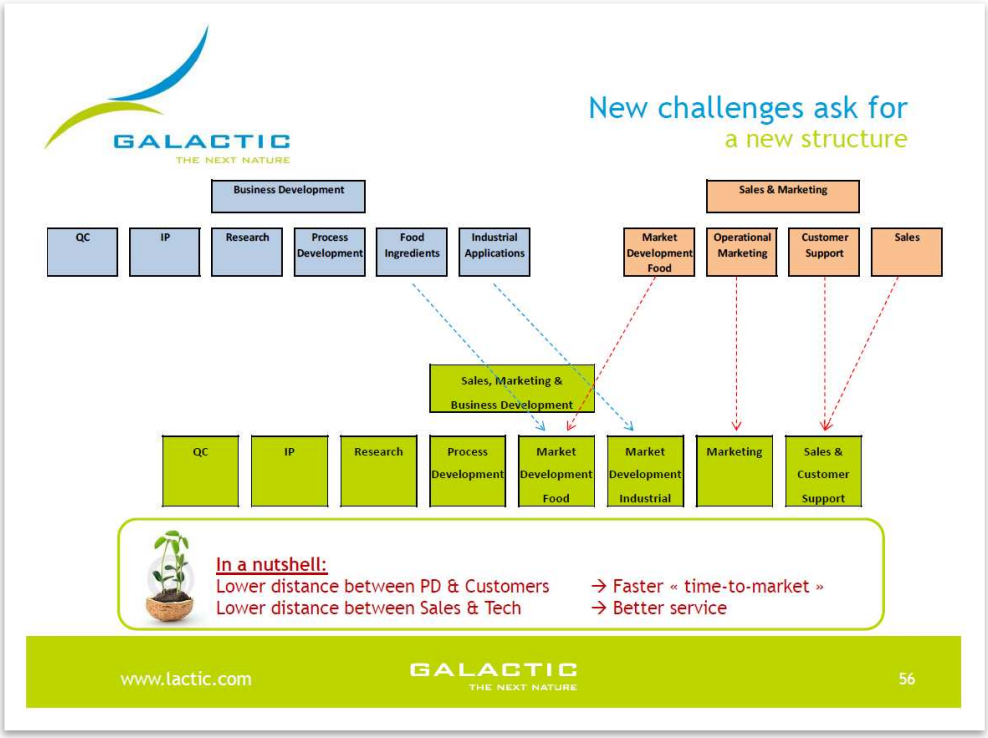
As said, Galactic had decided at the end of 2011 to reorient its overall strategy to react to the slow but relentless commoditization of its flagship products and turn the company from being a "me-too" commodity seller essentially to the food industry to being a reliable innovative solution provider in food, feed and industrial segments.

The figure below shows a slide used to present the management intention to the company's distributors at a Europe-wide seminar held in the city of Ghent early 2013.


*Figure 4.14: The intention of the management when enacting the 2012 strategic revolution at Galactic*
*(slide presented at a seminar bringing together all the company's European distributors in March 2013)*

To achieve that, the company had resolved to put the sales, marketing and R&D departments under the same leadership (see the next figure) and an ambitious program called "Competing for Growth: a new shape for a sustainable future" was designed around three pillars:

- Exploiting the company's core competencies in product & process development
- Enhancing the company's market & application knowledge through market-driven initiatives through partnering with customers
- Improving the company's image & notoriety (through increased market presence & enhanced communication)



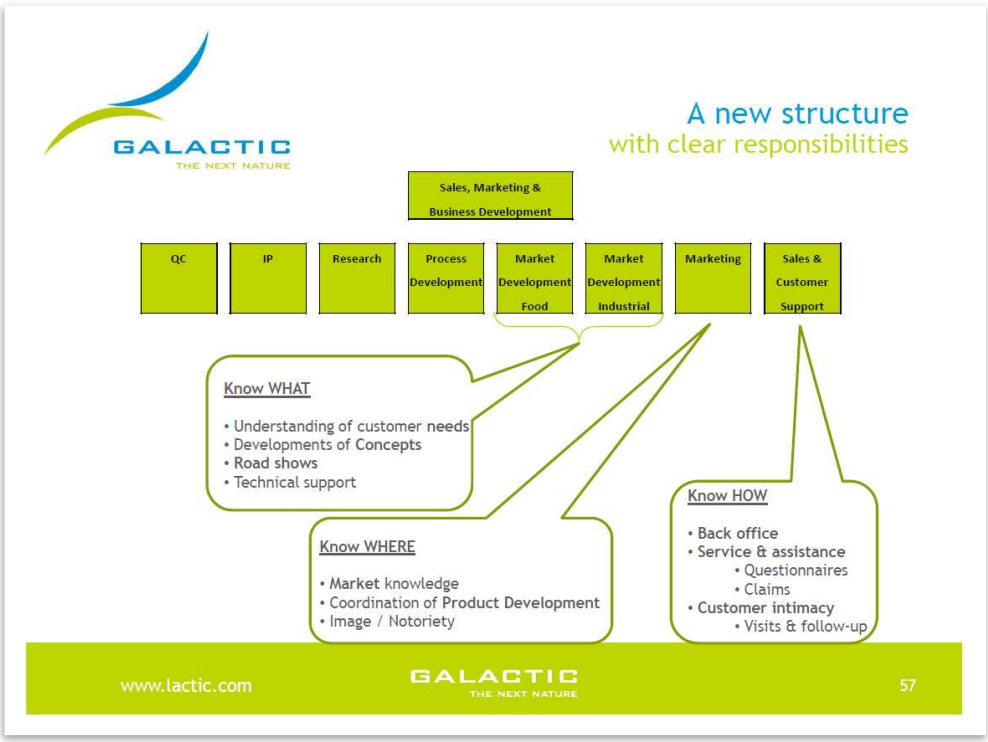




*Figure 4.15: Merging Sales, Marketing and Business Development*[176] *departments as the basis of the new strategy*

*(slide presented at a seminar bringing together all the company's European distributors in March 2013)*

In concrete terms, the first action was to improve what the company called customer reach, i.e. targeting and satisfying customers' needs, by focusing on key-segments and

[176] « Business Development » responsibilities cover Research & Development (processes, products and applications), Intellectual Property, Quality Control, and the evaluation of new development projects.

prioritizing markets. Hence, it was decided to increase the sales force, to split them in two teams, i.e. food and non-food, to increase technical resources, and to align those on the sales teams in two teams as well. At the same time, a priority was to restructure the distribution network, not only following a geographical segmentation as it was the case formerly, but by selecting specialists of each market segment instead of generalists "one-stop-shop" type of distributor.

A second action was to enhance operational agility by accelerating the speed of response and promoting collaboration. For the former, the speed of response, a point of attention was brought to better anticipate and plan the sales *ex-ante* (before orders are coming in) so that a better execution *ex-post* by logistic departments would be possible. A system of key-performance indicators (KPI's) was also put in place to raise the team members' awareness towards the main business drivers and success factors. For the latter, promoting collaboration, the management was hoping that the new location at the Galactic Innovation Campus would help breaking the boundaries between the teams (hence improving internal communication) but also that these new facilities would allow to organize product and application demonstrations, trainings of customers and distributors, and co-developments with them. The management restored also a marketing department worthy of the name and reinforced the team.

*Galactic employees get organized.*

At the same time, social elections were organized at Galactic. For the first time in its history the company will have a Work Council [177] representing its workers and employees in front of the management.

*Jungbunzlauer jumps into lactic acid…*

In the same year, Jungbunzlauer, a large privately-owned producer of citric acid, gluconic acid and xanthan gums headquartered in Switzerland, entered the lactic acid market as announced a couple of years before. They started producing in Marckolsheim, France, with an estimated capacity of 10 to 15.000 tons per year. They also claimed to embark on the manufacturing of sodium lactate and potassium lactate.

*…and Galactic reacts together with Purac to protect their intellectual property rights.*

Galactic and Purac strongly believed that Jungbunzlauer was bluntly infringing an important patent they were owning jointly on the purification of lactic acid by distillation. Since once is not the norm, the age-old enemies chose to join forces to protect their rights; they initiated a

[177] A work council is a "shop-floor" organization which functions as local/firm-level complement to national labor negotiations. Work councils exist with different names in a variety of related forms in a number of European countries, including Britain (*Joint Consultative Committee*); Germany and Austria (*Betriebsrat*); Luxembourg (*Comité Mixte*, *Délégation du Personel*); the Netherlands and Flanders in Belgium (*Ondernemingsraad*); France (*Comité d'entreprise*); Wallonia in Belgium (*Conseil d'Entreprise*) and Spain (*Comité de empresa) (https://en.wikipedia.org/wiki/Work_council).*

legal action against Jungbunzlauer in Paris court. The action started on April 11th with a "descriptive seizure" procedure[178] conducted by a bailiff at Jungbunzlauer factory in France to gather evidences of the infringement. Clear indications of the violation of the patent owners' rights were collected and the complainants were confident that they were holding a strong case. However, it is not easy for two foreign companies to win a case against a French company in front of a court in France, especially with very technical arguments when the court is obviously not made of chemists: Galactic and Purac will be dismissed two years later, after a hearing before the court. Purac will appeal the court's decision alone and, after much hesitation, they will finally decide to halt the action. The request of Jungbunzlauer who asked for compensations claiming a damaging and unfounded action will however be rejected.

*Galactic keeps on patenting its innovations anyway…*

Despite the bad experience that shows how difficult it is to defend its intellectual property even when one has a very well-articulated case, Galactic remained very active in its patent activity. It filed for five patents in the same year, including a patent on a new way to genetically engineer some species of lactic acid bacteria, a patent covering applications of Adagio (one of the key-products launched in the market the year before), and patents on new products and new production processes. In addition, Galactic acquired two patents previously held by K&Co on a technology to transform gypsum, a by-product of the lactic acid manufacture, into anhydrous calcium sulfate in the form of β-anhydrite III', a material having superior properties usable in the construction industry. K& Co was a small French company on the verge of bankruptcy.

*…because technology has value!*

End of the year, upon request from Total, Galactic and Futerro entered into a licensing agreement covering the former's technologies for L-lactic acid, D-lactic acid and the recycling of PLA (Loopla®). As a matter of fact, Total was not satisfied with only technology for making the polymer (PLA) but wanted also to secure its ability to produce the monomer (lactic acid) should the need arise. With this agreement, Futerro could either use the technologies referred to by itself, or grant sub-licenses under some restricted conditions. These technologies had been the subject of an in-depth analysis and a detailed due-diligence conducted by Total experts and their value was estimated

[178] The "descriptive seizure", also known as "infringement seizure" (in France: "saisie-contrefaçon", in Belgium: "saisie descriptive"), is a procedure which allows the holder of a patent right to obtain evidence from the premises of an alleged infringer without any prior warning. Although there are some minor procedural differences between the countries, the process is generally the following: after the judge issues a seizure order, an independent expert appointed by the judge, assisted by a bailiff, presents himself to the place where the alleged infringement is committed to collect all possible evidence. A report is drawn up by the expert, which is then provided to the patent owner. The patent owner must then initiate court proceedings against the alleged infringer, in order to be able to use this evidence in court.

by a famous consulting company. For Galactic, it was a clear recognition of the superiority of its technologies over others that Total could easily afford buying but, most of all, the deal entailed a substantial amount of money that would help the company' strategic reorientation. According to the licensing contract and thanks to a preliminary ruling agreement with the tax authorities, the total amount received in cash in 2012 was viewed as the present value of future annual licensing fees which was therefore booked in the balance sheet as deferred revenue and amortized in the next eight years. The sudden improvement of the company's cash position also allowed to bring back its long-term debt-to-equity ratio to a healthier level.

*In Japan, as in any other place, all kind of opportunities are worth taking.*

In Japan also B&G took advantage of an opportunity: the lactic acid production plant of Musashino, B&G Japan's main local competitor, was stopped for months because of Fukushima nuclear disaster the year before. B&G Japan, now well established on the market, took this chance to fill the empty space and increase its market share.

*Following Galactic, B&G adapts its stategy.*

Conversely, the situation in China was further deteriorating. The global demand of lactic acid was declining as a result of the global economic cool down. In the first quarter of 2012 for instance the total exports of lactic acid from China declined by 51% compared to the same period of the previous year and the competition was fierce since all lactic acid producers were trying to maintain their sales volumes. In the same time customers started to refuse price increases in line with the increasing purchasing alternatives due to the sharp increase of production capacities recently installed. In consequence the profitability of lactic acid sales had started to decline from the second half of 2011 and the negative margin trend worsened in 2012. The directors of the B&G board then decided to launch a profit recovery initiative since it was not assumed that the sales of pure lactic acid would recover the former profitability level. They wanted to accelerate the transformation of B&G and reduce its dependency on pure lactic acid sales by installing new production capacities for higher value adding products. Five projects were presented by the management among which three would ultimately be put in motion. These growth initiative projects aimed to contribute with higher margins but at limited sales quantities and the traditional sales would therefore remain the important cash contributor. Nevertheless, the successful implementation of the growth initiative depended largely on a successful marketing and sales approach. B&G management resolved to implement the same product promotion strategy based of customer-centric innovative marketing approach as the one Galactic was executing in Europe to enhance the promotion of new products. B&G started therefore to work on a concept to enhance the sales effectiveness by putting more focus on customer oriented product developments. A project was

under preparation to establish and staff a food application lab at B&G with increased resources in food applications.

***Environmental context (year 2012):***
***[Society]*** *The city of London shelters the Olympic games.*

***[Society]*** *Facebook is going public through an Initial Public Offering.*

***[Regulatory]*** *The EU adopted a reformed "Generalized Scheme of Preferences" (GSP) law on 31 October 2012*[179]*. Thailand, from where Purac imports almost all the lactic acid transformed and sold in EU, is on the list of eligible countries which means that they will have to pay zero duties on all their imports as from the 1st of January 2014.*

***[Competition]*** *Purac posts disappointing results with a negative organic sales growth and a contraction of sales volumes mainly triggered by a decrease in Food segments.*

***[Competition]*** *Purac announces that it has finalized the acquisition of a building in Georgia, USA, which will host a second manufacturing facility for their Biomaterials division*[180]*. With an investment of EUR 15 million, the start-up of the facility is scheduled for early 2014.*

***[Competition]*** *Purac announces that it has acquired the FiberLive™ technology from Vivoxid Ltd., Finland. The acquisition includes the intellectual property of the FiberLive™ technology and its key personnel. FiberLive™ is a unique composite material consisting of glass fibers and polymers, forming the strongest fully resorbable material currently available. This acquisition complements the activities of Purac Biomaterials.*

***[Competition]*** *BASF and Purac, who had been conducting research under a joint development agreement on succinic acid since 2009, now announce establishing a joint venture for the production and sale of bio-based succinic acid. The company will be called Succinity GmbH and will be operational in 2013.*

[179] The EU's "Generalised Scheme of Preferences" (GSP) allows developing countries to pay less or no duties on their exports to the EU. This gives them vital access to EU markets and contributes to their economic growth (Regulation No 978/2012). The GSP is subject to WTO law, in particular to the GATT and the so-called "Enabling Clause" which allows for an exception to the WTO "most-favored nation" principle (i.e. equal treatment should be accorded to all WTO Members). In order to allow ample time for economic operators to adapt smoothly to the new Scheme, it was decided that the reformed preferences would apply as of 1 January 2014.

[180] Purac Biomaterials develops, manufactures and markets resorbable polymers and monomers for medical applications, i.e. human implants and sutures, under the PURASORB® brand name.

***[Competition]*** *CSM, Royal DSM and Delft University of Technology are participating in a joint venture for bioprocess research. The new company Bioprocess Pilot Facility BV (BPF) is based in Delft and aims at scale-up research and education for next generation bioprocesses.*

***[Competition]*** *CSM announces strategic transformation. CSM divests its bakery supplies activities in North America and Europe and uses the proceeds to transform further into a bio-based products company comprising Caravan Ingredients and Purac businesses. This strategic transformation*[181] *entailed a new name for the company: Corbion.*

**2013**

*Galactic might have to go public.*

Since its incorporation Galactic had grown mainly organically by reinvesting every year a large part of its profits. The company had gained a reputation in its field of expertise, reached reasonable market share, set up a global sales network for its products and build a strong portfolio of technologies.

In order to support its growth, improve its market reach and be ready to tackle new market opportunities, especially by acquiring smaller EBIT-positive companies and investing in production capacities in the frame of its collaboration with Total, Galactic will need in the years to come fresh funds to an extent that exceeds its self-financing capability as well as the investment capacity of its current shareholders and its borrowing ability. Galactic started therefore to evaluate the possibility of floating part of its capital on the stock exchange[182] especially for the case it would have to follow Total in a full-blown industrial project for PLA[183]. On the one

[181] In addition to its lactic acid business, CSM was at this point the largest supplier of bakery products worldwide, producing and distributing an extensive range of bakery ingredients and products. Ingredients included dough mixes, emulsifiers, taste enhancers and conditioners as well as ingredients for filling cakes and pastries mainly for artisan and industrial bakers. Bakery products included semi-finished and finished products like frozen cakes and part-baked breads supplied to clients in the out of home or in-store segments. CSM was operating in business-to-business markets throughout Europe, North America, South America, and Asia, generating annual sales of € 3.1 billion with a workforce of around 9,700 employees in 28 countries. On the 7th of May 2012, CSM announced its plans to dispose of almost all the North American and European bakery assets and to focus on the remaining ingredients business through its two subsidiaries Purac and Caravan. CSM was actually selling off those same businesses that it had acquired over the last 12 years. CSM had spent over EUR 1 billion on acquisitions in the bakery area since its acquisition of Unilever's European Bakery Supply Business in the year 2000. Combined sales of the assets to-be-disposed amounted to EUR 2.4 billion, of which 55% was generated in the US. This drastic restructuring that resulted in a massive downsizing of the company was triggered by a profound mutation of the bakery industry, i.e. a structural shift from the traditional artisan bakery channel towards the cheaper and more convenient supermarket channel due to the difficult economic situation which reduced spending power of consumers.

[182] A process commonly referred to as Initial Public Offering ("IPO") or Stock Market Launch.

[183] As an indication, the investment estimated for a large scale lactic-to-PLA factory is about € 300 million.

hand, timing was not ideal because the company had not yet fully implemented its strategic turnaround. On the other hand, the performance of the equity market and the IPO climate were deemed supportive [184], especially in technology, health care, biotechnology and materials sectors. Galactic was therefore operating in one of the sectors most favored by investors in the last IPOs and recent IPOs for companies active in market similar to Galactic's had revealed extremely positive[185] which finally convinced the management that the time might be ripe, should the need for big money arise, as the global market was finding itself on firmer footing. This option would be put on hold however as long as Total would not decide to kick off the industrialization of Futerro technology.

*Galactic expands its portfolio of natural solutions through partnerships…*

In the meantime, Galactic continued executing its strategy aiming at moving from commodities to specialties by expanding its product portfolio of natural solutions. Galactic started selling bacteriocins[186] for food preservation with a newly-created product range called Galacins™. The company also started a partnership with THT[187] for the manufacture and sales of starter and protective cultures[188], as well as a partnership with Quality Partner, another spin-off of the University of Liège specialized in

[184] Capital markets had performed well in 2013 both in Europe and in the US and while equity capital volume had been increasing over the last 24 months, volatility had decreased by 63% (Source: Kempen & Co., « View on the Market », September 4, 2013). The global IPO market showed dynamism in 2013 with IPOs outperforming and strong returns in developed markets (Europe and North America).

[185] The IPO of BioAmber, a chemicals company which technology platform combines industrial biotechnology and chemical catalysis to convert renewable feedstocks into chemicals including succinic acid and 1,4-butanediol themselves used for making plastics, food additives and personal care products. The company went public in May 2013. The proceeds of this IPO amounted to $80 million for 43% of the shares, valuing the company $184 million. BioAmber's last audited financial statements before the IPO showed revenues of $2.3 million for a loss of $37.8 million and accumulated loss of $81.8 million (source: IPO prospectus, BioAmber).

[186] Bacteriocins are antimicrobials produced by bacteria that kill or inhibit the growth of other microorganisms. Many lactic acid bacteria (LAB) produce a high diversity of different bacteriocins. Though these bacteriocins are produced by LAB found in numerous fermented and non-fermented foods, nisin and natamycin are currently the only bacteriocins widely used as a food preservative. Nisin is a natural antimicrobial peptide obtained through the controlled fermentation of *Lactococcus lactis*, a bacterium also used as a ferment in many dairy products. It is extensively used to protect a wide range of food products against spoilage bacteria. Natamycin is a natural antifungal product obtained through the fermentation of *Streptomyces natalensis*. It plays the role of food additive to control the growth of yeasts and moulds primarily on the surface of cheese, meat and sausages. (http://www.lactic.com/en-us/products/productrange/galacin™.aspx)

[187] THT was set up in 1991 as one of the first spin-offs of the research carried out at the Walloon Centre of Industrial Biology (CWBI), an industrial biology research institute jointly established by the Bio-industries Unit of Gembloux Agro-Bio Tech and the Microbial Technology Department of the University of Liège.

[188] Starter cultures are preparations of living microorganisms used to facilitate fermentation in the manufacture of a variety of dairy products (butter, cheese, yoghurt, cultured milk) and in some meat products (dried sausages, salamis, chorizo) in order to protect these products against spoilage bacteria and pathogens, stabilize their color and texture, and enhance their flavor profile. Protective cultures are bacteria especially selected and developed for their ability to control the growth of pathogenic and/or spoilage microorganisms in fermented foods.

metagenomics[189]. As if that was not enough, at the initiative of their common shareholder Finasucre, Galactic joined forces with Naturex for the development of different products combining preservation and anti-oxidation properties in order to offer complete freshness solutions to the food industry by prolonging the products' microbiological safety and preserving their organoleptic properties at the same time.

*… and shoot for acquisitions…*

Galactic made an offer to acquire Chemital, a Spanish spice blender offering various functional blends for the meat industry, especially for meat preservation, but the deal will go to a more generous bidder. Galactic also initiated negotiations to take over a small American company that specializes in bio-solvents and mainly distributing ADM's ethyl lactate. The deal will not go through either but the two companies will nevertheless keep close contacts that later will prove very useful.

*…and opens sales offices in Italy and Germany.*

In line with its new strategy to come closer to its markets and customers, two fully-owned trading posts were established in Italy and Germany staffed with locals. Galactic Italia and Galactic Deutschland came to life but not for long since the two offices will be closed a couple of years later. Both attempts were launched too early while the portfolio of specialties was not yet large enough and it revealed difficult to justify and absorb the related overcosts.

*Mixed picture on the sales side for Galactic…*

Sales volumes were generally up 11% and higher than the quantities produced causing a decrease in inventories of finished goods and work in process, hence reducing the working capital requirement and benefiting the cash situation.

The problem lied in selling prices which experienced an average decrease of over 6%. The market entry of a new European competitor (Jungbunzlauer) and a violent defensive reaction of the market leader (Purac) explained this situation. This was confirmed by the fact that the relatively simple products, the commodity products, were impacted by the largest declines, while prices of specialty products that Jungbunzlauer was not producing remained relatively stable or had even, for some, displayed symbolic increases. Still, Purac's extreme reaction seemed disproportionate to the threat Jungbunzlauer presented and Galactic was wondering if the company undergoing restructuring still had a head.

*…which is about to lose an important cash cow…*

By mid of the year, the US company which was supplying a byproduct for the feed industry informed Galactic that,

[189] Metagenomics is an innovative technology that identifies the DNA of all micro-organisms in an ecosystem on the basis of one single analysis. Initially destined to the medical market, this revolutionary technique is now applied to the study of food products. It enables the identification of those microorganisms responsible for the alteration of a product and thus provides an opportunity for professionals in the food industry to anticipate potential issues and possibly prolong the product's shelf life as a result. (http://www.lactic.com/en-us/services/galacticfooddoctor™/metagenomics.aspx)

thanks to process improvements, it would no longer produce the byproduct that Galactic was transforming (according to the deal signed in 2003). This was a major blow for Galactic who would have to pull out of this market in Europe and who suddenly lost a substantial part of its profit. By misfortune, the feed range was precisely the fastest growing one with an increase of about 18% in one year…

*…and another one.*

The amount of royalties paid by the Chinese subsidiary B&G were collapsing (divided by 4 compared to the previous year). Indeed, given the difficult market situation in this region of the world in 2012, B&G shareholders decided to reduce the percentage of royalties to be paid by the subsidiary in order to preserve the company's financial autonomy.

*Some good news from the US though.*

At the same time, B&G Japan was suffering from the depreciation of its currency and Galactic Bioquimicos lost its largest customer in Brazil, a distributor, who considered its presence on the local market as a threat for its business, but Galactic Inc. took profit from a new outlet for its products in the American market (pet food) which allowed a sharp increase in sales doubling its production throughput in less than a year. The US subsidiary needed however to increase its market share by strengthening its presence in the pet food market and by continuing exploration of other value-added markets to ensure diversification.

*Galactic reorients its R&D to prioritize projects with short-term returns...*

On the R&D side, Galactic remained active with, among other projects, the support of a 2-years project with the Meurice Institute, an engineering high school, for the development of a new range of bacteriocins-containing fermentates [190] . The company however resolved to terminate a research program that was deemed not profitable in the short term and to dismiss the two researchers who were assigned to it. Another researcher did not want to follow the move of the department to the freshly incepted Brussels site and was not replaced.

*…and further invests in Futerro.*

Futerro was progressing as expected in developing its PLA process. Its shareholders, Galactic and Total, decided two substantial capital increases in order for the company to acquire new pieces of equipment and finalize its technology. In December, Futerro completed for the first time at industrial level the production of PLA with Galactic lactic acid and its newly-developed technology.

In China, B&G started using partially crystal dextrose from the market instead of liquid dextrose (production intermediate) from COFCO as from September. Surprisingly,

[190] Literally, a fermentate is a product made by fermentation. In practice, in the food industry, fermentates are minimally-processed liquid solutions containing various metabolites such as organic acids, peptides, amino-acids and other natural flavoring substances coming from the fermentation of sugars. In the US, these products are often declared as 'cultured sugar' or 'fermented sugar'. They are used for savory or preservation purposes generally in the frame of clean labelling initiatives.

because of overproduction, the market price of the former was lower than the price requested by COFCO on the basis of the calculation formula considered in the joint-venture contract. Managed as an autonomous profit center, B&G was contractually free to buy on the market should it be in its best interest but, of course, COFCO was not particularly pleased with this decision. In addition to being temporarily cheaper, the use of crystal dextrose allows saving processing costs thanks to a greater purity level.

***Environmental context (year 2013):***

***[Society]*** *Croatia becomes the 28th member of the European Union.*

***[Society]*** *Official launch of the negotiations for a Free Trade Agreement (FTA) between the EU and Thailand in March 2013.*

***[Shareholders]*** *Finasucre takes over the Holding S.G.D. that owns 20,8% of Naturex.*

***[Regulatory]*** *In October, the European Commission receives green light to authorize the use of lactic acid to reduce microbial surface contamination in beef carcasses. This approval follows the positive opinion of the European Food Safety Authority (EFSA) panel. The European Council's decision not to block the use of lactic acid as a decontaminant in beef slaughterhouses will improve hygiene and boost food safety for consumers. Lactic acid is already widely used to reduce microbial surface contamination in the USA.*

***[Regulatory]*** *Thailand has been classified by the World Bank as upper-middle income countries in 2011, 2012 and 2013. Accordingly, EU decides in October to remove Thailand from list of countries benefitting from the "Generalized Scheme of Preferences" (GSP) as from one year after the date of entry into force of this Regulation, i.e. as from the 1st of January 2015 (Regulation No. 1421/2013).*

***[Regulatory]*** *In December 2013, the EU modifies its common organization of the markets in agricultural products, and as part of it, the EU reforms once again its sugar policy. With the intention to let producers respond to market signals, production quota will be abolished on 30 September, 2017 and export subsidies are set at zero. It is expected that this reform will have a significant impact on the EU sugar market and prices in the future.*

***[Competition]*** *F. Rampinelli is outed as CEO of Purac. G. Hoetmer, Corbion CEO, takes the responsibility ad interim until a new CEO is found.*

***[Competition]*** *Purac announces that it has entered into an agreement to acquire BIRD Engineering B.V., a biotech contract research company, specifically in the field of industrial microbiology. BIRD has experience with various micro-organisms, mostly bacteria and yeasts, and has expertise in the field of the development of new strains, and development of fermentation processes.*

***[Competition]*** *Cargill's Animal Nutrition business and Purac announce their collaboration in the development and commercialization of bio-based animal feed solutions. These solutions promote stronger growth and better feed conversion in suboptimal conditions in poultry production while at the same time have the potential to significantly reduce the usage of antibiotics.*

***[Competition]*** *Purac signs a long term supply contract for the delivery of up to 10,000 tons annually of lactide to a customer in Asia. This lactide will be polymerized into high heat PLA. Further to the supply agreement, Purac and its partner have signed a joint development agreement where Purac's know-how in the area of high performance PLA will be combined with the partner's market access and application knowledge to further accelerate the commercialization of PLA.*

***[Competition]*** *Purac and Perstorp*[191]*, a leading specialty chemicals company, announce a research and business development partnership for caprolactone*[192] *lactide co-product, for amongst others coatings and adhesive markets.*

***[Competition]*** *Henan Jindan opens a sales office in partnership with BIC Group*[193]*. The joint venture is based in the Netherlands, with warehousing facilities close to Rotterdam.*

***[Currency]*** The Bhat, the Thai currency, depreciates by 15% against the Euro and 10% against the US dollar in the second

[191] The Perstorp Group is the world leader in several sectors of the specialty chemicals market for a wide variety of industries and applications. Its products are used in the aerospace, marine, coatings, chemicals, plastics, engineering and construction industries. They can also be found in automotive, agricultural feed, food, packaging, textile, paper and electronics applications. Perstorp has approx. 1,500 employees and manufacturing units in Asia, Europe and North America. Sales in 2015 totaled more than 11 billion SEK (€ 1.17 billion). Perstorp Holding AB is controlled by PAI partners. PAI Partners is one of Europe's major private equity companies. Perstorp has issued corporate bonds listed on the Luxembourg Exchange. (https://www.perstorp.com/).

[192] ε-Caprolactone or simply caprolactone is a cyclic ester, a member of the lactone family, produced on a very large scale as a precursor to caprolactam, itself used for the manufacture of Nylon 6, a widely used synthetic polymer.

[193] BIC specializes in trading ingredients, additives and specialties for food & beverage, feed, and personal care sourced in emerging countries, with a special focus on China. BIC is part of CHC Group (http://www.chcbiz.com/about-us/#).

half of the year, making Purac's flagship more competitive. Brazil also witnesses a fall of its currency which loses 23% against the Euro and 15% against the dollar, a situation that further enhances Purac's competitiveness on the international scene to the expense of Galactic which sees the Chinese currency appreciate (5% against the Euro) over the same period.

**2014**

*A former Galactic director enters Corbion's top management.*

The year started for Galactic with a surprise when it was made aware that its former Sales and Marketing director who had left the company in 2011 was appointed Senior Vice-President Food at Corbion, its main competitor.

*"Competition is a sin" (John D. Rockefeller)…*

The newcomer to Corbion's team obviously didn't help in reducing the company's aggressiveness in the marketplace. The hostile behavior of the competition that had strengthened again in 2013 lasted in 2014 especially in lactates and blends. Galactic reacted by promoting new "Low Cost In Use" solutions which, more efficient, allow a lower dosage and hence bring savings to the customers even at higher unit prices. A "win-win" approach. However, to avoid seeing its own volumes impacted negatively, Galactic was primarily targeting the competition's customers as well as those of its customers that were felt at risk. This new "XT" product range was made possible thanks to some of the company's recent researches in fermentation. The advantage did not live long though as Corbion started to promote the same kind of products about six months after Galactic launched them on the marketplace. The market leader started to copy the challenger… a turning point!

This pressure was also beginning to be felt on some specialty products such as calcium lactate whose price fell by about 20% at some specific Asian accounts. Galactic preferred to reduce its production throughput to focus on higher-end markets instead of fueling a downward price trend, and the company had to negotiate temporary lay-offs with the trade unions at the beginning of the year. The unit would come back to a 24/7 run-rate again by early September though.

*… but "Competition is always a good thing. It forces us to do our best." (Nancy Pearcey)*[194]

On the sales side however, things were falling into place slowly. The sales team had been greatly expanded from previous years and the current team was deemed sufficient to revive sales according to the new customer-centric strategy. All sales forces (including our application engineers) were on the road to meet with customers and prospects, discover their needs, offer new solutions, and de-risking investments in new products via upfront commercial commitments and/or partnering. Some of the company's

[194] She went on adding that "a monopoly renders people complacent and satisfied with mediocrity".

latest innovations such as the Adagio range of products, for which new applications were found, began to take off in the market, about three years after their first introduction.

*"Creativity may well be the last legal unfair competitive advantage we can take to run over the competition." (Dave Trott)*

Encouraged by these first fruits of success that confirmed that the path was promising, Galactic kept on innovating and launching new products with a focus this year on new market segments such as personal care and cosmetics. The company started a new production line for ultra-pure lactic acid based on an inventive technology it had patented years before [195] and dedicated to this very demanding sector. These new products, already sold since a couple of years by B&G in Asia, were successfully introduced in Europe at an international exhibition in Hamburg, Germany. The same year, Galactic launched GALATEA® in partnership with Taradon Laboratory[196]. GALATEA®[197] was a cutting-edge concept for the beauty industry based on the synergy between enzymes[198] with anti-ageing properties aiming to protect the body against oxidative stress.

At the same time, the company initiated a 2-years research program with an engineering high school for the development of propionic-based antifungal products for the food industry without forgetting to commit resources in more fundamental research by supporting a PhD thesis at the Catholic University of Louvain which purpose was to isolate and characterize new strains of bacteriocins-producing microorganisms directed specifically against Gram-negative pathogens[199].

*B&G gets into the feed industry with calcium lactate*

In China too, B&G was investing in new manufacturing lines: the company kicked off the production of calcium lactate for the animal feed industry. Galactic was also interested for Europe since it had to pull out of this market a couple of

[195] See year 2008 here above.

[196] Taradon is a small Belgian biotech company renting offices and lab space in the Galactic Innovation Campus.

[197] In Greek mythology, Galatea was the name given by Pygmalion to an ivory statue that he designed with love. In his opinion, Galatea was so perfect and graceful that he asked Aphrodite, the goddess of love and beauty, to bring Galatea to life.

[198] Lactoferrin (and more specifically apo-lactoferrin), lactoperoxidase and superoxide dismutase, aim to slow down the ageing process by impeding the three main causes of oxidative stress; namely free radicals, pro-oxidant oxygen species and metal ions capable of catalyzing oxidation reactions (http://www.lactic.com/Portals/0/Brochure/Galactic_Galatea_EN.pdf). Oxidative stress reflects an imbalance between the systemic manifestation of reactive oxygen species and a biological system's ability to readily detoxify the reactive intermediates or to repair the resulting damage. Disturbances in the normal redox state of cells can cause toxic effects through the production of peroxides and free radicals that damage all components of the cell, including proteins, lipids, and DNA (https://en.wikipedia.org/wiki/Oxidative_stress).

[199] Gram-negative bacteria are a group of bacteria that do not retain the crystal violet stain used in the Gram staining method of bacterial differentiation. They are characterized by their cell membranes, which are composed of a thin peptidoglycan cell wall sandwiched between an inner cytoplasmic cell membrane and a bacterial outer membrane. Gram-negative bacteria are spread worldwide, in virtually all environments that support life. The gram-negative bacteria include the model organism Escherichia coli, as well as several bacteria involved in human disease, such as *Pseudomonas aeruginosa*, *Neisseria gonorrhoeae*, and *Yersinia pestis*.
To the contrary, Gram-positive bacteria are bacteria that give a positive result in the Gram stain test due to the absence of an outer membrane. Six gram-positive genera are typically pathogenic in humans: *Streptococcus*, *Staphylococcus*, *Corynebacterium*, *Listeria*, *Bacillus* and *Clostridium*.

years before because of a lack of raw material, but after having brought a few containers on the continent B&G revealed unable to satisfy European needs and Galactic decided ultimately to stop importing this product, pulling out again from this market he just re-entered a few months before.

*Galactic divests r-PLA*

However, as Galactic continued to diversify into new areas, always with a certain coherence based on the properties and functionalities of the products and solutions it was developing, the polymer recycling business proved too far from his core business. The company therefore decided to sell out the customer base of the PLA recycling activity it had initiated in 2010 and all related tangible assets.

*The sky brightens the horizon…*

Sugar prices were going down continuously since the peak of 2011. At the end of 2014, Galactic secured contracts for substantial volumes at a 35% discount compared to the previous year. In addition, the downward trend of the Euro versus the US dollar enhanced Europe's competitiveness on the international scene, and by that improved the situation of Galactic's Belgian site. This coupled with a gradual appreciation of the Chinese Renminbi and an increase of freight cost from China to Latin America prompted Galactic to shift the sourcing for the East coast of this region from B&G to Galactic Belgium. Several thousand tons of different products and numerous customers were concerned. This change further helped the sales team in Europe to focus on specialties and enrich the product-mix without caring too much about filling the plant with volumes. As a consequence, several commodity customers were left to the competition when Galactic decided to cut off the downward spiraling price trend.

*…even in China…*

Despite the negative impact of the substantial volume shift from China to Belgium and competitive pressure from international competitors due to high raw material cost in China as well as due to exchange rate disadvantages, B&G performed rather well all through the year, especially thanks to strong momentum on the domestic market. The development of the sales of newly launched products was positive and contributed to the profitability of the company, especially after the successful expansion of the capacity to manufacture Ultra-Pure Lactic Acid and the focus to sell additional volumes for Feed Acidifiers and lactic acid in the feed industry in China. The financial position of B&G was solid, stock levels of finished products were low and the free cash-flow was positive which convinced the board of directors to increase the leasing and technology license fees paid to the shareholders. The situation of B&G Japan was tighter however because of currency exchange losses due to the depreciation of the Japanese yen.

*…but new clouds are forming.*

Since the creation of B&G, the city of Bengbu were it was headquartered developed tremendously. The establishment of impressive new road and railway

infrastructures opened up the city, in particular thanks to the high-speed train linking Beijing to Shanghai with a stop in Bengbu. As a consequence, densely populated residential areas were coming closer and closer to the industrial zone where COFCO and B&G had their factories and at the end 2014, B&G was notified of the mandatory relocation of its factory following an expropriation act issued by the Bengbu City Government. Sadly, such a relocation was mandatory and there was no room for negotiation with the government. Discussions with the city government of Bengbu on details about the compensation payments were initiated right away. Of course, such a move cannot be improvised and a multi-year plan was devised in order to limit as much as possible disrupting customers' supplies although no clear time schedule was available yet from the Authorities[200].

***Environmental context (year 2014):***

***[Economy]*** *Latvia officially adopts the euro as its currency and becomes the 18th member of the Eurozone.*

***[Society]*** *In March, Russia formally annexes Crimea after President Vladimir Putin signed a bill finalizing the annexation process. During an emergency meeting, the United Kingdom, the United States, Italy, Germany, France, Japan, and Canada temporarily suspend Russia from the G8. In response to Russia's actions destabilizing the situation in eastern Ukraine, the US imposed economic sanctions against Russia in April and the EU imposed economic sanctions in July, reinforced them in September. EU will further prolong the sanctions again in June and December 2015. Galactic faced some difficulties because of this situation primarily linked to the sharp depreciation of the Russian ruble and the resulting reduction of Russians' purchasing power.*

***[Society]*** *The Intergovernmental Panel on Climate Change (IPCC) releases the final part of its Fifth Assessment Report, warning that the world faces "severe, pervasive and irreversible" damage from global emissions of CO2.*

***[Competition]*** *Corbion announces that both G. Hoetmer and K. Kramer, respectively CEO and CFO, step down and hand over their responsibilities to T. de Ruiter, a former Danisco executive, as CEO and E. van Rhede van der Kloot as CFO. After conducting a comprehensive strategic review of the company and finding that growth and margins were under pressure and that costs were too high, the new CE0 decided*

[200] A first indication was given that the existing factory should have left the ground by end of 2018 but this was not confirmed. It will eventually remain an undisclosed/unclear moving target for years.

*to strengthen the company's core business in ingredients for food and biochemicals ("Biobased Ingredients"), while leveraging its technology to build new business platforms in the biotechnology arena ("Biobased Innovations") through "a differentiated management and capital allocation approach across these two business units"*[201]*. A key element of this updated strategy is to forward integrate in the bioplastics value chain by becoming a PLA producer*[202]*. With a view to improving productivity, the new CEO plans to simplify business processes and optimize manufacturing footprint which will result, amongst other measures, in about 200 job losses, globally across the company.*

***[Competition]** Corbion announces its intension to invest in a 75 thousands tons PLA plant (estimated EUR 60 million capex) in Thailand but this investment will only be enacted if and when they can secure at least one-third of plant capacity in committed PLA volumes from customers.*

***[Regulatory]** The 1st of January, EU's "Generalized Scheme of Preferences" (GSP) decided in 2012 comes into effect. Corbion Purac has no longer to pay duties on its imports from the group's main production site located in Thailand. However, on 22 May 2014, the Royal Thai Armed Forces, led by General Prayut Chan-o-cha, launched a* coup d'état*, the 12th since the country's first coup in 1932, against the caretaker government of Thailand, following six months of political crisis. EU suspends free trade negotiations with Thailand.*

***[Competition]** In June, Corbion factory in Thailand is forced to stop by the Authorities for a period of 30 days because of environmental problems. Galactic doesn't expect a real impact in Europe because of transportation time from Asia and the fact that they have most probably good inventory positions in Spain and The Netherlands to buffer logistics fluctuations, but Asian customers are exposed to delays and risk of product shortage during the summer season.*

**2015**

*Political instability and economic volatility in Latin America…*

The deterioration of the economic and political situation in Brazil impacted negatively the deployment of Galactic

[201] Corbion Annual Report 2014, p.5.

[202] Until then, Corbion Purac had always refrained from going down the value chain up to the polymer itself and had always stopped at the production of lactide, convinced that they could sell lactide as raw material to companies who would invest in polymerization units. It is worth to note that Corbion Purac did not hold the ownership of the polymerization technology that was actually developed together with Sulzer Chemtec (see year 2008 here above).

Bioquimicos. The sharp depreciation of the Brazilian Real[203] were making imports of lactic acid and lactates unaffordable, especially to compete against local producers (Corbion). Galactic Bioquimicos had no other option but to adapt its market approach and move its focus towards freshly developed new products (vinegars and fermentates) to offer alternatives to lactates for food preservation.

Although different, the situation in Venezuela was no better. President Maduro acknowledged that the country was in crisis and obtained the special powers from the chambers to apply priority measures. The local currency, the Bolivar Fuerte, further collapsed against the US dollar[204] which prevented the payment of overdue invoices by Bioquimicos' major customers. More than half a million dollars were at risk.

*…and a short-lived brightening in China.*

In China, the government relaxed again the Export Tax Refund for lactic acid and related products from 9% to 13%. A good news for B&G which will unfortunately not last long as the refund will be back to 9% again as of January 2016.

In the night of August 12, massive explosions resounded in Tianjin. The blast at a warehouse storing toxic chemicals was China's worst industrial accident in recent years. There has been criticism it was located too close to densely populated residential areas. The official casualty report was 173 deaths, 8 missing, and 797 non-fatal injuries. Local governments in China have submitted plans to relocate or upgrade almost 1,000 chemical plants in the wake of these explosions and the city government of Bengbu confirmed the mandatory relocation of COFCO's factories outside the city (about 20 km). Rumors claimed that the move would even have to be completed by the end of 2017. COFCO took the opportunity of the specter of this factory relocation to ask for renegotiating B&G's JV contract. In fact, COFCO has never been fond of the fact that Galactic had the majority

[203] From Galactic Bioquimicos' inception in 2012, the Brazilial Real (BRL) had depreciated by 80% against the Euro (from 2.51 in July 2012 to 4.48 in September 2015). The sharpest fall occurred during the year 2015 (from a low of 2.91 R$/€ in January to a high of 4.48 R$/€ in September), a 50% drop in less than a year!

[204] Since the government of Hugo Chavez established strict currency controls in 2003, there have been a series of five currency devaluations, disrupting the economy (Mander, Benedict, "*Venezuelan devaluation sparks panic*", Financial Times, 10 February 2013). On 8 January 2010, the value was changed by the government from the fixed exchange rate of 2.15 bolivares Fuertes (BsF) to 2.60 BsF for some imports (certain foods and healthcare goods) and 4.30 BsF for other imports like cars, petrochemicals, and electronics ("*Venezuela will slash value of currency, the bolivar*", BBC, 9 January 2010). On 4 January 2011, the fixed exchange rate became 4.30 BsF for 1 US dollar for both sides of the economy. On 13 February 2013 the BsF was devalued to 6.30 BsF/US dollar in an attempt to counter budget deficits ("*Chavez Devaluation Puts Venezuelans to Queue on Price Raise*". Bloomberg, 11 February 2013). What's worth, the black market value of the BsF was significantly lower than the fixed exchange rate, hence stifling domestic consumption and completely paralyzing the economy. In November 2013, it was almost 10 times lower than the official fixed exchange rate of 6.3 BsF per US dollar. In September 2014, the currency black market rate for the BsF reached 100 BsF/$; on 25 February 2015, it went over 200 BsF/$; on 7 May, 2015, it was over 275 BsF/$ and on 22 September, 2015, it was over 730 BsF/$ (https://dolartoday.com/). Venezuela had the highest inflation rate in the world in July 2015 (Pardo, Daniel,"*Living with Venezuela's high inflation*", BBC News, 8 July 2015).

of voting rights at the board of directors while COFCO was actually leading in terms of shareholding position. However, the eagerness showed by the city leaders will be reduced as quickly as it had swollen when they will become aware of the difficulties encountered to finance relocation compensations. The deadline will be lifted and, at the time this dissertation is written, no new timeline has been communicated yet.

*B&G shifts to crystal glucose as feedstock…*

COFCO's operations in Bengbu were suffering because of difficult market conditions and the company decided to stop its production of dextrose, forcing B&G to search for an alternative carbon source. B&G had been using partially crystal glucose bought on the market mixed together with COFCO's liquid dextrose since 2014 when market conditions allowed. B&G had now to shift 100% of its feedstock to crystal glucose which imposed some process adjustment.

*… but B&G remains a good contributor.*

Despite these hurdles and the devaluation of the Japanese yen affecting its Japanese subsidiary, B&G profitability increased and the level of royalties paid to its shareholders, COFCO and Galactic, was raised to double the level of previous year.

*Galactic keeps on improving its internal procedures…*

In Belgium, Galactic continued working on improving its structure and working processes. In May, the company implemented a new Customer Relationship Management system (CRM) which allowed to improve its market prospection activities with the help of clearly defined workflows and better sales follow-up procedures. The system was deployed in Europe and North America. Asia and Latin America will follow later.

*… opens a back office center in Moldova…*

A couple of months later, Galactic opened a back office center in Moldova to relocate some marketing and sales administration activities in partnership with a local service provider.

*… and continues to innovate at a high pace.*

In addition to these organizational streamlining initiatives, the company kept on innovating at a high pace. First, it filed for a patent on the innovative way to conduct the lactic acid fermentation that led to the "XT" range of products launched on the market the year before to resist competition's attempts to lower prices and gain market shares. Second, the company launched new lactic-based and acetic-based natural flavors to respond to the growing need for "clean label" solutions requested by its customers. Third, Galactic launched new natural solvent blends dedicated to the paint and ink industry as well as, fourth, new products for the cosmetics industry. Among these, two are real innovations: a nail polish remover with moisturizing properties and a range of PLA powders with different particle size distributions to be used as substitutes to polyethylene powders in facial scrubs and heavy duty soaps. Fifth, the same year Galactic commissioned a production line for manufacturing new products in powder form (sodium lactate powder and powder blends) which will be

fully used already beginning of 2016. This showed a strong interest on the demand-side for this new range of products but the inability to satisfy this surging demand on time brought frustrations in the market (customers, distributors) and among the sales people which somewhat disrupted the production organization. It will take several month to stabilize the organization and find a steady state again. Market success is sometimes as difficult to manage as failure…

*Galactic finally enters the pharmaceutical industry.*

After almost two years of investments, commissioning and heavy work on implementing production standards new to the company, Galactic finally succeeded in the production of first batches in its brand-new pharmaceutical facility located in its Brussels innovation campus. This unit will allow manufacturing lactated solutions for injectable infusions and peritoneal dialysis fluids. A lengthy product approval process is now awaiting the company but it constitutes a new diversification initiative that will open the access to a still untapped market.

*The company invests in automated drumming equipment…*

In its factory, Galactic announced its intention to invest rather massively in a new fully-automated drumming and bagging line in order to upgrade working conditions (reduction of absenteeism, improvement of ergonomy), to elevate the service level (reduction of customer claims), and to increase performance and flexibility in a context of growing volumes and expanding product range. This decision had as a corollary the dismissal of almost ten workstations which infuriated union's representatives.

*…as well as in World Class Manufacturing…*

At the same time, Galactic started a program of World Class Manufacturing with the help of a specialized consulting company in order to improve its operations. It will be implemented in Belgium in a first step and will be deployed to the other production locations in a later stage.

*…and plans to reorganize the production management.*

After five years at the helm of Galactic operations in the US, EBIE wanted to come back to Belgium and reintegrate its former position as Industrial Director, a move that was decided to take place in 2016.

*ADM pulls out of the market…*

In April 2015 though, a major change in the competition landscape was announced that would first impact the North American market but would soon have ripple effect up to Europe as well: ADM announced that it will stop producing lactic acid and ethyl lactate by year end.

*… creating nice opportunities for Galactic.*

Immediately after, Galactic signed a contract to supply one of the largest former customer of ADM in ethyl lactate in the US. This was a huge opportunity that had to be taken (long term perspective). But, despite the increase of production capacity that was made possible thanks to debottlenecking and limited investments, it will massively disrupt the production of esters in Belgium (short term) before additional production capacity would be added. Again, this situation, very positive for the company's future,

would impart frustrations among its clients and partners and pressure on its staff, both in production and in sales.

*Galactic regains access to US byproduct…*

In the US, Galactic and the US company from which it had sourced byproducts for the feed industry a few years before signed an agreement to resume the purchase of this byproduct. The sourcing of this byproduct was interrupted in 2013 and restarted in 2015 with however a smaller volume than before. This would allow Galactic to re-enter the animal feed market in Europe and promote new applications such as in oil fracking, a fast developing industry in the US.

*Mixed feelings about Futerro.*

In September of the same year, Futerro completed the last tests needed to finalize its PLA technology. This technology is now considered ready for industrialization and believed to be the most efficient in the world. However, oil prices were falling sharlply. They were at about 80 $/bbl at the beginning of the year and went down to 30 $/bbl in December. With plunging oil prices and a reorganization in progress, Total Petrochemicals had to revise its expansion plans and opted out of the joint venture by signing a "Settlement Agreement"[205]. An industrialization of Futerro's PLA process was not seen as a priority anymore as it is generally accepted that PLA can compete against oil-based polymers only when oil is above 80 $/bbl. As a consequence, Futerro's development activities were stopped in November and a significant reduction in value was recorded in Galactic's books for its shares in Futerro to take into account the absence of industrial project in the short term for the PLA. Galactic has nevertheless now the possibility to license out Futerro' state-of-the-art technology and it will not take long before discussions were initiated with interested parties.

*Sugar prices continue to go down.*

The downward trend in oil prices dragged along sugar prices which continued to fall until July 2015, to then initiate a recovery punctuated by major corrections.

Indeed, the decrease in oil prices makes the production of ethanol fuel less attractive, encouraging local sugar producers to sell their sugar instead of transforming it into fuel ethanol. In addition, too high a level of world stocks of sugar (45% of global consumption) and the depreciation of the Brazilian Real which stimulates the exports of one of the main sugar producing countries further weighted on world prices. A difficult situation for Finasucre but a good news for Galactic!

*The end of EU milk quotas open new opportunities to Galactic.*

In March, EU milk quotas regime was coming to an end. First introduced in 1984 at a time when EU production far outstripped demand, the milk quota regime was one of the tools introduced for overcoming these structural surpluses. Successive reforms of the EU's Common Agriculture Policy

[205] This agreement will actually come into effect in April 2016, date at which Galactic will be the sole shareholder of Futerro (source: Finasucre Annual reports 2014/2015 and 2015/2016).

have increased the market-orientation of the sector and, in parallel, provided a range of other, more targeted instruments to help support producers in vulnerable areas, such as mountain areas where the costs of production are higher. The final date to end quotas was first decided in 2003 in order to provide EU producers with more flexibility to respond to growing demand, especially on the world market. It was reconfirmed in 2008 with a range of measures aimed at achieving a "soft landing".

At the very date the quotas were lifted, some of the most efficient milk producing regions started to increase their output. That was especially the case for Ireland which had prepared for this already years in advance (as soon as the final date to end quotas was known) and large additional milk processing factories have been erected which resulted in overproduction of some byproducts such as whey permeate[206].

By September, Galactic had signed a Memorandum Of Understanding with a major dairy producer headquartered in Ireland to evaluate the possibility to produce lactic acid out of one of its dairy byproducts that will be piling up with the sharp increase in milk production expected following the cancellation of EU milk quotas. Future will tell if lactic acid, which name literally means “milk acid” although it has never been commercially produced from milk, will ever see the etymology of its name come true. Yet, a long way to go before it will materialize but a great potential for additional growth for Galactic on the long run.

***Environmental context (year 2015):***

***[Society]*** *A refugee crisis roils Europe.*

***[Society]*** *ISIS terrorists strike on three continents (Paris, France; Suruc, Turkey; San Bernardino, USA).*

***[Society]*** *The world’s climate is changing, in good part because of human activity. Governments around the world have been slow to address the potentially catastrophic threat. The landmark 1992 Kyoto Treaty failed to deliver its promised emissions cuts. The 2009 Copenhagen climate summit produced little. The 147 countries that turned up in Paris in late November 2015 for a new climate-change “COP 21” summit avoided that fate. After two weeks of intense talks, they reached common ground and nearly all countries committed to reduce carbon emissions for the first time. The 31-page document hardly solves the climate-change challenge, however, which is why some climate-change activists criticized it for being too little, too late.*

[206] Whey is the liquid remaining after milk has been curdled and strained. It is a co-product of the manufacture of cheese or casein. Whey Permeate also known as Deproteinized Whey (DPW) is a modified dairy product obtained by the removal of protein from whey.

***[Economy]*** *Beijing sent shock waves through global financial markets in August when it devalued its currency against the dollar. Many investors took the devaluation as a sign that the Chinese economy was slowing down faster than reported and that Beijing was using its currency to try to reignite growth.*

***[Economy]*** *The world is losing interest in China. The recent announcement of Microsoft to close its two factories and transfer to Vietnam could cost 9,000 Chinese jobs. The same thing can be devastating in the years to come as Japan announces moving at least 200 factories from China to the Philippines.*

***[Economy]*** *After seven years of negotiations, the United States and 11 other countries finally reached agreement in October on the Trans-Pacific Partnership (TPP), the largest regional trade deal in history.*

***[Regulatory]*** *The European Union's generalized scheme of preferences (GSP) is withdrawn from over 6,200 Thai products including lactic acid and derivatives. This decision obliges Corbion to pay again 6.5% duties on all their imports from their Thai plant to Europe.*

***[Competition]*** *In March, Archer Daniels Midland (ADM) announces that it will stop its lactic acid production by year end. In April, Corbion announces the acquisition of ADM' sales portfolio in the US. The production assets are not part of the deal.*

***[Competition]*** *In July, Jindan launches an Initial Public Offer to get listed on the small-cap market in Shanghai Stock Exchange. Only institutional investors are invited to participate.*

***[Competition]*** *In September, Corbion Purac and Malladi Specialties Limited (MSL)* [207] *signed an acquisition agreement. No production facilities is included in the transaction. Production remains with Malladi Drugs and Pharmaceuticals Limited (MDPL), also part of the Malladi Group, which will produce derivatives on behalf of Corbion Purac.*

***[Competition]*** *Corbion Purac announces the launch of a new multifunctional meat ingredient portfolio at this year's IFT in Chicago. Verdad® Avanta™ provides advanced food safety*

[207] MSL is a leading manufacturer in India of lactic acid and lactic acid based derivatives such as calcium lactate, sodium lactate and buffered lactic acid and supplies the pharmaceutical, home & personal care, chemical and food industries in India.

*and quality in a wide variety of ready-to-eat (RTE) and raw meat and poultry products.*

***[Competition]*** *A new lactic acid producer named Baisheng Bio starts in China with a product of good quality and very aggressive pricing strategy. Prices drop by 5% in average.*

## *II.5. Conclusion to the narrative*

Our story ends here, in the year 2015, in the middle of an epoch that we named "Contemporalis", a period in which the company had to adapt its overall market strategy to react upon the commoditization of its main products. In addition to visible organizational and structural changes, a deeper change had been necessary: a change of mindset. A real cultural change had to be initiated in order to bring the Customer from the periphery of the company's activity to the very center of it. A Copernican revolution for Galactic. A long process that is not yet finalized at the time this dissertation is written but positive signs are undoubtedly at sight.

Whereas "Modernitas" had been the time for fast geographic expansion with most of the key management people sent abroad, "Contemporalis" had seen most of them being brought back to the headquarter.

The figures 4.16 and 4.17 show how the current group structure and the top management look like in 2015-2016, respectively.

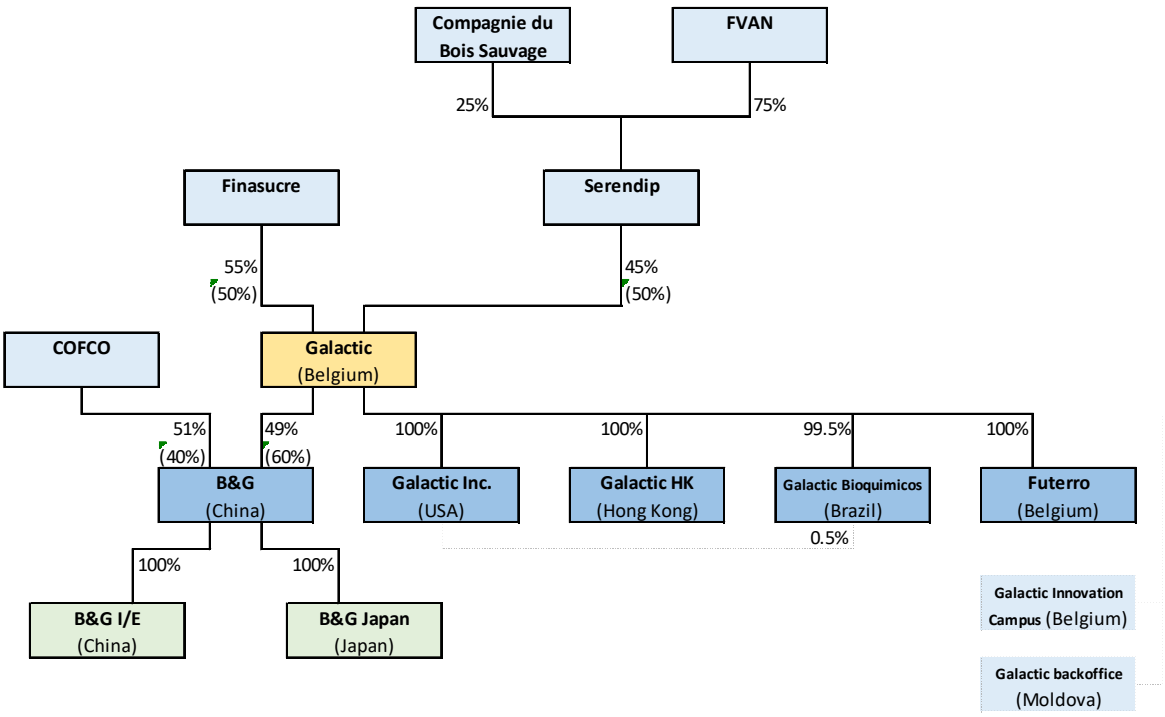
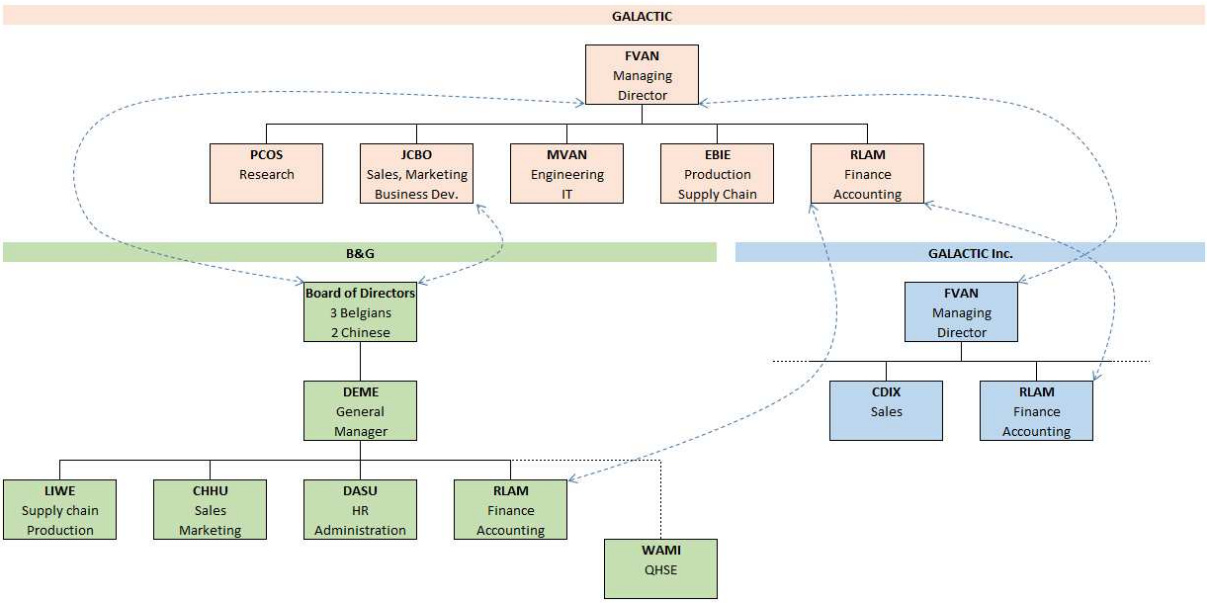



*Figure 4.16: Group structure in 2015-2016*
*(% of control in brackets; the dotted line rectangles are not fully-incorporated companies but other operational locations)*

At this point in time, the company that started 20 years ago with 4 young engineers in the basement of an old pub in Brussels with almost no assets apart from their enthusiasm and candor has become a

small group of companies employing almost 400 people spread over seven locations on three continents, with consolidated sales revenues of more than 80 million Euros, and trusted by about 2000 customers among which the biggest agro-food and chemical companies in the world.




*<u>Figure 4.17:</u> Organizational chart of the main entities' top management in 2015-2016*
*(The structure of Galactic Inc is truncated and the other entities such as B&G Japan, B&G Import & Export, Futerro and Galactic Bioquimicos are not shown to preserve readability)*

# Appendix III

## *Program for the calculation of the largest Lyapunov exponent*

In this appendix, we present the program of the algorithm used in Section 3.2.2. to measure the Lyapunov exponent. This algorithm was designed by Wolf et al. (1985) and slightly modified to improve its lisibility. A very clear explaination of the logical approach followed by this algorithm can be found in Cheng & Van de Ven (1996).

```
Program fet1
integer dim,tau,evolv
dimension x(16384),pt1(12),pt2(12)
character*5 txt5
character*12 txt12

z(i,j)=x(i+(j-1)*tau)

type *, 'DIM,tau,dt,scalmx,scalmn,evolv ?'
! accept*,DIM,tau,dt,scalmx,scalmn,evolv
dim=2
tau=1
dt=1
scalmx=0.0001
scalmn=0.3
evolv=1

open (unit=11,file='output_story.txt')
open (unit=1,file='parameters_input.txt')

do k=1,12
  txt12(k:k)=" "
end do
read (1,'(a12)')txt12
```

```
lgtxt=len(txt12)
do k=1,lgtxt
   if (txt12(k:k).eq.",")txt12(k:k)="."
end do
nval=1
nvla_from=0
do k=1,lgtxt
  if (txt12(k:k).eq." ".and.nval.eq.1) then
    nval=0
    nvla_from=k
  end if
end do
do k=nvla_from+1,12
  txt12(k:k)=" "
end do

continue
read (txt12,'(i5)')dim

do k=1,12
  txt12(k:k)=" "
end do
read (1,'(a12)')txt12
lgtxt=len(txt12)
do k=1,lgtxt
   if (txt12(k:k).eq.",")txt12(k:k)="."
end do
nval=1
nvla_from=0
do k=1,lgtxt
```

```
  if (txt12(k:k).eq." ".and.nval.eq.1) then
    nval=0
    nvla_from=k
  end if
end do
do k=nvla_from+1,12
  txt12(k:k)=" "
end do
read (txt12,'(i5)')tau

do k=1,12
  txt12(k:k)=" "
end do
read (1,'(a12)')txt12
lgtxt=len(txt12)
do k=1,lgtxt
   if (txt12(k:k).eq.",")txt12(k:k)="."
end do
nval=1
nvla_from=0
do k=1,lgtxt
  if (txt12(k:k).eq." ".and.nval.eq.1) then
    nval=0
    nvla_from=k
  end if
end do
do k=nvla_from+1,12
  txt12(k:k)=" "
end do
read (txt12,'(f10.4)')dt
```

```
do k=1,12
  txt12(k:k)=" "
end do
read (1,'(a12)')txt12
lgtxt=len(txt12)
do k=1,lgtxt
   if (txt12(k:k).eq.",")txt12(k:k)="."
end do
nval=1
nvla_from=0
do k=1,lgtxt
  if (txt12(k:k).eq." ".and.nval.eq.1) then
    nval=0
    nvla_from=k
  end if
end do
do k=nvla_from+1,12
  txt12(k:k)=" "
end do
read (txt12,'(f10.4)')scalmx

do k=1,12
  txt12(k:k)=" "
end do
read (1,'(a12)')txt12
lgtxt=len(txt12)
do k=1,lgtxt
   if (txt12(k:k).eq.",")txt12(k:k)="."
end do
```

```
nval=1
nvla_from=0
do k=1,lgtxt
  if (txt12(k:k).eq." ".and.nval.eq.1) then
    nval=0
    nvla_from=k
  end if
end do
do k=nvla_from+1,12
  txt12(k:k)=" "
end do
read (txt12,'(f10.4)')scalmn

do k=1,12
  txt12(k:k)=" "
end do
read (1,'(a12)')txt12
lgtxt=len(txt12)
do k=1,lgtxt
   if (txt12(k:k).eq.",")txt12(k:k)="."
end do
nval=1
nvla_from=0
do k=1,lgtxt
  if (txt12(k:k).eq." ".and.nval.eq.1) then
    nval=0
    nvla_from=k
  end if
end do
do k=nvla_from+1,12
```

```
  txt12(k:k)=" "
end do
read (txt12,'(i5)')evolv

close (1)

ind=1
sum=0.0
its=01

npt=0
i=0

open (unit=1,file='data_input.csv')

109 continue
  i=i+1
  read (1,'(a12)',err=99,end=99)txt12
  lgtxt=len(txt12)
  do k=1,lgtxt
     if (txt12(k:k).eq.",")txt12(k:k)="."
  end do

  read (txt12,'(f10.4)')x(i)

  npt=npt+1
  goto 109
99 continue

  close (1)
```

```
  write (*,*) "npts =",npt

npt=npt -  dim*tau - evolv

di=1.e38

do i=11,npt
   d=0.0
   do j=1,dim
      d=d+(z(ind,j)-z(i,j))**2
   end do
   d=sqrt(d)
   if (d.gt.di.or.d.lt.scalmn) goto 30
   di=d
   ind2=i
30 continue
end do

40 do j=1,dim
  pt1(j)=z(ind+evolv,j)
  pt2(j)=z(ind2+evolv,j)
end do

df=0.0
do j=1,dim
   df=df+(pt1(j)-pt2(j))**2
end do

df=sqrt(df)
```

```
its=its+1
sum=sum+alog(df/di)/((1.0*evolv)*dt*alog(2.))
zlyap=sum/float(its)

do k=1,12
  txt12(k:k)=" "
end do
write (txt12,'(f12.5)')zlyap
lgtxt=len(txt12)
do i=1,lgtxt
  if (txt12(i:i).eq.".")txt12(i:i)=","
end do

write (11,*) txt12

indold=ind2
zmult=1.0
anglmx=0.3
70 thmin=3.14

do i=1,npt
  iii=iabs(i-(ind+evolv))
  if (iii.lt.10) goto 100
  dnew=0.0
  do j=1,dim
     dnew=dnew+(pt1(j)-z(i,j))**2
  end do
  dnew=sqrt(dnew)
```

```
  if (dnew.gt.zmult*scalmx.or.dnew.lt.sclmn) goto 100

  dot=0.0
  do j=1,dim
    dot=dot+(pt1(j)-z(i,j))*(pt1(j)-pt2(j))
  end do

  crh=abs(dot/dnew*df)
  if (cth.gt.1.0)cth=1.0
  th=acos(cth)

  if (th.gt.thmin) goto 100

  thmin=th
  dii=dnw
  ind2=1
100 continue
end do

if (thmin.lt.anglmx)goto 110

zmult=zmult+1.
if(zmult.le.5.) goto 70
zmult=1.0
anglmx=2.*anglmx
if (anglmx.lt.3.14) goto 70
ind2=indold+evolv
dii=df
110 continue
ind=ind+evolv
```

```
if (ind.ge.npt) goto 120
di=dii
goto 40

120 continue

open (unit=1,file='results_output.txt')
write (*,*) "zlyap=",zlyap
write (*,*) "evolv*its=",evolv*its
write (*,*) "di=",di
write (*,*) "df=",df

do k=1,12
  txt12(k:k)=" "
end do
write (txt12,'(f12.5)')zlyap
lgtxt=len(txt12)
do i=1,lgtxt
  if (txt12(i:i).eq.".")txt12(i:i)=","
end do
write (1,*) "zlyap=",txt12

do k=1,12
  txt12(k:k)=" "
end do
write (txt12,'(f12.5)')evolv*its
lgtxt=len(txt12)
do i=1,lgtxt
  if (txt12(i:i).eq.".")txt12(i:i)=","
```

```
end do
write (1,*) "evolv*its=",txt12

do k=1,12
  txt12(k:k)=" "
end do
write (txt12,'(f12.5)')di
lgtxt=len(txt12)
do i=1,lgtxt
  if (txt12(i:i).eq.".")txt12(i:i)=","
end do
write (1,*) "di=",txt12

do k=1,12
  txt12(k:k)=" "
end do
write (txt12,'(f12.5)')df
lgtxt=len(txt12)
do i=1,lgtxt
  if (txt12(i:i).eq.".")txt12(i:i)=","
end do
write (1,*) "df=",txt12
close (1)
close (11)
write (*,*) "END"
read (*,*)

call exit
end
```

# Appendix IV

*Data structure for the isolation of concepts and themes in designing the code-book for Exploration and Exploitation*

**Aspect: EXPLORATION**

| Emiprical studies | Concepts - 1st Order (Gioia et al., 2012) | Themes - 2nd Order (Gioia et al., 2012) |
|---|---|---|
| **Brion, Mothe & Sabatier, 2010** | The firm encourages employees to locate partners to have access to new markets | Alliance to access new markets |
| **Lavie & Rosenkopf, 2006** | The alliance involves a new partner | Alliance with a new partner |
| **Lavie & Rosenkopf, 2006** | The alliance involves a partner pretty different to the previous partners in terms of size (asset value), advertising intensity, financial strength (cash to long-term debt ratio) and industry focus (four-digit SIC code) | |
| **Lin, Yang & Demirkan, 2007** | Exploration index = Total of new alliance partners / Total of all alliance partners | |
| **Cummings, 2013** | Alliances with new partners | |
| **Lubatkin, Simsek, Lin & Veiga, 2006** | The firm looks for creative ways to satisfy its customers' needs | Creative solutions & new ideas |
| **Bierly & Daly, 2007** | The company frequently experiment with radical new ideas (or ways of doing things) | |
| **Bierly & Daly, 2007** | Employees frequently come up with creative ideas that challenge conventional ideas | |
| **Morgan & Berthon, 2008** | The business unit follows other companies' ideas within the same industry | |
| **Morgan & Berthon, 2008** | A "pioneering" strategy is pursued by the business unit | |
| **Voss & Voss, 2012** | Artistic decisions emphasize creating revolutionary new conceptual approaches | |
| **Voss & Voss, 2012** | Artistic decisions emphasize experimenting with radical new works | |
| **Voss & Voss, 2012** | Marketing decisions emphasize challenging ourselves to increase the number of first-time theatergoers | |
| **Patel, Messersmith & Lepak, 2013** | The venture looks for creative ways to satisfy its customers' needs | |
| **Lubatkin, Simsek, Lin & Veiga, 2006** | The firm actively targets new customer groups | Development of new customer groups |
| **Jansen, Van den Bosch & Volberda, 2006** | The unit regularly uses new distribution channels | |
| **Brion, Mothe & Sabatier, 2010** | The firm sells to new customers in new markets | |
| **Voss & Voss, 2012** | Marketing decisions emphasize initiating programs designed to attract new audiences | |
| **Patel, Messersmith & Lepak, 2013** | The venture actively targets new customer groups | |
| **He & Wong, 2004** | An objective for undertaking innovation is to open up new markets | Development of new markets |
| **Sidhu, Volberda & Commandeur, 2004** | Little information is gathered on product preferences of customer groups that we do not currently serve (demand-side information-acquisition scope) | |
| **Sidhu, Volberda & Commandeur, 2004** | We are knowledgeable about all important opportunities in the geographic regions in which we operate (geographic information-acquisition scope) | |
| **Sidhu, Volberda & Commandeur, 2004** | We are well informed about the price and quality aspects of products in neighbouring geographic regions (geographic information-acquisition scope) | |
| **Lubatkin, Simsek, Lin & Veiga, 2006** | The firm aggressively ventures into new market segments | |
| **Jansen, Van den Bosch & Volberda, 2006** | The unit frequently utilizes new opportunities in new markets | |
| **Brion, Mothe & Sabatier, 2008** | The firm sells to new customers in new markets | |
| **Cao, Gedajlovic & Zhang, 2009** | The firm opens up new markets | |
| **Voss & Voss, 2012** | Marketing decisions emphasize seeking out audiences in new markets | |
| **Patel, Messersmith & Lepak, 2013** | The venture aggressively ventures into new market segments | |
| **Gibson & Birkinshaw, 2004** | The management systems encourage people to challenge out-moded traditions/practices/sacred cows | Development of new procedures |

**Aspect: EXPLORATION**

| Emiprical studies | Concepts - 1st Order (Gioia et al., 2012) | Themes - 2nd Order (Gioia et al., 2012) |
|---|---|---|
| He & Wong, 2004 | An objective for undertaking innovation is to introduce new generation of products | Development of new products |
| He & Wong, 2004 | An objective for undertaking innovation is to extend product range | |
| Sidhu, Volberda & Commandeur, 2004 | We know well the product and process innovation efforts of our customers (demand-side information-acquisition scope) | |
| Lubatkin, Simsek, Lin & Veiga, 2006 | The firm creates products or services that are innovative to the firm | |
| Jansen, Van den Bosch & Volberda, 2006 | The unit accepts demands that go beyond existing products and services | |
| Jansen, Van den Bosch & Volberda, 2006 | The unit invents new products and services | |
| Jansen, Van den Bosch & Volberda, 2006 | The unit experiments with new products and services in its local market | |
| Jansen, Van den Bosch & Volberda, 2006 | The unit commercializes products and services that are completely new to the unit | |
| Bierly & Daly, 2007 | Compared to competitors, a high percentage of the company sales come from new products launched with the last 3 years | |
| Morgan & Berthon, 2008 | Product innovation is "offensive" (as opposed to "defensive") | |
| Morgan & Berthon, 2008 | The products offer unique features not available from competitors' offerings | |
| Morgan & Berthon, 2008 | The products are innovative | |
| Brion, Mothe & Sabatier, 2008 | The firm introduces new generation products | |
| Brion, Mothe & Sabatier, 2008 | The firm proposes products which are totally new to the market | |
| Mom, Van den Bosch & Volberda, 2009 | The manager searches for new possibilities with respect to products/services, processes, or markets | |
| Mom, Van den Bosch & Volberda, 2009 | The manager evaluates diverse options with respect to products/services, processes, or markets | |
| Mom, Van den Bosch & Volberda, 2009 | The manager focuses on strong renewal of products/services or processes | |
| Cao, Gedajlovic & Zhang, 2009 | The firm introduces new generations of products | |
| Cao, Gedajlovic & Zhang, 2009 | The firm extends its product range | |
| Brion, Mothe & Sabatier, 2010 | The firm introduces new product generations | |
| Brion, Mothe & Sabatier, 2010 | The firm offer totally new products for the market | |
| Patel, Messersmith & Lepak, 2013 | The venture creates products or services that are innovative to the firm | |
| Ming, 2014 | Number of designs for new form factors that are first introduced in a year | |
| Kyriakopoulos & Moorman, 2004 | During the project, prior thinking was challenged and/or changed with respect to targeting & segmentation, product positioning & differentiation, product distribution, product design, product quality, pricing and promotion | Development of new skills or knowledge |
| Atuahene-Gima, 2005 | The firm learns product development skills and processes (such as product design, prototyping new products, timing of new product introductions, and customizing products for local markets) entirely new to the industry | |
| Atuahene-Gima, 2005 | The firm acquires new managerial and organizational skills that are important for innovation (such as forecasting technological and customer trends, identifying emerging markets and technologies, coordinating and integrating R&D, marketing, manufacturing, and other functions, managing the product development process) | |
| Atuahene-Gima, 2005 | The firm learned new skills in areas such as funding new technology, staffing R&D function, training and development of R&D, and engineering personnel for the first time | |
| Atuahene-Gima, 2005 | The firm strengthens innovation skills in areas where it has no prior experience | |
| Mom, Van den Bosch & Volberda, 2009 | The manager has activities requiring to learn new skills or knowledge | |
| Brion, Mothe & Sabatier, 2010 | The firm encourages employees to adopt new managerial and organizational skills that are important for innovation | |
| Voss & Voss, 2012 | Artistic decisions emphasize challenging traditional artistic boundaries | |

**Aspect: EXPLORATION**

| Emiprical studies | Concepts - 1st Order (Gioia et al., 2012) | Themes - 2nd Order (Gioia et al., 2012) |
|---|---|---|
| He & Wong, 2004 | An objective for undertaking innovation is to enter new technology fields | Development of new technologies |
| Sidhu, Volberda & Commandeur, 2004 | We are well aware of technological and technical developments within our industry (supply-side information-acquisition scope) | |
| Sidhu, Volberda & Commandeur, 2004 | A careful watch is kept on industries that are technologically related to ours (supply-side information-acquisition scope) | |
| Atuahene-Gima, 2005 | The firm acquires manufacturing technologies and skills entirely new to the firm | |
| Lubatkin, Simsek, Lin & Veiga, 2006 | The firm looks for novel technological ideas by thinking "outside the box" | |
| Lubatkin, Simsek, Lin & Veiga, 2006 | The firm bases its success on its ability to explore new technologies | |
| Bierly & Daly, 2007 | The company is usually one of the first companies in its industry to use new, breakthrough technologies | |
| Brion, Mothe & Sabatier, 2008 | The firm enters new technological fields | |
| Cao, Gedajlovic & Zhang, 2009 | The firm enters new technological fields | |
| Brion, Mothe & Sabatier, 2010 | The firm enters new technological fields | |
| Brion, Mothe & Sabatier, 2010 | The firm encourages employees to acquire new technologies and skills | |
| Brion, Mothe & Sabatier, 2010 | The firm encourages employees to find partners that provide access to new technological practices | |
| Patel, Messersmith & Lepak, 2013 | The venture looks for novel technological idea by thinking "outside the box" | |
| Patel, Messersmith & Lepak, 2013 | The venture bases its success on its ability to explore new technologies | |
| Mom, Van den Bosch & Volberda, 2009 | The manager has activities that are not (yet) clearly existing in the company policy | Development of new activities |
| Rothaermel & Deeds, 2004 | Number of alliances that focus on the upstream activities of the value chain (basic research, drug discovery and development) | Exploratory alliance (focus on upstream activities - Ex.: research agreement) |
| Lavie & Rosenkopf, 2006 | The alliance involves a knowledge-generating R&D agreement | |
| Gibson & Birkinshaw, 2004 | The management systems are flexible enough to allow to respond quickly to changes in the markets | Flexibility to changes |
| Gibson & Birkinshaw, 2004 | The management systems evolve rapidly in response to shifts in business priorities | |
| Mom, Van den Bosch & Volberda, 2009 | The manager has activities requiring quite some adaptability | |
| Mom, Van den Bosch & Volberda, 2009 | The manager has activities of which the associated yields or costs are currently unclear | Unknown future - Unknown consequences of actions |

Aspect: **EXPLOITATION**

| | Concepts - 1st Order (Gioia et al., 2012) | Themes - 2nd Order (Gioia et al., 2012) |
|---|---|---|
| **Mom, Van den Bosch & Volberda, 2009** | The manager has activities of which a lot of experience has been accumulated | Building on accumulated experience |
| **Lavie & Rosenkopf, 2006** | The alliance involves an old partner | Alliance with an old partner |
| **Lavie & Rosenkopf, 2006** | The alliance involves a partner very similar to the previous partners in terms of size (asset value), advertising intensity, financial strength (cash to long-term debt ratio) and industry focus (four-digit SIC code) | |
| **Cummings, 2013** | Alliances with repeat partners | |
| **He & Wong, 2004** | An objective for undertaking innovation is to reduce production cost | Reduction of costs or consumptions |
| **Lubatkin, Simsek, Lin & Veiga, 2006** | The firm commits to improve quality and lower cost | |
| **Morgan & Berthon, 2008** | The business unit seeks to reduce costs to the customer through process | |
| **Brion, Mothe & Sabatier, 2008** | The firm reduces production costs and/or consumptions | |
| **Cao, Gedajlovic & Zhang, 2009** | The firm reduces its production costs | |
| **Brion, Mothe & Sabatier, 2010** | The firm reduces production costs or consumption | |
| **Patel, Messersmith & Lepak, 2013** | The venture commits to improve quality and lower cost | |
| **Gibson & Birkinshaw, 2004** | The management systems cause a waste of resources on unproductive activities | |
| **He & Wong, 2004** | An objective for undertaking innovation is to improve yield or reduce material consumption | |
| **Lubatkin, Simsek, Lin & Veiga, 2006** | The firm constantly surveys existing customers' satisfaction | Deeper penetration of existing customer groups |
| **Lubatkin, Simsek, Lin & Veiga, 2006** | The firm penetrate more deeply into its existing customer base | |
| **Jansen, Van den Bosch & Volberda, 2006** | The unit introduces improved, but existing products and services for its local market | |
| **Jansen, Van den Bosch & Volberda, 2006** | The unit expands services for existing clients | |
| **Mom, Van den Bosch & Volberda, 2009** | The manager has activities which serve existing (internal) customers with existing services/products | |
| **Cao, Gedajlovic & Zhang, 2009** | The firm enhances existing markets | |
| **Voss & Voss, 2012** | Marketing decisions emphasize getting single-ticket buyers to attend multiple shows | |
| **Voss & Voss, 2012** | Marketing decisions emphasize encouraging more frequent attendance by the core audience base | |
| **Voss & Voss, 2012** | Marketing decisions emphasize persuading existing ticket buyers to provide greater financial support | |
| **Patel, Messersmith & Lepak, 2013** | The venture constantly surveys existing customers' satifaction | |
| **Patel, Messersmith & Lepak, 2013** | The venture fine-tunes what it offers to keep its current customers satisfied | |
| **Patel, Messersmith & Lepak, 2013** | The venture penetrates more deeply into its existing customer base | |

Aspect: **EXPLOITATION**

| | Concepts - 1st Order (Gioia et al., 2012) | Themes - 2nd Order (Gioia et al., 2012) |
|---|---|---|
| **Jansen, Van den Bosch & Volberda, 2006** | The unit increases economies of scales in existing markets | Economy of scale |
| **Rothaermel & Deeds, 2004** | Number of alliances that focus on the downstream activities of the value chain | Exploitative alliance (focus on downstream activities - Ex.: tolling agreement) |
| **Lavie & Rosenkopf, 2006** | The alliance involves an agreement based on existing knowledge involving joint | |
| **Bierly & Daly, 2007** | A strong emphasis is placed on improving efficiency | Improvement of efficiency |
| **Mom, Van den Bosch & Volberda, 2009** | The manager has activities of which it is clear how to conduct them | Improvement of existing activities |
| **Mom, Van den Bosch & Volberda, 2009** | The manager has activities which he carries out as if it were routine | |
| **Gibson & Birkinshaw, 2004** | The management systems work coherently to support the overall objectives of the | Improvement of existing procedures |
| **Gibson & Birkinshaw, 2004** | People often end up working at cross-purposes because the management systems | |
| **Bierly & Daly, 2007** | The company frequently adjusts its procedures, rules, and policies to make things | |
| **Mom, Van den Bosch & Volberda, 2009** | The manager has activities which clearly fit into existing company policy | |
| **Kyriakopoulos & Moorman, 2004** | During the project, prior skills and procedures improved with respect to targeting & segmentation, product positioning & differentiation, product distribution, product design, product quality, pricing and promotion | Improvement of existing skills or knowledge |
| **Atuahene-Gima, 2005** | The firm upgrades current knowledge and skills for familiar products and | |
| **Atuahene-Gima, 2005** | The firm strengthens its knowledge and skills for projects that improve efficiency of | |
| **Mom, Van den Bosch & Volberda, 2009** | The manager has activities which he can properly conduct by using his present | |
| **Brion, Mothe & Sabatier, 2010** | The firm encourages employees to upgrade current knowledge and skills for familiar | |
| **Brion, Mothe & Sabatier, 2010** | The firm encourages employees to upgrade skills in product processes in which the firm already possesses experience | |
| **Brion, Mothe & Sabatier, 2010** | The firm encourages employees to reinforce the search for solutions that are close to | |
| **Brion, Mothe & Sabatier, 2010** | The firm encourages employees to enhance skills that improve productivity of current | |
| **Voss & Voss, 2012** | Artistic decisions emphasize maximizing the contribution of in-house artistic and | |
| **Atuahene-Gima, 2005** | The firm invests in enhancing skills in exploiting mature technologies that improve | Improvement of existing technologies |
| **Bierly & Daly, 2007** | The company excels at refing existing technologies | |
| **Brion, Mothe & Sabatier, 2008** | Ratio of known technologies sourced externally to the total number of technologies. Known technologies are defined as technologies that are being used by the firm for some time. They are not new to the firm or the industry. They are known and familiar. | |

Aspect: **EXPLOITATION**

| | Concepts - 1st Order (Gioia et al., 2012) | Themes - 2nd Order (Gioia et al., 2012) |
|---|---|---|
| **He & Wong, 2004** | An objective for undertaking innovation is to improve production flexibility | Improvement of production processes |
| **Atuahene-Gima, 2005** | The firm upgrades skills in product development processes in which it already possesses significant exeperience | |
| **Lubatkin, Simsek, Lin & Veiga, 2006** | The firm increases the level of automation in its operations | |
| **Morgan & Berthon, 2008** | The business unit seeks to improve processes to reduce costs | |
| **Morgan & Berthon, 2008** | The business unit seeks to improve processes to reduce the time taken for unit production | |
| **Morgan & Berthon, 2008** | The business unit aims to add value to its products and/or services through process improvements | |
| **Brion, Mothe & Sabatier, 2008** | The firm improves the flexibility of production process | |
| **Brion, Mothe & Sabatier, 2010** | The firm makes production processes more flexible | |
| **Patel, Messersmith & Lepak, 2013** | The venture increases the levels of automation in its operations | |
| **He & Wong, 2004** | An objective for undertaking innovation is to improve existing product quality | Improvement of existing products |
| **Lubatkin, Simsek, Lin & Veiga, 2006** | The firm continuously improves the reliability of its products and services | |
| **Lubatkin, Simsek, Lin & Veiga, 2006** | The firm fine-tunes what it offers to keep its current customers satisfied | |
| **Jansen, Van den Bosch & Volberda, 2006** | The unit frequently refines the provision of existing products and services | |
| **Jansen, Van den Bosch & Volberda, 2006** | The unit regularly implement small adaptations to existing products and services | |
| **Jansen, Van den Bosch & Volberda, 2006** | The unit improves its provision's efficiency of products and services | |
| **Morgan & Berthon, 2008** | Product and/or processes are analysed to search for improvements | |
| **Brion, Mothe & Sabatier, 2008** | The firm imroves the quality of its existing products | |
| **Brion, Mothe & Sabatier, 2008** | The firm introduces products that are slightly different | |
| **Cao, Gedajlovic & Zhang, 2009** | The firm improves existing products | |
| **Cao, Gedajlovic & Zhang, 2009** | The firm improves its products' flexibility | |
| **Brion, Mothe & Sabatier, 2010** | The firm enhances existing product quality | |
| **Brion, Mothe & Sabatier, 2010** | The firm introduces slightly different products | |
| **Voss & Voss, 2012** | Artistic decisions emphasize offering shows that stay close to own strengths | |
| **Voss & Voss, 2012** | Artistic decisions emphasize producing shows similar to those that have done well in the past | |
| **Patel, Messersmith & Lepak, 2013** | The venture continuously improves the reliability of its products and services | |
| **Ming, 2014** | Number of designs for existing form factors that are produced in a year | |
| **Atuahene-Gima, 2005** | The firm enhances competencies in searching for solutions to customer problems that | Providing existing solutions to customers |
| **Mom, Van den Bosch & Volberda, 2009** | The manager has activities primarily focused on achieving short-term goals | Short-term goals |

# Appendix V

*Data structure for the isolation of concepts and themes in designing the code-book for Causation and Effectuation*

Aspect: **CAUSATION**

| Reference | 1st Order (Gioia et al., 2012) - Concepts | 2nd Order (Gioia et al., 2012) - Themes |
|---|---|---|
| **Sarasvathy, 2001** | Decision based on expected return | Analysis to provide expected return ("gain more") |
| **Chandler et al., 2011** | Analysis of long run opportunities and selection of what was thought to provide the best returns | |
| **Chandler et al., 2011** | The decision making is largely driven by expected returns | |
| **Chandler et al., 2007** | We analyzed the long-run opportunities and selected what we thought would provide the best returns. | |
| **Chandler et al., 2011** | Implementation of control processes to make sure objectives are met | Deployment of defined business model - Control to reach target |
| **Chandler et al., 2007** | We organized and implemented control processes to make sure we met objectives. | |
| **Chandler et al., 2011** | Design and planning of business strategies | Design of strategy - Planification |
| **Chandler et al., 2011** | Clear and consistent vision for what we want to do and where we want to end up | |
| **Chandler et al., 2011** | Planning of production and marketing efforts | |
| **Chandler et al., 2011** | Development of a strategy to best take advantage of resources and capabilities | |
| **Chandler et al., 2007** | We designed and planned business strategies. | |
| **Sarasvathy, 2001** | Exploiting preexisting knowledge | Exploitation of preexisting knowledge |
| **Sarasvathy, 2001** | Need to choose between means to achieve the given effect | Selection of resources needed |
| **Chandler et al., 2011** | The product that we now provide is quite similar to the original conception | Improvement of existing products |
| **Chandler et al., 2011** | Research and selection of target markets with the help of meaningful competitive analysis | Definition of targets (market surveys) |
| **Chandler et al., 2007** | We researched and selected target markets and did meaningful competitive analysis. | |
| **Sarasvathy, 2001** | Effect is given | |
| **Sarasvathy, 2001** | Focus on the predictable aspects of an uncertain future | Prediction of an uncertain future |
| **Sarasvathy, 2001** | Aims at predicting an uncertain future | |

**Aspect: EFFECTUATION**

| Reference | 1st Order (Gioia et al., 2012) - Concepts | 2nd Order (Gioia et al., 2012) - Themes |
|---|---|---|
| Sarasvathy, 2001 | Decision based on affordable loss or acceptable risk | Assessment of affordable loss / acceptable risk ("lose less") |
| Chandler et al., 2011 | The decision making is largely driven by how much the organization can afford to lose | |
| Chandler et al., 2011 | The management is careful not to risk so much money that the company would be in real trouble financially if things don't work out | |
| Chandler et al., 2007 | We were careful not to commit more resources than we could afford to | |
| Chandler et al., 2007 | We were careful not to risk more money than we were willing to lose with our initial idea. | |
| Chandler et al., 2007 | We were careful not to risk so much money that the company would be in real trouble financially if things didn't work out. | |
| Chandler et al., 2007 | We used agreements with other people and organizations to help deal with changes in our business environment. | Alliance - Partnership |
| Chandler et al., 2007 | Friends, family, and other network contacts provided services that we otherwise would have had to pay for | |
| Chandler et al., 2007 | We were able to use family, friends, and other network contacts to provide low cost resources. | |
| Chandler et al., 2011 | Evaluation of the set of resources and means available, and of the different options | Definition of resources available |
| Chandler et al., 2011 | The organization adapts what it is doing to the available resources | |
| Chandler et al., 2011 | The organization avoids courses of action that restricts its flexibility and adaptability | |
| Chandler et al., 2007 | We adapted what we were doing to the resources we had | |
| Chandler et al., 2007 | We avoided courses of action that restricted our flexibility and | |
| Chandler et al., 2007 | We have focused on taking advantage of our resources and capabilities | |
| Chandler et al., 2007 | Our first consideration when selecting among business options was our knowledge and resources. | |
| Chandler et al., 2007 | Our decision making has been based on the knowledge and resources we | |
| Chandler et al., 2007 | When we started the business we carefully looked at our knowledge and resources before thinking about different alternatives for | |
| Chandler et al., 2007 | When selecting opportunities our decision-making is focused more strongly on what we know how to do well than on external factors. | |
| Sarasvathy, 2001 | Means or tools are given | |

**Aspect: EFFECTUATION**

| Reference | 1st Order (Gioia et al., 2012) - Concepts | 2nd Order (Gioia et al., 2012) - Themes |
|---|---|---|
| Sarasvathy, 2001 | Need to choose between possible effects that can be created with given | Choice of possible targets |
| Chandler et al., 2011 | The organization tried a number of different approaches until it found a business model that worked | |
| Chandler et al., 2011 | It is possible to see from the beginning where we want to end | |
| Sarasvathy, 2001 | Focus on the controllable aspects of an unpredictable future | Control of an unpredictable future |
| Sarasvathy, 2001 | Aims at controlling an unpredictable future | |
| Chandler et al., 2007 | We tried a number of different approaches until we found a business model that worked. | Development of new business models |
| Chandler et al., 2011 | The product that we now provide is substantially different from the original conception | Development of new product |
| Chandler et al., 2011 | Experimentation of different products and business models | |
| Chandler et al., 2007 | We experimented with different products and/or business models. | |
| Chandler et al., 2007 | The product/service that we now provide is substantially different than we first imagined. | |
| Chandler et al., 2011 | Use of substantial number of agreements with customers, suppliers and other organizations and people to reduce the amount of uncertainty | Seeking pre-commitments from customers |
| Chandler et al., 2011 | The organization uses pre-commitments from customers and suppliers as often as possible | |
| Chandler et al., 2007 | We used a substantial number of agreements with customers, suppliers and other organizations and people to reduce the amount of uncertainty. | |
| Chandler et al., 2007 | We used pre-commitments from customers and suppliers as often as | |
| Sarasvathy, 2001 | Exploiting contingencies | Seizing opportunities - Exploiting contingencies |
| Chandler et al., 2011 | We allow the business to evolve as opportunities emerge | |
| Chandler et al., 2011 | The organization is flexible and tries to take advantage of unexpected opportunities as they arise | |
| Chandler et al., 2007 | We allowed the business to evolve as opportunities emerged. | |
| Chandler et al., 2007 | We were flexible and took advantage of opportunities as they arose. | |

# Appendix VI

## *Curriculum Vitae*

| | |
|---|---|
| Familly name: | **BOGAERT** |
| First name: | **Jean-Christophe R.A.** |
| Addresses: | Chaussée de Tournai, 411<br>7812 Ligne (Ath) |
| Phones: | +32.475.53.10.99 (Mobile-Belgium)<br>+32.2.332.25.40 (Work-Belgium) |
| E-mail: | Jcbo@lactic.com |
| Place & date of birth: | Ixelles - May 25th, 1969 |
| Nationality: | Belgian |

## ***Professional experience***

*(2011 – now)*

***Corporate Vice-President – Sales, Marketing & Business Development*** *GALACTIC s.a.* (Belgium)
www.lactic.com, subsidiary of FINASUCRE (staff: 4.000 - 7th largest producer of sugar worldwide) and COMPAGNIE DU BOIS SAUVAGE (investment company listed on NYSE Euronext). GALACTIC - the second largest producer of lactic acid - develops sustainable, innovative, and health-friendly solutions in the field of food safety, nutrition, and green chemistry. With headquarters in Belgium, production facilities in the United States (Milwaukee), China (Bengbu, Hong Kong) and Belgium (Escanaffles), and additional sales offices in Japan (Tokyo) and Brazil (Curitiba), GALACTIC employs almost 400 people and is active in more than 65 countries. GALACTIC is also active in biopolymers through its subsidiary Futerro (www.futerro.com).
Direct report to the CEO.

*(2002 – now)*

***Member of the Board of Directors*** *- Anhui COFCO Biochemical & GALACTIC Lactic Acid Co., Ltd. – "B&G"* (China)
*www.bglactic.com*, joint venture between Anhui COFCO Biochemical and GALACTIC s.a. Production of lactic acid and derivatives by fermentation. Anhui COFCO Biochemical is a subsidiary of COFCO Group, China's largest food processor, manufacturer and trader (Fortune 500 since 1994). Based in China, B&G produces and sells more than 50,000 mT of lactic acid based chemicals, additives and ingredients used in food, feed, cosmetics, pharmaceuticals, and many other industrial sectors. B&G employs 225 people and exports to 46 different countries. B&G has a subsidiary, B&G Import & Export, for trading chemicals and ingredients in and out of China as well as a subsidiary in Tokyo, B&G Japan Ltd, to provide best services to japanese customers.

*(2011 – 2017)*

***Director - Sales, Marketing & Business Development EMEA*** *– GALACTIC s.a.* (Belgium)
The Sales, Marketing & Business Development department is the result of the merger in 2011 of three departments under one leadership for the EMEA region

with the aim to improve operational agility and customer reach, hence reducing the time-to-market for GALACTIC's innovations.

*(2009 – 2011)* ***Business Development Director*** *– GALACTIC s.a. (Belgium)*

With an internal staff of 25 people and several external cooperations, the Business Development department oversees different activities:

- Research & Development (microbiology & bacterial metabolism, purification technologies, chemical synthesis, biodegradable polymers).
- Process Development & Improvement.
- Quality Control & Product Characterization.
- Products & Application Development for food, pharma, cosmetic and industrial sectors (sales support).
- IP, Licensing & Patenting.
- Business Plans & New Projects.

*(2002 - 2009)* ***Managing Director*** *– Anhui BBCA & GALACTIC Lactic Acid Co. Ltd*. (China).

Production & sales of lactic acid and derivatives. Capacity: 50.000 mT/yr. Staff: 225. Set up of the company, plant erection and start up, organization of APAC sales network, global P&L responsibilities (Sales & Marketing, Production & Maintenance, Administration & H.R., Finance & Accounting, Supply Chain).
Break-even reached within two years after plant commissioning, highly profitable since then.
Turnover: ~50 million USD.

***Managing Director*** *– Anhui Bengbu BBCA & GALACTIC Biochemical Import & Export Co. Ltd*. – "B&G Import & Export" (China).

*(1996 – 2002)* ***New Business Development Manager*** *- GALACTIC s.a.* (Belgium)

*(1998 – 2001)* ***Plant Manager*** *– GALACTIC s.a.* (Belgium)

*(1994 – 1996)* ***Project Manager*** *– BRUSSELS BIOTECH s.a*. (Belgium)

Supervision of external researches. Participation to conception and start-up of a lactic acid producing plant for BIOPROCESS TECHNOLOGY s.a. Implementation of the Quality Control department.

*(1991 – 1993)* ***Project Engineer*** *– ADVANCED TECHNICS COMPANY s.a.* (ATC - Belgium).

Bacteria isolation and characterization. Improvement of fermentation processes. Study of purification technologies for organic acids.

*(1990 – 1991)* ***Trainee*** *– U.C.B. BIOPRODUCTS* (Belgium).

Purification of human recombinant apolipoprotein for pharmaceutical use (treatment of aterosclerosis).

Technical expertise for the 'Station d'Essais et d'Analyses' – CERIA, Belgium.
Expert for the European Community (DG XII) – AIR programs.

## *Other assignments*

*(Since 2016)* ***Chairman of the Board*** *– GREEN2CHEM* – Green2Chem provides a low-cost bioreactor technology to produce plant-derived compounds. It develops biotechnology production processes for bioactive plant-derived substances for neutraceutical, cosmetic and pharmaceutical use. www.green2chem.com

*(Since 2014)* ***Non-executive Director*** *– GREEN2CHEM*

*(Since 2010)* ***Non-executive Director*** *– MATERIA NOVA* – Research & Development Centre active in white biotechnology, plastics & composites, surface treatment & interfacial characterization. About 100 scientists. www.materia-nova.com

## *Education*

*(2015 – 2017)* ***Doctorate in Business Administration*** (ongoing)
Business Science Institute - Luxembourg
Université Jean Moulin Lyon 3 – Institut d'Administration des Entreprises (IAE) – IaeLyon School of Management
*Thesis:* 'Organizational ambidexterity for medium-sized firms in a context of growing uncertainty'.
*Key concepts:* organizational ambidexterity, corporate strategy, change management, uncertainty, chaos, exploitation/exploration, causation/effectuation, fragility/antigragility.

*(2015 – 2016)* ***Certificate of Research in Business Administration***
Business Science Institue - Luxembourg
University of Technology Sydney (UTS) – Sydney Business School
Center of Management & Organisation Studies (CMOS)

*(2012 – 2013)* ***Executive Master in Corporate Finance***
Vlerick Business School (Ghent University & Katholieke Universiteit Leuven)
*Score:* 17/20
*In-company project:* 'Alternative sources of capital for GALACTIC: key-elements for an IPO'.
*Key concepts:* book value, DCF, Monte Carlo simulations (Crystal Ball®), real options (decision trees, Black & Scholes), multiples, SOTP, share price & share split.

*(1991 – 1994)* ***Master Degree in Business Engineering*** (Commercial Engineer)
ICHEC Brussels Management School – ISC Saint-Louis
*Rating:* Magna Cum Laude (with great honors).
*Thesis:* 'Rentabilisation d'une entreprise biochimique en Région Bruxelloise : étude des voies de diversification et recommandations stratégiques (le cas de Brussels Biotech s.a.)'.
*Key concepts:* IRR, NPV, SWOT analysis.

*(1987 – 1991)* ***MSc - Engineer in Biochemistry*** (specialized in biotechnology)
Institut des Industries de Fermentation – Institut Meurice Chimie (IIF-IMC)
*Rating:* Summa Cum Laude (with highest honors). Major of the year.
*Awards:* Award of the Meurice Institute. Award of the Belgian Bioindustry Association (BBA).
*Thesis:* 'Cinétique de fermentation : application au cas de la production d'une apolipoprotéine recombinante par *Escherichia Coli* '.
*Key concepts:* optimization of culture parameters (bacterial growth and chemical induction).

Applied Biotechnology course, Prof. K. Ch. A. R. Luyben, Faculté Polytechnique, Université Libre de Bruxelles, Brussels, Belgium (1991 – 1992).
« Management & Motivation », seminar, John De Sloovere, Brussels (May 2002).
« People Management », seminar, Management & Communication, Brussels (June 2003).
« Chinese Accounting and Finance », seminar, CEGOS Shanghai (May 2003).

## *Awards*

Award of the Meurice Institute – Belgium (June 1991).
Award of the Belgian Bioindustry Association - Belgium (June 1991).
Anhui Friendship Award – China (May 2005).
Bengbu Science & Technology Corporation Award - China (June 2006).
State Friendship Award – the highest distinction for a foreigner in P.R. China (September 2006).

## *Languages*

French (mother tongue), English (fluent), Dutch (intermediate), Mandarin Chinese (basic)

## *Publications & communications* (selection of main references)

'Nitrogen and glucose metabolisms of recombinant *Escherichia Coli* on rich medium', poster, Gottlieb Duttweiler Institut, Rüschlikon, Switzerland (October, 1992).
'Recombinant *Escherichia Coli* growth kinetics on rich medium: nitrogen and glucose metabolisms', oral presentation, Forum for Young Searchers, University of Liège, Belgium (July, 1993).
'L'industrie des matières plastiques : problématique et solutions', HEC Saint-Louis, Brussels,Belgium (December, 1993).
'Production and novel applications of natural L(+) lactic acid: food, pharmaceutics and biodegradable polymers', oral presentation, Applied Microbiology Congress, Brussels, Belgium (December, 1995).
'Production and novel applications of natural L(+) lactic acid: food, pharmaceutics and biodegradable polymers', Cerevisiae 22(1), 46-50 (1997).
'Method for purifying lactic acid', Patent WO 98/55442 (1998).
'Method for producing dimeric cyclic esters', Patent WO 99/43669 (1998).
'Polylactic acids (PLA): new polymers for novel applications', oral presentation, Index'99 Congress, Geneva, Switzerland (April 1999).
'Economic overview of current and future PLA developments – from raw materials to end-products', oral presentation, International Symposium on Recent Advances in Ring Opening (Metathesis) Polymerization – RO(M)P'99, Mons, Belgium (April, 1999).
'Poly(lactic acids): a potential solution to plastic waste dilemma', Macromol. Symp. 153, 287 – 303 (2000).
'Lactic acid', in Natural Food Antimicrobial Systems, Ed. A.S. Naidu, California State Polytechnic University, USA, CRC Press ISBN 0-8493-2047-X (2000).
'Method for purifying cyclic esters", Patent WO 01/70721 (2001).
'Sustainable development approach for commodity polymers', oral presentation, ATOFINA seminar, Belgium (June 2003).
'Method for the production of polylactide from a solution of lactic acid or one of the derivatives thereof', Patent WO 20060014975 (2003).
'Method for producing lactic acid by the fermentation of self-sufficient medium containing green cane juice", Patent WO 20100112652 (2008).
'Patron du bout du monde: Jean-Christophe Bogaert (B&G)', interview, Dynamisme 214 (September-October 2008).
'Continuous process for obtaining a lactic ester', Patent WO 20110160480 (2009).
'Solid calcium lactate in substantially spherical form', Patent WO 20110300220 (2009).
'Method of purifying lactic acid by crystallization', Patent WO 20110319660 (2009).
'Lactochemistry: the birth of a new biobased chemistry", oral presentation, San Francisco, USA (2009).
'Chemical recycling of PLA by alcoholysis', Patent WO 20120029228 (2010).
'Chemical recycling of PLA by hydrolysis', Patent WO 20120142958 (2010).
'Lactochemistry: the (re-)birth of a new biobased chemistry", Specialty Chemicals Magazine, 30-32 (May 2010).
'Green Chemistry as a promising way', oral presentation, 8th Congress of the European Chemical Regions Network, Brussels, Belgium (Octobre 2010).

‘From Idea to biobusiness: how to’s and what not’s’, oral presentation, 2nd CINBIOS Forum for Industrial Biotechnology & the Biobased Economy, Mechelen, Belgium (November 2010).
‘Process for producing a lactic ester from a fermentation liquor containing ammonium lactate’, Patent WO 20130274505 (2011).
‘Process for producing and purifying a concentrated lactic salt’, Patent WO 20120203032 (2012).
‘Method for increasing the shelflife of food products’, Patent WO 20140045776 (2012).
‘Key Interview: Opportunities for Lactic Acid Fermentation in Food Safety and Nutrition’, Food Ingredients First (July 2014).
’20 years of bio-based innovations: an example of successful bio-business in the real economy’, oral presentation, 5th CINBIOS Forum for Industrial Biotechnology & the Biobased Economy, Mechelen, Belgium (November 2014).
‘Survie à long terme dans un contexte d’incertitude croissante : L’ambidextrie organisationnelle est-elle la réponse ?, Revue Economique et Sociale (March 2016).