

SUSTAINABLE BUSINESS GROWTH
HOW MAY DECISION-MAKING GUIDE THE TRANSITION JOURNEY?

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Sustainable business growth - how may decision-making guide
the transition journey ?

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Le doyen
Mehdi Farsi

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Abstract

During periods of intense growth, bankruptcy is an imminent threat to the success of companies. Continuous adaptation of internal capacity, processes and operations is a challenging task that not all companies achieve successfully. Many small or medium-sized enterprises (SME) disappear as fast as they grow and managers often feel frustrated about practical recommendations towards growth; this is mainly due to the significant number of decisions that managers have to make on a regular basis when the company grows. Finding a way to reduce the risk of bankruptcy during intense periods of growth is therefore a great need. Sustainable business growth is a company's appropriate pace of growth that increases its economic, social and environmental capital—or at least one of these—without decreasing any capital stock. The objective of this research is to provide solutions to growing firms' managers in order to guide the transition journey of their SMEs towards sustainable business growth.

This research specifically investigates what type of decisions managers have to make during growth, what impact these decisions have on the growth trajectory of the firm and how the risk of bankruptcy can be measured during growth. The thesis is segmented in three research studies— each of them building upon the previous one.

First, the author proposes a classification framework of the main types of decisions to be considered by growing firms; by conducting a case study with several embedded units of analysis, the author zooms into specific decisions and identifies three main patterns (a series of steps that have to be followed by the decision-maker) of decisions and represents them visually.

Second, the author conducts a longitudinal case study in a Swiss family-owned SME wood construction company that has experienced a process of intense growth between 2010 and 2015; in total 492 decisions made during this period have been collected and analysed so as to investigate their impact on the growth trajectory of the company. Results show that growing SMEs can take advantage of their growth to improve their performance by being more efficient, by fully considering social aspects and by integrating stakeholders more comprehensively.

Third, the author builds a multi-method simulation model with the objective to represent a company's operations evolution during growth as well as the decision-making process inherent to business growth. The model combines two major techniques, namely system dynamics (SD) and agent-based (AB) modelling. Calibration allows fitting the model behaviour to reality based on the empirical longitudinal case study data, thus enhancing its validity. Simulation output indicates that only 21,10% of the runs launched allow the company to maintain solvency; growing firms go bankrupt in 79,90% of the cases. Sensitivity analyses help with identifying

that the efficiency of the decision-making process highly influences the risk of bankruptcy; several key performance indicators (KPIs) also influence the growth trajectory such as the credit limit allowed by the bank, the rapidity at which clients pay their invoices and the proportion between temporary and permanent employees applied by the firm. An ideal combination of parameters' values increases the probability to sustainable growth to 69% - compared to only 21% in the initial situation.

Even if it seems as though luck is an important factor to experiencing sustainable growth, specific and tangible advice is provided to SME managers as well as to their financial partners, which can positively affect the growth trajectories of their firms. This thesis confirms that decisions made during growth periods have a strong impact on positively influencing the trajectory of growing SMEs and that this impact can be quantified. It allows measuring the probability of sustainable business growth and gives specific answers on how to increase it.

Keywords: *Business growth management, Decision-making, Sustainability, Agent-based simulation, System-dynamics, Small and medium-sized companies, SMEs, Longitudinal case study, Family business*

Résumé

En période de croissance intense, le risque de faillite, pour beaucoup d'entreprises, peut devenir imminent. Adapter sans cesse l'organisation interne et les processus, les fonctionnements et les opérations, sont des défis que peu d'entreprises sont capables de relever avec succès. De nombreuses petites et moyennes entreprises (PME) disparaissent aussi rapidement qu'elles ont grandi et leurs managers ne savent pas, la plupart du temps, comment agir ou réagir durant ces périodes de transition. Cela est en partie dû aux multiples décisions qui doivent être prises de manière récurrente quand l'entreprise se développe. Trouver un moyen de réduire le risque de faillite pendant les pics de croissance intense serait donc de grande utilité. Une croissance durable se définit par un rythme d'évolution qui permet d'augmenter les capitaux économiques, sociaux et environnementaux de l'entreprise (ou au moins l'un d'entre eux), sans pour autant réduire sa valeur. Le processus de prise de décision joue un rôle important. L'objectif de cette recherche est d'amener des solutions concrètes aux managers durant les phases de transition, afin de conduire les PME vers une croissance durable.

Cette recherche analyse spécifiquement quels types de décisions doivent être prises pendant les phases de croissance, quels impacts ont ces décisions sur la trajectoire des entreprises et comment le risque de faillite peut être mesuré pendant ces phases de développement intense.

La thèse est structurée en trois projets de recherches. Tout d'abord, l'auteure propose une méthode de classification des principales décisions à considérer par les entreprises en croissance. Par le biais d'une étude de cas longitudinale qui comprend plusieurs unités d'analyses imbriquées, l'auteur zoome à l'intérieur de décisions spécifiques. Elle identifie trois séquences (différentes étapes qui doivent être suivies par la personne qui prend la décision) et les représente de manière visuelle.

Dans un second temps, l'auteure conduit une autre étude de cas longitudinale dans une PME familiale suisse, active dans le domaine de la construction en bois, qui a connu une phase de forte croissance entre 2010 et 2015. Les 492 décisions prises durant cette période sont collectées et analysées afin d'identifier leur impact sur la croissance de l'entreprise. Les résultats de cette analyse montrent qu'une PME peut même bénéficier de sa croissance et améliorer sa performance en devenant plus efficace, en considérant davantage les aspects sociaux (le bien-être des employés par exemple) et en intégrant davantage de parties prenantes.

Dans un troisième temps, l'auteure développe un modèle de simulation qui combine plusieurs méthodes, dans le but de représenter la manière dont une entreprise évolue lors de sa croissance. Le processus de prise de décision, inhérent à toute phase de croissance, est également modélisé.

Le modèle associe deux méthodes principales, à savoir la dynamique des systèmes, et la modélisation orientée agents.

A l'issue de la calibration, le modèle est capable de reproduire la réalité observée en entreprise durant l'étude de cas, ce qui augmente sa validité. Les résultats de la simulation indiquent que seules 21,10% des entreprises sont capables de maintenir une croissance durable. 79,90% d'entre elles font faillite. Les analyses de sensibilité permettent d'identifier que l'efficacité du processus de prise de décision a une influence prépondérante sur le risque de faillite. Au même titre, plusieurs indicateurs clés de performance influencent la croissance : la limite de crédit accordée par la banque, la rapidité à laquelle les clients paient les factures et la proportion appliquée par l'entreprise entre le nombre d'employés fixes et le nombre d'employés temporaires. En combinant de manière idéale les valeurs de ces paramètres, la probabilité d'une croissance soutenable passe à 69% (contre seulement 21% dans la situation initiale).

Même s'il semble qu'une part de chance soit inévitable pour assurer une croissance durable, des conseils spécifiques et concrets sont formulés à l'attention des managers de PME et de leurs partenaires financiers. Cette thèse confirme que les décisions prises durant les périodes de croissance impactent de manière considérable la trajectoire des PME et que cet impact peut être quantifié. Cette étude permet de mesurer la probabilité de réaliser une croissance durable et donne des réponses spécifiques à son amélioration.

Mots-clés: *Gestion de la croissance, Prise de décision, Durabilité, Simulation orientée agents, Dynamique des systèmes, Petites et moyennes entreprises, PME, Étude de cas longitudinale, Entreprise familiale*

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1 Introduction

What is one of the major risks for a company? Bankruptcy... What is one of the major causes of business failure? Success... How can this be? Because success means that the performing company will continuously get new customers and will need to constantly adapt its internal processes and operations in order to absorb the growth triggered by success; which is a challenging task and might in many cases lead to failure. Consequently, the concept of business growth both fascinates and frightens managers. Whether they praise it or fear it, all managers know the famous mantra "grow or die"; which means that almost every company has growth on its agenda (Heffes and Sinnett, 2006). Business growth - also called firm growth - was originally defined by Penrose (1959) as the increase in a firm size measured from one period to another. Implementing growth in a sustainable way remains a challenge. By "sustainable" the author refers to the idea of maintaining stable long-term economic, social and environmental performance (Figge et al., 2002). There are numerous examples of companies that rise extremely fast but are not able to align their operations' capacities and then become extinct as fast (Batra, 2017). Therefore, how can one evaluate the risk of bankruptcy of companies during periods of intense growth? In addition, what can growing firms do to increase the probability of achieving sustainable growth?

Due to its importance for companies and for the global economy, the topic of business growth has been handled by many academics coming from different fields, who have been studying it with a broad range of perspectives and approaches for several decades (Davidsson et al., 2010). Elements such as characteristics and capabilities of the growing firm, strategies that lead to growth, challenges encountered during growth periods, models or stages of growth, have all been studied theoretically and empirically over the past decades. Recently however, several researchers have come to the conclusion that a coherent picture set by the extant literature is difficult to obtain (Davidsson et al., 2010). Therefore, the theoretical development has dramatically slowed down (McKelvie and Wiklund, 2010) and present academic findings are full of contradictions (Andersson and Tell, 2009). As an ultimate consequence, managerial recommendations that should be formulated towards practitioners are not conclusive and growing firms managers are often frustrated (Achtenhagen et al., 2010). Achtenhagen et al. (2010) call for some innovative approach on how to study this phenomenon, in order to further contribute to its understanding, e.g. by focusing on its practical aspects or by considering growth as a dynamic process rather than as a dependent or independent variable only.

Besides this first observation, there is one aspect that was mentioned in previous studies as a key issue but was not investigated in depth afterwards: the decision-making process that entrepreneurs have to go through during growth periods. Decisions made during periods of growth are considered as important for three main reasons. First because they partly determine if a firm will grow, plateau or decline at any given time (Hendrickson, 1992), second because the speed with which they must be made puts managers under an intense pressure (Kotter and Sathe, 1978), and third because the number of decisions constantly increases during periods of growth (Donald and Clifford, 1973), therefore requiring a highly effective decision-making process. Even though this aspect of growth seems important and responds to substantial practical needs, it has not been studied in detail in the past. Recently, Brown and Mawson (2013) developed the concept of “trigger points” which play a major role in shaping the growth trajectory of firms as they both can develop firms further or cause severe turbulence. The authors call for research that would help understand the dynamic nature of trigger points as well as the transmission mechanisms by which these events permeate throughout organizations; this suggestion of future research could be handled from the perspective of the decision-making process of growing firms’ managers.

1.1 Research motivation

The purpose of this research is to understand how operations decision-making influences adaptation capability of small and medium-sized enterprises (SMEs) and hence may guide companies towards sustainable growth trajectories. To this end, focus was put on the representation of growth as a dynamic process (as recommended by Davidsson et al. 2010), punctuated by the decisions made by growing firms’ managers. This new approach of representing growth will contribute to theory building. In this thesis, the analysis is solely based on SMEs since they feature specificities in comparison to larger companies in terms of objectives, constraints, growth strategies, and growth trajectories (Armstrong, 2013). Globally, SMEs contribute massively to the employment and economic value creation and may thus be considered as the backbone of both developed and developing economies.

The thesis is organized in three main research studies; each of them building upon the previous one. The first objective is to map the territory of operations decisions during a growth period according to the three performance dimensions of the triple bottom line (economic, social and environmental) while acknowledging their intimate interrelatedness (Dyllick and Hockerts, 2002, Venkatraman and Nayak, 2015). Through a longitudinal case study, the author will investigate different sequences of complex decisions by distilling their inherent patterns. In

doing so, the objective is to evaluate the effects of these decisions on sustainable growth - cf. Widell (2012). Second, the author will observe five consecutive years of intense growth of an SME, while investigating how the company evolves during this transition period so as to identify dynamics inherent to growth that can guide business growth on a sustainable path. Furthermore, all operational decisions that affect the company will be analysed by referring to the framework developed in the first research study. The author's hypothesis is that numerous operations decisions that have to be made during growth periods have substantial repercussion on the overall financial health of the company. Third, based on longitudinal empirical data collected during research study two, a model will be built which represents the company's operations and their expansion during a growth phase. Simulation-based research is particularly suitable to shed new light on this process. By running different analyses through the model, the author will be able to precisely measure the risk of bankruptcy of a growing SME and to identify parameters that highly influence growth trajectories. Depending on how operations capacity is built up, the risk of bankruptcy may become very high; thereby, bankruptcy could be seen as a fatal deviation from a sustainable growth trajectory. The ultimate objective is to depict what parameters should be closely monitored during growth and what would be their ideal values in order to maximise the probability of achieving a sustainable growth.

The conclusions presented in this thesis are drawn from the specific challenges faced by one company in a growth phase; the use of this case study makes this research particularly relevant for businesses in similar situations or within the same local economy. Furthermore, relating these challenges to concepts discussed in literature ensures that the findings can be generalized more broadly through a process of theoretical abstraction, thus increasing the external validity of the results. The collected data will be used at different levels of analysis, for different purposes and will therefore be stretched as much as possible to make the most out of them.

The relevance of this research originates from several elements. First, it will answer the call of several researchers who demand that growth be studied as a process, therefore capturing the complexity and multidimensionality of the concept by not treating it as a dependent or independent variable only. Combining qualitative and quantitative approaches is also considered as useful to improve the general understanding of the concept of growth (Achtenhagen et al., 2010). Moreover, the relationships between antecedents and effects of growth are of the greatest interest (Davidsson et al., 2010). This thesis will extend operations management theory towards a more nuanced picture of operations-related decision-making processes during business growth—exceeding the current operations management focus on strategic decisions relating to capacity (Olhager et al., 2001)—and will contribute to business

growth literature by integrating the concept of sustainability. Second, by means of simulation modelling, the thesis will bring a new perspective on how to observe growth, therefore contributing to the theory development about this phenomenon. The particular approach, which considers decisions as key elements of a growth period, will advance operations management theory in the area of growth management. Third, this subject is particularly relevant in terms of managerial implications as growing firms often feel lost and unsupported during growth periods and lack the knowledge on how to maximize their chances of achieving a sustainable growth. By providing evidence on how to reduce the risk of bankruptcy through an efficient decision-making process, this study will help managers lead their companies to sustainable business growth trajectories.

1.2 Structure of the research

This section briefly presents the structure of the research. The thesis has been achieved with the help of three main research studies – each of them building upon the previous one. As the results of each research study are used to develop the next research study phase, the structure of the thesis is organized accordingly.

First, the literature review (chapter two) provides a global view of the concept of business growth and of the current state of the art of this concept. The chapter clarifies the positioning of this study within the framework of business growth. Second, the developed research framework is presented (chapter three); it formalises the objectives and research questions and directly connects them to the different research studies of the thesis. The following chapters (chapter four, five and six) present in detail the different research studies of the project; each chapter provides the specific methodology and the related outcomes. More specifically, the three main research studies consist of the following:

The first research study is presented in chapter four. This first phase focuses on operations decisions themselves, mapping their territory and analysing a minor amount of them in detail. As a result, three major patterns (sequences of steps followed while making one decision) are identified and enlightened. Moreover, the development of a cubical matrix of classification allows organizing the main types of decisions that managers of growing firms have to make on a regular basis. This first step will contribute to the theoretical conceptualization of the decision-making process that takes place during growth periods. Precise propositions are developed.

The second research study is presented in chapter five. A five-year period of growth is analysed by means of a longitudinal case study; each decision made during this period is investigated in

detail. Three main interesting phenomena about the company's operations performance arise as a result of this second phase, related to efficiency, "sociality" and comprehensiveness. Moreover, cycles of decisions are identified. The whole data collected during the longitudinal case study also serve for the next and last stage of the study.

The third research study (chapter six) presents the multi-method simulation model that is built and based on empirical data with the objective to represent a company's operations' evolution during growth. The development of the model would not have been possible without the understanding that arose from the two first phases of the research. The complete development of the model is presented along with the analyses that are performed once the model is validated and calibrated – it matches therefore reality convincingly. The main results of the research stem from this model analyses.

Afterwards, chapter seven singles out the key contributions derived from the three main research studies of the thesis. The final section (chapter eight) concludes the thesis, provides limitations of the research and potential future axes of development.

Some parts of the research have been published already in conference papers (Schwab et al., 2014, Schwab et al., 2015, Schwab et al., 2016, Schwab et al., 2017b) and academic journals (Schwab et al., 2017a). However, as the complete research follows one main idea, the author has decided to structure the thesis as a complete monography. The published papers are slightly different in terms of content and differ from the presented thesis especially in terms of structure.

2 Literature review

Business growth—also called firm growth—was originally and seminally defined by Penrose (1959) as the increase in a firm’s size from one period to another. Many researchers have studied business growth for the past decades; taking different perspectives, using several methodologies, mixing methods, scholars have generated an important amount of knowledge about business growth. Because of this large quantity of different studies, one might encounter difficulties to set a coherent picture about what has been studied or not until today. The objective of this review is twofold. First, it attempts to highlight the main aspects that are included in the concept of growth and second, it tries to organize the collected literature in a way that points out what could still be studied and would be of interest about the topic of business growth. The objective is not to be exhaustive - as it is considered an impossible task anyway (Achtenhagen et al., 2010) - but rather to understand how this thesis can contribute to the existing knowledge on the business growth concept.

While going through the existing literature, the focus was put on the general contribution of the article under review. For each article presented in this review, the main objective of the paper as well as the applied research methodology was identified. If one article was in-between two categories, it was eventually put in the most representative one of its contribution. Articles considered as not adding sufficient contribution to the subject were left out. The selection of articles was made according to the following process. First, a research was conducted on several research databases (mainly using Web of Science, ProQuest, Business Source Premier and Emerald), selecting journals that are related to operations management, to business management and to entrepreneurship. Journals were selected according to their ranking and on different quality criteria. All the articles having been reviewed by peers and corresponding to the keyword “growth” with the focus on business growth were retained – i.e. all articles related to economic growth, biological growth or mathematical growth were excluded; this was checked by scanning titles and abstracts. Each article was read and the ones not related directly to the topic were removed from the list. After having read all of them, some new related articles found in the references were added to the initial amount of articles. Moreover, additional recent articles identified thanks to e-alerts (with the criteria of “growth”) of these databases were added as well to the final set of articles reviewed. The time range for papers selection was first broad – also papers published decades ago which created the bases of the concept of business growth were retained. During the research, some new rounds of literature identification were regularly made, focusing on very recent papers (published between January 2013 and August 2017).

These papers were integrated progressively in the thesis, by reorienting the research study and reinforcing the discussions.

Reviewed articles have been classified in eight categories from which seven are related to certain aspects of the growth process (strategies related to growth, characteristics of growing firms, capabilities and resources of growing firms, models or stages of growth, pace of growth, challenges encountered during growth, link between growth and performance or profitability). One category (clarification of the subject) stands alone and contains a relatively new stream of research, which tries to clarify what has been studied already and what knowledge has been developed within this important set of growth-related literature. Table 1 presents the eight categories and number of selected papers related to each of them:

Subject	Number	Percentage
Strategies related to growth	19	23%
Characteristics of growing firms	17	21%
Capabilities and resources of growing firms	8	10%
Models or stages of growth	14	17%
Pace of growth	3	4%
Challenges encountered during growth	6	7%
Link between growth and performance or profitability	7	9%
Clarification of the subject	8	10%

Table 1 - Literature fields

2.1 Strategies related to growth

The first category of papers concerns strategies related to growth. Growing strategies have been investigated since the year 1994 until today (2017) – with current research still going on. There are 19 articles that were classified in this category. The majority of articles of this category consider strategy as the independent variable and growth as the objective (Hay and Kamshad, 1994) or as the dependent variable (Titus et al., 2011). In this respect, different strategies are compared such as domestic and international expansion (Kathuria et al., 2008), inward and outward operations (Hernández and Nieto, 2016), the launch of new related and unrelated products; product improvement, retention of clients; and the acquisition of new clients (Barbero Navarro et al., 2012). Other subjects tackled are the outcomes of different innovation types (Azari et al., 2017), the impact of innovative activities on growth for young firms (McKelvie et al., 2017), organic and acquisition growth (Lockett et al., 2011), or strategies for recovery (Schoenberg et al., 2013). Some authors also specify that several strategies should be combined (Von Krogh and Cusumano, 2001, Barbero Navarro et al., 2012). Recently, Achtenhagen et al.

(2017) have identified eight different growth modes that companies might combine over time. Some authors observe the firm behaviour or characteristics that might influence their strategy choice such as: to be a family business (Le Breton-Miller and Miller, 2008), the way they perceive situation and environment (Neill and York, 2012), their size and age (Armstrong, 2013) and their types (adventurists, focused, unfocused and survivors) (Merz et al., 1994) which all lead to different results of their strategy in terms of growth. A few articles consider the performance as the dependent variable related to firm's strategic behaviour (Soininen et al., 2012). The major contribution of these articles is to explain what can set off the growth of a company and which strategies a company might follow if it wishes to grow. For a recent review about strategic aspects contributing to growth, read Demir et al. (2017).

2.2 Characteristics of growing firms

The second category of papers relates to the characteristics of growing firms. 17 articles fall in this category. This subject was of great interest for many years as these articles have been published since the year 1963 until 2017. The literature in this field investigates if firm growth is somehow related to firm's characteristics. These characteristics can be either internal (e.g. firm's size) or external (e.g. industry in which the firm operates). Some authors have observed specific groups of growing firms such as Parker et al. (2010) who studied high-growth firms and identified that the "gazelles" (high-growing firms) which continue to grow rapidly are those which are least likely to sell shares to others, including members of the workforce, directors and venture capitalists. Brüderl and Preisendörfer (2000) tried to identify if new firms were presenting characteristics predisposing them to become fast growing businesses. Cameron et al. (1987) compared growing, stable and declining firms and identified that only growing firms do not present certain dysfunctional attributes. The oldest study of this review used the threshold companies and provided recommendations about what strategies these firms should follow (Donald and Clifford, 1973).

Some articles concentrate on one specific set of characteristics. For example Boardman et al. (1981) have demonstrated that four financial characteristics of growing firms might have a relationship with their incidence of failure. More recently, Solomon et al. (2013) have shown that firms will benefit more or less from the assistance they get while growing depending on their characteristics (such as age, size, etc.). Bhattacharya (2014) also found that size and age of the company have significant positive effects on the growth of both young and old businesses. A study of Delmar and Wiklund (2008) has depicted the positive reinforcement link between the growth motivation of a manager and the growth of the company itself. Braidford

et al. (2017) have scrutinized the owner's innate dispositions and mindsets towards or against business growth. Risk preferences also seem to change as a venture ages and increases in size (Wennberg et al., 2016). Entrepreneurs' behaviours and competencies to achieve ambidexterity (the ability to explore and exploit simultaneously) has also been identified as a characteristic leading to growth success (Volery et al., 2013).

Finally, some studies demonstrate that several characteristics are significant and should be studied together such as industry, strategy and top management (Weinzimmer, 2000) or organizational characteristics and organizational effectiveness (Sadler and Barry, 1967). Yazici et al. (2016) revealed 16 important growth factors inducing growth and observed that one factor on its own cannot influence the growth. Following the same logic, other studies show that even if the growth journey is heterogeneous, growing firms (1) present a similarly homogenous set of organizational capabilities that enable growth (Chan et al., 2006), (2) correspond to clusters that lead to certain growth paths (McMahon, 2001) and (3) reveal different associations between relationships with customers, long-term contracts, organization of production size, and growth of sales and employees in small size manufacturing firms (Valsamakis and Sprague, 2001).

These studies consider again growth as the dependent variable and try to relate it to the firm's characteristics. Many aspects have been studied in order to understand which – set of – characteristics might predict business growth or growth performance. As observed in the review of literature of this stream of research, there is no common understanding of what the main characteristics that forego growth launch are; it is rather the combination of the different characteristics depicted as influencing growth, which help with understanding why business growth takes off.

2.3 Capabilities and resources of growing firms

This category of articles presents a similar approach – what characteristics should a company present in order to grow - but considers more specifically firm's capabilities and resources. The eight articles falling in this category (published between 1997 and 2015) are mainly based on the classic Penrose's theory (1959) which explains that growth is the result of the acquisition and combination of several resources that create and maintain the competitive advantage of the firm. In this respect, authors investigate the interaction between resource-accumulating and organizing processes (Ghoshal et al., 2000), and the benefits coming from the knowledge acquired from internationalization (Naldi and Davidsson, 2013). Network capabilities were

identified as enabling the service offering to exert a positive non-linear effect on sales growth (Kohtamäki et al., 2013) or as a potential solution for supporting managers of growing firms (Fischer and Reuber, 2003). More globally, some authors identified that it is necessary to synchronize and integrate both classic resource-based view and extended resource-based view (bounded and relational resources) to develop a long-run competitive advantage and therefore sustain growth (Lewis et al., 2010). Earlier, Teece et al. (1997) had developed the dynamic capabilities approach in order to stress how combinations of competences and resources could be developed, deployed, and protected thus exploiting existing internal and external firm-specific competences to address changing environments. Quite recently, Chandler et al. (2009) have made a contribution, by using transaction cost economics as a theoretical background. They were able to identify under which conditions – related to the firms' resources and capabilities organization - employment growth is linked to sales growth. Koryak et al. (2015) provide a recent review and synthesis on capabilities and their influence on the growth of SMEs. Except of the latter, and like in the preceding category, these studies focus on specific aspects of the firm. Together with the last category of articles, this category tends to show that, depending on the perspective chosen, growth is definitely specific to the firm's characteristics. This involves that, following that approach, growth cannot be understood as a global concept and therefore related results can only be generalized with difficulty.

2.4 Models or stages of growth

This category takes a very different approach and considers models or stages of growth. 14 articles are included in this category. The reviewed articles have been published between 1983 and 2013. Many authors publishing these types of articles share a biological view in regards to firms. They indeed consider that each firm grows (like a human being for example) through a set of stages or steps, separated by transition phases or crisis (Greiner, 1972, Kazanjian and Drazin, 1989, Baghai et al., 1996, Churchill and Mullins, 2001). Some of these authors have also tried to develop models that might explain how firms grow (Hendrickson, 1992), or demonstrate how their performance can be measured (Davidsson and Klofsten, 2003, Keeble et al., 2003). This type of work has often made it possible to identify the complexity of the phenomenon of growth, such as in the case of Delmar et al. (2003), who identified several paths of growth and demonstrated that growth is a complex multi-dimensional concept. More recently, some papers try to link the stages of growth to specific aspects such as the logistics and supply chain processes (de Haan et al., 2007), the innovative capability (Nirjar, 2008) or the entrepreneurial orientation, with an attempt to develop an integrative model (Wiklund et al.,

2009). In 2010, Levie and Lichtenstein published a piece of research, based on a review of 104 papers, which uses models of business growth and which demonstrates that stage models are not suitable for understanding growth; they agree therefore with other authors who have already criticized this approach. After this study, very few scholars have continued pursuing this approach. One might count the one of Gabrielsson and Gabrielsson (2013) who created a dynamic model that explains the growth phases of an International New Venture and which recognizes rapid advancement, survival, crises and retrenchment, therefore adding new elements which had not been integrated before. Related to the most recent findings in this stream, future research should determine what lies behind growth dynamic as well as when, where and with which contextual variable the states of growth change (Levie and Lichtenstein, 2010, Wright and Stigliani, 2012).

2.5 Pace of growth

Surprisingly, only three studies were found which consider the pace at which firms can afford to grow. The main point here is to consider that the rhythm at which a company grows is important and might contribute to sustain its growth or not. The approach might be exclusively financial (Churchill and Mullins, 2001) or more general, including also aspects such as resources and market position. Vermeulen and Barkema (2002) identified that if one of the several aspects of growth (high speed, irregular rhythm, large scopes, etc.) has to go faster, the other should remain stable, as the pace affects profitability. Despite their small number, these studies contribute to the field by demonstrating that not only why and how firms grow but also at which rhythm they grow are important issues. This is in line with the warning formulated by Kotter and Sathe (1978) who said that the speed (or the rhythm) at which decisions have to be made during growth periods might influence the growth trajectory of the firm.

2.6 Challenges encountered during growth

Six articles were put in the category of challenges encountered during growth, which were excluded from this review. These articles presented a consulting approach only, with no clear methodology or theoretical contribution. Three of them were published unevenly between 1965 and 1999 and the latter three between 2008 and 2011. All of them try to identify challenges that growing firms risk to encounter and to give some advice either to identify symptoms when they occur (Merriden, 1999, Ropega, 2011) or to find effective solutions (Dake, 1965, Olson et al., 2008, Fleck, 2010). The contribution of these articles is interesting in terms of identification of general problems and theoretical solutions. However, it lacks a more concrete approach, which

could support the decision-making process of managers on a day-to-day basis for operational decisions. Tactical and strategic decisions might also be addressed differently.

2.7 Link between growth and performance or profitability

All the articles with the objective to verify if growth is related to performance or profitability were written between 2009 and 2016 (seven articles reviewed in this category). The main idea is usually to demonstrate that growth should not always be considered as a sign of success, as it does not automatically lead to profitability or other types of performance (Davidsson et al., 2009). Achieving profitability before striving for growth seems more efficient than growing first and then targeting profitability afterwards (Steffens et al., 2009). Some studies have also demonstrated that strategy-making processes (Verreynne and Meyer, 2010) or top management teams (Eisenhardt, 2013) might have an influence on growth performance. This subject encounters a growing interest as profit has been intuitively linked to growth for a long time but it appears that the reality might be different. This underlines again the necessity of finding a way to manage periods of growth efficiently in order to achieve a sustainable growth but a higher performance as well, as the correlation between the two aspects is not always apparent. More recently, some studies still depict positive relationships between growth and performance or productivity. Investigating further high-growth firms (so called gazelles), Senderovitz et al. (2016) have found a positive relationship between growth and profitability among gazelle firms; nevertheless this relationship is stronger for firms with a broad (rather than a niche) market strategy. A positive relationship between productivity and growth has also been noticed (Du and Temouri, 2015) as well as between knowledge management and growth performance in the construction industry (Abu Bakar et al., 2016).

2.8 Clarification of the subject

Very recently, mainly between 2009 and 2013, a new area of research about business growth has appeared. The eight studies in this category perform growth-literature reviews in order to either identify what theoretical knowledge can be accumulated from the previous studies (Shepherd and Wiklund, 2009), or to understand what the inconsistencies between previous studies are (Achtenhagen et al., 2010) or to identify which specific questions could still be handled by researchers (Davidsson et al., 2010, McKelvie and Wiklund, 2010, Stam, 2010, Wright and Stigliani, 2012). The emergence of this new type of articles is representative of the current state of research about business growth. Indeed, business growth is recognized as a complex concept. Related studies following different methodologies, means of measurement

and definitions of the phenomenon are not always comparable and thus might lead to erroneous conclusions. These studies justify the subject of the present research. Elements that have to be carefully considered by future researchers are the following:

- **Focus:** It is not possible to provide an overview on the subject of business growth, thus researchers should rather decide to focus on one precise aspect and study it deeply (Andersson and Tell, 2009). Combined study results will create a coherent picture of the phenomenon.
- **Results comparison:** Attention should be paid to comparing apples with apples and not apples with oranges (Shepherd and Wiklund, 2009); which means that only aspects that are highly correlated can be compared to create a worthwhile knowledge accumulation.
- **Questions to ask:** Research should focus more on *how* firms grow rather than on *how much* they grow (McKelvie and Wiklund, 2010) or even on *who*, *when*, *where* and *what* makes firms grow (Wright and Stigliani, 2012).
- **Concept:** Business growth is considered as a process by practitioners and should therefore be studied in that perspective by academicians (Achtenhagen et al., 2010).

2.9 Conclusion of the literature review about business growth

The objective of this literature review was not to be exhaustive by reviewing all articles on one precise aspect of growth but rather to identify the main aspects that have been studied already as well as to determine where there is room for making both a theoretical and practical contribution. Figure 1 illustrates the concept of business growth as it has been studied and understood so far by literature presented above and it shows how this study positions itself in this field of research. Mainstreams from literature appearing on Figure 1 include strategies used in order to launch growth periods, the characteristics and capabilities of the growing companies, the pace at which companies grow, the challenges encountered during growth, the relationship between growth and performance as well as profitability and the different models or stages of growth. The subject of the thesis will focus on the dynamic process of growth punctuated by triggering events. In particular, the study will focus on SMEs as they feature specificities in comparison to larger companies while growing (Armstrong, 2013).

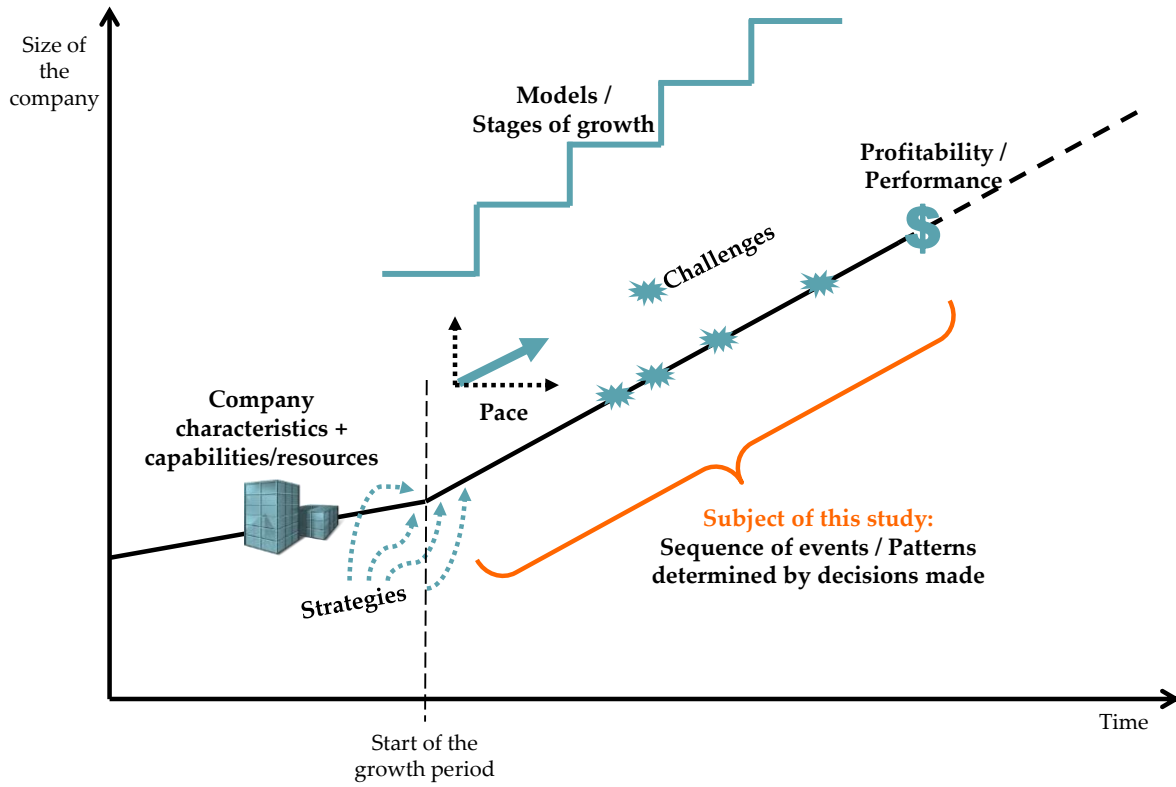


Figure 1 - Current state of research about business growth and positioning of this study

3 Development of the research framework

In this chapter, the main objective is to position this research regarding what has been studied already and to propose a new approach towards the study of growth. As seen in the previous section, recent assessments of the academic literature conclude that a coherent picture of the complex concept of business growth is widely lacking; theoretical development in the field of business growth are less frequent and academic findings are often contradictory (McKelvie and Wiklund, 2010). These shortcomings ultimately imply that managerial recommendations are not conclusive and growing firms' managers are often frustrated because they are unable to find relevant answers to their problems in academic literature (Achtenhagen et al., 2010). This situation calls for new research on this subject that both contributes to existing theory and supports managers of growing firms. In order to answer the call of numerous researchers, this study will take into consideration three major elements that were highlighted by the literature and that will be presented hereafter; the role of sustainability, the role of the decision-making process and the risk of bankruptcy during growth. Growing intensively without being able to last is of course meaningless for a company; consequently, sustainability of growth is crucial for ensuring the survival of the company. Moreover, one of the main differences between stable (non-growing) companies and growing companies is the number and the diversity of decisions they have to make during a similar period. The author will therefore develop these concepts hereafter.

3.1 Sustainability of growth

The first major construct in the framework of this research is sustainability. For operationalizing sustainable development, Elkington (1997) proposes the "triple bottom line" (TBL). This concept comprises the economic, social and environmental aspects of sustainability and postulates their intense interrelatedness. The author integrates the concepts of business growth and sustainable development in the concept of "sustainable business growth" while relating it closely to the domain of operations management. The author departs from Kambil (2007) who assessed sustainable growth rate as "the maximum pace at which a company can grow revenue without depleting its financial resources". This definition is then extended towards a broader set of financial but also non-financial parameters representing growth. Further, it is extended to a broader range of performance objectives, including not only financial resources but also other economic as well as social and environmental capital (Figge et al., 2002). To extend the previous definitions found in the literature, for this study, "sustainable business growth" is

defined as a company's appropriate pace of growth that increases its economic, social and environmental capital—or at least one of these that will lead to higher overall competitiveness taking into consideration performance thresholds for the remaining capital stock.

Although some research has been done on business growth - e.g., Delmar et al. (2003), Furlan et al. (2014) -, the interface of business growth and sustainability has been barely addressed. It has been recently demonstrated that sustainability should be embedded at a strategic level in order to sustain long-term organizational performance (Virakul, 2015); if this is done, it helps firms to overcome challenges such as the ones encountered by growing firms. Moreover, sustainability is a main concern for construction industry as its projects have strong environmental and social impacts (Opoku and Fortune, 2010). Therefore, the role of sustainability will be fully considered in the approach of this thesis. The interrelatedness of sustainability aspects will also be addressed.

3.2 Role of the decision-making process

In terms of operations management (OM) and based on Slack and Lewis' (2002) conceptualization of matching operations resources with market requirements, the process of growth implies the need of adapting production capacity to growing demand. Research on long-term capacity management focuses on the timing and volume of capacity increases (Olhager et al., 2001). An extension of capacity implies the need for strategic, tactical and operational managerial decision-making necessary for adapting current resources (equipment, employees, etc.) and adapting internal processes (such as research and development, purchasing, manufacturing, sales, etc.) to the extended production capacity. All these adaptations require managerial decisions; therefore, effective decision-making is crucial for steering sustainable business growth. During periods of growth, managers face extraordinarily high numbers of decisions that will determine to a considerable extent if their firm will grow, plateau or decline at any given time (Hendrickson, 1992); and their urgency puts managers under intense pressure (Kotter and Sathé, 1978). Poor decision-making entails major risks for a company and can even lead to business failure (Amankwah-Amoah, 2015). By the use of an extreme case study context, Useem et al. (2005) identified three main elements that might convey a manager to make wrong decisions: stress, ambiguity in authority and undertraining. According to them, dealing with these elements is not a managerial natural capacity. They warn managers that faulty leadership decisions can bring down a company, and claim that efficiency of the decision-making process is crucial in determining the future trajectory of a company. Decisions act as trigger points and therefore offer firms a valuable opportunity to grow but might also cause

firms difficulties in terms of their abilities to manage or absorb growth (Brown and Mawson, 2013). Moreover, several levels of decisions rules in the process of growth have been identified (Gancarczyk, 2016), which increase as well the complexity of the process. Although decision-making is a key subject, and its facilitation is a major purpose in OM, there is a dearth of studies that address the dynamic process of decision-making and its implications on growing companies.

General management theory suggests that a decision-making process can be broken down into various steps, such as identification of a problem, identification and weighting of decision criteria, development and analysis of alternatives and, finally, selection and implementation of alternatives (Robbins and Coulter, 2002). Recent research has shown the inclination of decision-makers towards bias and hence the importance of scrutinizing decision-making procedures (Kahneman et al., 2011). In any case, it may be stated that decision-making cannot be reasonably regarded as a kind of “one-off” exercise but implies the opportunity for managers to intervene at various points of the process.

It may be further argued that managers of growing firms—who face high levels of uncertainty—cannot leverage the strength of a probability-based systematic decision-making process but have to rely on heuristics (Mousavi and Gigerenzer, 2014). A heuristic is defined as a simple rule of thumb that leads to decisions—which could deviate from the “optimal” decision—in a short time and with limited information. It has been observed that heuristics perform better than sophisticated decision-making support tools in business life under specific conditions (Katsikopoulos and Gigerenzer, 2013). Azar (2014) mentions that a “default heuristic [...] is more likely to be optimal when the cost of obtaining information is higher and when the variation in possible outcomes is lower”. Applying a heuristic allows managers to make most decisions quickly and efficiently (although not always with positive outcomes).

On the other hand, it has been underlined that heuristics are prone to bias and may consequently lead to severe and systematic errors (Tversky and Kahneman, 1974), in particular if they are based on experience only, because a new situation might differ from what was experienced in the past. Even experienced decision-makers face some biases when they think intuitively. This is especially true in a period of business growth, when the company’s managers are under extreme pressure to make decisions quickly, which increases biases and the risk of making wrong decisions and departing from a sustainable growth path. Kahneman et al. (2011) produced a 12-step checklist that helps managers to avoid several biases that might appear during the decision-making process. They also argue that, in order to build decision processes

that reduce bias and therefore improve the quality of decisions at an organizational level, a reflective approach should be used for complex decisions (Kahneman et al., 2011). Otherwise, inappropriate decisions will be made, with severely negative consequences, and the company will drift towards a non-sustainable growth path by diminishing its economic, social or environmental capital stock, or all of these.

Hang and Wang (2012) found that the decision-making process of SMEs is substantially different from that of large firms; small firms often follow a problem-solution-analysis progression rather than the usual problem-analysis-solution progression. In addition, the nature of growth makes SMEs face decisions that are different from what they have experienced in the past and, consequently, managers cannot always rely on personal experience (Ghattas et al., 2014). Moreover, an effective decision-making process is related to the organizational learning that the company can gain during periods of growth. The necessity of learning how to develop competences during change periods has for example been demonstrated by Zangiski et al. (2013) who constructed a framework that helps with understanding the structure of interconnected relations between learning and competences variables. Yao et al. (2013) also investigated the relationship between organizational learning and OM. Consequently, how well a firm performs during a growth period depends heavily on its adaptive capacity and may partly explain why some firms improve while others sometimes decline.

A quantitative theory that suits well with this approach is the real options theory. Like the Net Present Value (NPV) analysis, the real options approach involves “projecting future cash flows and choosing an appropriate discount or probability rate” (Mills et al., 2006). However, the real options approach also includes another interesting aspect, which is missing in the NPV analysis. In the real options theory, managers can influence the outcome by interventionist actions that add value over time (Anderson, 2000). This means that the real options theory combines strategy and finance, which are two of the main aspects that have to be controlled during a period of business growth. While applying this method, Mills et al. (2006) recommend managers to emphasize scenario thinking by defining precisely what scenarios might take place, including as many relevant factors as possible, and to determine the order of preferences among strategies. They also endorse by verifying that the strategies being compared are each conceived as a series of interrelated choices whose synergetic connections could be changed by new external developments and by management intervention in the future. As seen previously, this logic is closely related to the management of growth, where managers have to make a choice among several strategies, which all include a series of interrelated decisions that might be modified according to changes occurring outside or inside the organization. The theory of real

options has been applied in several studies in the field of OM (Kogut and Kulatilaka, 2001, Mills et al., 2006, Driouchi et al., 2009, de Treville and Trigeorgis, 2010, Driouchi and Bennett, 2012) and would be promising for the specific case of decision-making for guiding capacity expansion and business growth on a sustainable path.

Grenadier and Malenko (2010) have combined the real options theory with the Bayesian theorem. The Bayes' theorem confronts two events, quantifying the probability of one event to induce the other, going therefore from the consequences to the causes. The formula actually formalizes mathematically the links between the phenomena observed and the knowledge stored. Grenadier and Malenko (2010) have demonstrated that when the traditional real options model is extended to include the Bayesian feature, the implied investment behaviour differs significantly from that predicted by standard real options models. In their study, Grenadier and Malenko (2010) show that a firm faces different types of uncertainty. Unlike the standard models, the uncertainty in their setting is "a combination of uncertainty over future shocks and Bayesian updating, or learning about the nature of past shocks". Therefore, they are able to demonstrate that there is an additional benefit to waiting: the opportunity to learn more about the nature of past shocks and to use this information to make a better investment decision in the future. This gives rise to an additional trade-off between investing now and waiting, embodied by what they call the "option to learn". Driving the decisions that must be made by Bayesian updating or learning, the firm becomes certain about past events and thus uncertainty involved in decision-making diminishes over time. Therefore, waiting and learning may constitute a valuable strategy for decision-making that is characterized by high initial uncertainty, as is the case with growing firms.

The importance of the decision-making process during growth periods has been demonstrated in this section and will be considered in the development of this thesis.

3.3 Risk of bankruptcy

A non-supported growing company might eventually risk failing during its intense growth. Attempts to measure bankruptcy risk have been made and partly successfully achieved by academics from the financial field mainly - for systematic literature reviews on bankruptcy prediction, one can refer to Cybinski (2001); Kirkos (2015); and do Prado et al. (2016). Parnes (2010) highlights the importance of early detection of bankruptcy risk developments in SMEs for investors. Research presents contradictory results regarding the size of the firm control variable for predicting bankruptcy. The size of SMEs (small or medium) does not affect the

failure risk which is equivalent for both types in the study of Gupta et al. (2015). Contrarily, Williams (2014) found that business failure does vary based on firm size. In the case of family businesses, family involvement in management reduces the risk of business failure but this effect is moderated by entrepreneurial orientation (Revilla et al., 2016). Corporate governance variables are considered as important predictors of bankruptcy, but they are likely not to be prompt enough to save firms anyway (Darrat et al., 2016). Very recently, De Bock (2017) has extended a predictive model of bankruptcy using a new method that outperforms several well-established and powerful methods in the field. Closer to the field of operations management, the role of operating cash flows as a predictor of bankruptcy has been investigated by Gupta et al. (2014) – with no improved prediction performance compared to defaults models. From an operations management point of view, the risk of bankruptcy during intense periods of growth has never been measured; to the best of the author’s knowledge, such an approach has not even been attempted. Consequently, this thesis will attempt to bridge this gap by providing another approach of measuring the risk of bankruptcy, with the attempt of completing the pure financial approach.

3.4 Objectives of the research

The positioning of this research includes the concept of sustainability of growth, the necessity of considering the decision-making process and the risk of bankruptcy obligatorily connected to growth trajectories. Considering business growth as a process, the objective of this research is to measure the risk of bankruptcy for SMEs that face intense periods of growth. For this aim, the author will investigate how decisions made by managers during periods of growth influence *how* firms grow. As presented in Figure 1, this aspect of business growth concept can be further explored; hence, there is room for knowledge contribution towards this approach. Moreover, to the best of the author’s knowledge, the risk of bankruptcy has never been measured precisely from an operations management point of view. This study will improve the understanding of how firms grow and therefore will have a practical contribution by providing solutions to growing firms that have to go through complex transition phases.

As shown in Figure 2, this study concentrates on the period starting after that growth has been set off, called the “transition period” (Brown and Mawson, 2013) where trigger points affect the growth trajectory.

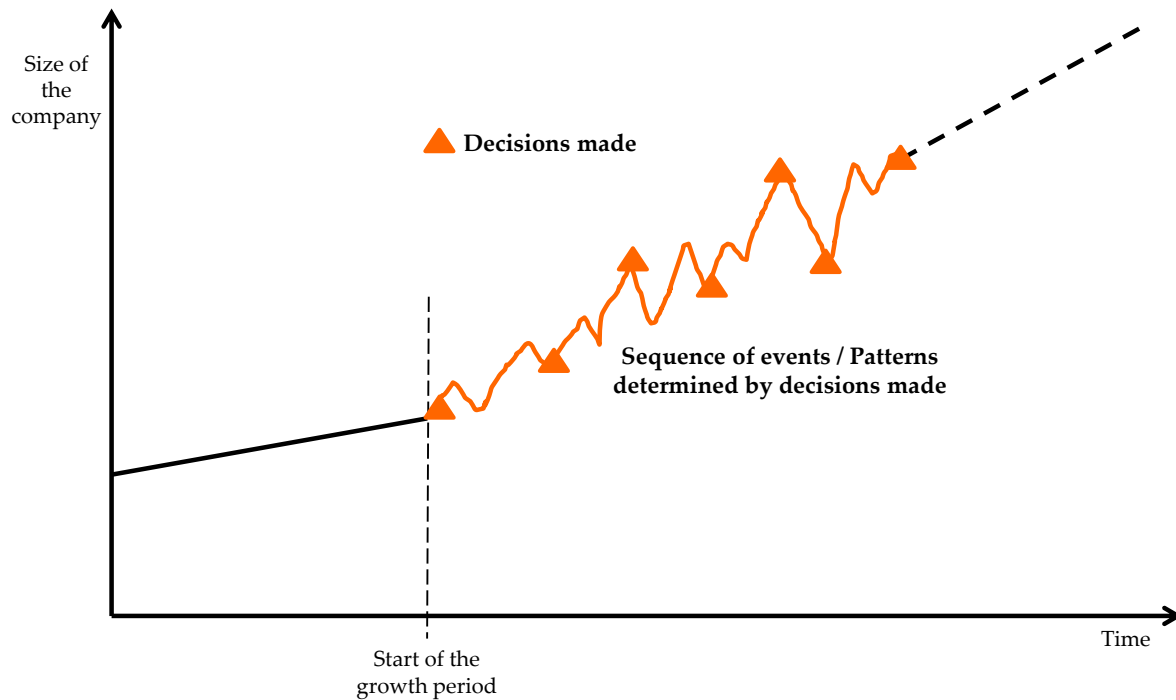


Figure 2 - Transition period resulting in sustainable business growth, determined by decisions made

In order to contribute to the understanding about how decisions influence firms' growth and of what is the risk of bankruptcy during growth phases, this study will first represent growth as a dynamic process and explain what type of decisions managers have to make on a regular basis. Then, the author will attempt to detect sequences of decisions that are made during growth periods. Finally, the objective is to determine quantitatively the impact that decisions and other Key Performance Indicators (KPI) might have on the growth trajectory of firms. The ultimate aim is to realise how risky growth periods are and to understand which elements need to be monitored for increasing the probability of success.

Seven research questions have been formulated. Each of them corresponds to the concerned research study of the thesis (namely research study one, two or three). More specifically, research questions can be formulated as follows:

Research study 1 (chapter four):

- (1) What types of decisions have to be made by a growing SME manager on a regular basis?
- (2) How can the decisions be classified and what types of decisions can be derived based on this classification?
- (3) Which patterns (series of steps within one decision) can be observed while zooming into a decision?

Research study 2 (chapter five):

- (4) What is the impact of decisions on the growth trajectory of the SME?
- (5) Which cycles (series of different decisions) appear during a period of growth?

Research study 3 (chapter six):

- (6) How can the risk of bankruptcy during growth be measured?
- (7) How can the decision-making process of growing SME managers be supported in order to sustain the growth of their firm? And more precisely:
 - a. What is the impact of efficiency to make decisions on the growth trajectory of the firm?
 - b. What is the impact of sensitivity towards well-being and environment on the growth trajectory of the firm?
 - c. Which key performance indicators (KPI) can be monitored in order to increase the probability of a sustainable business growth?

Moreover, the following elements arising from the literature review will be taken into account, thus following the recommendations formulated by previous authors. The presented thesis addresses the research gap identified by the literature research and will focus on *how* firms grow (McKelvie and Wiklund, 2010) rather than on *why* they grow or *how much* they grow. Answering the recommendation of Achtenhagen et al. (2010) and of Davidsson et al. (2010), growth will be studied as a process. Many previous researches treated growth as a dependent variable – the resulting outcome of a combination of parameters. Therefore, considering growth as a dynamic process will allow studying other outcomes deriving from the growing process itself. Moreover, the focus will be to follow growth processes as they evolve, therefore investigating the effects resulting from transitions periods (Davidsson et al., 2010). In order to contribute to the accumulation of theoretical and managerial knowledge in the field, the decision-making process of managers during growth periods will be the focus while studying growth processes. The first research of this study will be based on a longitudinal case study as many authors call for this type of methodology (Davidsson et al., 2010, Brown and Mawson, 2013) at the level of the manager and at the level of the organization (as recommended by Andersson and Tell (2009) who considers that it is the managers that make the difference). By concentrating on the decision-making process itself, one diminishes the risk of having meaningless generalization of results (Shepherd and Wiklund, 2009) as it might not necessarily be linked to firms or sector characteristics.

The final aim is to measure the risk of bankruptcy during growth periods and to determine how decisions and other key performance indicators influence the growth trajectory of the firm. Based on the research studies that will be presented in the next chapters, it is expected to confirm that decisions made during growth periods can influence positively the growth trajectory and that their impact can be quantified, in order to measure the probability of sustainable business growth and to support the decision-making process of managers.

4 Research study 1: understanding growth decisions

This chapter introduces the first research study of the thesis and has the objective to answer the research questions (1), (2) and (3), which are:

- (1) What types of decisions have to be made by a growing SME manager on a regular basis?
- (2) How can these decisions be classified and what types of decisions can be derived based on this classification?
- (3) Which patterns can be observed while zooming into a decision?

Methodology specific to this research study is presented first. Results achieved at that stage follow. In this chapter, the author will introduce the longitudinal case-study method, which is used also in the second research study of the thesis (presented in chapter five). The company-case from which the majority of analyses arise and that was suitable for conducting a longitudinal case study is also presented in this chapter. In each methodological chapter of the thesis, specific elements of data analysis will be provided, in order to understand how collected data were processed and which results came out of them.

4.1 Classification framework for operations decisions

First, it is necessary to map the territory of operations decisions to be considered by SMEs during growth periods against the canvas of sustainability. A classification along the triple bottom line is proposed: i.e. the economic, social and environmental dimensions. It follows from the logic of closely interrelated sustainability dimensions (Elkington, 1997) that during a growth phase a SME's decision-making entity needs to keep a close eye on all three dimensions in order to increase (or at least maintain) its economic, social and environmental capital. As social and environmental considerations are partly economic (e.g. energy efficiency, increase of productivity by improving working conditions, etc.), partly the result of constraints (social, legal, etc.) and partly the result of beliefs of the managers (e.g. ethical aspects), the author proposes that sustainable growth inevitably requires this simultaneous drive towards the TBL.

The first idea was to consider only two main concepts that describe the situation of growing SMEs: the Triple Bottom Line (economic, social and environmental dimensions) and the supply chain (supplier, focal firm and customer). The aim was to propose a classification of indicators referring to these combined dimensions (a matrix with 3x3 cells) and to observe if following at least one indicator for each cell would help a company to grow sustainably. Indeed, the first observations suggested that considering all the cells of the matrix might be positively associated with sustainable growth. However, the author was not fully satisfied, because simple

consideration of different aspects of growth was not explaining how to deal with them. This dissatisfaction led to analyse the data differently and finally one main aspect of the management of growth that was missing in the analysis was identified (as discussed in the literature already): the obligatory decision-making process that had to be made by managers during growth periods. Indeed, as shown in the findings chapter, the growth stage of the company is inherently correlated with several operations decisions that have to be made by managers. More specifically, the level of urgency of a decision is strongly correlated to the specific growth of the company. Therefore, the dimension of levels of decision-making (strategic, tactical, and operational) to the previous ones has been added, which led to develop a cubical matrix (3x3x3). Refer to Figure 3 below for a visual representation of the matrix. The three concepts chosen as axis of the cubical matrix help with mapping the territory of operations decisions to be taken by SMEs during growth; indeed they refer to the 1. breadth of performance (TBL), 2. the actors involved (supply chain), and 3. the managerial levers (decision level).

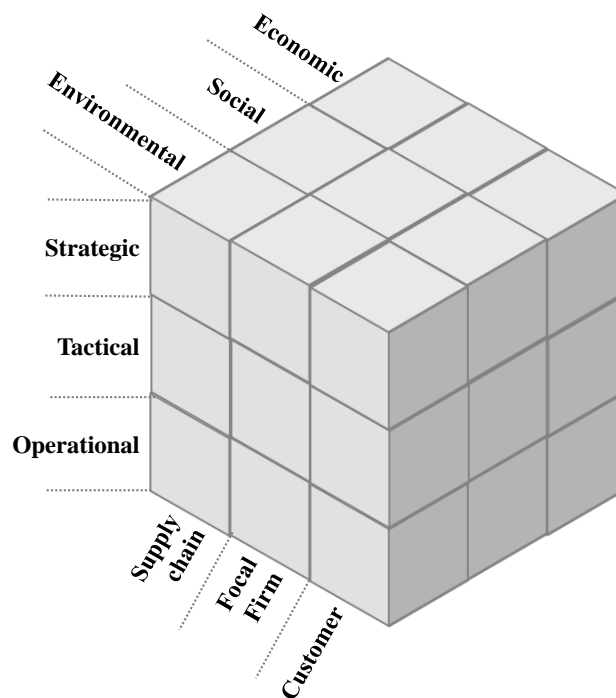


Figure 3 – Matrix mapping the territory of operations decisions

Holistic TBL thinking has superseded one-dimensional consideration of the financial and economic performance as managerial ideal in business studies in general and in operations management in particular (Gimenez et al., 2012a). Nonetheless, business is still far from acknowledging all three-performance dimensions in an integrated way. Operations decisions steering companies during their growth periods are supposed to make explicit upon which sustainability dimensions they touch and

how these dimensions may possibly be interlinked through win-wins or trade-offs (Seuring and Müller, 2008).

Operations decisions may be differentiated according to the actors they affect. In a traditional view, supply chains embrace focal firms and their upstream (suppliers) and downstream (buyers) extensions, possibly also including facilitators such as providers of financial, logistical, and consultancy services (Mentzer et al., 2001).

The managerial lever of supply chain and operations decisions may vary considerably; thereby, Gunasekaran et al. (2004) distinguish between a strategic, tactical and operational decision level. The strategic level refers to top management decisions that imply long-term and high-impact commitment substantially, thus affecting competitive priorities and organisational goals. The tactical level rather deals with the question how resources may be acquired, developed and allocated in order to achieve strategic organisational goals. On an operational level, decisions affect day-to-day delivery of a company's value proposition to customers, being subject to various ad-hoc disturbances of higher-level plans.

The combination of these aspects allow for categorizing any operations decision on the journey towards sustainable business growth. Such categorization helps managers of growing SMEs to a better understanding of main features of operations decision and clarifying the type of decisions they have to make, in order to be able to focus better. Moreover, it can be presumed that a growing firm that makes operations decisions related to all the cells of the matrix will achieve a more sustainable growth than a firm that would only partially consider the matrix's cases. This conceptual framework is used to support the development of three empirical cases that illustrate how various types of managerial decisions may guide a firm on its growth path.

4.2 Methodology: longitudinal case study with 3 embedded units

4.2.1 Longitudinal case study design

This section rationalizes why longitudinal case study design has been chosen for the two first research studies of the thesis and how a longitudinal case study is conducted.

Conducting longitudinal research implies studying phenomena over time. Longitudinal research can therefore be seen as “a number of cross-sectional snap-shots of a phenomenon taken over time” (Ahlström and Karlsson (2009)). The central focus of longitudinal field studies is on “progressions (i.e. the nature, sequence and order) of activities or events that an organizational entity undergoes as it changes over time” (Ahlström and Karlsson, 2009). Kuula

and Putkiranta (2012) have observed that longitudinal studies are important in revealing root-cause effects, as well as in exploring new territory where the research questions deal with the question of what is happening and what the key issues are, an idea developed by Voss et al. (2002). Those considerations are in line with the purpose and the subject of the present research. However, longitudinal case studies are rarely conducted due to the difficulty of accessing data over an extended period of time and, more generally, due to the amount of efforts, time and skills that is required (Czarniawska-Joerges, 1992, Ahlström and Karlsson, 2009, Kuula and Putkiranta, 2012). Ahlström and Karlsson (2009) argue that the researcher should ideally gain the status of an employee in order to increase the quality of observations that are made during a longitudinal case study research; it goes without saying that such involvement is challenging for academics and consequently rather rare. Czarniawska-Joerges (1992) also says that one should seize the opportunity to conduct such a study when given this possibility.

Despite these challenges involved in this kind of research design, several authors studying business growth call for the use of longitudinal case studies, in order to understand the dynamic part of the process (Davidsson et al., 2010, Brown and Mawson, 2013). Longitudinal research designs have previously been used to assess sustainable business practices, but only occasionally (e.g., Baronet and Tremblay, 2015). One of the noteworthy characteristics of longitudinal designs is that they keep the external environment of the case meaningfully constant, which allows for controlling many aspects which would otherwise (while comparing different cases) introduce several bias and make comparisons difficult - as discussed already.

For the present thesis, it was therefore decided to apply this method and to conduct a longitudinal case study, as it appeared to be the most suitable methodology for exploring the growth phenomenon. This method has been applied for the two first research studies of the thesis, with different embedded units of analysis (Eisenhardt, 1989). In the first research study, the author compared three embedded units of analysis within the selected firm (presented hereafter). In the second research study (presented in chapter five), with five years of data available, the research design of a single case study with five embedded units of analysis was adopted; thereby, each year of company growth represents one embedded unit.

4.2.2 Selection of the company case and other sources of data

The case that will be shortly presented hereafter is precisely suited for the research design of a longitudinal case study and for providing the desired units of analysis. As mentioned by numerous authors, growth phenomenon understanding requires ideally a deep investigation of one company – e.g. by conducting a study over several years and by accessing highly detailed

information. Since the author happens to be involved at a managerial level in a SME, it was decided to select her company as the principal source of data collection.

The selected company is a Swiss family-owned SME wood construction company—SCHWAB-SYSTEM—that has been in a process of intense growth in terms of financial parameters, market share and physical assets for several years (mainly between 2010 and 2015). According to the classification of Achtenhagen et al. (2017), the company follows a growth of type 1 (organic). At the beginning of the growth phase, in 2010, the company employed around 20 employees and had a quite stable turnover of approximately CHF 6m per year (with a slightly increasing trend). As customization is one of the leading competitive advantages of the company, its dominant manufacturing strategy is BTO (build to order) with the majority of the work produced on an order-by-order basis. The company elaborates projects for a variety of customers including private customers, architects, other companies active in the construction industry and public customers such as State entities. At the end of 2013, after two years of intense growth, the turnover had already doubled; the company employed 70 employees (53 on the shop floor and construction sites) and had invested in new equipment as well as in the rental of provisory production buildings in order to further drive the growth; (e.g. Bakar and Yusof, 2016, have also measured growth performance through company turnover and employment growth). The construction of a new factory (which also includes the administrative part of the company) and its complete relocation was terminated in spring 2014. Consequently, many operations decisions had to be made during this period, regarding the constant reorganization that SCHWAB-SYSTEM was experiencing. The case is therefore suitable for conducting longitudinal case studies as it may be conceived as (theoretically) representative of the population of growing SMEs.

Being involved in this company provides the substantial advantage that in-depth data collection on an ongoing basis as required for longitudinal research designs is possible. However, the author's involvement in the company also obviously raises the question of objectivity of the research process and requires appropriate measures to ensure the internal validity of the findings. This potential bias was addressed through in-depth discussions with the PhD director, including critical questioning of data collection procedures, interpretations and conclusions. Additionally, the data collected in the author's company were complemented with other sources of data - Swiss companies active in the construction sector that similarly experienced intense periods of growth at some point in their development. Their comments helped with adjusting and interpreting the results as precisely as possible.

Data collected in the selected case-company has been used throughout the whole research process.

4.2.3 Data collection

The longitudinal case study is informed by various sources of data. The author collected retrospective data from the period 2007 to 2010 and real-time data between the years 2010 and 2014. The data collection thus covered the completely intensive growth period over which the three embedded cases occurred at SCHWAB-SYSTEM. The author conducted direct observations while subsequently summarizing essentials in a case study logbook. Two major approaches to collect data were used: (1) readout and interpretation of internal documents of diverse types in either paper or electronic form and (2) interviews with managers and CEO of the company.

The author collected a substantial amount of archival data in the form of reports, meetings minutes, enterprise resource planning (ERP) data, and informatics files covering the years 2007 to 2010, i.e. the pre-growth period. The main sources of data comprise a summary of all decisions made during weekly meetings of the executive board, a list of all major investments maintained by the accounting department, a list of all engagement and lay-off maintained by the human resources (HR) department, a list of all projects realized as maintained by the production department and a list of all marketing actions that were made or refused as maintained by the sales/marketing department. Moreover, all the internal files that were modified between 2010 and 2014 were reviewed, together with all the emails of the CEO and vice-director of the company. Data collection was completed by repeatedly interviewing all members of management as well as of the middle management directly in the company. In order to minimize the potential introduction of biases, the managers did not see any results of the data collection before giving their own ideas on what the major decisions that the company had to make during the considered period were. Missing data were also completed during these series of interviews. More specifically, the author conducted six extensive semi-structured interviews with the CEO over the period 2010 to 2014. The CEO had worked for the company since 1982 and had deeply been involved in its development during this period. Furthermore, the author conducted nine interviews with other employees of the company. The choice of interviewees was made according to their contribution to decisions made during the growth period and also according to their knowledge about the operations processes. A preparation of the interviewees was made prior to the interviews, in order to provide support for the interviewees to recreate the history of the years between 2010 and 2013 (interviews were made during 2014). The

interviews were structured in three parts. Part A consisted in general questions about the growth period. In part B, the processes related to the concerned department were discussed. During part C of the interview, specific questions were asked, in order to understand in more details what decisions were made during the growth period. A typical question for this initial part was “what are the main decisions that have been made during the growth period?” Each interview was recorded and extensive hand-written notes were made. All interviews have been transcribed right at the end of the session and a final written version was submitted to the informant in order for him/her to validate the transcripts. Shorter follow-up interviews were done if necessary, to clarify inconsistencies. All employees were interviewed only once; except the director of production with whom three interviews were conducted. All interviews were made in the company, during working time. Some follow-up informal discussions with the CEO of the company took place a few times outside of the company. But all data were systematically recorded and included in the logbook of the author.

The author enhanced the internal validity of the research results by repeatedly triangulating all data collected (Yin, 1984), both within and between the different sources of information. For example, decisions found in the archival data (2007–2010) were discussed with employees who worked in the company at that time and who had participated in the decision-making process. By doing so, possible bias stemming from direct observation were minimized, and the author was thus able to better approximate the “true story” (Pentland, 1999).

The author analysed the data over time, across the three different units of analysis (i.e. the operations decisions in the first research study, and the years of growth in the second research study). Afterwards, the author put the information together in a chronological order, using the technique of “story writing” (Ahlström and Karlsson, 2009). The objective was to get a global view of the changes that had happened from 2007 to 2014, and to clearly separate actions from perceptions, as well as decisions made from results obtained.

As planned, there was a going back and forth between data and literature in order to strengthen the identification and validation of typical growth dynamics.

4.2.4 Design for identifying patterns within decisions

To answer the research questions of this first part, the objective is to zoom into an operation decision. The author adopted the research design of a single case study with three embedded units of analysis (Eisenhardt, 1989). Therefore, the applicability of the conceptual model through a longitudinal case study has been investigated, allowing for studying the process of

growth in a company as it evolves, scrutinizing company growth and identifying the sequences of decisions that have to be made. Through theoretical sampling (Eisenhardt, 1989), the author has selected three extreme cases within the company as embedded units of analysis. All feature noticeably complex decisions that had to be made by SCHWAB-SYSTEM on a strategic operations level and with considerable implications for customers and suppliers, as well as for social and environmental sustainability. Each decision had been fully implemented or realized, which allowed an analysis of the achievement of its objectives. The cases will be presented in their chronological order of appearance. The author limits the sample to these three cases because the other operations decisions that were made by the company during the observed period were less complex and therefore did not seem to yield any new important theoretical insights. As recommended by Eisenhardt (1989), the author applies theoretical sampling for choosing cases which are likely to replicate or extend the emergent theory.

The first case addresses the choice of localization of the new plant. It thus arises from the choice of building a new factory - made already in 2007. The company considered four different alternatives before making its final decision. The choice of the localization was particularly critical in terms of operations because the organization of the new plant would be strongly linked to the shape-, slope- and elevation of the land – the organization of the production lines and other manufacturing processes depend on the shape of the factory. The decision process lasted around 4 years until the company eventually found a suitable plot of land in 2011.

The second case relates to the choice of implementing a human resources (HR) department. This resulted mainly from the important number of recruitments that occurred between 2011 and 2013 that drastically changed the whole organization of the production teams and of the operations in general – e.g. many new workers were moved to remote construction sites and were therefore very rarely in the company headquarters; new processes and communication tools were introduced; standard training guidelines for new workers were set up; rules and regulations had to be sophisticated; etc. In short, the whole HR organization implied by the growing number of recruitments could no longer be taken care of by the managers of the company that were already encountering difficulties fulfilling their own duties. The complete decision process lasted around one year before the HR department was set up comprising of an HR director as well as an executive assistant.

The third case occurred unexpectedly in 2013. SCHWAB-SYSTEM had the opportunity to rent its entire roof to a company that installs solar panel. Consequently, it could take part in the development of renewable energy in Switzerland. Following the same logic of contributing to

sustainable development, the company decided to invest in a wood chip heating system that allows the use of its own wood waste to heat the entire building. By this cascading use of woody biomass, residual waste of the production process is valorized for energy generation (Seuring and Gold, 2012); as a result, the building creates more energy than it consumes. This case demonstrates how production processes can be made to be more sustainable by intelligently closing material flow cycles through the investment in a local heat and power plant. The decision was made within 6 months approximately.

Coming back to the matrix, the three cases are all linked with the strategic level of decisions (as already mentioned) as the impact of the decisions concerns a long-term horizon. However, in terms of TBL, each case refers to a different dimension, economic-, social- and environmental respectively. In terms of supply chain, all cases concern the focal firm. The first case concerns the entire supply chain - as each supplier or customer that visits the company is affected by the choice of its localization – just as well as the third case even though it concerns only indirectly the supply chain actors.

4.2.5 *Data analysis*

Following the method proposed by Åhlström (2007), the author analysed the case study data (presented in section 4.2.3 – data collection) along a number of coding categories that the author defined inductively, based on the different steps—including consideration, reflection, decision-making and related processes—that appeared in many of the operations decisions the author analysed. The author subsequently checked the validity of these categories by discussing them with the company’s managers (Van de Ven and Poole, 1990). For all data collected, the author observed whether the decision-maker (in this case the company’s CEO) was:

1. considering an alternative (A)
2. having a feeling (F)
3. working on the alternative (W)
4. thinking about the alternative, reflecting (T)
5. asking for opinions (O)
6. looking for (objective) information (I)
7. setting a deadline (E)
8. attending to a triggering event (TE) or
9. making the decision (D).

After categorising the data referring to the three decisions, the analysis identified patterns - a pattern is a series of steps that compose one decision - that were representative of a decision.

To provide visual support, the author aggregated the results in a series of charts in order to show the process of decision-making during the period of growth (Figure 5 on page 37). The author was then able to identify different types of decision-making process, from which the author derived research propositions that explore new theory and form the basis of subsequent theory testing. Even though it is extremely challenging to compare the growth process occurring in different companies due to differences in the context, this approach of theoretical abstraction through the process of conceptualization and de-contextualization of the operations decision-making process allows for a certain degree of external validity (Avenier, 2010).

4.3 Findings: classification of decisions and highlight of patterns

This section presents the first results obtained by this research. First, a link between growth and operations decisions is made explicit; second, patterns appearing during decision-making process are identified and presented into details. A summary of major outcomes obtained so far closes this section and highlights how subsequent parts will build upon them.

4.3.1 *Link between growth and operations decisions*

Operations decisions made during the growth period were strongly linked to one or several growth parameters, such as the increase in the number of employees or in sales volume. Indeed, what characterizes the decision-making process of a growing firm is that its operations decisions are linked to its specific stage of organizational growth. This means that the need for action (i.e. decision-making) evolves together with the company's growth. In this case study, for example, the decision to establish an HR department was clearly linked to the number of employees hired by the company. The decision was not even considered before the year 2012, when managers only vaguely discussed it. However, as the number of employees increased drastically, it suddenly became urgent to establish an HR department, which was realized only in late 2013, just before the need for a decision became critical.

“Even several months after our growth had launched [July 2013], it was almost impossible for me to conceive that we could need an HR department at 100%; especially because none of the companies in our field from our region were using this type or resource. Moreover, up to then I always managed everything alone. However, all the changes – related to growth – that were taking place in the company were worrying our teams and, all of a sudden [November 2013]; I realized how much I needed an HR team.” (SCHWAB-SYSTEM CEO) (NB: all direct quotes translated by the author).

The decision to build a new plant was strongly linked to the development of the sales volume of the company; the higher the sales volume and number of projects, the greater the urgency to being able to operate the new building. Before production was moved to the new plant (in 2013), several large projects had to be refused by the company because of their space and production capacity requirements.

“At that time [2012], we have felt really cramped in our plant for two or three years. I always knew that I only had two choices: 1) keeping the current plant, which would imply reducing the workload of the company and reducing the teams, or 2) building a larger plant, hiring more people and accepting more workload. Second option was clearly the one I liked most...” (SCHWAB-SYSTEM CEO).

Installing the solar panel and heating systems at the new plant was indirectly linked to the company's growth, as these decisions were dependent on the construction of the new plant. However, from a project management point of view, the decision had to be made before the roof and other systems would be installed.

“The main issue here was an engineering static matter. Could the building structure support the additional weight on the roof? We had to quickly answer this in order to reinforce the structure if necessary” (SCHWAB-SYSTEM CEO).

A pressure for time linked to growth was therefore also present regarding this decision.

4.3.2 Identification of patterns during the decision-making process

The analysis shows a basic pattern to each decision-making process (see Figure 4). Each decision process starts with a consideration phase, including the consideration of a first alternative, followed by a positive feeling related to this option and by obtaining reassuring or encouraging information from an external source related to the decision. This is followed by a reflection phase (discussed below). The decision phase systematically includes a positive feeling about the currently considered alternative.

“As long as I don't feel at ease with a strategic decision, it is rather impossible for me to make it. All the decisions I've made in my life that had the most valuable impact were stemming from positive feelings related to them” (SCHWAB-SYSTEM CEO).

A decision with a lower level of complexity would follow the same pattern but without the reflection phase.

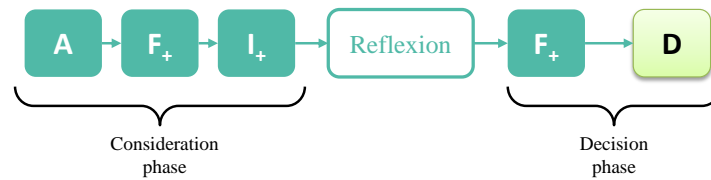


Figure 4 - Basic decision-making pattern

NB: the complete legend is available on Figure 5 below

The data indicate that several patterns may arise during the reflection phase (see Figure 5). The author calls the first pattern the “easy with no work” pattern. In that case, the reflection phase is the one described at the top of Figure 2, where the decision-maker complements initial positive feelings and supporting information with additional feelings and information; options are devised, the feasibility of which is evaluated via a loop back to feelings and information. During the reflection phase, the decision-maker links up positive feelings and positive information about the considered alternative. No tangible work (such as making financial forecasts, sketching several plant implementation options, comparing different quantified offers, etc.) is required from the decision-maker. S/he might want to get an external opinion for validating the solution but this step is not mandatory. The author has chosen to call this the “evaluation of feasibility” as it lasts until the decision-maker is certain that the solution can be implemented.

“The only thing that mattered here was to know if it was feasible to implement the decision. As long as the answer to this question was “yes”, I don’t see why I would have refused it” (SCHWAB-SYSTEM CEO).

Then s/he exits the loop to go on with the decision phase.

The second is the “difficult with no work” pattern, presented in the centre of Figure 5. When the decision is recognized as particularly difficult by the decision-maker, an additional step is added, which the author calls “reflecting”. This step appears because the decision-maker is not convinced about the necessity of such a decision. Because of this hesitation, right after the consideration phase, negative feelings start to arise and make him/her literally ruminate about the considered alternative, with a tendency to refuse it.

“I was thinking and thinking again about this decision, without achieving certainty that it was the right thing to do. The more I was thinking about it, the more I doubted it.” (SCHWAB-SYSTEM CEO).

The decision-maker will subsequently ask for an external opinion that supports the alternative (brings positive information), which makes him/her start reflecting again, this time with a tendency to accept it. This “evaluation of necessity” loop might not stop until a triggering event appears that shows to the decision-maker that this decision is necessary for the company’s health. The triggering event leads to the decision phase.

“Today [March 2014], when I see the positive impact of this decision, I don’t understand how I could hesitate for so long” (SCHWAB-SYSTEM CEO).

In this sequence again, no tangible work can be done – the decision-maker can only “think” about the decision.

The last pattern that was identified is called the “difficult with work” pattern (see bottom of Figure 5). The main difference of this pattern is that the decision-maker has to “work” on the decision; s/he has to do something tangible and concrete to evaluate the potential of implementation of the project. At the beginning of the reflection phase, s/he will work on the decision with enthusiasm, maintaining positive feeling and receiving positive information. However, after a while, the decision-maker might get information that is no longer positive or start to get tired of working without being able to make a decision, so a negative feeling arises.

“At times during the search for a new location [2010], I felt very frustrated. I knew it was urgent to move the plant and I had the feeling that all the information I got was slowing us down, that all the answers I was waiting for were causing more delay” (SCHWAB-SYSTEM CEO).

S/he continues working with anxiety until s/he asks for a clear deadline (expiry) and gets more information that is negative, which increases the negative feeling. In this sequence as well, only a triggering event will allow the decision-maker to drop his/her first alternative and consider a new one, which will start the loop again.

“It took me quite some time considering another alternative and start working on it again, almost from scratch. However, quite rapidly, I felt this one was the right one. Information I got was also encouraging and everything went fast. From my point of view, when everything sets up easily, you probably are on a good track” (SCHWAB-SYSTEM CEO).

Only the “work with enthusiasm” loop can lead to the decision phase.

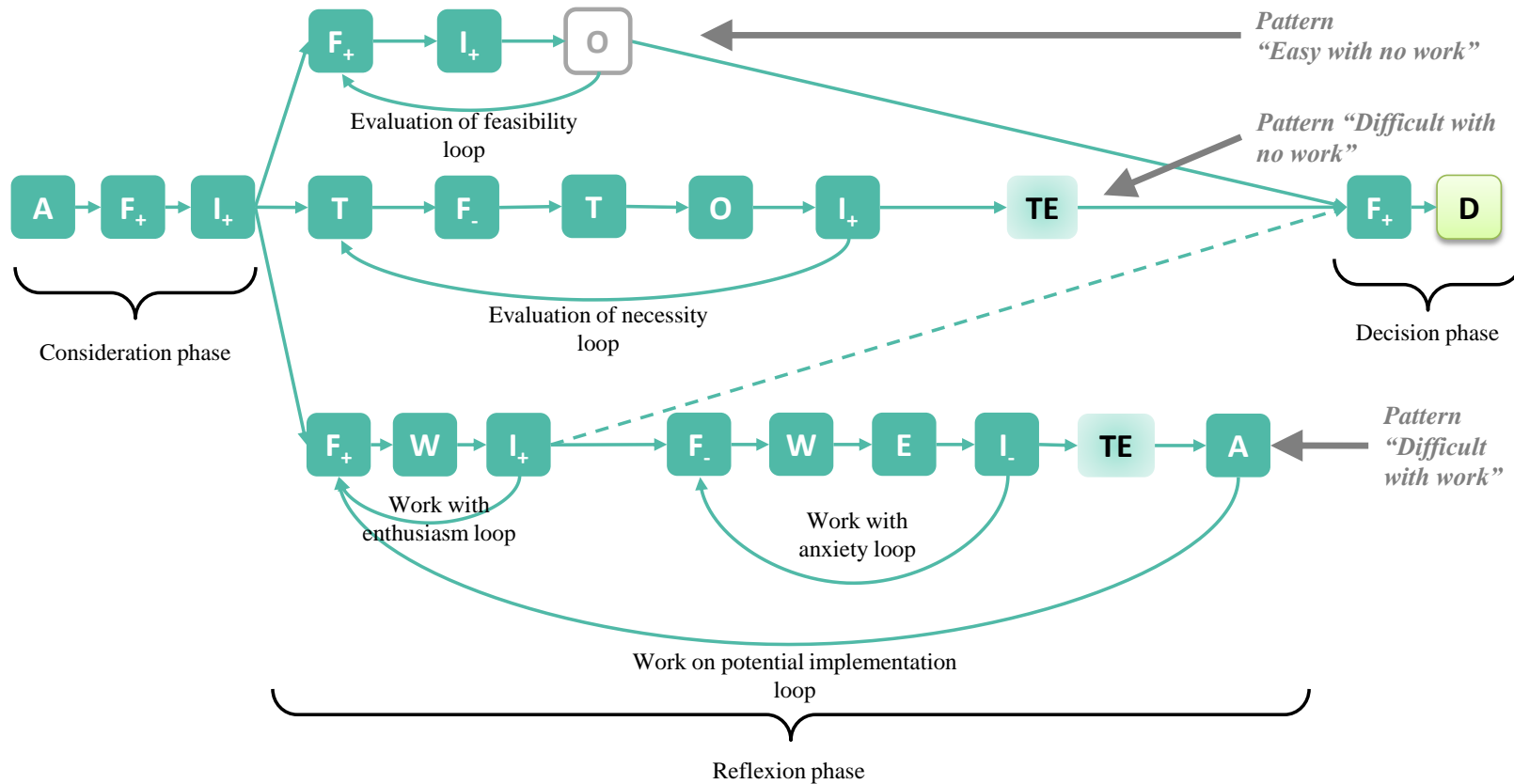


Figure 5 - Decision-making patterns comprising the reflection phase

Legend:

A: considering an alternative
F: having a feeling
W: working on the alternative
T: thinking about the alternative

O: asking for opinions
I: looking for (objective) information
E: setting a deadline
TE: assisting to a triggering event
D: making the decision

+: positive
-: negative
Solid line: path to next step
Dotted line: alternative path

Green box: mandatory step
White box: optional step
Pastel green box: external event

4.3.3 Resulting outcomes used for next research study

This section provides outcomes arising from the first research study. These results will become the departure point for the following research study.

The objective of this first research study was to develop a decision-making framework that guides managers on their firm's sustainable growth. The ultimate goal was to understand which pattern should be followed according to the type and nature of the operations decisions that have to be made. For complex operations decisions, the author has identified three possible patterns (sequences of decision components) by means of three purposefully sampled embedded units of the case study, each referring to a different TBL dimension. The units of analysis illustrate three typical decision-situations a growing SME may face that are situated on a strategic level and present a high level of complexity. Each unit refers to different parts of the cubical matrix – i.e. represents different types of operations decisions; in particular, they correspond to a different TBL dimension of the matrix (see Figure 6). The case material has allowed the identification of several patterns (sequences of decision components) that appear during the decision-making process. Following the recommendation of Achtenhagen et al. (2010) and of Davidsson et al. (2010), this research has studied growth as a process, therefore not treating it as a dependent variable but as intermediary variables while studying other outcomes.

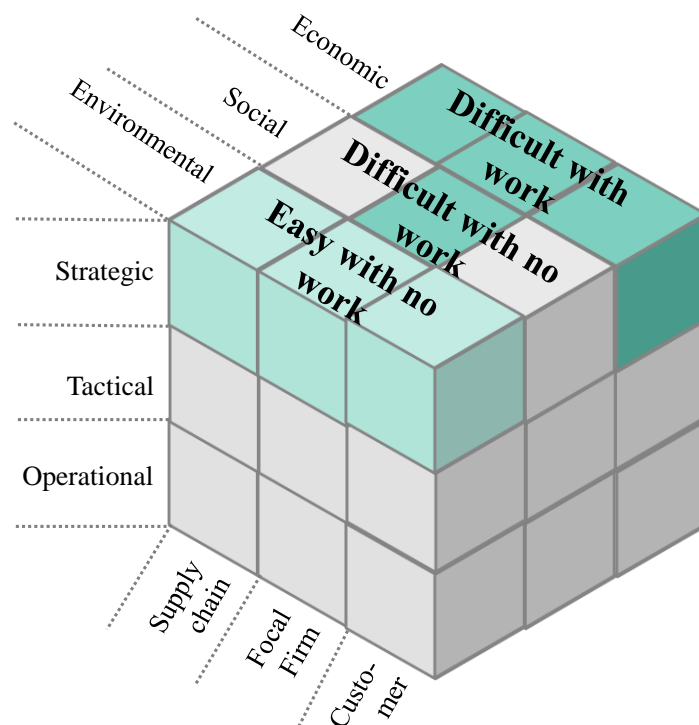


Figure 6 - Link between matrix cases and patterns

The analysis: (1) helps managers to understand what type of operations decision they currently consider and how they should be addressed (prioritization); (2) shows managers at which step of the pattern they currently are, in order for them to accelerate the decision-making process if necessary; and (3) encourages managers to consider operations decisions on all three dimensions of the TBL in order to achieve sustainable growth. Based on this identification and related analysis of the company between 2007 and 2014, the author proposes below a set of research propositions as a basis for next steps of the research and for propositions to be tested afterwards.

Even if effective, the 12-step procedure proposed by Kahneman et al. (2011) appears to be time-consuming and to require substantial resources for validating the decision. Since the large number of decisions to make during the growth process (Kotter and Sathe, 1978) generally overwhelms managers of SMEs, time as well as other resources are not available to top managers to address all decisions in this way. These resource constraints force managers during periods of growth to prioritize their decisions in order to determine whether multi-step verification is necessary. This analysis shows that there is a clear time pressure related to particular facets of growth (sales volume, number of employees and building process) that impacts on the decision-making process. A firm that does not grow will either not have to make certain types of decisions at all or not under similar time pressure. Based on these observations, the author can formulate the following propositions, which will be further investigated with empirical quantitative modelling in chapter six:

P1.1a: The available time for making decisions during the growth phase is shorter than during the pre-growth phase.

P1.1b: For a given period, a firm in a growth phase needs to make more decisions than during its pre-growth phase.

P1.1c: For a given period, a firm in a growth phase needs to make decisions that are more diverse than during its pre-growth phase.

If the level of complexity of the decision is high and if much is at stake for the company, it appears reasonable that the decision-maker should invest time and resources in a sophisticated process for increasing the probability of making a good decision. Under these circumstances, a decision made intuitively may be severely biased by the heuristic shortcut relying on the experience/expertise of the manager (Tversky and Kahneman, 1974) and may thus have substantial negative consequences for the company's growth path and possibly endanger its survival altogether. Therefore, decisions of high complexity and impact should be made following one of the complex sequences that are identified in this research. This

recommendation is in line with the reflective checklist approach proposed by Kahneman et al. (2011). In order to free resources for focusing on complex high-impact decisions, the decision-maker has to rely on heuristics (based on experience/accumulated knowledge and intuition) for the vast number of low-complexity and in particular low-impact operations decisions. Furthermore, decisions with high levels of uncertainty but no crucial impact on firm performance may also be tackled by heuristics, as sophisticated probability-based decision-support tools are not efficient in such cases (Mousavi and Gigerenzer, 2014). Thus, one important piece of practical guidance for managers is that they should separate intuitive “slim decision-making” from sophisticated “reassuring decision-making”. Such prioritization of decisions facilitates the appropriate distribution of resources within decision-making. Based on these considerations, the author formulates the following research propositions:

P1.2a: Distinguishing between low-complexity and low-impact decisions and high-complexity and high-impact decisions (“prioritization”) enhances the overall outcome of operations decision-making for ensuring sustainable growth, given the limited resources of management.

P1.2b: Additional reflection (by steps such as thinking, information gathering, opinion gathering as well as various reflective loops) enhances the outcome of high-complexity decision-making for ensuring sustainable growth.

If redundant negative feelings occur during the reflection phase, a triggering event is necessary to make the manager get out of the current loop and enter the final decision phase. If a decision is made before the manager gets out of the loop, the risk of negatively affecting the company’s sustainability is much higher. Thus, the author would like to make the following proposition:

P1.3a: To ensure the sustainability of growth, a highly complex decision should be made only once the decision-maker has run through the complete pattern (the complete sequence of steps in Figure 2).

P1.3b: To ensure the sustainability of growth, managers have to support the decision-maker by helping him/her to get out of the loop, for highly complex decisions.

Regarding the classification of operations decisions (Figures 3 and 6), a firm following a classical growth pattern (i.e. not focused on TBL performance) will tend to cover predominantly economic/financial indicators in order to manage growth. For sustainable growth, however, a firm should adequately address all TBL dimensions in its operations decisions (Dyllick and Hockerts, 2002, Figge et al., 2002, Venkatraman and Nayak, 2015).

It seems reasonable to formulate the following research proposition referring to the overall objective of ensuring sustainable corporate growth:

P1.4: The more dimensions of the TBL are considered by a company's management when making decisions during periods of growth, the more likely it is that the company will proceed on a path to sustainable growth, i.e. increase its economic, social and environmental capital—or at least one of these—without decreasing any capital stocks.

This first research study allows answering the research questions (1), (2) and (3). Decisions made during growth periods are identified and classified; while zooming into decisions, patterns are highlighted. The preliminary results about sustainable business growth help with (1) mapping the territory of operations decisions during growth by referring to the breadth of performance (TBL), the breadth of actors involved in the supply chain (SC) and the decision level (strategic, tactical, and operational) (thus constituting a matrix that serves as a classification framework for operational decisions) and (2) understanding what sequences of steps happen during the decision-making process so as to distil and highlight their inherent pattern and to understand their effect on business growth (decision-making patterns). The former concept, the (3x3x3 cells) matrix allows for categorizing any operations decision on their journey towards sustainable business growth. Such categorization helps managers of growing SMEs to gain a better understanding of main features of operations decision and to clarify the type of decisions they have to make, in order to focus better. The latter concept includes three different decision-making patterns that present various degrees of complexity. The pattern “Easy with or without work” is the simplest one. The patterns “Difficult with no work” and “Difficult with work” both require a triggering event to help the decision-maker with getting out of an (otherwise) endless loop and finally making the decision. For complex operations decisions, one of these three decision-making patterns has to be followed by the decision-maker in order to yield good results.

This research study therefore provides some understanding of microelements (the decision itself) of the decision-making process. Derived propositions will have to be tested later on. As the next research step, it is now necessary to zoom out in order to observe a complete period of growth and to investigate links between decisions.

5 Research study 2: observing a whole period of growth

This section introduces the second research study of the thesis. It builds upon the previous results achieved and has per aim to answer the following research questions:

- (4) What is the impact of decisions on the growth trajectory of the SME?
- (5) Which cycles (series of different decisions) appear during a period of growth?

This section refers to the case-company and longitudinal methodology which were presented in chapter four previously.

5.1 Methodology: longitudinal case study with 5 embedded units

For answering the research questions, the author investigates the impact of decisions on the growth trajectory of the case-company through longitudinal case study again, allowing for the studying of the process of growth as the company evolves. With five years of data available, the author adopted the research design of a single case study with five embedded units of analysis (Eisenhardt, 1989); thereby, each year of company growth represents one embedded unit. The pre-growth years were not considered in this study as they involved much fewer and less complex decisions in comparison to the growth period and therefore did not seem to yield any new important theoretical insights (Eisenhardt, 1989). Each decision that had an impact on the operations of the company - be it minor or major - during the period of five years was collected, resulting in an exhaustive list of decisions.

5.1.1 *Data analysis*

The collected data (presented in section 4.2.3 – data collection) were analysed so as to investigate the operations decisions made within and around business growth as well as their impact on the growth path of the company. The objective was to focus on the question “how was the decision made and how did it influence the growth’s path of the firm?” To this end, data have been analysed over time, across the different embedded units (i.e. years) of the longitudinal case study.

The following aspects of each decision were organized in a table: (1) short description of the decision (2) date of consideration of the decision (3) date when the decision was made (4) date when the decision was applied (5) current status of the decision (is the decision in process, made, applied or checked already?) (6) nature of the decision (was the answer YES or NO?) (7) financial consequence of the decision (expense/loss, neutral, or revenue/benefit).

On this basis, all the decisions were classified into several categories, which were (a) Accept projects (b) Hire / Fire employees (c) Organize the management / the plant (d) Invest (into infrastructure, equipment, vehicles, etc.) (e) Make marketing actions (f) Improve well-being (g) Support environment and (h) Develop / Stabilize business. For the category of accepting projects, as the amount of decisions was excessive compared to others categories, it was decided with the production managers of the company to include only the decisions of accepting projects with a potential turnover of more than CHF 100'000.-. All other projects that were more modest were considered as not affecting the company in terms of operations reorganization and were therefore not included in the final decisions list.

Based on this empirical data, the duration necessary to make and to apply the decisions were calculated in days, weeks, months and years. Moreover, four main variables were introduced. According to the previous results, the author integrated in the analysis the type of sequence followed by the decision-maker as well as three levels of the matrix for operations decisions: the level of decision, the triple bottom line and the supply chain. Once the data preparation was completed, the whole gathered information was combined, verification was realized, duplicated data were removed, and the global consistency of the data was checked. 492 decisions were collected.

Analysis was supported by the software package SPSS. Decisions were filtered based on their level (strategic, tactical, and operational) and/or on their status (pending, made, applied, and checked). Moreover, data were systematically split across the five embedded units (i.e., the years 2010-2014), facilitating its comparison over the years. Besides the observation of descriptive data and frequencies, the majority of analyses were simple and multivariate regressions (dependency between variables), ANOVA analyses (compare units) (see tables in appendices 10.1.1 and 10.1.2), Pivot table observations, Chi-square tests (test of independence) (see tables in appendices 10.1.3, 10.1.4 and 10.1.5) and Kolmogorof-Smirnov test (type of distribution followed by the data) (see table in appendix 10.1.6).

These methods aim at grasping most relevant features of the company's evolution of operations over the five years in order to identify changes, improvements or challenges that the company faced. Furthermore, the author investigated how the company reacted to the different opportunities and challenges that appeared during its growth and how these reactions determined – at least partly- its future trajectory.

5.1.2 *Research quality*

Internal validity of the research results are enhanced by triangulating all data collected (Yin, 1984), both within and between the different sources of information; in this way possible bias stemming from direct observation has been minimized. The case study protocol has been developed in order to collect, organize and thus maximize the benefits of the varied sources of information. Based on the data edited and structured in the table described above, the analysis aims at identifying how the trajectory of the growing company is influenced by the decisions made during the five observed years. It has been demonstrated many times that growing firms present different characteristics, follow several strategies, discover different types of challenges on their road of transition and that the criteria used to define a growing firm often vary (e.g., Delmar et al., 2003). Therefore, those aspects of growing firms are highly difficult to compare and generalization of results has been quite challenging. However, operations decisions that have to be made by managers are comparable to a certain extent. Theory-led abstraction of decision-making and its impact on the growing company ensures a certain degree of external validity, i.e. generalizability, of the results.

5.1.3 *Identification of cycles of decisions*

This section is dedicated to a slightly different approach towards the available data; the objective here is to investigate if decisions appear in an order that could be precisely identified and therefore anticipated. In other words, one of the questions raised at this stage is the following: “is it possible to anticipate the type of decision (category) that will have to be made and at which rhythm the decisions will appear during growth periods?”

For answering this question - research question (5) -, the collected decisions have been arranged by category on a daily-basis time-axis. For each day since 2010-01-01 to 2014-12-31, if one or several decisions of e.g. category “accepting project” were made, this precise number was written on the corresponding day time-axis. If no decision was made, zero was indicated. Then, a second time-axis has been created, with cumulative values. If first decision occurred on day 3 and second decision occurred on day 7, then number 0 (equivalent to no decision made yet) was written on days 1 and 2; number 1 (equivalent to one decision made) was written on days 3, 4, 5, and 6; number 2 (equivalent to two decisions made since the beginning) was written on day 7, and so on. Each time the value changes on the axis, it means that an additional decision of the same category has just been made. This was achieved for all categories of decisions. The same steps were repeated for the dates when decisions were considered (i.e. not made yet).

After that, the author started to observe different combinations of decisions. A “combination” is a selection of several categories of decisions. A combination might consider all categories (eight in total) or only a selection of them. Regardless of the number of categories considered in the combination, each time a decision of all considered categories is made, a cycle is closed and the cumulative number of selected categories’ decisions is reduced by 1. Figure 7 illustrates this concept; in this case, the author considers all categories: develop business, accept project, hire, invest, organize, improve well-being, support environment and make marketing (see the left-hand part of the figure). On 2010-12-12 (see date at the very top), decisions from 7 out of 8 categories have been made already; 14 decisions of type “accept project”, 5 decisions of type “hire”, 7 decisions of type “invest”, etc. There is only one decision of the type “develop business” that is missing to complete the full combination. On 2010-12-13 a decision of that omitted category appears and therefore the combination is full (refer to orange cell “TOP”). A new cycle is closed and all cumulated numbers are reduced by 1 – “develop business” becomes zero again, “accept project” decreases to 13, “hire” to 4, “invest” to 6, etc. They will increase again after the next decisions are made. If this precise combination considered a lower number of categories, some cycles would have been closed already.

		06.12.2010	07.12.2010	08.12.2010	09.12.2010	10.12.2010	11.12.2010	12.12.2010	13.12.2010	14.12.2010	15.12.2010	16.12.2010	17.12.2010	18.12.2010	19.12.2010	20.12.2010	21.12.2010	22.12.2010
MADE	Develop / Stabilize	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
MADE	Accept project	14	14	14	14	14	14	14	13	13	13	13	13	13	13	13	13	13
MADE	Hire	5	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5	5
MADE	Invest	7	7	7	7	7	7	7	6	6	6	6	6	6	6	6	6	6
MADE	Organize	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0
MADE	Improve well-being	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0
MADE	Support environment	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1
MADE	Marketing	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1
	All 8	TOP																

Figure 7 - Cycles detection

The author investigated nine different combinations of decisions, starting with the most complete ones (e.g. eight categories together, refer to Figure 7 or mixing the apparition of decisions made and decisions considered together) and then reducing one by one the number of categories in the combination. Each combination was observed by year and over the whole period in the following manner: 1) how many cycles were completed, 2) the average time spent for a cycle (in days), 3) the average number of decisions made within one cycle for the

considered categories and 4) the average number of decisions made within one cycle for all decisions (not only the considered categories).

It quickly became apparent that there were four categories of decisions (accept project (A), hire-fire (H), invest (I) and organize (O)) which were made on a substantially more frequent basis. While focusing on these four main categories of decisions, the author selected three main combinations. The first combination considers simply the four categories over the observed period – each time one decision of each type is made, a cycle is closed. In the second combination, it was observed that there were some differences over the periods – in the first period of growth (up to July 2010), no decision of type organization (O) was made, therefore cycles were closed when A-H-I decisions were made. Then hiring (H) reduced for a while (up to April 2012), therefore cycles were closed when A-I-O decisions were made. Afterwards decisions of all types occurred (up to June 2014) and cycles were completed again when A-H-I-O decisions were made. Finally, investments decreased (second half of 2014) and cycles were closed when A-H-O decisions were made. The last combination simply allowed a cycle to be closed each time a variant of A-H-I, A-I-O, A-H-O or A-H-I-O decision was made.

It might be important to notice that the order within which the four categories of decisions appear in a cycle is not taken into consideration. While starting this phase of analysis, some investigations have been made in order to eventually identify a precise order of appearance of decisions that would always be identical. There was no conclusive evidence of such a precise order of appearance. While discussing these first results with the CEO of the case-company, he mentioned that:

“For me, the precise order in which decisions appear is not important; what matters is the combination of decisions (regardless of the precise order of appearance). It would be helpful to be able to anticipate the next vital decisions that will come up. As long as I know which decisions will be part of a cycle, it does not make any difference to know in which order they will appear.” (SCHWAB-SYSTEM CEO)

Consequently, the author started to investigate cycles that combined decisions of the same type, regardless of which decision was starting or closing the cycle. Indeed one might want to know at which rhythm the combination of decision will appear and that at least one decision of each type will have to be made. The order in which those decisions appear does not provide any significant help for the decision-maker.

5.2 Findings: impact of decisions on growth's trajectory and identification of cycles

This section is organized into several sub-sections, each of them providing explanations about the impact of decisions on the growing firm's trajectory. Sections 5.2.1 to 5.2.5 focus on the performance of the company; section 5.2.6 provides interesting input on the sequences in which decisions appear (cycles) and on the pace at which decisions have to be made during growth periods. Section 5.2.7 provides a summary of all outcomes of this research study and explains how they will be used again in the last research study of the thesis.

5.2.1 Evolution of the performance of the company

Before analysing the data collected, a few observations were made about the performance of the company over the years. A high growth firm is considered "an enterprise with average annualized growth (in number of employees or turnover) greater than 20 per cent per annum, over a three year period, with a minimum of 10 employees at the beginning of the growth period"¹. Moreover, growing firms also present the characteristics of needing (1) a bank credit to support growth and (2) working capital that needs to be greater than a reasonable bank line (Sharlit, 1989) because its liquidities decrease.

In this case, the company faced an increase of 47% in its sales three years before investing in its new production building. After this important increase in terms of workload, the level of sales remained stable for three years. As soon as the company could build its new production plant, the sales increased again by 33% between 2012 and 2013. Between the years 2013 and 2014, the sales increased by 104%. The company employed 15 employees at the beginning of the period of growth. The increase between the years 2010 and 2014 was 33%, 35%, 63% and 61% respectively per year. It was also observed that the company incurred an important bank debt in the year 2011 to finance its new plant. Except at its creation in 1946, it was the first time that the company needed external financial sources to support its growth. The level of liquidities of the company decreased drastically (minus 160%) between the years 2011 and 2013 which also required an adaptation of the supporting bank line.

All of these results clearly place the case-company in the category of high growth firms. Moreover, so far, even though the financial balance of the company was weakened during the

1 Organisation for Economic Co-operation and Development, 2008, p. 61

growth period, the company's overall financial health is well (in 2017) and the future business perspectives are pleasing. The author will now relate these performance results to the analysis of the collected data and observe the impact of the company's performance on its sustainable business growth.

5.2.2 What does a decision look like?

Out of the 492 decisions observed, 15% are strategic, 49% are tactical and 36% are operational. 91% of them resulted in a positive decision (the manager said yes to the proposal). 6% of the decisions have been made already but have not been applied yet. 25% of decisions have been made and applied and 57% have been checked already. The rest of them are still in progress (as of the cut-off date of 31 December 2014) or have been abandoned. As foreseen, the majority of the decisions (82%) concern the focal firm (i.e. the case-company itself), 13% of them concern clients and only 5% concern suppliers.

Overall, the time spent to make a decision is slightly longer than the time spent to apply a decision. 5,5 months are necessary (median) to make a strategic decision (min = 1 month, max = 4 years). Strategic decisions are applied in 6,1 weeks (median). For operational decisions, the time to make a decision is 6 weeks (median) (min = 1 week, max = 7 months) and 15 days (median) are necessary to apply it.

The majority of the decisions are made on a one-by-one basis. Indeed, only 133 decisions (32%) were made together with at least one other decision the same day. These decisions are not necessarily related to each other. This might show the limited capacity of the manager to make several decisions at the same time.

Concerning the sequences followed by the decision-maker, overall the sequence "easy with or without work" appears in 71% of the cases, the sequence "difficult with no work" appears in 16% of the cases and the sequence "difficult with work" in 13% of the cases; which seems quite intuitive. By applying a chi-square test, the author observed that the variable "sequence" was correlated with the variable "level of decision" which means that they are not independent. Observing then the appearance of each sequence while splitting the data by levels of decision, strategic decisions follow in the majority of the cases (45%) the sequence "difficult with work". This result is much higher than what was predicted by the chi square test. This may be explained by the fact that a strategic decision requires more thinking and reasoning than other types of decisions.

5.2.3 *Do more but do it efficiently*

Considering decisions that have been made already, the author completed a comparison of the number of decisions made across the units of analysis (see Table 2 below). First, one might notice that the number of decisions has been constantly growing each year since 2011. This corresponds to the growth of the company in terms of turnover and number of employees. However, the relative increase (in %) tends to slow down over the years. This might be a sign for a stabilization period. The current research does not allow for verification as data were collected only until the end of 2014, but it could be investigated in future research. However, the result seems in accordance with proposition (P1.1) formulated at the end of the first research study – the number of decisions made during growth is higher than during pre-growth phase.

Year	Number of decisions	Relative change (in %)
2010	34	-
2011	30	-12%
2012	67	+123%
2013	131	+96%
2014	166	+27%

Table 2 - Number of decisions made by the company over the years

In order to find out which variables explain the duration necessary for making decisions, the author used two different types of multivariate regression (ascending and descending) to select the most relevant variables. Both regressions lead to a model that represents satisfyingly the reality ($R^2=0,882$) with the following independent variables: date of consideration of the decision, year when the decision was made, sequence followed by the decision-maker. One can therefore deduce that time spent for making a decision increases or decreases over time and that the sequence of decision-making also has an influence on it; both preliminary results ask for more investigation. It was also interesting to notice that the duration for making a decision is not influenced by the matrix cell concerned by the decision, nor is it linked to the category (type) of the decision. Even the financial consequence of the decision has no impact on the duration.

To understand what type of relationship exists between the date of consideration of the decision and the duration to make it, the author applied a series of simple regressions, by splitting the observations according to their level (strategic, tactical, and operational). It was indeed not meaningful to mix strategic decisions with operational decisions, as the time spent on average to make decisions in both categories varies greatly. The results for the strategic and operational

decisions are the most significant. As the slopes are clearly negative, time spent to make decisions shortens over time. The same can be observed for tactical decisions, even though the resulting R^2 is lower. The difference between the levels might be explained as follows: there was a bigger room for improvement regarding the learning potential at the strategic level as the company management did not have significant experience in making these kinds of decisions. For the operational level, the learning curve might be explained due to the gaining of experience resulting from a high number of decisions made in this category. Tactical decisions are somewhere in between the two other categories and therefore, no real improvement can be observed. Overall, it clearly shows that there is a gain in efficiency at any level; the company makes more decisions and more rapidly over the years.

This efficiency gain is consistent with the results of other studies about organizational learning. In their empirical study, Arumugam et al. (2013) observed that knowledge creation and transfer enhance performance. According to them, learning and the resulting knowledge creation are time dependent. Therefore, they call for longitudinal investigation that would provide insights into the dynamics of the effects of learning. This longitudinal study contributes to this by providing an example of a company that dynamically learned how to be efficient in its decision-making process.

Making a parallel with the number of decisions made by the company that increased drastically each year (see Table 2), one might presume a capability problem in terms of making the decisions or in terms of the quality of the decisions outcomes. However, this was not the case; the most likely explanation is that the company was able to reduce the duration required to make a decision without losing in quality and could therefore handle a higher number of decisions for an identical period. Today (2017) the company's health shows that the quality of the decisions made has remained constant over the years. Useem et al. (2005) were also able to demonstrate that the more critical decisions are, the more efficient the decision-making process will be. They also strongly recommend keeping on improving leaders' decision-making capabilities if a company faces new markets, chaotic conditions and a new position. Improving its decision-making process was therefore crucial for this case-company. The study of Paul et al. (2004), who investigated empirical validity of using memory support on cognitive-conflict type of decisions, also presented similar results. They observed that this technique leads to faster decision-making in groups with a perceived good quality of decision. This demonstrates that a faster decision-making process can maintain an identical level of quality of decisions. These results that concern groups and not individual decision-making process incited the author to

observe how the collaboration between managers of the case-company as well as the quality of their organization could be linked to the decision-making efficiency.

Investigating the decisions according to their categories, the author observed that the only category that did not exist at all in 2010 and kept increasing drastically over the years is “organize the management and the plant”. Besides this, investments decrease over time (their percentage is lower and lower each year), marketing actions and the number of employees hired has also stabilized during the last year. Interestingly, the number of accepted projects remains stable. These observations represent a typical growth period; the company has to invest more at the beginning, as well as hire more people, and then it slowly stabilizes. The number of projects accepted is not higher in terms of number but in terms of workload. However, as the company grows, managers have to keep organizing their teams as well as the plant repeatedly.

In the attempt to verify if organizing the company was related to the organizational learning of the management team, the author investigated the link between the duration to make a decision and the sequence followed by the decision-maker. The hypothesis was that both sequences integrating a “difficult path” would be linked with the duration, as they both require a good collaboration between managers in order to be finalized. The author therefore filtered decisions on this basis in order to run the regression again. Interestingly, it was observed that there was only a highly significant relationship between the duration to make a decision and the sequence “difficult with no work” followed by the decision-maker ($R^2 = 0,722$). Not only does the company need the learning of the manager her/himself, but it also requires for the organization to learn something. Indeed, as this sequence of decision requires a triggering effect to motivate the decision-maker going out of his/her cogitating loop, other managers also need to improve their team work skills to support her/him at the right time. Moreover, this sequence does not allow the decision-maker to “work” on the decision and therefore other managers’ support is crucial. The link between management support and decision-making efficiency has been studied by Heffner and Sharif (2008) who developed a framework that can be applied in a managerial decision making process. They found that most competitive organizations are the ones that can “learn to learn”; companies that are able to incorporate learning processes into operations and management continually improve their knowledge. They also point out that knowledge of employees has to be integrated in order to generate sustainability. This result seems to be verified in this case as the knowledge accumulated by different managers supports the decision-making process globally.

Related to efficiency, the author finally observed that only 57 decisions out of 416 had been made instantaneously (i.e. in 1 to 10 days). All other decisions had been made only later (i.e. the manager waited before making the decision). While waiting to make a decision, the manager has time to observe what comes out of the precedents decisions (what is their impact on the company) and eventually to adjust its decision-making process accordingly. From this point of view again, waiting would equal learning. This observation is totally consistent with the results of Grenadier and Malenko (2010) who developed this “option to learn”, linked to real options theory. As each decision (e.g. hiring new profiles, establishing new working techniques, buying new machines, ...) might impact other elements and provide the company with new information, managers do not only have the option to wait or to act now, they also have the “option to learn”; in this way they might use new information gathered and absorbed during the waiting time to make a better decision afterwards. This rationale seems applicable in the observed case, even though it is likely that the case-company managers did not “learn on purpose” and did wait to make their decisions only because they did not know what decision to make when starting to consider them.

5.2.4 Do more but do it socially

One of the most surprising results concerns the TBL aspects. It was observed that all together, much more decisions were concerning social aspects (31,10%) than environmental aspects (2,64%). One possible explanation could be that the company had more room for improvement in terms of social aspects. This is verified by observing the drastic increase of consideration of social decisions over years (7 in 2010 up to 70 in 2014). Indeed, in its old building, the company could not offer good working conditions to the employees. Moreover, decisions that improve the well-being of employees (which are included in social aspects) might be necessary if the company wants to have a stable growth. Consequently, growth obliged somehow the company to consider more aspects that are social. Another explanation might be related to the results of Martinez (2014) who developed a model that explains heterogeneity in business conception of environmental and social responsibility. The model might imply a spreading of consideration towards green and social aspects across multiple levels in the organization; managers can trigger a "maturation" journey to start e.g. with an environmental development that will then lead to developing social aspects at the individual level of the company (philanthropic activities for example). One might envision that the same phenomenon will happen here; considering and developing first social aspects will then naturally lead the company to consider environmental aspects in a second stage.

Furthermore, the fact that the majority of environmental decisions are made on the strategic level warrants some discussion. Indeed, this link between strategic and environmental decisions seems somehow intuitive, as it might be more difficult to take care of environmental issues in operational decisions than in decisions that are long-term oriented. Environmental objectives need strategic (long-term) planning and involve substantial investments. On the other hand, almost half of all operational decisions are socially oriented. This might be explained by the fact that many decisions that result in improving the well-being of employees are operational. Moreover, social decisions are most of the time highly correlated with productivity; whether environmental decisions intervene at another level, not necessarily correlated to productivity.

Results concerning the TBL fill to some extent a gap identified by several researchers. Seuring (2013) or Brandenburg et al. (2014) for example, in their review for SSCM, found that the social dimension is almost completely missing or comprehended in a far too simplified manner. Therefore, they both recommend evaluating social aspects in detail. Brandenburg et al. (2014) also highlight that a lack of social sustainability research might give the impression that social aspects are only theoretical constructs with limited relevance. Just the once will not hurt, this research demonstrates empirically that there are some cases where social aspects are fully considered, even more than environmental aspects. By using the author's matrix for consideration of the operations decisions a way to fill another gap is proposed, as identified by Seuring (2013) who claims that decision-making should integrate all three aspects of the TBL and that in particular their interrelations require further research.

5.2.5 Do more but do it comprehensively

Based on the preliminary results of the first research study of the thesis, one of the objectives of this thesis was to observe the appearance of each matrix cell overall. It was very interesting to observe that 6 out of 27 cells represent 80% of the decisions made. This proportion follows eventually a Pareto distribution (see Figure 8 below). The six cells all concern the focal firm (so the company itself), however, they combine economic and social aspects and all levels of decisions (strategic, tactical and operational). This means that with 80% of its decisions, the company covers a large variety of challenges that appear during the growth journey.

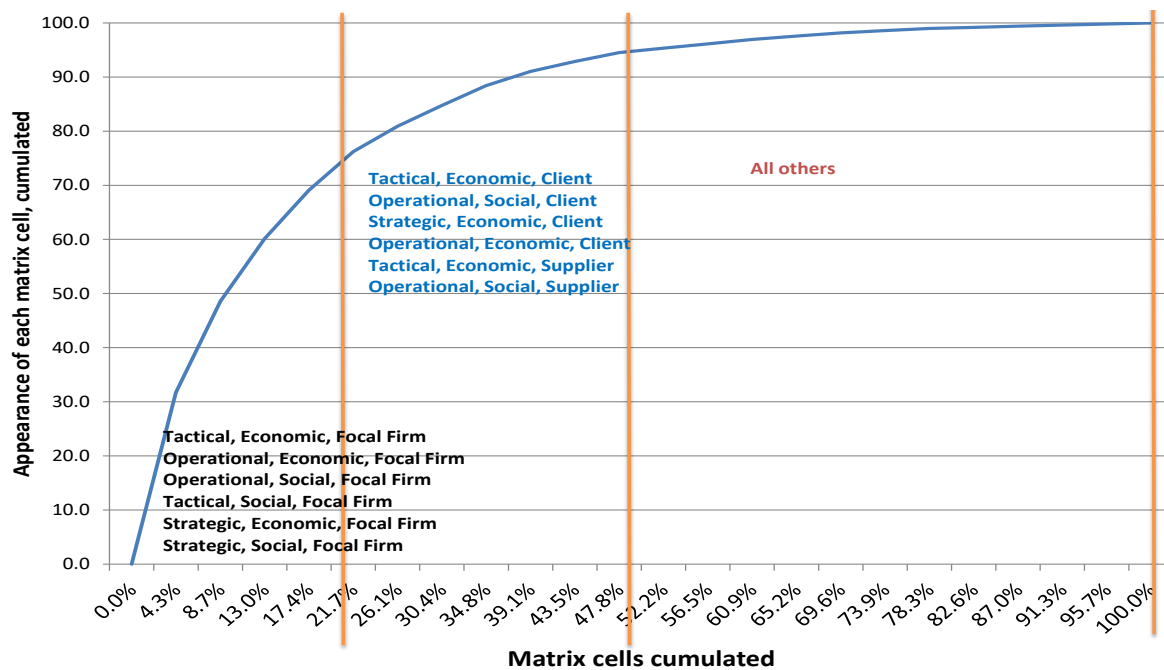


Figure 8 - Pareto distribution / ABC classification for matrix cells apparition

At the end of 2014, the company considered 23 cells out of 27. Cells excluded were “strategic-social-client”, “strategic-social-supplier”, “tactical-environmental-client”, and “operational-environmental-client”. This shows that at this stage of its development, the company does not fully consider clients and suppliers and mainly focuses on itself (focal firm). Consequently, there is room for improvement at this level for the case-company. Another explanation is that it is quite challenging to make (e.g.) a strategic decision that concerns a social aspect of the supplier; this might also explain that there are fewer decisions considered that fulfil these matrix cells.

Regarding the evolution of the company towards matrix cells consideration, in 2010 only ten cells were considered. One cell was added in 2011, followed by six new cells in 2012. Three additional cells were added in 2013 and again in 2014. Consequently, each year, new matrix cells were considered by the company, which was integrating other levers of its supply chain, as well as other levers of the TBL. The result is that a growing company seems to use its growth not only to do more but also to consider more and more stakeholders as well as TBL aspects over time. Wu and Chang (2012) have made similar observations by studying the performance impact of electronic supply chain management diffusion. They also observed that the well achievement of performance was done at the external diffusion stage (i.e. last stage) rather than at adoption or internal diffusion stages. They explain this regarding the time-lag effect that plays a significant role in leading the full-achievement of the supply chain management (in their case) internally and only afterwards externally. In this case, one might suppose that the

company is still in the process of expanding the variety of decisions considered and that it will achieve a complete consideration of the matrix cells in the near future.

5.2.6 Cycles of decisions and pace at which they appear

This section presents the results concerning the cycles (series of decisions) that appear during growth periods, obtained with methodology presented in section 5.1.3 – identification of cycles of decisions. Table 3 below provides detailed information about the outcomes of the eight most interesting combinations observed (the combination mixing decisions considered and decisions made was finally abandoned in order to focus on decisions made only). Combinations with the most interesting results are in the left part of the table. The combination that considers all categories (eight in total) is at the very right of the table.

The author would like to provide complementary information with combination “Variants A-H-I-O” as an example. With this combination, in total over the whole period, 85 cycles of decisions have been made with an average time spent (in days) of 50 days in 2010 up to only 12 days in 2014 (including week-end days) – which means that, in 2014, every 12 days, at least one decision of type “accept project”, one decision of type “hiring-firing”, one decision of type “invest” and one decision of type “organize” are made.

While observing the evolution of cycles made over the years, one will notice that 2011 (the second year of growth) has the lowest number of cycles ended. The first year of growth (2010) is probably denser in terms of decisions because growth was being launched and many decisions were necessary to actually initiate the growth period. 2011 is lighter as things got moving slowly and as of 2012, a faster pace is noticeable. During the following three years, up to the end of the observed period, a cycle is closed first on a monthly basis and finally on a semi-monthly basis.

		Variants A-H-I-O A,H,I or A,I,O or A,H,O or A,H,I,O	Periods A-H-I-O A,H,I → A,I,O – > A,H,I,O → A,H,O	A,H,O,I	A,H,O,I,W	All except E & M A, H, O, I, W, D	All except D & M A, H, O, I, W, E	All except M A, H, O, I, W, E, D	All 8 A, H, O, I, W, E, M, D
Number of cycles	ALL	85	61	49	26	15	11	11	11
<i>(a cycle is over each type the mentioned combination of decisions is made completely)</i>	2010	7	6	1	1	1	1	1	1
	2011	3	2	2	1	1	1	1	1
	2012	17	8	8	3	3	1	1	1
	2013	26	19	19	7	4	5	5	5
	2014	32	26	19	14	6	3	3	3
Average time spent for a cycle (in days)	ALL	21	29	36	70	119	163	163	163
	2010	50	50	203	244	346	244	346	346
	2011	91	161	209	231	129	231	129	129
	2012	26	48	48	146	146	437	437	437
	2013	15	23	23	76	125	109	109	109
	2014	12	13	18	26	61	112	112	112

Table 3- Results of cycles' analysis

Legend of decisions categories:

I: invest

M: make marketing

A: accept projects

H: hire-fire

O: organize

W: improve well-being

E: support environment

D: develop business

On average, over the whole period, a combination of these four types of decisions is made every 21 days, which represents less than a month. This means that during a period of growth, the decision-maker (the CEO in most of the SME cases) has to get ready to make decisions as important as hiring a new employee, investing a significant amount of money, reorganizing part of his/her plant and accepting a client's project of more than CHF 100'000.- several times a month.

“In 2014, I had the feeling I was doing nothing but making important decisions. Each week, I had to decide crucial things for my company that I was used to decide once or twice a year beforehand. This made me feel uncomfortable. I had no idea if this was normal or if I was somewhat crazy. Now (2017) that I've understood that making decisions is part of the journey and crucial for the sustainability of the company's growth, I decide things much more rapidly and with no doubt that deciding has to be part of my primary activities” (SCHWAB-SYSTEM CEO).

It appears to be crucial for a decision-maker actually to stay effective while making decisions, especially during growth periods. While not deciding, disequilibrium remains in the operations of the company and if this lasts for too long, this disequilibrium might eventually lead the company to critical situations. This result is again consistent with the advices of Useem et al. (2005) who observe that efficiency of the decision-making process is crucial in determining the future trajectory of a company, especially in the context of chaotic conditions or, in this case, disequilibrium. In order to be trained and ready for facing numerous decisions, the decision-maker might feel more comfortable if s/he knows how many decisions s/he will have to make on average and at which pace. The decision-maker will probably also be more efficient at deciding while being conscious of the quantity of decisions that are supposed to pop up in the intense growth period. This is in line with the study of Clemen and Reilly (2013) who mention that it is important in some situations to consider future decisions as well as the immediate decision at hand. Being aware of the type (category) of decision that will appear in the majority of the cases is also an advantage for the decision-maker. S/he might even anticipate what type of decision will have to be made next, if s/he already has made three out of four decisions within a cycle. This would demonstrate a high-capability to efficiently lead the company during growth periods.

5.2.7 Resulting outcomes used for next research study

This section provides outcomes arising from the second research study. These results will be used in the following and last research study of the thesis. The objective of the second research study was to observe a complete period of growth and to understand how decisions influence the growth's trajectory of the firm. The ultimate goal was twofold; first, it was to identify which categories of decisions have to be made on a regular basis and at which pace; second, it was to collect and compute data that might be used to develop a simulation modelling representing a growth phase.

It was observed that effective managerial decision-making is an important contingency factor and a key measure during growth periods. Regarding the decision-making process itself, eight major categories of recurring decisions during growth periods were identified, while average speed and specificities of decisions were recorded. In terms of impact of decisions, the author has identified that companies can make the most out of their growth and benefit of not only doing more things, but also of doing things better; a growing company can specifically act on three main axes, i.e. efficiently, socially and comprehensively. In terms of improving its efficiency, a growing company might learn how to make a larger number of decisions during a similar period, without diminishing their quality. Learning can be observed among managers of the company who acquire the ability to support each other during the decision-making process. Regarding the second axis, a growing company will consider social aspects as key-elements all along its path and take actions to improve stakeholders' well-being. The environment is considered as well, however more actions are taken regarding social aspects. This fills a gap acknowledged by the review papers by Seuring (2013) and Brandenburg et al. (2014) who found that the social dimension is almost completely missing in modelling research or not yet fully understood. Therefore, they both recommend evaluating social aspects in detail, which the author will do in the last research study. Finally and concerning the third axis, the growing firm will integrate new actors in its global reflexion and behaviour. The result is that a growing company seems to use its growth not only to do more things but also to consider more and more stakeholders as well as TBL aspects over time.

Collaboration between middle and top management is crucial for maximising the efficiency of the decision-maker – and therefore the chances of the company to have a sustainable growth. In terms of cycles of decisions, the author observed that during peaks (very intense growth) periods (2014 in this case-company), the number of completed cycles reaches 32 – with a complete combination of decisions made every 12 days on average.

This part of the analyses: (1) raises the necessity to make decisions at a steady pace during growth periods; (2) encourages managers to consider social aspects during the whole period of growth; (3) inspires managers to make decisions as diverse as possible that concern a maximum of cells of the matrix (framework of research study one); (4) reassures managers that the feeling of doing nothing but deciding is totally normal and should even be a priority during growth phases; and (5) provides very complete data (collected and computed) that will be reused to create the modelling simulation and to calibrate it. The complete list of data that will be used for the next research study is provided in appendix 2 (section 10.2).

This second research study answers research questions (4) and (5). The impact of decisions on growth's trajectory is measured; cycles of decisions are identified and the pace at which decisions come up is computed. This research study provides some understanding of a global period of growth and of the relationships between multiple aspects that have to be taken into consideration while growing. Thanks to the data collection and the analyses realized in that research study, information necessary for building a model that represents a period of growth (last research study of the thesis) is available. Still open research questions that will be answered in the ultimate research study of this thesis are questions (6) and (7).

6 Research study 3: creating the model representing a period of growth

This chapter builds on empirical findings of a five-year longitudinal case study on sustainable business growth and operations capacity extension. It introduces the last and most complex research study that answers the following outstanding research questions:

- (6) How can the risk of bankruptcy during growth be measured?
- (7) How can the decision-making process of growing SME managers be supported in order to sustain the growth of their firm? And more precisely:
 - a. What is the impact of the efficiency to make decisions on the growth trajectory of the firm?
 - b. What is the impact of the sensitivity towards well-being and environment on the growth trajectory of the firm?
 - c. Which KPI can be monitored in order to increase the probability of a sustainable business growth?

In order to answer these research questions, the author has built a simulation model that represents a complete period of growth. The ultimate objective is to develop a supporting tool that can heighten awareness of companies' CEO and managers about what the challenges are during growth periods and eventually also about what key aspects have to be tracked during growth in order to maximize the chances to have a sustainable growth.

This chapter provides information about the model development and is divided into three main sections. The first one presents simulation modelling, and explains which choices have been made in terms of simulation modelling techniques for this research. The second section provides details about the different types of analyses that were performed once the model was built and calibrated. The third section presents the main results coming out of the analyses as well as what advice can be provided to companies' managers.

6.1 Methodology: simulation modelling

Simulation allows for modelling interactions within and also across organizations; it is a frequently used methodological approach for understanding fundamental processes and interactions and for developing theory in terms of gaining structural insights within a certain research domain (Davis et al., 2007). Simulation is particularly beneficial when the underlying research question captures a variety of highly interrelated variables - which leads to high levels

of complexity (Davis et al., 2007, Harrison et al., 2007). More specifically, Jahangirian et al. (2010) underline that simulation is well-suited to address difficulties that arise from distributed decision-making within organizations. Moreover, simulation-based studies allow for the analysis of various forms of strategic decision-making in different contexts of complexity and turbulence. These issues would be rather demanding—not to say impossible—to investigate by analytical modelling due to problems of the multitude of variables to be controlled for (Leitner and Wall, 2015). According to Will et al. (2002), quantitative model-driven empirical research methodology provides interesting opportunity for OM researchers to further advance theory in the field.

Among the major existing simulation techniques two are of high relevance for the presented study, i.e., system dynamics (SD) and agent-based (AB) modelling. They are commonly used separately or, more recently, also in combination. SD has been introduced by Forrester (1961) as a methodology for facilitating managerial decision-making that is grounded on the idea of nonlinear dynamics, causality, and feedback. Typically, SD allows for modelling a system by a set of simple processes with circular causalities (causal loops) among them; the behaviour of the system under investigation results from the interrelated processes (Sterman, 2000). Besides the study of Sterman et al. (2007) who have used System Dynamics in order to demonstrate that disequilibrium dynamics and bounded rationality need to be considered while determining competitive outcomes, and the study of Oliva et al. (2003) who addressed the issue of negative feedback loops that can limit growth, SD has not been an approach used to represent the process of business growth. SD is rather used for modelling sales evolution or pricing strategies of different products (Reiner et al., 2009, Reiner et al., 2015).

AB has found increasing application in management studies as it is used to gain a deeper understanding of the complex nature of several phenomena such as comparing and evaluating organizational models, observing team formation towards action, improving energy outcomes, understanding group behaviours (Ghose et al., 2015), representing manufacturing resources or aggregations of resources (Lam and Ip, 2010) and simulating vehicle routing problems in logistics distribution (Fan et al., 2009). The principle of AB modelling is to specify the behaviour of agents individually and to see how they interact with each other over time. Agents can be of any type and this simulation technique allows for an important degree of flexibility towards the modelling process (Macal and North, 2010). AB promises to have far-reaching effects on support decision making at different levels of management (Serova, 2013).

While it is an important decision in the research design phase which modelling paradigm is most useful for the problem at hand, there may be cases where a hybrid approach—i.e. combining paradigms—might be more appropriate and enhances simulation outcomes. To determine which techniques to use or to combine, one needs to specify the design of the model and to condense the parameters that will be integrated to represent the reality (Swinerd and McNaught, 2014). By doing so, and for answering the research questions, the author decided to combine elements of SD and AB simulation, in order to represent the growing firm and the decision-making therein as a whole. A hybrid simulation-based research could contribute to a deeper understanding of the consequences of the decision-making process of managers during growth periods as well as of the dynamics of the operations and organization of the growing company. Both SD and AB have demonstrated their relevance to model operations management problems. SD has been popular for studying a variety of strategic management issues, such as the diffusion of new products on the market. In terms of operations management, it also deals effectively with stock management and logistics problems. AB slowly becomes popular in several facets of operations management representation. Most represented issues are supply chains, market and competition, project and assets management – with at time a high level of complexity. Recently, these two techniques have also been combined, e.g. modelling a market through AB and its supply chain or product diffusion through SD; modelling restaurant business operations with consumers and restaurants modelled as agents and money flowing within each restaurant groups as SD. Moreover, new phenomena have been modelled with combined techniques such as designing flexible manufacturing supply chain, user satisfaction of a product and network capacity. To the best of the author’s knowledge, a combination of these techniques has not been used so far to model the impact of growth decisions of a company from an OM point of view. The use of these simulation techniques is warranted as the multitude of variables precludes analytical modelling approaches (Wall, 2015).

The author used the software AnyLogic (www.anylogic.com) to create the models, one of the few software tools that allow combining modelling techniques. In order to present the methodology and results of the simulation part of this study in a systematic way, the author has followed the guidelines proposed by Rahmandad and Sterman (2012).

6.1.1 Overview of the model and interrelatedness of parameters

The main objective of the model is to represent the period of growth of a SME. Its complete description is available in appendix 10.3; the main dependencies transcribed in the model are the following:

There are clients who order projects to the company – some clients will order several projects during their relationship with the firm. When new projects are accepted, resources are organized in order to complete them. Projects are sorted according to their level of urgency. Clients' satisfaction is influenced by the capacity of the company to achieve projects on time. Clients' satisfaction influences the word-of-mouth and the intention of repeating orders.

One of the major processes modelled in the company is the allocation of resources to projects. Resources are of two types: permanent and temporary employees. Permanent employees are allocated first, and teams might then be completed by temporary employees. Medium-term forecasts are made in order to determine how many employees should be hired / fired each week. The level of happiness of employees is continuously measured. It is influenced by the quantity of workload and by the well-being actions made by the company.

Another important aspect modelled is the financial set of processes of the company: liquidity and credit limit evolution as well as payment processes. Almost all processes of the model somehow influence the liquidity level. When a project is completed, clients pay the final invoice and liquidity level increases. When the company pays wages, suppliers invoices, amortization or investments, the level of liquidity decreases. Financial processes related to the financial partner are also modelled; the financial partner defines the credit limit, debt level and leasing amount.

Depending on its evolution over time, the company will start to grow – e.g. by accepting more projects, hiring more employees, investing in infrastructure, etc. As a result, and in order to maintain or restore equilibrium continuously, some decisions will pop up in the model, each time disequilibrium appears. Each decision will remain “under process” for some time, until the decision-maker finally makes a decision. As soon as the decision is made, it impacts the operations of the company and restores equilibrium, at least for a while.

All aspects of the model (parameters, variables, etc.) are somehow interrelated to each other, in order to match with reality as well as possible. Economic, social and environmental actions impact each other aspects continuously during the simulation. Therefore the model is considered as dynamic and addresses the interrelatedness of the TBL pillars as well as the evolving aspects of growth.

6.1.2 Development and construction of the model

In order to keep the model fully under control during its development, parameters were added on a stepwise basis. 302 steps were necessary to develop the complete model – the list of all detailed steps in their chronological order of integration while building the model up has been the common theme for the author during the model creation. The model was constructed first with separated sub-models (as advised by Rahmandada and Sterman, 2012) that were brought together in the end. The major parts of the model are presented in this chapter while giving an overview of the model logic; logic specific to each sub-model, main elements, functions and events are described in detail in the appendix 3 (section 10.3).

In order to grasp how a company's operations evolve over time, the dynamic dependencies of operations and financial processes as well as the behaviour of major actors have to be modelled. The modelling logic comprises two main processes: the operations and the decision-making process. The former operates continuously; each time disequilibrium appears between two or more elements of operations, a decision arises. Each decision has to follow a sequence of steps (pattern) according to its own characteristics before being made. Once it is accomplished, it impacts the operations and restores equilibrium. However, if a decision is not made for a long time, disequilibrium remains and the risk of negative repercussions increases.

More specifically, the hierarchy of the case-company is synthesized into three main hierarchical levels: 1) the company's CEO, who is the decision-maker (this is a common situation in SMEs), represented merely by the company itself (single agent) 2) the managers (population of agents) and 3) the employees (population of agents). Clients of the company are another population of agents who order projects (population of agents) on a regular basis. The company single agent contains many of the operations dynamics observed in the case-company (projects allocation, temporary and permanent employees recruitment, payment systems, investments, organization of the teams, etc.). The populations themselves contain specific dynamics such as happiness evolution of employees (SD feature), client satisfaction evolution (SD feature), project progress, etc. All of these logics are described in the appendix 3. Decisions with specific characteristics and behaviour (eight populations of agents, one by category) come up each time disequilibrium appears and will impact the operations differently each time they are made. Decisions are also described in the appendix 3.

Figure 9 represents the different population of agents and the relationships between them in the model. As seen on the figure, a decision arises when disequilibrium appears (as shown on the scale at the top of the figure).

In order to base the model on a real-world case and to derive valid recommendations for business practice, the author used empirical data from the case-company SCHWAB-SYSTEM. As mentioned previously, decisions were collected during its period of constant reorganization. Besides that, numerous internal processes related to operations within the company were identified and recorded as well. The totality of elements (decisions and processes) that were collected during the longitudinal case study has been integrated in the model logic and behaviour.

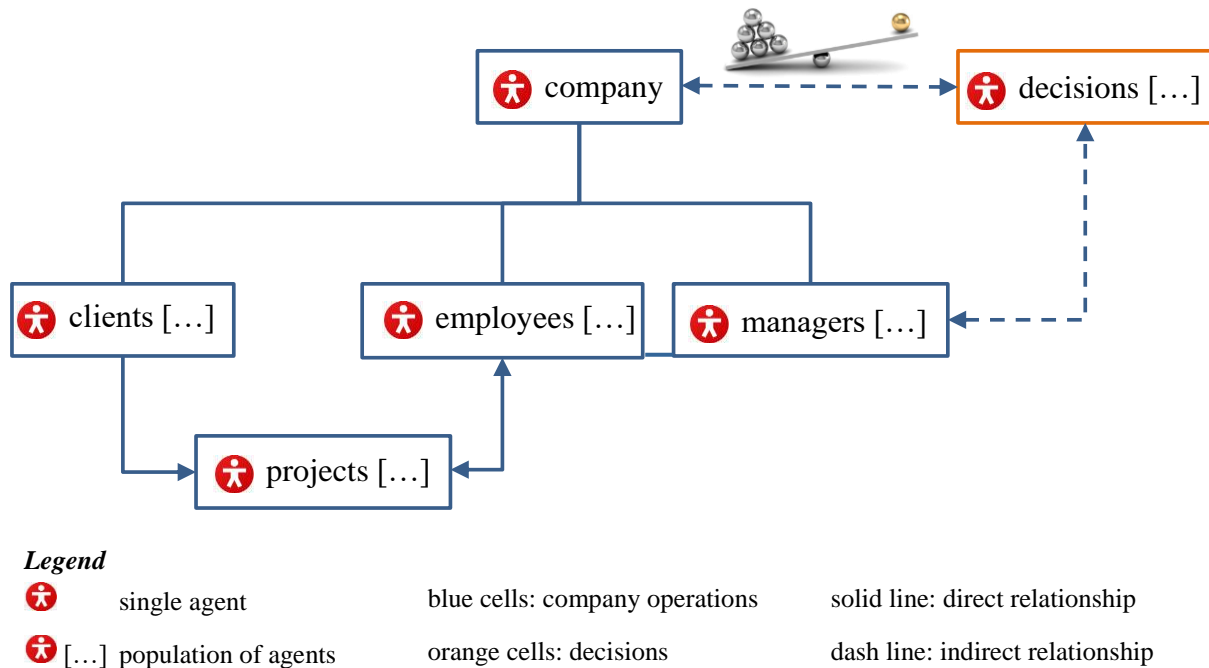


Figure 9 - Decision arising from disequilibrium

With respect to empirical data collection, the model development has been realized in several phases. First, based on archival data and direct observation, the author developed a basic model and observed if it corresponded to what happened in the company. An initial series of adaptations was introduced. Second, some of the interviews with managers have been conducted, in order to verify that the first model and the relations between its core elements were representative of the reality. Once the model was entirely completed, a last series of interviews was conducted with the CEO of SCHWAB-SYSTEM and with the CEO of another construction company as well, in order to validate its main mechanism and logic.

While creating the model, one of the first questions that arose was the choice on units in terms of time. In order to grasp and represent as much details as possible, it was decided to choose the unit “day” in the model properties. The level of details that can be reflected this way is the most representative of the level of analysis and of the type of data that was collected in the case-company. On the one hand, a bigger unit (e.g. week) would not have been able to transcribe all

the details of the processes observed. On the other hand, a smaller unit (e.g. hour) would have been too precise, regarding the fact that observed processes take place on a daily basis as the highest frequency.

In order to match with the reality of the case-company, the model start date was set to 2010-01-01 and the comparison period ended on the 2014-31-12.

The selection mode for simultaneous events is FIFO (in the order of scheduling).

AnyLogic, as most of the Java-based software, allows for writing some information in a console using the so-called “traceln” function. This function is particularly useful for the model designer in order to verify that the model is doing what it is supposed to do – verifying the model behaviour only based on visualizing what happens during simulation is very difficult and sometimes even impossible; it can also be used to analyse in detail what happens during simulation; and finally it can help the model-user to follow what the model is doing while running (Rodeghero et al., 2015). Traceln function was used to track all important information coming out from the running simulation. In order to control what information was written down in the console, boxes were created for each subpart of the model. If e.g. the box “allocate projects to resources” is ticked, related information is written down in the console. The model user can therefore follow how projects are sorted according to their level of urgency and how permanent and temporary workers are allocated to projects. As soon as the box is unticked, information stops being written in the console. Refer to Figure 10 to see the console writing control. If all boxes are ticked, the console writes everything that happens during simulation down.

CONSOLE: processes to check in console tick / untick ALL

<input type="checkbox"/> ALLOCATE employees to projects	<input type="checkbox"/> INVEST and PAY	<input type="checkbox"/> HIRE	<input type="checkbox"/> CLIENTS behaviour	<input type="checkbox"/> DECISION making-process
<input type="checkbox"/> COMPLETE PROJECTS	<input type="checkbox"/> collect CASH	<input type="checkbox"/> FIRE	<input type="checkbox"/> respect ENVIRONMENT	<input type="checkbox"/> support of MANAGERS to decision-making
<input type="checkbox"/> JOIN allocated projects		<input type="checkbox"/> TEMPORARY		
<input type="checkbox"/> put to REST		<input type="checkbox"/> ORGANIZE		
		<input type="checkbox"/> improve WELLBEING		
				<input checked="" type="checkbox"/> LEARNING-CURVE based on SEQUENCE

Figure 10 – Console writing control

In order to build a model as efficient as possible (in terms of coding), duplication has been avoided. This means that all codes that are used by several elements (functions, events, etc.) have been wrapped in common functions that can be called up from everywhere. Wrapping codes helps with keeping the model clear and easy-to-adapt when necessary – a code has to be

changed only once (in the wrapped function) rather than several times in all elements where its content would otherwise appear.

The main level in AnyLogic always refers to the reference level. All levels in the model are somehow connected to the main level. At the main level, there are three agents: the company (single-agent), the clients (population of agents) and the projects (population of agents). As the author focuses on the growth of one company, the case-company is represented as a single-agent. In that case, all clients in the model work with this company and this company completes all projects. It could be possible in future research to turn the single agent into a population of agents – meaning that there would be several companies on the market, each of them having its own clients and projects. Including competition would help with observing the impact of the growth of the competitors on the growth of the firm (as they might not be independent).

Clients order one or several projects to the company that will complete them. Clients and projects being represented as population of agents means that each client represents one agent among the population; similarly, each project represents one agent among the population of projects. This means that within one population, all agents share some common characteristics, but they are unique and can behave or be treated differently than their peers to a certain extent.

There are more populations of agents embedded in the company single-agent –e.g. permanent and temporary employees, managers and decisions. When a population is embedded in an agent, it means that each agent of this type (company in this case) contains the same embedded agents – e.g. if there were several companies in the model at hand, each of them would contain permanent and temporary employees, managers and decisions.

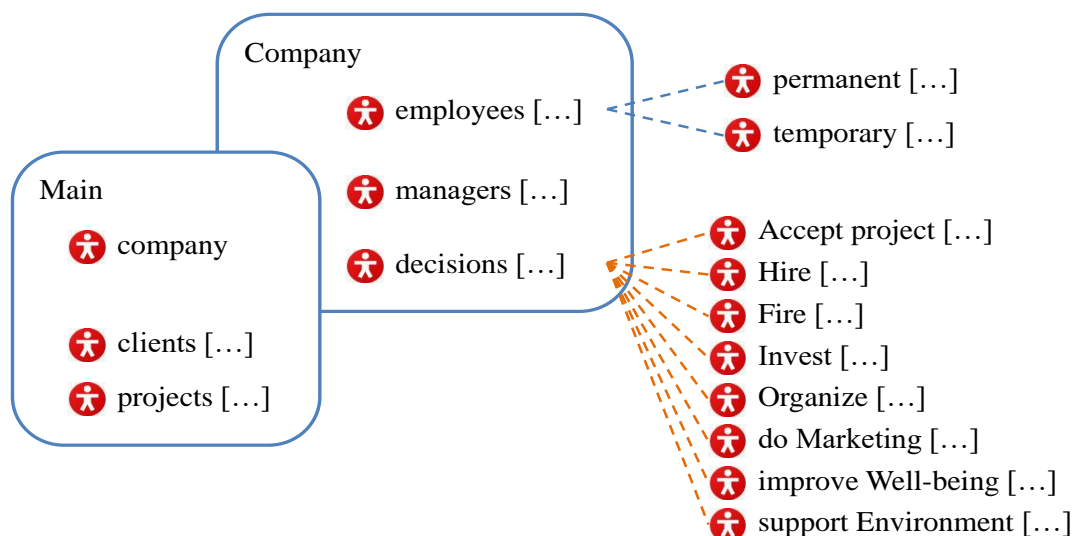


Figure 11 - Model structure with embedded agents

Populations might also be created as an abstract type of agents, and therefore several populations of agents extend the abstract population. In the model, this is the case with employees and decisions populations. Abstract populations and their extension will also be presented in detail in the appendix 3. Figure 11 explains visually how populations are embedded to each other and which populations share the same basic characteristics. The complete model is presented in detail in appendix 3. The entire programming logic is also described in the appendix, which is structured as follows:

- Section 10.3.1 presents the main level of the model – the dashboard with most important KPIs to monitor during growth periods.
- Sections 10.3.2 to 10.3.7 present the different populations of agents, namely clients, projects, employees (abstract, permanent and temporary) and managers. Each population logic and behaviour is described in detail.
- Sections 10.3.8 to 10.3.11 present some fundamental operations of the company such as the completion of projects, the payment processes, etc. Main operations are described; related variables and functions are explained in detail.
- Sections 10.3.12 presents the decisions population; highlighting the main logic and behaviour of this population of agents.
- Sections 10.3.13 to 10.3.20 present all decisions categories in detail. Each decision type has its own specificities and programming characteristics; they all are presented in these sections.
- Sections 10.3.21 to 10.3.23 present the final model configuration; how growth can be visualized during simulation, how bankruptcy is identified while the model is running and how the initial values of the simulation were set.

Appendix 3 therefore allows the understanding all the specificities of the model creation; main aspects, logic and processes are described there in detail. Moreover, appendix 6 (section 10.6) presents complete documentation about the model.

6.1.3 Correspondence with empirical data

Before closing the presentation of the model, the author would like to synthesize which information was collected, observed, analyzed and discovered thanks to the empirical data, and that was then fully introduced into the model. The objective while creating the model was to properly represent the operations of an SME and the dynamic of growth, represented through

the decision-making process made each time disequilibrium appears and other internal processes, with the final aim of being able to measure the risk of bankruptcy and to understand which parameters highly influence the trajectory guiding to sustainable growth. In order to develop a model close to reality, the totality of elements and logics that have been presented in this methodological part are based on empirical data; not a single part of the model has been created arbitrarily.

In the first research study of this thesis, the author zoomed in on decisions and identified three patterns that are followed by the decision-maker and which sometimes require the support of managers. This full logic has been integrated into the model by means of the decisions and managers populations. The author also proposed a classification for the decision through the cubical matrix, which helps mapping the territory of decisions. Each decision that pops up in the model corresponds to one precise matrix cell – respecting the distributions of all characteristics – and can therefore be classified accordingly. This allows observing and tracking the diversity of decisions made. Average time to make and to apply decisions has been modelled according to collected data.

In the second research study, the complete period of growth was analyzed into details. It became apparent that a growing company could take advantage of its growth to perform better and act on three axes: efficiently, socially and comprehensively. All of these evolving aspects have been represented in the model. During the growth journey, the company learns how to make a larger number of decisions during similar – or even shorter - periods; this is modelled through the time in process that decreases when a certain number of decisions of the same category are made. The company can take actions to improve stakeholders' well-being and to support environment seriously – this is modelled through the sensitivity towards well-being and environment concerns, which are presented in appendix 3, sections 10.3.19 and 20. Finally, through diverse types of decisions that appear in the model, the company integrates new actors in its global reflexion and behaviour. Moreover, the model reflects how many decisions were made instantaneously (percentage computation). During this second research study, the author also identified that some decisions from different categories are always made one after the other. This logic was transcribed through cycles of decisions and can be observed in the model exactly as it is in reality.

Moreover, internal processes of the company have been modelled into details in order to represent global operations in their entirety. As liquidities are at the heart of a firm's challenges during growth periods, the time during which cash is unavailable for the company is critical.

Based on information collected in the company, it was possible to integrate several dynamic variables that continuously calculate the cash-to-cash cycle time, assuming that the shorter it is, the better for the company operations and flexibility over time. Liquidity is also represented on a chart on the main page of the model. To continue along financial parameters, all modelled elements have been taken out of the profit and loss and balance sheets of the company over the years. For example, quantity of investments during the growth, and location costs - converted in infrastructure value - were extracted from the balance sheets. Turnover level comes from the profit and loss statement. Quarterly level of liquidity has been collected directly through the accounting software of the company. All leasing contracts between 2010 and 2014 were recorded in an excel sheet (Figure 12):

Date	Total courtage	Total	Peugeot 307SW	Peugeot 807	FARO	Toyota Hiace	Toyota Verso	Peugeot 3008	Toyota Hiace	IVECO	Evoco 2013	Peugeot 207	Toyota Verso/Lun a 2014	Renault Trafic	Peugeot Boxer 2014	Peugeot Boxer 2015	Renault Trafic 2015 (L)	Renault Trafic 2015 (G)	FARO focus	PRESE	Scie Martin T75	MANITOU	Kindig UNIQ-S	ARTESA toupee	FARO laser 3D	CNC/men userie
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01.02.2010	3 854.75	3 854.75	795.00	852.80	2206.99																					
01.03.2010	3 854.75	3 854.75	795.00	852.80	2206.99																					
01.04.2010	3 854.75	3 854.75	795.00	852.80	2206.99																					
01.05.2010	3 854.75	3 854.75	795.00	852.80	2206.99																					
01.06.2010	3 854.75	3 854.75	795.00	852.80	2206.99																					
01.07.2010	3 854.75	3 854.75	795.00	852.80	2206.99																					
01.08.2010	3 881.30	3 881.30	852.80	2206.99	2271.00																					
01.09.2010	3 881.30	3 881.30	852.80	2206.99	2271.00																					
01.10.2010	3 881.30	3 881.30	852.80	2206.99	2271.00																					
01.11.2010	3 881.30	3 881.30	852.80	2206.99	2271.00																					
01.12.2010	4 729.40	4 729.40	852.80	2206.99	2271.00	820.10																				
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01.08.2013	11 471.50	11 471.50	852.80	893.70	2244.65	823.30														1843.80	522.35			4 028.15		
01.09.2013	12 156.10	12 156.10	852.80	893.70	2244.65	823.30														1843.80	522.35			4 028.15		
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01.03.2014	16 520.80	16 520.80	852.80	893.70	2244.65	823.30														1843.80	522.35			4 028.15		
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01.05.2014	16 520.80	16 520.80	852.80	893.70	2244.65	823.30														1843.80	522.35			4 028.15		
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01.07.2014	15 598.45	15 598.45	852.80	893.70	2244.65	823.30														1843.80	522.35			4 028.15		
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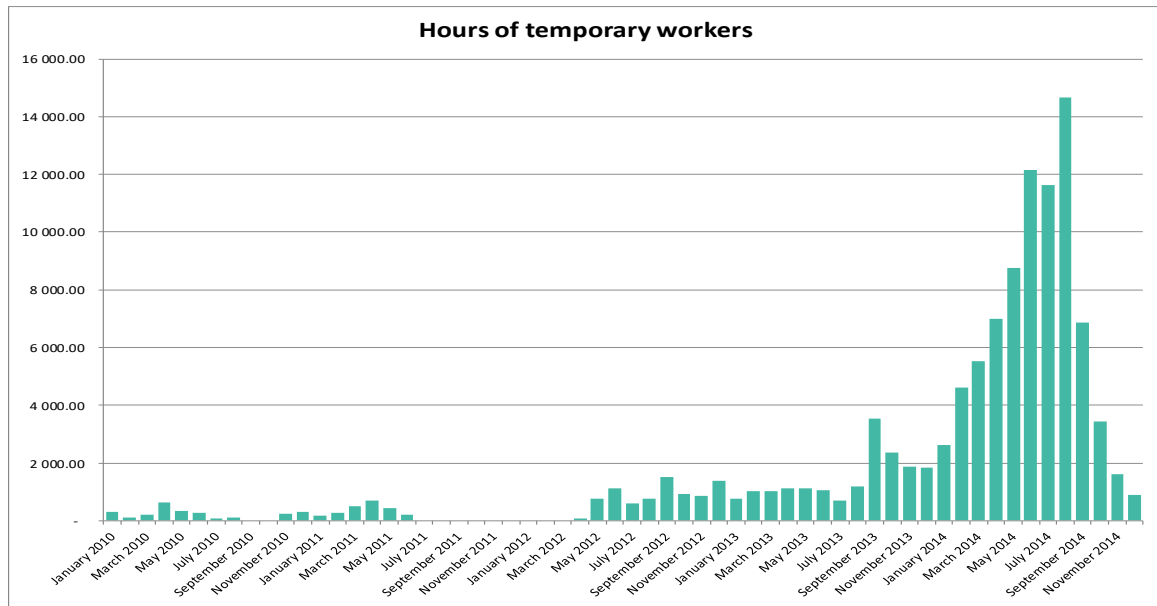


Figure 13 – Hours of temporary workers during growth period observed

The number of permanent workers during growth was easily found and this goes back to the beginning of the operations of the company in 1946 (Figure 14).

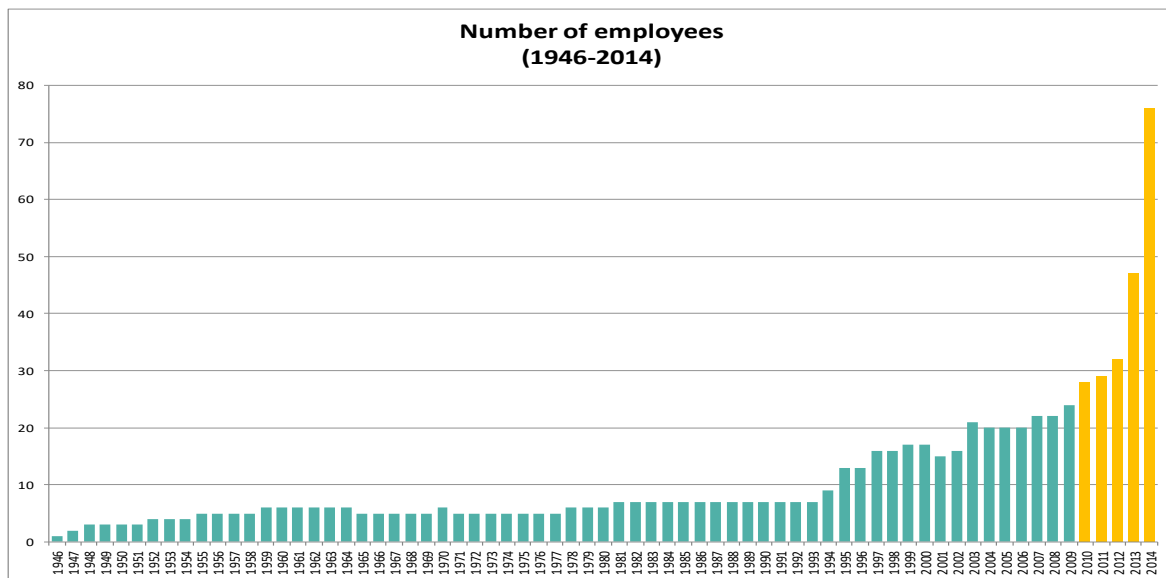


Figure 14 – Number of employees (in yellow, years of intense growth)

Equilibrium between the number of permanent employees and the level of infrastructure was observed through the balance sheets and was transcribed in a database in the model.

Having been measured or collected in the case-company, all of these elements can be observed as well when the model is running in order to make sure it keeps its behavior under control and to verify the growth trajectory of the current simulation.

6.1.4 *Verification of the model*

Once the model is entirely built, an important step is to verify whether it behaves as expected. For example, if it is decided that wages have to be paid on a monthly basis the 28th of the month, one has to make sure the model effectively does this operation on the correct date and it keeps doing it each time a new feature is added (which could potentially, if introduced wrongly, stop the payments of wages). Such an error would falsify the model logic and behaviour. In order to create the model in a controlled way, the author first built several sub-models, each of them corresponding to specific dynamic processes of the growing company. All sub-models were then combined and each element / code / function / event of the assembled model was checked again. Some control variables and specific tests were used to verify the model behaviour. A complete verification was done twice and only minor elements had to be adapted. Globally, the model logic has been tested and verified according to demanding criteria - e.g. each sub-part of the model corresponds to what happens in reality in the company. Logic aspects were discussed with several managers in order to triangulate information and improve the model design. Each time a new feature was added, all elements directly or indirectly linked to it were checked again in order to insure global control. Moreover, a special logbook was used to keep records of each element that was included or adapted during the creation of the model. More than 300 steps were achieved and completely recorded. For each of them, the following elements were recorded in the table logbook:

Column header	Explanation
N° of steps	Step number realized – allows remembering in which order elements were included in the model
Model / Sub-model	Part of the model concerned by the current step
Step description	Complete description of the logic of the current step based on what was observed in the company
Action in AnyLogic	Precise actions realized in AnyLogic - coding logic arising from logic observed in reality
Location in AnyLogic	List of all concerned elements in AnyLogic (functions, events, variables, etc. and their respective locations - population levels)
Check creation	First check made after the creation of the step - indicated by a check viewed value (✓)

Column header	Explanation
Verification in AnyLogic	Use of console to certify the model does what it is supposed to do
Final check when OM part completed	Second check made once operations have been entirely modelled - indicated by a check viewed value (✓)
Final check when DECISIONS part completed	Third check made once decision-making process has been entirely modelled - indicated by a check viewed value (✓)
Remark for check	Special warnings while checking the current step (if required)

Table 4 - Steps for creating and verifying the model

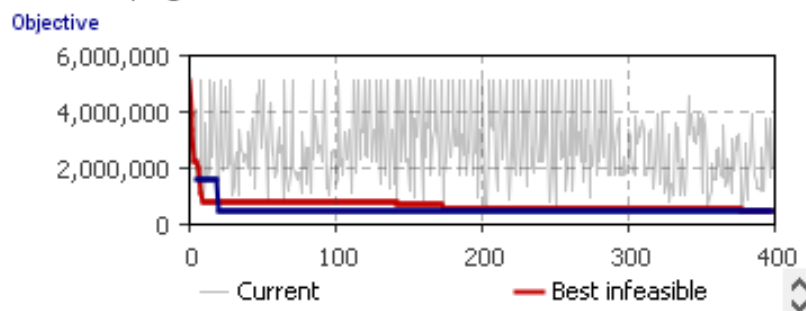
Once the whole logic had been verified several times, an ultimate verification was made with the purpose of cleaning the model up and making it more comprehensible for users. The following aspects were checked: (1) all elements modelled have a meaningful effect and are correctly used, (2) all initial values are correct, (3) all names of model elements are consistent and coherent in relation to one another, (4) each function / event contains a description that mentions its role in the model, and (5) each complex code integrates comments that explain the logic behind. In order not to omit anything, all these points were tested, population of agents by population of agents. This phase was somehow time-consuming but allowed being confident in the model's capability of representing the reality, in terms of logical behaviour.

6.1.5 Validation and calibration of the model

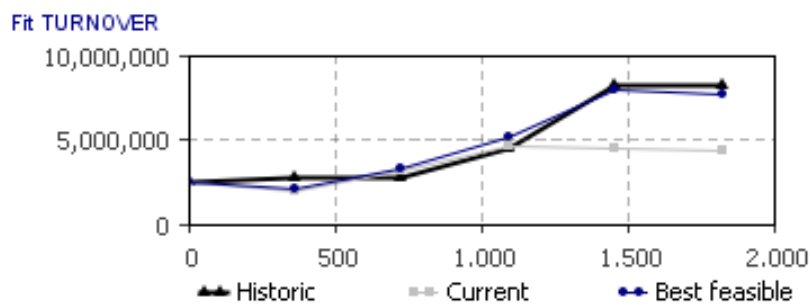
In order to validate the model, it is necessary to match model behaviour with empirical data. Model validation is an important aspect of any model-based methodology (Barlas, 1996). If the model is able to reproduce the growth phase that was observed and recorded thanks to data collection, its predictive power increases drastically. Before starting to run analyses, the author therefore calibrated the model by fitting it as closely as possible to reality based on the empirical longitudinal case study data, thus enhancing its validity, accuracy and power of explanation.

	Current	Best
Iteration:	405 <i>infeasible</i>	28
Objective: ↓	1,965,756.244	435,896.885
initial Num Of Clients	19	18
sensitivity To Wellbeing	0.898	0.88
repeating Profile Value	0.193	0.247
marketing Do Rate Value	13.501	16.494
rate Environment Protect Value	2.066	1.631
recurrence Need Temporary Value	5	5
recurrence Need Permanent Value	1	1
recurrence Check Client Satisfaction Value	2	1.5

Calibration progress



Criteria



Fit PROJECTS

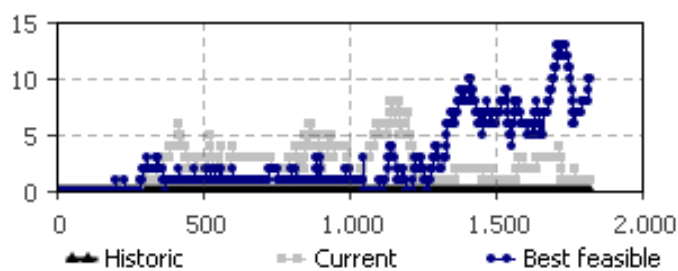


Figure 15 - Calibration process

AnyLogic allows for calibrating model behaviour by comparing its output with empirical data. Calibration in AnyLogic is another kind of experiment that can be programmed. The primary experiment that is created by any model developed is called the “simulation” experiment. All elements that were presented in the previous sections and in the appendix 3 are visible when the experiment “simulation” is run. When calibrating the model, another experiment has to be

created; it is based on the same model (so logic behind is identical as the logic presented in the preceding section) but it requires additional input; and visualization of the experiment is different. Figure 15 shows extracts of what is seen during the calibration process - some of the charts displayed during the calibration process as well as a non-exhaustive list of parameters that were calibrated by AnyLogic.

The logic works like this: during the calibration experiment, the model will try a significant number of combinations of parameters values, in order to observe which combination output matches best the real data during and at the end of the period of growth that is observed. Each run combines values differently. During the calibration experiment, an initially unknown number of runs will be done – each of them combining different parameters values that will be presented below – until the output matches reality as close as possible. More precisely, calibration will be stopped, if the value of the objective function stops improving significantly. At the top of Figure 15, one might see the values of parameters during the calibration process.

The left column indicates the values of the run that is currently achieved. The right column indicates the selected values of the best combination obtained until then – output matching best reality. The charts on the bottom of Figure 15 show (a) in black, the historic data – that the model is supposed to match with – (b) in grey, the current output and (c) in blue, the best output up to then. Some criteria might also be included for the run to be considered as feasible – e.g. in this case, the amount of delayed payments needs to stay below a certain level, otherwise the run will be considered as infeasible, even if matching quite well with reality. Calibration experiment will stop once there is no significant improvement in terms of “best results” obtained, when parameters’ values combination is the best one obtained until then and no other combination leads to better results. When calibration stops, the combination of the best parameters values can be copy-pasted into the main experiment “simulation”. Standard simulation can then be run again with the calibrated set of values, in order to verify that other elements – not considered as objective during calibration – also match well with reality. The set of values obtained after calibration was achieved can be found in appendix 5 (section 10.5).

While creating the calibration experiment, the programmer needs to indicate (1) the period during which model simulation needs to match with reality, (2) parameters which will vary during calibration, (3) data sets that are selected to match with reality, and (4) the objective of calibration – in this case, it is necessary to minimize the difference between model output and empirical data.

(1) Period of comparison

The calibration period is identical to the company study (from 01.01.2010 to 12.31.2014). It means that it each run will go from 01.01.2010 up to 12.31.2014 and will then stop. A run with new combination of values will start again for the same period. This process will go on like that until no further improvement is achieved. If the calibration is achieved successfully, the model will be able to reproduce the same growth during these five years; the predictive power of following years (since 2015) will therefore be much higher.

(2) Parameters to vary during calibration and range of values

Parameters that required value adjustment were selected and integrated in the calibration experiment parameters list. The range of values tolerated for each of them had to be set together with the step value (calibration can be discrete or continuous). For example, the initial number of clients in 2010 was estimated by the company as lying between 10 and 40. So those values were set as the boundaries for this parameter with a discrete step of 1 – which means that the calibration experiment would test combinations with values of 10, 11, 12, ... up to 38, 39, and 40 clients in order to choose the value best matching output with reality.

(3) Data selected to match with reality

Eleven elements have been selected for the matching objective in the calibration experiment: turnover evolution (once a year), number of decisions made per year for each category (eight different calibration objectives) (once a year), number of temporary employees (once a week), number of project delayed (once a month), and liquidity level (once per quarter).

They are presented in the table below:

	Data	Comparison frequency	Type of data
1	Turnover	1x / year	Separated
2	Number of decisions made of type Accept projects (A)	1x / year	Cumulative
3	Number of decisions made of type Invest (I)	1x / year	Cumulative
4	Number of decisions made of type Organize (O)	1x / year	Cumulative
5	Number of decisions made of type Hire (H)	1x / year	Cumulative

	Data	Comparison frequency	Type of data
6	Number of decisions made of type Fire (F)	1x / year	Cumulative
7	Number of decisions made of type make Marketing (M)	1x / year	Cumulative
8	Number of decisions made of type improve Wellbeing (W)	1x / year	Cumulative
9	Number of decisions made of type support Environment (E)	1x / year	Cumulative
10	Liquidity level	1x / quarter	Separated
11	Number of projects delayed	1x / month	Separated
12	Number of temporary workers	1x / week	Separated

Table 5 – Data used for calibration (matching with reality)

All real data that need to be compared to model output have to be organized in several spreadsheets and then copy-pasted into “tables function” in AnyLogic. Function tables allow for importing numbers (e.g. from a spreadsheet of empirical data) and are then used as the basis of comparison during the calibration process. The number of data integrated in table function depends on the frequency of comparison – e.g. for data that are compared once a year, at the end of the year, only five numbers had to be copy-pasted - one for each year with correct matching in terms of timing as well (refer to Figure 15 for an example). As the model unit is days, the matching has to be indicated in days – e.g. in order to match with the value of the model output on the 01.01.2011, the number 365 has to be indicated in the table function, next to the real data observed on that precise date. Number one corresponds to the first day of the model simulation period – the 01.01.2010. All elements copy-pasted in “table function” were supposed to match reality quite well once the calibration process was completed.

After each calibration result obtained, the author ran the simulation again with calibrated parameter values and validated other elements as well, such as the evolution of number of permanent employees and managers, the evolution of amortization values, the correct match of several decisions characteristics (such as the appearance of economic, social, and environmental aspects; duration necessary to make a decision on average; the number of decisions refused by category, etc.). The complete list of criteria checked for the calibration to

be validated covered the totality of elements that were measured thanks to empirical data in order to match all facets of growth as well as possible.

(4) Calibration objective

As long as the model output was differing significantly from what happened in the case-company, the author kept calibrating it by adding supplementary parameters. In total, 54 parameters (out of 239) were calibrated. 23 trials were necessary to obtain finally a combination of parameters that allows the model to match reality well enough – e.g. each output trial has been saved in a comparison sheet. A summary of observations was used to compare and weight the results. After each calibration, the average deviation was computed together with the standard deviation and coefficient of variation. The selected output for all main elements calibrated had an average of 2% and a standard deviation of 8%. Three other calibration outputs led to satisfying averages (with one even better than the selected one) but they all presented higher standard deviations. Moreover, in the adopted output, most important parameters such as the turnover value, the number of permanent employees and the number of decisions made were closer to reality than in any other calibration output.

While the best set of parameters values was chosen, it was then used as the basis for all analyses that followed. As mentioned at the beginning of this section, the objective of calibration was to fine-tune the values of a series of parameters in order to adapt the growth trajectory of the modelled company, in order to make it correspond as much as possible to the trajectory of the real-case company. Once the calibration achieved, the predictive power of the model increases drastically; the model can then be used to observe which parameters highly influence the risk of bankruptcy during growth. In other words, the calibrated model can be used as the basis for sensitivity analyses.

6.1.6 Analyses performed

This section presents the analyses that have been made once the model representing a growth period was entirely calibrated and matched reality conclusively. The section is organized in two main sections; the first section presents the “compare runs analysis” and the second presents the “sensitivity analyses”. Originally, compare run analysis was not supposed to be achieved; however, when calibration was completed, the first observations led to investigate the results in some different way than what was intended and this analysis was made in addition. Compare runs and sensitivity analyses are both different experiment types in AnyLogic – so was the

calibration experiment. Therefore, they all are based on the same logic as the standard simulation experiment; however, they require other inputs and display different information.

6.1.6.1 Compare runs analysis

Once calibration was completed, the author observed an unexpected but nevertheless very interesting phenomenon: while using the parameters' values resulting from calibration and launching standard simulation run again, the author was barely able to generate runs that did not lead to bankruptcy. As the hypothesis was that after calibration all runs would approximately generate the same growth trajectory, this result was unforeseen. Contrarily to what was first expected, the majority of runs did not seem to yield a sustainable trajectory. Considering that many elements of the model are stochastic (such as rate of appearance of events, distribution function used to set values of some variables, etc.), AnyLogic produces continuously different runs. Consequently, even using exactly identical initial parameters values, runs generated randomly by the model produce very different outputs. Only a minority of them matched what happened in reality in the case-company.

Consequently, it was necessary to add an intermediary step before starting the sensitivity analyses. Indeed, it would have been meaningless to start sensitivity analyses in order to isolate the effect of one specific variable only, if outputs were already continuously different while maintaining the same values of parameters. Hence, the author decided to first conduct a compare runs analysis, in order to measure the probability (risk) of bankruptcy, while keeping all parameter's values constant. Compare runs analysis allows the comparison of several runs, each of them keeping parameters' values constant but changing the model inputs thanks to stochastic behaviour of the model (random seed). The author observed which percentage of runs was exactly leading to sustainability with this combination of values. The second time around, while making the sensitivity analyses, it would be possible to compute again the exact percentage of sustainable runs when changing the values of parameters one by one. This would eventually lead to compare the primary result (with initial combination of values) with percentages obtained for each sensitivity analyses, in order to extrapolate meaningful results. While changing the values of parameters, the evolution of the percentage of runs leading to sustainable growth could be measured precisely – and therefore it would answer research question (6). Compare runs analysis also gives the possibility to observe how many runs look alike the trajectory of the case-company, how many of them perform better than the case-company, how many of them underperform while staying sustainable and how many of them lead to bankruptcy.

While creating the compare runs analysis, the author had to choose which output to display – by the means of several charts. Each run displays its output on the same chart as previous runs, which facilitates comparisons between runs. Information was chosen to be displayed on 27 different charts during compare runs analysis (e.g. turnover, number of permanent employees, liquidity, number of decisions by category, organization level, etc.). 1000 runs were realized for the comparison in order to achieve statistic validity - 100 being the minimum advised by Carling and Meng (2016) - and to compute the percentage of runs leading to bankruptcy. Runs leading to bankruptcy are identified and stopped as soon as the amount of delayed payments reaches the critical level set in the model. At the end of the compare runs simulation, all results displayed on charts are exported in 27 excel sheets in order to store all data in detail; the computation of how many runs lead to bankruptcy was programmed to be made automatically and this precise percentage is stored. The author will present main results obtained by this analysis in the results chapter (section 6.2.1).

6.1.6.2 Sensitivity analyses

Thanks to the compare runs analysis, it was possible to compute the precise percentage of runs that lead to sustainable growth. The objective of the sensitivity analyses was to recalculate this percentage by varying one variable at a time, in order to observe how the growth trajectory was impacted: positively or negatively. E.g. by varying the variable “sensitivity to well-being” from 0% to 100%, with a step of 10% for example, for each value a series of runs were launched in order to compute the percentage of trajectories leading to sustainable growth. The objective was to see how each variable was influencing the risk to go bankrupt. For each iteration, replications were used with a number varying between a minimum of 150 replications and a maximum of 1000 replications, with a confidence level of 95%. Similarly as in the compare runs analysis, random seed (unique simulation runs) was used.

According to the initial research question (7), the objective was to observe the impact of the efficiency of the decision-maker him/herself and of the team of managers to make decisions during growth and the impact of the sensitivity towards well-being and environment. However, the author also wanted to identify KPIs that could be monitored in order to increase the probability of a sustainable business growth. In order to select meaningful KPIs, it was decided to focus on parameters that could to a certain extent be adapted by the growing firm – e.g. the initial number of clients is not a value the company can easily act on, so is the average workload of projects or the delays to achieve them; therefore there is no reason to observe their impact on growth trajectory.

The following table presents the parameters that vary during sensitivity analyses:

Analysis	Parameter	Unit	Min value	Max value	Step	Value used when not varying
Decision-making	Efficiency of managers to support the decision-maker	%	10%	100%	10%	20%
Decision-making	Efficiency of the decision-maker to make decisions	%	10%	100%	10%	80%
Decision-making	Sensitivity to well-being	%	0%	100%	10%	100%
Decision-making	Sensitivity to environment	%	0%	100%	10%	100%
KPI	Clients' rapidity to pay	Days	0	90	10	30
KPI	Maximum number of temporary allowed according to the number of permanent employees	Proportion of people	1	5	0,5	3,881
KPI	Credit limit allowed by the bank (% of turnover – risky part)	%	15%	65%	5%	25%

Table 6 – Parameters varying for sensitivity analyses

In order to observe the real impact of each variable on the risk of bankruptcy, all other parameters values were kept at their initial, most realistic or best value. While computing sensitivity analyses, values of parameters not varying were set at the values found on the very right column of Table 6. The first half of Table 6 concerns more specifically the decision-making process efficiency and the diversity of decisions considered and made by the company. These parameters might affect the growth trajectory for several reasons.

As observed during the second research study of the thesis, managers play an important role in the decision-making process. While being responsible for about two-thirds of the decisions that are made during growth periods, managers need to be aware of the support they have to give to the decision-maker, in order to let him/her go through the complete pattern that leads to finally making and applying the decision. Poor collaboration between managers might substantially increase the risks of bankruptcy – when decisions are not made sufficiently and promptly,

disequilibrium remains and might lead to a company running out of liquidity. Based on these observations, the author posits that managers might improve the probability of a sustainable growth by being more efficient at supporting the decision-maker:

P2.1: Higher efficiency of managers to support decision-making process reduces bankruptcy risk.

The decision-maker him/herself has an important role during the decision-making process. As explained in detail in appendix 3, section 10.3.12 (presentation of the decisions population and behaviour of the decision-maker), if the efficiency of the decision-maker to make decisions remains very low, the time necessary to restore equilibrium in the company will remain very high which considerably increases the risk of bankruptcy. Therefore, the author suggests that decision-makers who are able to make decisions rapidly during growth periods increase the chances of success:

P2.2: Higher efficiency of the decision-maker to make decisions reduces bankruptcy risk.

Propositions (P2.1) and (P2.2) are also related to the propositions (P1.3a) and (P1.3b) formulated in section 4.3.3 (resulting outcomes of research study one of the thesis), stating that to ensure the sustainability of growth, the decision-maker has to run through the complete pattern and that the managers have to support him/her getting out of loops for complex decisions.

As mentioned in the positioning of the research, sustainability with the triple bottom line approach is an inherent concept integrated in the criteria that is believed to be playing an important role to ensure sustainable growth. The diversity of decisions made during growth implicates considering aspects such as the well-being of the employees and the support towards environment; this way, all TBL pillars are concerned. Contrarily, focusing only on economic aspects might increase the risk of bankruptcy. A lack of sensitivity and responsiveness towards well-being of employees during growth periods might eventually lead to a series of resignations, which will give rise to clients' dissatisfaction, amount of pending work and, again, lack of liquidity. Likewise, a lack of sensitivity and support towards environmental concerns might temporarily worsen the relationship with the bank and might decrease clients' satisfaction – as long as they are informed about it – which might lead again to cash issues. Environmental concerns have been connected to financial institutions and to clients who represent in this case the society (not modelled as a standalone figure in the model otherwise). The following propositions are thus derived:

P2.3: Higher sensitivity towards well-being of employees reduces bankruptcy risk.

P2.4: Higher sensitivity towards supporting the environment reduces bankruptcy risk.

Propositions (P2.3) and (P2.4) are connected to proposition (P1.4) in section 4.3.3 which states that the more dimensions of the TBL are considered by a company's management in making decisions during growth periods, the more likely it is that the company will proceed on a sustainable growth's path.

In addition to propositions already developed in the first research study of the thesis, the second half of Table 6 proposes KPIs that are supposed to have a considerable impact on growth trajectory and on which the company may act if necessary. As seen previously, the major risk for the company is, by far, to run out of cash. As explained with the cash-to-cash cycle – the time period between when a company pays cash to its suppliers and receives cash from its customers-, a business must support its expenditures for a period of several weeks or months. Cash-to-cash cycle determines the amount of cash needed to fund ongoing operations. During growth period, the risk to increase the cash-to-cash cycle is high; as expenditures increase rapidly, if the time necessary to collect cash from the clients remains the same or increases a little, the possible liquidity gap will increase drastically. While examining the components of the cash-to-cash cycle, offsetting actions such as requiring payments in advance or negotiating longer payments terms with main suppliers might be necessary for the growing company. In the model, the rapidity at which clients pay the company when work is partly or fully realized is directly related to the cash-to-cash cycle time. As delays in client payments are one of the major risks during growth periods, it is assumed that actions shortening the cash-to-cash cycle time will increase the probability of sustainable growth:

P2.5: Tightening credit to customers or requiring payment in advance – with the aim of reducing days sales outstanding - reduces bankruptcy risk.

Regarding the suppliers side, actions might also be taken. Delayed payments causing bankruptcy are in the majority of the cases temporary wages that cannot be paid for an extensive period (refer to appendix 3, section 10.3.22 for bankruptcy identification detailed explanation). Allowing an important proportion of temporary workers compared to the number of permanent employees raises this risk. Therefore, keeping this proportion lower might have a positive impact on growth trajectory:

P2.6: Lower number of temporary workers compared to permanent employees reduces bankruptcy risk.

From a different perspective, the risk of lacking liquidity also highly relies on the credit limit level that the bank allows during periods of growth. If credit limits are only based on the preceding year published balanced sheet, they might sometimes be inadequate regarding the

rapid evolution of the firm. Credit limit helps – if necessary – to bridge the gap between payments of suppliers and cash collection from clients. Therefore, if banks would allow a higher credit limit to high-growing firms, the impact on growth trajectory might be significantly positive:

P2.7: Higher credit limit obtained from the bank reduces bankruptcy risk.

All of these propositions will be tested during the sensitivity analyses; parameters that have the major impact on increasing the probability of sustainable growth will be recorded.

After having compiled these results, the author also tried a combination of values considered as the “best set of values” possible regarding the previous results obtained. For this set, the following values were used:

Parameter	Unit	Value used for best set
Efficiency of managers to support the decision-maker	%	50%
Efficiency of the decision-maker to make decisions	%	100%
Sensitivity to well-being	%	80%
Sensitivity to environment	%	80%
Rapidity to pay	Days	10
Maximum number of temporary allowed compared to the number of permanent employees	Proportion of people	1,5
Credit limit allowed by the bank (% of turnover – risky part)	%	65%

Table 7 – Best set of parameters values

In this best set, efficiency in decision-making is very high, the company considers a nice diversity of decisions, clients are encouraged to pay rapidly, the bank allows a higher credit limit and the proportion of temporary workers compared to permanent workers remains reasonably risky. For values that influence the growth trajectory, the best result obtained was kept for this best set of values. For values that do not affect significantly the growth trajectory, the best theoretical value was kept. The tested proposition here is as follows:

P2.8: Perfectly monitoring all major parameters influencing growth trajectories reduces bankruptcy risk.

Similarly as with compare runs analysis, during sensitivity analyses, runs leading to bankruptcy are identified and stopped as soon as the amount of delayed payments reaches the critical level set in the model. When a run stops, the next one starts directly again, from the first day of growth period. The number of iteration for each sensitivity analysis depends on the step value of Table 6 and varies between nine and eleven iterations of minimum 150 replications each. At the end of each sensitivity analysis (after all iterations are completed), the simulation stops and all results are exported into 26 excel sheets; the computation of how many runs lead to bankruptcy was programmed to be made automatically and this precise percentage is stored, next to the value of the parameter currently being adapted (e.g. sensitivity to well-being = 50%; percentage of sustainable runs after five years = 23%; percentage of sustainable runs after ten years = 13%). Each excel sheet contains the complete data exported from AnyLogic at the end of the analysis; values are reported on a daily, weekly, monthly, quarterly or yearly basis – it depends on the excel sheet- for each replication of the entire iteration. Each excel sheet also makes automatically computations and provides very detailed information about the percentage of sustainable runs and about the evolution of the observed parameter over time (min, max, average and standard deviation for each year of growth). While creating the AnyLogic code which exports the results after each iteration of sensitivity analysis, the author programmed it so that each analysis was exported in the same excel file but on different sheets, named according to the value of the parameter during the current iteration (e.g. for sensitivity to well-being, after iteration with value = 10%, results of all replications are exported in excel file “Sensitivity To Wellbeing” on sheet “10”; after iteration with value = 20%, results of all replications are exported in excel file “Sensitivity To Wellbeing” on sheet “20”, etc.). This way, all results are combined. Another excel file was used to bring all final percentages after five and ten years together which allows for a visual comparison. These tables will all be shown in section 6.2.2 (results of sensitivity analyses).

6.2 Findings: bankruptcy risk computation and possible improvements

This section finally introduces the main results obtained thanks to the model developed and presented in methodology section 6.1. The model is able to reproduce an intense period of growth, identical to what was observed in the case-company, and to generate future years of growth as well in order to observe the growth trajectory in the long run. Once the model was completed and fully calibrated, two main analyses have been achieved: compare runs and sensitivity analyses. Compare runs had per aim to measure the risk of bankruptcy for the combination of values parameters identified as best matching the case-company business growth. Once this risk was acknowledged, sensitivity analyses could start; risk was measured again for each value's change and compared to the primary risk. The final objective of these analyses was to identify which parameters have the highest influence on the growth trajectory of a company and to measure precisely the inherent remaining risk of bankruptcy, regardless of how well parameters were monitored.

6.2.1 *Results of compare runs analysis*

Compare runs analysis allows the comparison of several runs, each of them keeping parameters' values constant but changing the model inputs thanks to stochastic behaviour of the model. The primary objective of this analysis was to observe which percentage of the runs was leading to sustainability with the combination of values coming out from the calibration process. Second, compare runs analysis was used to observe how many runs look like the trajectory of the case-company, how many of them perform better than the case-company, how many of them underperform while staying sustainable and how many of them lead to bankruptcy.

While running the compare-runs analysis a thousand times, important differences between runs were observed. This might be due to the fact that all subparts of the company processes are dynamically interlinked and that the model is evolutionary and scalable; many of its variables' values change over time according to e.g. the experience gained by operations managers and decision-makers, the level of happiness of employees, the number of projects delayed, etc. This evolutionary logic is probably causing significant differences between runs. It is also by means of this scalable process that the model is able to create intense periods of growth. Otherwise, each run would either lead a company to bankruptcy or to a stable evolution (which means no growth at all).

For each run, 27 indicators were observed, amongst other turnover evolution, number of permanent and temporary employees, as well as number of decisions by category made by the

decision-maker, evolution of liquidity, amortization and credit limit, number of projects delayed, etc. When the model is run in a regular simulation, it indicates instantly whether the company reaches one of the indicators that are considered as bankruptcy (such as unreasonable delayed payments for example) and it stops. During compare runs analysis, in order to verify whether the run was driving the company to failure or not, the author tracked several variables and observed their final values, once the run was terminated. These control variables are essentially financial, i.e. 1) the amount of delayed temporary wages - according to model behaviour, this category of payments is the second one the company might agree to delay and therefore it reaches sometimes important amount not remitted on time (refer to appendix 3, section 10.3.11 for details about payment processes), 2) the amount of delayed wages; 3) the amount of delayed amortization. The first category of payments to be delayed is the investment category, which is not considered here because delayed investment will decrease the organizational level of the company overall but will not necessarily lead to bankruptcy. If the company reaches any of the maximum levels allowed for those variables, it means that it has been running out of liquidities and the run is considered as having failed. Another non-financial variable is also taken into consideration: 4) the global level of happiness of employees; if this number is very low and if the number of permanent employees at the end of the observed period is drastically decreasing, one might consider the possibility that all employees are about to resign because they are awfully unhappy at work. This would also cause bankruptcy. External factors such as environmental disasters or recall of products in some specific industries are not integrated in the potential causes of bankruptcies. They might be object of future studies.

In order to analyse the results in detail, runs were classified into three categories: 1) runs with performance similar to the case-company 2) other solvent less performant runs and 3) runs leading to bankruptcy. The author will first discuss the risk of bankruptcy and then present the runs in more details.

Percentage of risk of bankruptcy

Among the 1000 runs that were launched, only 211 (21,10%) allowed the company to maintain solvency; this percentage was much lower than what the author would have expected.

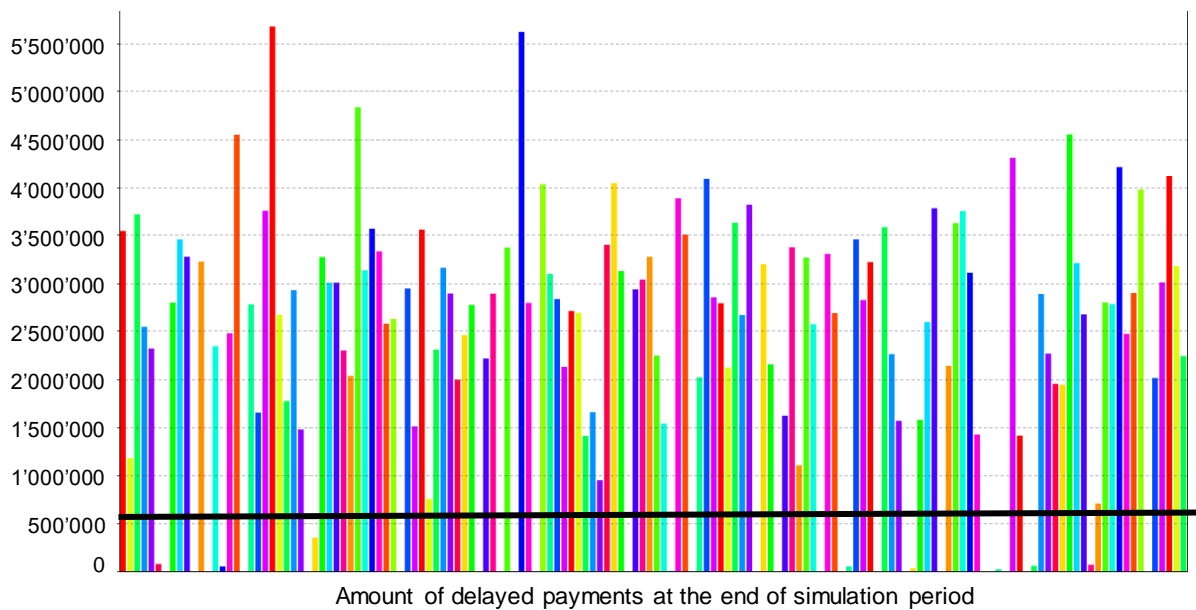


Figure 16 - Delayed temporary wages value at the end of each run and maximum value allowed (horizontal bold black line)

Figure 16 shows the most critical financial control variable. Only runs where the variable value stays below 500'000 Swiss francs can be considered as solvent.

As mentioned already above, it is quite surprising to notice that the case-company was able to generate a sustainable growth over several years while the chance to go bankrupt is very high. When the author discussed this result with the CEO of the company, he simply said, “*I have no doubt about that. I am sure we were not far from crossing the line from time to time during the last four years. Nevertheless, I am happy we did not know how risky it was. Otherwise I would probably not have tried expanding my operations capacity and I would have missed out on great opportunities*”. This first insight goes in the direction of Hendrickson’s observation (1992) who explains that firms might grow, plateau or decline and that the border between the three options is sometimes very thin. As observed here, the company experienced intense growth, but it could also have only plateaued or even declined during the same exact period.

Runs with output similar to empirical data

As a next step, the author tried to find out which of the 1000 runs fitted the company reality best. For that purpose, all major indicators that were measured in the company with the model indicators were compared. The comparison of values was made at different time intervals during simulation (once a day, once a week, once a month or once a year, depending on the

data observed – e.g. turnover is tracked once a year and the number of projects delayed is tracked on a daily basis). To select the best runs, the author observed those that present the lowest difference globally. Indicators that were the most important in the comparison were the turnover and the number of permanent employees (both of them are relevant indicators in terms of growth measurement, Bakar et al. 2016).

Only eight runs were accepted (run 25, 36, 56, 127, 709, 745, 784 and 881). All of these runs had a low amount of delayed payment (their level was even lower than what the case-company experienced). At the end of the observed period, on average, happiness of employee was around 93% (which is high); client satisfaction was very high (99%) because almost no projects had been delayed in those performance runs. Organization level was also very high (95% on average) which means that the company was able to make enough decisions to reorganize its operations processes and to maintain a good level of organization. The turnover of the last year of growth was around 7,5 million Swiss francs. The case-company was able to generate 8,2 million but the extra million was generated by one huge project (of about 1 million) that the real company accepted and that could not have been reproduced by the model (workload outrageous with respect to what was introduced in model logic). This difference is therefore acceptable. The number of permanent employees hired is also matching reality with less than a 3% gap. Figure 17 shows some of the output charts, with run 25 highlighted in red.

While zooming into those eight performance runs, it is interesting to observe where the case-company over or under-performed. First, no run was able to perform much better than the case-company in terms of turnover generation. Moreover, no run was able to achieve this outcome with a credit limit lower than the one set for the case-company (one million Swiss francs). The number of temporary employees hired was quite similar to reality in all runs. With a number of temporary workers staying relatively low (average of 21 workers) for two and a half years and then growing up to more than 80 temporary employees.

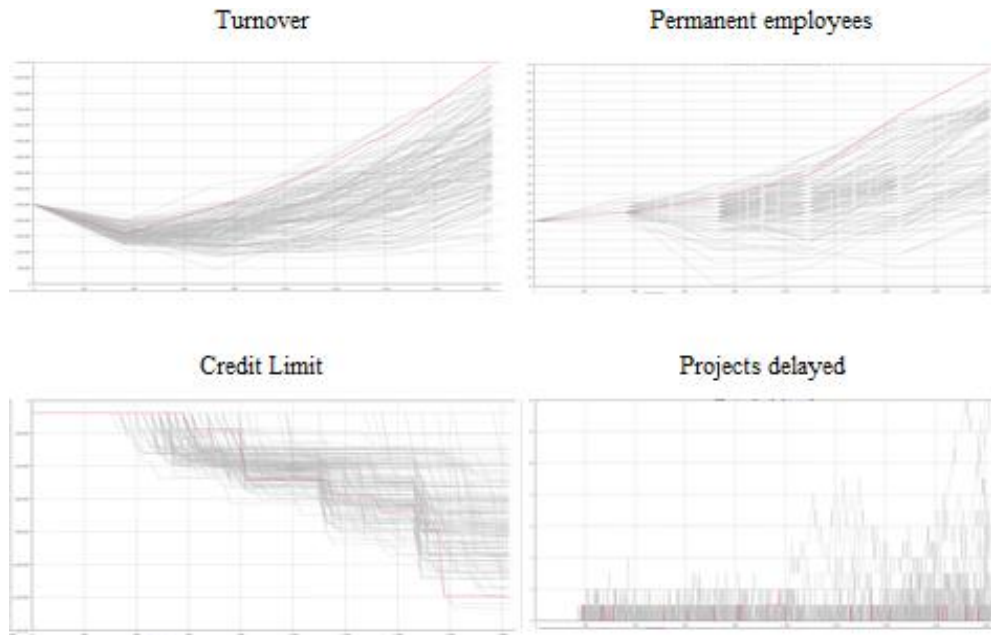


Figure 17 – Global results with run 5 highlighted in red

As mentioned already, all eight runs were able to generate a delayed amount of payments lower than the case-company, which leads to the conclusion that the case-company could have performed better from that point of view. In terms of decisions made, all runs were able to maintain a high level of organization by making fewer decisions than the case-company (runs generated between 51 and 54 decisions made versus 74 made by the case-company). Only two runs were able to generate about the same number of decisions regarding marketing actions. All other runs made between 105 and 127 decisions – which is higher than what the case-company did. Two out of eight runs made exactly the same amount of decisions to protect the environment (11). Six of them made fewer decisions. As protecting environment is hypothesised to be a key component during growth, one might consider that the case-company performed well here. In terms of decisions with the aim of improving well-being, runs needed a maximum of 14 decisions to maintain a high level of happiness within employees. The case-company made 24 decisions for increasing well-being over the five years. One might here either consider that the company under-performed (took a disproportionate amount of time making decisions that were not worthwhile) or that it attached a real importance to the well-being of its people and therefore shows it is possible to grow while taking care of employees at the same time. Overall, the author concludes that the case-company could have performed better (been more efficient) for some indicators, but globally its performance and efficiency was respectable.

Other solvent runs

203 other runs did not lead the company to bankruptcy. Interestingly, five of them generated a turnover similar to the eight most performant runs with less permanent employees (35 on average at the end of the growth period). Global happiness of employees within those runs was on average lower (up to 82%) which seems to show that most of them were over-occupied. Within those five runs, the number of decisions related to well-being was also always lower. One might therefore observe that it would have been possible to perform better than the case-company (generate similar turnover with less permanent employees) but social aspects would have been forsaken. In the long run, it would be of interest to investigate if growth could stay sustainable. Four runs generated more well-being decisions made than the case company did. However, turnovers generated were lower (maximum 4,1 million in 2014) with a team of 37 permanent employees. One run (126) had a very low level of organization at a certain period (24%) which lowered its turnover in 2011 but was finally able to generate a high turnover (7,2 million in 2014) – probably because it was able to increase at the organizational level again while making organizational decisions.

Runs that lead to bankruptcy

As mentioned previously and unexpectedly, the majority of runs led to bankruptcy, even though with the same initial values, some of them performed quite outstandingly. The stochastic behaviour of the model seems to have an important impact on the growth trajectory; the differences between the runs are therefore important. It might be of interest to investigate further which parameters affect the risk of bankruptcy the most. The compare runs analysis itself does not allow at this stage for an observation of some tendencies among this class of runs. The results are elaborated in more detail in the next section, which redraws the sensitivity analyses performed and the most vivid results.

6.2.2 Results of sensitivity analyses

The objective of the sensitivity analyses is to observe the impact of a selection of parameters (presented in methodology section 6.1.6.2) that might comprehensively influence the probability of achieving sustainable growth, according to the author's propositions. Four parameters related to the decision-making process and three KPIs were selected. This section will transcribe the main results obtained. For each sensitivity analysis, results are recorded in a table and show the percentage of sustainable runs after five and after ten years of growth during the simulation modelling. Table 8 shows the colour legend for the results values:

Null	0%	Higher than	25%
Lower than	10%	Higher than	30%
Between	10% and 25%	Higher than	50%
		Higher than	60%

Table 8 – Legend for values of sensitivity analyses results

The average percentage of runs leading to sustainable growth in the initial situation is situated around 21%. Any configuration that leads to a higher percentage is considered as more efficient. Percentages lower than 10% start to be really critical and the null percentage is highlighted – meaning that in this combination of values, no run is able to sustain growth after five or ten years.

Managers' efficiency to support the decision-maker

The first proposition (P2.1) was to test whether poor collaboration between managers might substantially increase the risks of bankruptcy – or, in other words, if managers might improve the probability of a sustainable growth by being more efficient at supporting the decision-maker. Supporting the decision-maker means helping him/her going through the complete pattern (sequence of steps until the decision is made) of the related decision the manager is in charge. The proposition was that the higher the efficiency in supporting the decision-maker, the higher the percentage of sustainable runs. Table 9 transcribes the results:

Efficiency to support decision-maker (%)	% sustainable runs after 5 years	% sustainable runs after 10 years
10	29%	17%
20	21%	14%
30	21%	12%
40	31%	13%
50	23%	15%
60	24%	9%
70	21%	12%
80	20%	12%
90	21%	12%
100	21%	10%

Table 9 – Results of sensitivity analysis: efficiency of managers to support the decision-maker

As one might see, the efficiency in supporting the decision-maker does not seem to have a significant impact on the percentage of growth trajectories that are sustainable, with an average percentage of sustainable growth of 23,13% after five years and 12,60% after ten years, and a very low standard deviation of 3,81% and 2,42% respectively. There is only one case where the percentage of sustainable runs falls below 10% (in yellow on the table) but it remains close to the average of 12%. Proposition (P2.1) is therefore rejected; the efficiency of managers to support the decision-maker does not yield any significant improvement in the survival of growing firms. Consequently, proposition (P1.3b) of section 4.3.3 is rejected as well.

Efficiency to make decisions

Still related to the decision-making process, proposition (P2.2) tests whether the decision-maker him/herself can make a difference while being more or less efficient in deciding. As observed and explained previously, any decision-maker (with efficiency low or high) will improve his/her capability of making decisions efficiently during growth while gaining experience throughout the whole process. However, keeping efficiency very low will moderate the positive effect of gaining experience and time necessary to make decisions will remain very high even after many decisions have been made. On the contrary, a decision-maker with a high efficiency will make decisions considerably more rapidly and will therefore increase the likelihood of restoring equilibrium more often. Proposition (P2.2) thus states that the higher the efficiency of the decision-maker, the higher the probability of sustainable growth. Table 10 shows the respective results:

Efficiency of decision-maker (%)	% sustainable runs after 5 years	% sustainable runs after 10 years	# of runs were all employees resigned 10 years
10	12%	0%	92
20	19%	1%	13
30	14%	2%	4
40	13%	3%	-
50	20%	7%	-
60	27%	10%	-
70	26%	15%	-
80	30%	15%	-
90	31%	17%	-
100	31%	17%	-

Table 10 - Results of sensitivity analysis: efficiency of the decision-maker

Results are much more significant here. After five years of growth, if the efficiency is very high (between 80% and 100%), the percentage of sustainable growth trajectories increases up to 31%; and remains at 17% after ten years. On the contrary, if efficiency remains very low (between 20% and 50%), the percentage of sustainable runs will decrease drastically after ten years. With the lowest efficiency (10%), there is no chance of survival after ten years. Interestingly, with a still very low efficiency of decision making (20%), the percentage of sustainable runs after five years remains almost at 20%; however, the percentage of runs sustainable after ten years again almost reaches 0%. This seems to indicate that even if in the medium-term, low efficiency might be supported by the company; in the long run, it will still be devastating. Moreover, it was interesting to observe that, in this sensitivity analysis, during some runs, bankruptcy was not the result of a lack of liquidity but due to the resignation of all employees. The number of runs leading to this case is indicated in the very last column of the table – 92 runs for an efficiency of 10%, 13 runs for an efficiency of 20% and four runs for an efficiency of 30%. Apparently, employees suffer from the incapability of the decision-making to restore equilibrium in the company and finally decide to quit the firm. Therefore, it can be stated that proposition (P2.2) is not rejected; the efficiency of the decision-maker affects the probability to follow a sustainable path during growth periods. Consequently, proposition (P1.3a) formulated in section 4.3.3 is not rejected either.

Sensitivity to well-being

This sensitivity analysis and the next one are both directly related to the sensitivity of the decision-maker and the impact his/her sensitivity might have on the growth trajectory of the growing firm. The proposition (P2.3) concerns the sensitivity towards the well-being of the employees. As explained above, a lack of sensitivity and responsiveness towards the well-being of employees during growth periods might lead to a series of resignations (because employees feel critically busy and no action is taken to support them) which will give rise to clients' dissatisfaction, the amount of pending work and lack of liquidity. Proposition (P2.3) verifies that the sensitivity of the decision-maker positively influences the percentage of sustainable runs; refer to Table 11 below:

Sensitivity to wellbeing (%)	% sustainable runs after 5 years	% sustainable runs after 10 years	Global happiness MEAN after 10 years	Global happiness MIN after 10 years	Global happiness MAX after 10 years
0	26%	15%	49%	32%	62%
10	23%	12%	80%	60%	98%
20	28%	14%	85%	77%	94%
30	23%	13%	85%	75%	97%
40	17%	9%	89%	84%	97%
50	23%	13%	87%	79%	96%
60	25%	10%	91%	85%	96%
70	24%	9%	88%	82%	98%
80	33%	19%	89%	81%	98%
90	24%	14%	91%	86%	99%
100	29%	14%	90%	81%	97%

Table 11 - Results of sensitivity analysis: sensitivity to well-being

At first sight, it seems that sensitivity to well-being does not have a significant impact on the sustainability of growth; the average percentage of sustainable trajectories after five years is about 25% and about 13% after ten years with standard deviations of 4,2% and 2,8% respectively. There is no tendency of improvement or deterioration if sensitivity increases or decreases. It even seems that the percentage of sustainable runs when sensitivity to well-being is null (0%) remains quite high (26% after five years and 15% after ten) – which is much higher than what one would expect. However, with the aim of investigating this result further, the author studied two more parameters for each sensitivity analysis: the turnover and the global happiness value of all employees - as explained in the presentation of the model, global happiness is the average of all individual levels of happiness of all working employees. When sensitivity to well-being is null, turnover does not increase for ten years. After year seven, turnover starts to decrease again; which is not a sign of sustainable growth. Moreover, as observed in Table 11, global happiness remains always above 80% on average after ten years, except when sensitivity to well-being is null; in this case, the average sensitivity falls down to 49% with a minimum at 32% and a maximum at 62%. One might expect that in this case, resignations will start to happen which will cause difficulties for the company. This phenomenon might already be observable in the model simulation. As seen below in Figure 18, the only evolution where a number of permanent employees (on average) decreases after seven years is when sensitivity to well-being is null (turquoise line on the chart). This already shows

the tendency towards resignation that appears when well-being is neglected for a significant period.

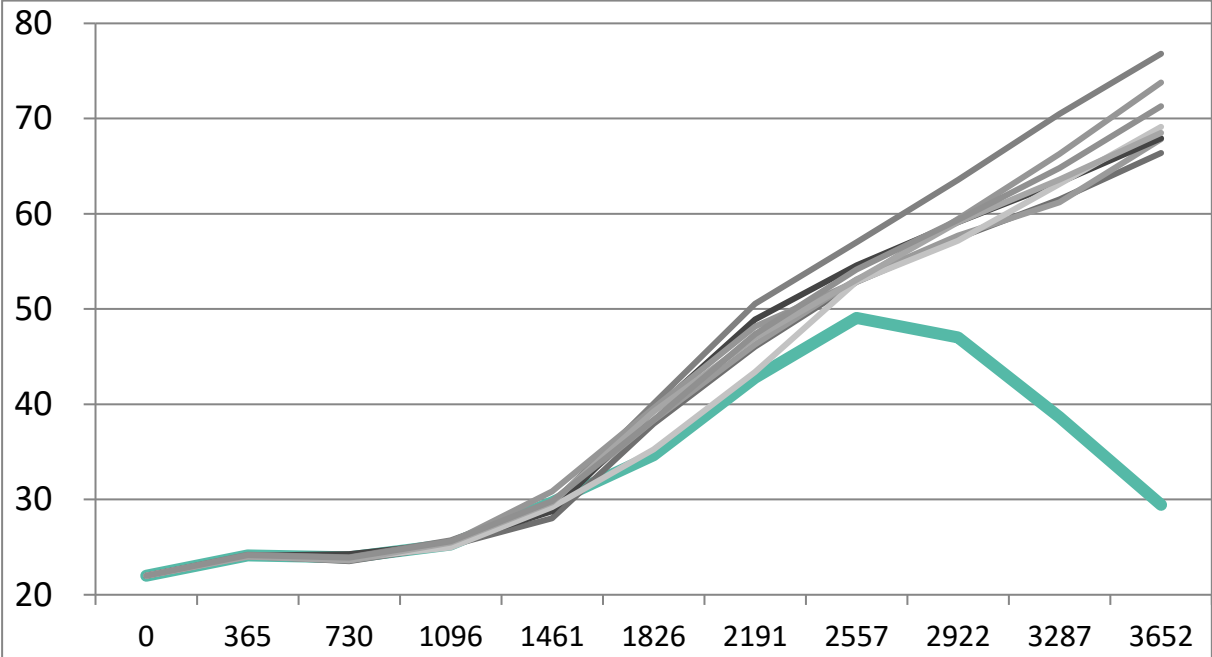


Figure 18 – Evolution of the number of permanent employees – turquoise line for null sensitivity to well-being

As a result, proposition (P2.3) is rejected even if some tendencies might be observed when sensitivity to well-being is null. Future researches should try to combine another element in this sensitivity analysis in order to measure if the impact is higher – e.g. due to market behaviour elements such as the repeating profile percentage of clients or the rate at which they order projects, etc. If market conditions are more demanding, maybe global happiness will decrease faster or it will decrease as well when sensitivity to well-being remains quite low (below 50% for example).

Sensitivity to environment

Similarly to the previous analysis, proposition (P2.4) tests the sensitivity of the decision-making towards supporting the environment. A lack of sensitivity and support towards environmental concerns might decrease clients' satisfaction and temporarily worsen the relationship with the bank, which can once again cause problems with to cash. Therefore it is expected that the higher the sensitivity to environment, the higher the probability of achieving a sustainable growth. Results of this sensitivity analysis can be found in Table 12:

Sensitivity to environment (%)	% sustainable runs after 5 years	% sustainable runs after 10 years
0	19%	7%
10	22%	9%
20	19%	7%
30	33%	14%
40	26%	11%
50	21%	11%
60	22%	11%
70	27%	13%
80	25%	17%
90	26%	11%
100	29%	14%

Table 12 - Results of sensitivity analysis: sensitivity to environment

Similarly to the sensitivity to well-being, no significant relationship between the sensitivity to environment and the percentage of sustainable growth trajectories can be observed. The average remains at 24% with a standard deviation of 4,2% after five years, and at 11% with standard deviation of 3% after ten years. However, one will notice that after ten years of growth, if the sensitivity to environment remains very low (between 0% and 20%), the percentage of sustainable runs falls below 10%, which is not the case with a higher sensitivity towards environment. Once again, the proposition is rejected even if there is a tendency appearing for low values.

This proposition (P2.4) as well as the previous one (P2.3) are linked to proposition (P1.4) in section 4.3.3 which states that the more dimensions of the TBL are considered by a company's management in making decisions during growth periods, the more likely it is that the company will proceed on a sustainable growth's path. Considering especially social and environmental decisions, this proposition is rejected. The author investigated this further by combining low values of sensitivity towards well-being and towards environment to see the effect on growth trajectories. The result can be seen in Table 13:

Sensitivity to environment AND to wellbeing (%)	% sustainable runs after 5 years	% sustainable runs after 10 years
0	27%	12%
10	23%	10%
20	24%	11%
30	26%	11%
40	26%	13%
50	29%	11%

Table 13 – Results of sensitivity analysis: sensitivity to environment AND sensitivity to well-being

However, even with both parameters values kept very low, the impact is not significant in terms of percentages. In terms of number of employees and turnover evolution however, one might observe on Figure 19 that both KPIs fall in the majority of the cases after eight years of growth, just as it was already observed for the sensitivity to well-being alone.

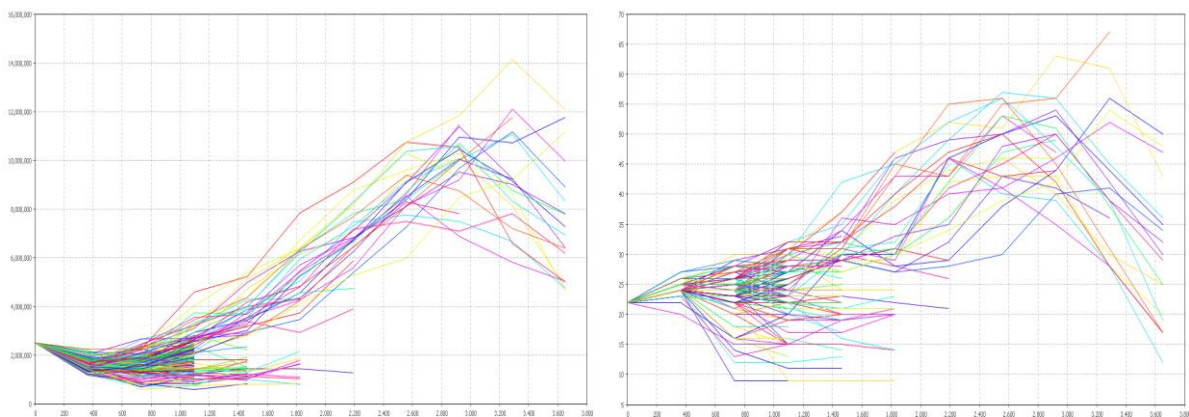


Figure 19 – Turnover and number of employees' evolution when both sensitivities are set to zero

In order to investigate further the phenomenon, this proposition could also be tested in regards to decisions that are mainly economically oriented but which remain diverse - considering for example organizational, investments and hiring-firing types of decisions.

Clients' rapidity to pay

The following analyses are all connected to components of the cash-to-cash cycle of the company. Delays in clients' payments for example is one of the highest risks at all times but especially during growth periods. It might sound quite reasonable to expect that reducing the time necessary for clients to pay advances or receive final invoices when they have received

their products will positively affect the sustainability of growth. However, measuring precisely this impact remains necessary and might bring some very precise insights for managerial behaviours during growth periods. Proposition (P2.5) tests the relationship between the days sales outstanding and the probability of a sustainable growth. Results are recorded in Table 14:

Clients rapidity to pay (days)	% sustainable runs after 5 years	% sustainable runs after 10 years
0	40%	19%
10	33%	22%
20	29%	17%
30	27%	12%
40	18%	11%
50	12%	4%
60	7%	1%
70	5%	0%
80	6%	0%
90	2%	0%

Table 14 - Results of sensitivity analysis: clients' rapidity to pay

As expected, the percentage of sustainable runs increases drastically if the number of days to pay decreases; at ten days, more than 30% of runs are sustainable after five years; if the company is even able to require payments before starting working on the projects (zero days delay), the percentage increases up to 40% of sustainable runs. On the opposite, if clients' rapidity to pay decreases drastically to 60 days or more, the percentage of sustainable runs decreases dramatically. At 60 days, only 1% of the runs are sustainable after ten years. Above 60 days (if clients pay at 70, 80 or 90 days), there is no chance for the company to survive even ten years. The standard deviation is therefore important; 13,4% for five years and 8,7% for ten years, which means that this KPI has an important impact on the growth trajectory of the company. A growing firm that allows its customer to pay after large delays (more than 30 days) increases its risk of bankruptcy drastically. Knowing that during growth periods, there are many internal processes to adapt and reorganize already, watching payments delays might conceivably not be a top priority to the company's managers. Moreover, right before a growing period, the level of liquidity remains always very high and therefore payment delays do not have to be followed carefully. However, once growth is launched, this KPI should be strictly followed up by financial managers in order to avoid increasing bankruptcy risk needlessly. Payment processes should be reviewed and new conditions might be integrated such as

requiring a percentage of pure advance at the project start and then several other payments during active projects. Subdividing payments in several small invoices is much more efficient than sending only one final invoice at the very end of the project.

Proposition (P2.5) is therefore not rejected; the more rapidly clients pay, the higher the probability of sustainable business growth. In addition, the longer the payments delays are, the higher the risk of bankruptcy becomes. This KPI is therefore definitely a parameter that should be tracked during growth periods; actions to keep payment delays as short as possible should be undertaken by any growing company.

Maximum proportion between temporary and permanent employees

Still regarding the cash-to-cash cycle but from the suppliers side, proposition (P2.6) tests whether the ratio of temporary workers to permanent workers influences the growth trajectory. The assumption is that the lower the proportion is – which means that the number of temporary workers allowed by the company remains low in comparison to the number of permanent employees – the higher the probability of sustainable growth. Increasing the number of temporary workers seems to be risky first because the level of organization of the company will suffer, but also because the temporary payments will become an important source of expenses. As individual temporary salaries are higher than individual permanent salaries on average and for an equivalent performance, the amount of payment that is due to placement agencies can become very high if the number of temporary workers remains high for long periods. The proportion of temporary workers according to the number of permanent employees has been tested from one to five. At one, each permanent worker might get only one temporary worker to work with. So the proportion will be 50/50 (in total, the company will hire e.g. 10 permanent and 10 temporary workers). At five, each permanent employee might get matched with five temporary workers (in total, the company will hire e.g. 10 permanent and 50 temporary workers). A higher proportion was not allowed by the case-company and therefore other values were not tested. Table 15 shows the results of this sensitivity analysis.

Max proportion of temporary (proportion)	% sustainable runs after 5 years	% sustainable runs after 10 years
1	27%	3%
1.5	57%	26%
2	47%	16%
2.5	43%	22%
3	26%	14%
3.5	28%	15%
4	41%	24%
4.5	25%	13%
5	28%	17%

Table 15 - Results of sensitivity analysis: ratio of temporary employees to permanent employees

Results are just as interesting as they are surprising. As one might see, a proportion of four temporary employees per permanent employee yields interesting results in terms of sustainability after five and ten years. However, and oppositely, a proportion of 1,5 temporary employees per permanent employee seem to yield even better results (26% of sustainable runs after ten years and 57% after five years). Even more unforeseen is the result yielded by the proportion of one temporary for one permanent worker. In this configuration, there is almost no hope for sustainable growth after ten years. Therefore, the gap between 1 and 1,5 is substantial. It seems that a company should avoid restraining exceedingly the proportion of temporary workers (1:1); an undersized proportion might probably prevent the company from answering the majority of the clients' needs and is therefore counterproductive on the long run. However, the company should rather employ a small proportion of temporary workers (1,5:1) or, if the necessity of hiring more people appears, jump to a higher proportion (4:1). Any proportion in-between does not bring about improvement. Either the company focuses on profitability and restricts the number of temporary workers to 1,5 for one, or it focuses on the client's satisfaction and therefore allows a higher number of temporary workers (4:1). Regarding the proposition (P2.6), results show that the proposition is not rejected; the (1,5:1) proportion increases the probability of a sustainable growth but a lower proportion decreases this probability drastically. Therefore, keeping the proportion low has a positive impact on growth trajectory as long as it does not excessively put a constraint on the number of temporary workers who are hired.

Credit limit allowed

Independently of the cash-to-cash cycle, liquidity level will always depend on the credit limit level that the financial partner will allow during growth periods. As seen in the section of appendix 3 presenting the computation of credit limit (10.3.10), many constraints are held to set the level of credit limit that is most of the time inappropriate for growing firms. Therefore, the proposition (P2.7) verifies that the credit limit allowed by the bank impacts the probability of a sustainable growth; with the assumption that the higher the credit limit, the higher the probability of a sustainable growth. The credit limit is computed based on a percentage of the previous year's published turnover of the company (refer to appendix 3, section 10.3.10 for the detailed explanation of how the credit limit is computed). While making the sensitivity analysis, the author varied this percentage, which is usually set at 25%, from 10% to 65%. The objective was to observe the impact of constraints even stricter than what is typically allowed and to observe the impact of less stringent constraints. 65% being the maximum level of loans allowed (compared to equity), the author decided to test the same value for the credit limit computation. Table 16 reports the results of the sensitivity analysis:

Credit limit allowed (% of turnover)	% sustainable runs after 5 years	% sustainable runs after 10 years
10	12%	3%
15	15%	5%
20	25%	15%
25	25%	15%
30	35%	25%
35	37%	26%
40	39%	30%
45	40%	33%
50	46%	38%
55	50%	42%
60	51%	45%
65	52%	51%

Table 16 - Results of sensitivity analysis: credit limit allowed by the bank

The results clearly show that the credit limit allowed significantly affects the percentage of sustainable runs. By increasing the credit limit from 25% to 30% solely, the probability of achieving a sustainable growth already rises by 10%. With a credit limit of 50%, the probability again rises by ten more percent. Finally, with a credit limit allowed identical to the proportion

of debt versus capital (65%), the percentage of sustainable growth reaches more than 50%. More importantly, this percentage is identical after five and ten years; which means that the risk of going bankrupt disappears after five years of intense growth. Therefore, proposition (P2.7) is not rejected by these results; a higher credit limit obtained from the bank increases the probability of a sustainable growth and drastically reduces the risk of bankruptcy; making it even disappear after five years.

Best set of values

The last proposition formulated for sensitivity analyses proposition (P2.8) tests whether perfectly monitoring all major parameters cited previously will increase the probability of sustainable growth; if decisions are diverse and are made efficiently and if sufficient support is given to the decision-maker, if clients pay rapidly and if the financial partner allows a high credit limit, if the proportion between temporary and permanent employees remains under control, how is the risk of bankruptcy impacted? It might be quite logical to foresee that the risk of failure will decrease, when all influencing parameters are tracked from the beginning and continuously. However, by how much will the risk of bankruptcy decrease? Table 17 shows the results of the best-set analyses that were done. The first line indicates the results of the best combination of internal parameters only – with credit limits remaining at 25% of the turnover. The next two lines include also an improvement of the external parameter “credit limit”; the only parameter, which varies among these lines, is the proportion between temporary and permanent employees:

Clients rapidity to pay (days)	Sensitivity to wellbeing (%)	Sensitivity to environment (%)	Efficiency of decision-maker (%)	Efficiency to support decision-maker (%)	Number of temporary VS permanent (proportion)	Credit limit allowed (% turnover)	% sustainable runs after	% sustainable runs after
							5 years	10 years
10	80	80	90	50	1.5	25	55%	22%
					4	65	67%	60%
					1.5		69%	61%

Table 17 – Results of sensitivity analysis: best set of values

As one might see, when the credit limit remains at its initial value (25%), the percentage of sustainable trajectories after five years exceeds 50% and represents therefore the best value reached until now. However, after 10 years of growth, the percentage falls again to 22%, which is close to what was obtained with initial values. Though, when the credit limit is high, the percentage of runs, which are sustainable after five years almost, reaches 70%. After ten years of intense growth, the percentage remains at more than 60%, which is by far better than the initial results. Even if the risk of bankruptcy does not disappear entirely, it remains at a lower level than in any combinations tested until now.

As a result, proposition (P2.8) is not rejected; closely monitoring influencing parameters increases the probability of achieving sustainable growth; after five years in all cases – even if only internal parameters are monitored closely – and after ten years only if the external parameter credit limit is also adapted (for supporting the company's development).

6.3 Discussion: resulting outcomes of the last research study

This section provides outcomes arising from the third and last research study. Results were observed thanks to the development of a simulation model representing a growth phase. First, this last research study allows modelling a growth phase in detail from an OM perspective, which is something that had not been achieved beforehand. Second, the model makes the measurement of bankruptcy risks possible. Moreover, it provides interesting information about decision-making parameters and other KPIs that highly influence the probability of achieving sustainable growth.

6.3.1 Risk of bankruptcy

As mentioned already, the most unexpected result of this research is probably the percentage of runs that lead to bankruptcy; taking into account that, with the same initial values, some runs perform quite exceptionally. Even though surprising, this result is nevertheless in line with the observation of Satterthwaite and Hamilton (2017) who found that 25% of high-growing firms emerge to die very rapidly and that those who stay alive contribute massively to employment – among other things. In this model, sustainable runs create trajectories that are profitable and create employment. As shown in the literature review, performance and profit were intuitively linked with growth for a long time but it appears that the reality is different. This study is just one more example showing that growth will lead to high performance and profitability only if it is successful – which is by far not a reality in the majority of the cases. Growth might be

related to profitability but it also has a negative effect on survival. It therefore seems to show that partially due to luck when a company grows; even if all major aspects are quite well monitored, the risk of going bankrupt remains very high. The role of luck was already observed by who mentioned that it is not at all clear how much impact a CEO has on his company and how much success depends on skill or pure luck. Several authors already investigated the proposition that growth paths might be random to a certain extent (Derbyshire and Garnsey, 2015) and that performance towards growth is primarily a game of chance (Coad et al., 2015). This thesis' results seem to verify this proposition; the stochastic influence in the model might create very profitable and outstanding runs just as it might create very risky runs that lead to bankruptcy. This observation has important practical implications. CEOs of growing firms may want to be aware of this before engaging in an intense period of growth – on purpose or not – just how high the risk of bankruptcy is. The psychological aspect linked to bankruptcy, which is considered as the fear of failure in entrepreneurship, influences entrepreneurial actions and outcomes. The CEO of SCHWAB-SYSTEM was not aware of the risk he was taking while leading his company to intense growth. Being conscious of the risk, he might probably have adapted his decisions in order to keep the growth more curbed. According to the fact that the case-company encountered some great success towards its growth, this would have been unfortunate. On the other side, being aware of the risk might help with getting prepared for it. When requiring to exit, the strategy developed by the CEO of the company will depend on three typologies (DeTienne et al., 2015). Moreover, choosing to grow for an extensive period might also increase the risk unnecessarily. Achtenhagen et al. (2017) have observed that once a company has created a public image of growth, it might want to keep growing in order to meet public expectations. However, as results show that the percentage of sustainable growth after ten years is about 10% lower than the percentage of growth after five years of intense growth, choosing to grow eternally can be hazardous. Therefore, while measuring the risk of bankruptcy, entrepreneurs might still choose to grow, but for a limited period only. The benefit of taking a pause before continuing to grow has been highlighted by Daunfeldt and Halvarsson (2015) who found that high-growth firms are essentially “one hit wonders” – high growth is not persistent over time and tends to be followed by stagnation periods. Looking into the company's operations Bryan et al. (2013) have examined the relationship between productivity, firm strategy and bankruptcy risk; they found that productivity is associated with reducing bankruptcy risk. The author's model reflects productivity towards the organization level of the company and the performance level of employees-, which might be reduced when they are overloaded with work. Those parameters might therefore be tracked meticulously in order to

ensure a high level of productivity, which supports sustainable growth. As noticed in the literature review, the correlation between sustainable growth and performance is not straightforward; this underlines again the necessity of finding a way to manage periods of growth efficiently. Moreover, as observed by Oliva (2001), maintaining a high-service quality while growing rapidly is a real challenge, because positive loops driving growth might rapidly become vicious cycles leading to a death spiral and eventually causing failure. These positive or negative spirals have also been clearly observed in the model; a first negative phenomenon will result in creating other negative dynamics, which will all together very rapidly lead to bankruptcy. The author therefore investigated further which parameters highly affects the risk of bankruptcy in order to reduce the risk of vicious cycles as much as possible; a discussion of these results is presented hereafter.

6.3.2 *KPI: Decision-making*

One of the major proposition of this research was that the decision-making process – which includes the efficiency to make decisions and the diversity of decisions made – would highly influence the probability of achieving sustainable growth. The sensitivity towards environment impacts the trajectory only on the long-run (ten years horizon) and only if the sensitivity remains very low. The sensitivity to well-being affects the turnover and the number of permanent employees' evolution rather than the percentage of sustainable runs and only if the sensitivity to well-being is close to or totally inexistent. The negative impact of low sensitivity to well-being is in line with the observations of Farooq et al. (2014) who provides evidence that firms with strong corporate social responsibility practices achieve higher productivity because their employees are motivated and as well as cost benefits due to low turnover. It therefore seems that the decisions made towards social and environmental aspects affect not only the behaviour of the firm but also the behaviour of its employees.

The results regarding the mitigated impact of sensitivity to environment and sensitivity to well-being parameters together differ slightly from what has been observed by Isada and Isada (2017) who quantitatively verified the relationship between solutions to social or environmental problem and the sustainable growth of a company. However, the importance of maintaining a high organizational level in order to ensure sustainable growth confirms their observations. Boubakary (2015) found that the ethics (personal value) of the decision-maker exert a positive and considerable influence on the growth of SMEs. This observation was more nuanced in this thesis' results as the sensitivity of the decision-maker has a light impact on sustainability of growth. Casado-Díaz et al. (2014) have shown that corporate social responsibility activities

have a positive impact on firm performance, which is higher for service firms than for manufacturing firms. This might partly explain why some propositions are rejected; even though the case-company has an engineer-to-order strategy, which might be to some extent considered as a service and not only as a pure manufacturing production. Another explanation might be that, while facing an intense period of growth, a company which spends an important amount of time on making social and environmental decisions will lose in efficiency overall. Focusing on these types of decisions might be more appropriate during stable or light growth periods. From an entrepreneurial perspective, an additional explanation might arise. The case-company is a family business that follows a product differentiation strategy. Basco (2014) explored the influence of the family upon firm performance and observed that, when following this strategy, family firms perform better if they balance their family and business-oriented decision-making. Social aspects are very important for most family firms; however, business-oriented decisions have to be accurately balanced during growth periods in order to ensure performance along the journey. All of these interesting outcomes would require future research to observe if results would be identical for different industries or for other high-growth firms rather than any kind of – less intense – growing firms.

As observed in the results, the support of managers towards the decision-maker does not have a significant impact on growth trajectory. However, the efficiency of the decision-maker to actually make decisions has a significant impact on the percentage of growth trajectories. A very efficient decision-maker reduces the risk to go bankrupt and an inefficient decision-maker increases this risk drastically, especially after ten years of growth. Moreover, while being inefficient at making decisions, a decision-maker increases the risk of resignations of employees. As mentioned by Villanueva and Djurkovic (2009), managers have to play an important role in terms of ensuring that employees feel an emotional attachment to the company; this phenomenon is – at least partly – achieved through the sensitivity to well-being and through the ability of making – hire- decisions rapidly which will allow the company to take care of its employees and therefore reduce their propensity to leave the company. Making a connection back to the outcomes of the first research study of this thesis, ul Abdin et al. (2017) have examined the impact of using heuristics while making investment decisions. Besides influencing the decision-making process, heuristics also affect investment performance. This dynamic is linked to all “investment” decisions in the model (refer to appendix 3, section 10.3.17 for investment decisions behaviour). While discussing the first outcomes of this thesis, propositions (P1.2a) and (P1.2b) arise; the use of heuristics for distinguishing between low-impact and high-impact decisions would enhance the overall performance of operations and

additional reflection would be required only for high-complexity decisions. In the model, investment decisions are already separated into different levels of complexity and impact – individual, collective and infrastructure investments – and different means of investment – cash, leasing and loans. Relying on heuristics might therefore be appropriate for individual investments, or leasing – easier to obtain; additional reflection might however be necessary for infrastructure investments requiring the procurement of loans. Several other types of decisions are also clearly split in the model logic (e.g. accept projects decisions where the level of decision making is modulated according to the price of the project; hire and fire decisions where the process followed is different depending on if it is a temporary or a permanent employee who is considered). However, some decisions are not as clearly separated in the model logic - because the company gives all of them the same priority (e.g. organizing, marketing, environmental, and well-being). The case-company could maybe find a way to prioritize the decisions falling in these categories as well, in order to rely on heuristics for some of them and to spend additional reflective time only on few carefully chosen decisions. By doing this, social and environmental decisions might possibly increase their positive impact on the trajectory of growth.

6.3.3 KPI: Proportion of employees

It has been mentioned already that the use of temporary workers is very common in the construction industry worldwide. Temporary workers are required for increasing the flexibility of the company during peaks and for reducing the layoff costs. On the other side, temporary wages are relatively high and might rapidly account for an important part of the global payment traffic of the growing firm. Therefore, choosing a correct proportion of temporary workers in regards to the number of permanent workers is a critical question. The proposition was that a smaller proportion of temporary workers would help the company achieve sustainable growth – as the risk of running out of cash would be unreasonable with a large proportion of temporary workers. However, interestingly enough, this proposition was not rejected but only to a certain limit. A proportion of 1,5 temporary per permanent employee yields the best percentage of sustainable trajectories. In the opposite direction, a proportion of four temporaries per permanent employee also ensures a higher percentage of sustainable growth trajectories. However, all values in-between (from 2 to 3,5) provide worse results and a proportion of 1 temporary per permanent employee dramatically increases the risk of bankruptcy. In the construction industry, it seems impossible to grow while not using temporary agencies (Forde et al., 2008). This observation is confirmed in this case as an insufficient proportion increases the risk of bankruptcy during periods of growth. This result also has important implications for

managers of growing firms. As the processes of hiring and firing temporary workers mainly rely on the middle management – instead of the top-management – managers might need to know that the minimum amount of temporary to hire should be 1,5 per permanent employees in order to ensure sustainable growth. They might then rather choose to keep this proportion reasonable (1,5:1) or to increase it drastically up to 4 temporaries per permanent employee - during periods of higher workloads or very short deadlines to meet. Proportions in-between do not bring any benefit to the company and would even reduce its performance or increase the risk of bankruptcy. Reaching the proportion of (4:1) might be required when permanent employees are overloaded by work. As their satisfaction is negatively influenced by perceived workload imbalance (Galup et al., 2008), increasing the number of temporary workers might be a good solution in order to re-establish equilibrium. Reducing potential beneficial proportions to only two options (1,5 or 4 for 1 permanent employee) helps again with improving the efficiency of the managers for conducting operations management. Specific rules might be set for the managers to know when it is best to switch between reasonable proportions to higher proportions. As fluctuations in the number of temporary employees should be reduced, deriving decisions of hiring permanent employees will also be made more efficiently if the 1,5 or 4 proportion is observed for an extensive period. Additional reflective time could be shortened and therefore once again increase the overall probability of achieving sustainable growth.

6.3.4 KPI: Financial parameters

As discussed above, the major risk during growth periods is to run out of liquidity. Therefore, parameters linked to the cash-to-cash cycle of the company are expected to have a significant impact on the probability of sustainable growth of the growing firm. The financial parameters tested in the sensitivity analyses were the clients' rapidity to pay and the credit limit allowed by the bank (in percentage of the turnover). As assumed, the more rapid the clients pay, the higher the probability of a sustainable growth. More specifically, it was interesting to observe that allowing a delay higher than 50 days would almost always lead to bankruptcy; and that being able to reduce this delay to 10 days or even to 0 days (assuming that the client would pay for the project before the company starts working on it) drastically increases the probability of sustainable growth. This result bridges the gap in literature because to date, very few studies have attempted to measure the impact of the rapidity to pay of clients on the risk of bankruptcy. This parameter was rarely associated with the risk of failure, even though this study shows it has a noteworthy impact. This result of course has practical implications as well. Financial managers of growing firms should be aware that allowing their customers to pay with large

delays (more than 30 days) dramatically increases the risk of bankruptcy. Before growth periods, liquidity is always and logically at a high level – a low level of liquidity would not support initiating a growth period anyway. Therefore, financial managers should focus on avoiding payments delays. Consequently, they should not lose sight of clients who pay at 30 days or more and see to it that corrective action is taken to decrease the delay. Once growth starts, their focus will be on adapting internal processes and there might not be enough time to prioritize dealing with payment delays. Once the level of liquidity reaches a critical value, it might be too late to adjust payments conditions. This is especially true in the construction company where most of the time new offers are made, given to clients, discussed and accepted only after a few months; and then projects start only after another monthly delay. As a result, benefits of stricter payments conditions might be reaped by the company a year later; which might of course be far too late for avoiding bankruptcy caused by a lack of cash. Therefore, financial managers might want to continuously track strictly this KPI, starting at the latest when growth launches, when the level of liquidity is still very comfortable. Stricter conditions such as requiring a percentage of pure advances at the project start and subdividing payments in several small invoices might be perfectly acceptable by clients as long as conditions are thoroughly explained from the beginning.

In comparison with internal efforts that the growing firm can undertake during or before periods of growth, the positive impact that might be made by the bank remains however much higher. Indeed, the results clearly show that the credit limit allowed significantly affects the percentage of sustainable runs. The regular amount of credit limit allowed represents – simply put – 25% of the last published turnover. A small increase (from 25% to 30%) already decreases the risk of bankruptcy by 10%. If increased to 50%, the credit limit reduces again the risk by 10%. With a credit limit identical to the proportion of debt versus capital (65%), the percentage of sustainable growth reaches more than 50%. Moreover and most importantly, this percentage is identical after five and ten years; which means that the risk of going bankrupt disappears after five years of intense growth. The proposition that a higher credit limit obtained from the bank increases the probability of sustainable growth is therefore not rejected; the results even show that a higher credit limit considerably reduces the risk of bankruptcy; making it disappear after five years.

In terms of theoretical contribution, this result bridges a gap identified by Fraser et al. (2015) who observed that literature provides little information about the impact of financial constraints on small business growth. Their results show that an increase in internal finance relaxes financial constraints. However, as observed during the simulation runs, this option is not

possible for a high-growth firm which therefore will be constrained by a lack of working capital or by always increasing term-loan rejection rates since the 2008 financial crisis (Fraser et al., 2015). Many researchers have studied the negative impact of the 2008 financial crisis on bank policies – including the reduction of loan extended –. Some global restrictions such as BASEL III are now applied by most banks worldwide, in order to limit risks of allowing unjustified or excessive credits. Therefore, simply put, the reaction of banks after the financial crisis was to reinforce constraints for accessing bank services. The objective was of course to reduce risk of bankruptcy for banks and increasing rules and constraints is in many cases suitable for this type of goal. However, several researches have provided evidence that SMEs suffer from these constraints. Krishnamurthy (2015) shows that legal restrictions can impair small businesses' access to finance, and therefore limit the growth of medium-size establishments. Brown and Earle (2017) estimate that improving financial access for firms would imply a massive increase of jobs for each million dollars of loan; they therefore suggest a real effect of credit constraints. The impact of finance constraints on the growth of firms was even evaluated by Gautam and Vaidya (2014) who found that finance constraints are really binding for high-growth firms. All of these results are confirmed by this study, which shows that when the credit limit remains very low, the percentage of sustainable growth falls drastically, even the rare trajectories that lead to success are limited in terms of turnover evolution, jobs creation and performance. One might presume a link between credit limit and efficiency – e.g. a higher credit limit might be an incentive to be more efficient, spending less time on dealing with payments issues, etc. Silver and Vegholm (2009) have observed that standardized systems that prevail within bank organizations are one of the reasons that explain difficulties that banks encounter when trying to meet the needs of their SMEs' customers. This phenomenon is easy to apply to high-growth firms' situations; as the turnover evolves very rapidly during growth, the standardized bank system – which computes the credit limit level based on the past year's turnover – might be totally out of sync regarding the current turnover that is achieved by the company. As one Swiss banker with whom the author discussed said:

“We know that the way we compute credit limit allowed is maybe not suitable for growing SMEs. Indeed, they might be achieving a much higher turnover than the one we think they are. But before getting their new published balance sheet, we cannot measure their turnover in a confident manner, and therefore we are obliged to limit our support.”

SMEs are also restricted in their capacity to provide intermediary financial results during the year – which might maybe help the bankers revise their support more often than on a yearly basis only. Would that be useful anyway? Realistically, most SMEs (1) will ask for an increase

of their credit limit the earliest after six months of growth since the last increase (when yearly financial results were published and credit limits adapted accordingly), (2) have limited financial human resources and therefore will need at least two full months to prepare intermediary financial results, (3) will need to wait another two months for the processing of their request and adapting to (if agreeing) the credit limit conditions. This whole process lasts for almost ten months and therefore the benefits of increasing the credit limit at that time are very limited. Rather than keeping their standardized approach, bankers should therefore find another way to compute credit limit allowed for high-growing firms, in the interest of the firm but in their own interest as well. Indeed, the author's results clearly show that increasing constraints and reducing support for growing firms increases the risk of bankruptcy by far; achieving the opposite of the initial objective – which was to reduce the risk of bankruptcy of the bank's clients and the bank itself. Yoshino and Taghizadeh-Hesary (2015) have developed a scheme for assigning credit ratings to SMEs in order to enable banks to adjust their loans based on the financial health of their client. This model could contribute to computing the risk of bankruptcy and help identify the financial health of a growing company. While parametrizing it with initial values corresponding to the company, the risk of bankruptcy could be precisely measured; and the impact of the bank support could be highlighted. The proposition of the authors that healthy SMEs could borrow more money from banks at lower interest rates because of their lower default risk could therefore be applied as well to high-growth firms. Banks should already be aware of the fact that the higher their financial support towards growing firms, the higher the probability that their clients will make a sustainable growth.

While better supporting their clients, banks would also receive other advantages. SMEs who perceive the capacity of their banks to provide meaningful advice will become more satisfied (Madill et al., 2002) and therefore more loyal (Silver and Berggren, 2010). The corporate image of the bank will also be positively impacted by the ability of the bank to meet SMEs' specific needs (Vegholm, 2011). Banks supporting growing firms could even benefit of developing their services abroad; if the supported firm eventually grows internationally (Eriksson et al., 2017). To recapitulate, banks may have a strong interest in revising their approach regarding the support they provide to growing firms. This would not only increase the probability of sustainable growth of their clients but it would also reinforce their relationship. This approach seriously questions the current direction that banks have started to follow after the financial crisis of 2008; while demonstrating that, in terms of sustainable growth, reducing financial constraints might lead to much better results than increasing them. Even if the model also shows that a hundred percent guarantee cannot be reached – because luck will always be a necessary

part of success – the probability of achieving sustainable growth will be powerfully affected by the bank support.

According to Paulet et al. (2014) SMEs try to adapt their strategies to the new context – arising after the financial crisis – and do their best to diversify their funding sources in order to guarantee their growth but also their future financial and economic profitability. Therefore SMEs might choose to turn to other sources of funding such as trade credit (Casey and O'Toole, 2014) or angel and capital investors who have other decisions policies and for whom economic potential, specific human capital, strategic readiness, and passion matter differently (Hsu et al., 2014). Whatever source of funding is chosen by the growing firm, the financial partner should be aware of the role it will play for supporting sustainable growth; and SMEs should insist on accessing enough support in order to reduce their risk of bankruptcy.

6.3.5 *KPI: Best set of values*

As each parameter has been analysed separately until now, the best set of value had per aim to evaluate the impact of combining individual results collected. The best probability of achieving a sustainable growth after five and ten years until now was at 50%; while combining several influencing parameters together, the probability of success reaches the level of 70%.

First, one might observe that the risk of failure is never null, even with all major parameters perfectly monitored during the whole period of growth. A 30% of risk of bankruptcy remains in any case. This risk might be linked to one of the first observations, which seems to indicate that luck is always a part of the growing process that cannot be entirely eliminated. However, most entrepreneurs might withstand this level of risk. Risk-averse profiles might also choose not to grow, or at least not for extensive periods, while being aware of the risk that remains in any case.

Second, it is of interest to notice that there is no need to track countless numbers of parameters in order to positively influence the growth trajectory of the company; monitoring just a few appropriate parameters will already considerably enhance the probability of sustainable growth. Internally, the company might choose to focus especially on (1) encouraging the clients to pay rapidly – by splitting the total price in several invoices, from which some might be sent ahead of the project start; (2) monitoring closely the number of temporary employees who are hired compared to the number of permanent employees – allowing either a proportion of (1,5 : 1) or of (4 : 1); and (3) remaining as efficient as possible while making decisions – of any category – during the whole period of growth – decisions made rapidly will help with navigating the firm

efficiently. While keeping internal parameters under control, the probability of achieving sustainable growth after five years exceeds 50%. However, this percentage falls again after ten years, which seems to indicate that monitoring internal parameters only is not sufficient on the long run. Indeed, externally, there is one parameter that should be negotiated as strongly as possible; the credit limit allowed by the bank. A high credit limit combined with internal KPIs well monitored will reduce dramatically the risk of failure during growth and reach the level of 70% of chances of success.

Operations managers as well as financial managers are especially engaged in monitoring these KPIs. In terms of operations management, the level of organization of the company will also have to remain as high as possible, even though this might be achieved through the capability of the decision-maker to make decisions regarding organizational aspects. While focusing on these aspects, the company might already feel more confident towards growing and might know how and when to act in order to ensure sustainable growth.

Conclusion

This research study answers research questions (6) and (7) which were the last questions remaining open until now. It covers a complete period of growth with the help of the modelling software AnyLogic. Based on the different simulation runs – standard simulation, compare runs and sensitivity analyses – it was possible to measure the probability of achieving sustainable growth after five and ten years. Once the risk of bankruptcy was precisely measured, major parameters concerning the decision-making process and KPIs that highly influence this probability were identified and tested. The “best set” combination allowed for observing how the percentage of sustainable growth could be positively impacted if all critical KPIs and parameters were perfectly monitored during growth periods.

7 Contribution

Considering business growth as a process, the ultimate objective of this research was to investigate how managerial decision-making in SMEs may guide companies towards sustainable growth trajectories. By exploring new theory at the interface of business growth and sustainable development, this study represents a novel and powerful approach to analysing the influence of decision-making on key measures of a growing company and of evaluating the risk of bankruptcy, therefore providing support to managers of growing firms.

In terms of the methodology application, this research answers the call of several researchers who have been asking for someone to study growth as a process, in order to capture the complexity and multidimensionality of the concept and to bring insights on a new approach of studying growth. Moreover, this thesis satisfies the need to conduct longitudinal case studies in order to study a company as it evolves during the growth period. Following the structure of the thesis, contributions will be presented in three main sections and are deemed relevant for both academia as well as practice.

7.1 Contribution of research study 1: understanding growth decisions

The investigation around business growth started with the impact of decisions on growth. The objective of research study one was to zoom into operations decisions made while growing in order to improve the understanding already gained about how firms grow. The following research questions have been investigated in the first research study of the thesis:

- (1) What types of decisions have to be made by a growing SME manager on a regular basis?
- (2) How can the decisions be classified and what types of decisions can be derived based on this classification?
- (3) Which patterns (series of steps within one decision) can be observed while zooming into a decision?

After defining sustainable business growth, this research proposed a categorization of decisions along the three dimensions of the triple bottom line (economic, social and environmental dimensions), the supply chain (supplier, focal firm, and customer) and the levels of decision-making (strategic, tactical, and operational), for classifying operations decisions made during growth periods. Then, based on a longitudinal case study with three embedded units of analysis, various complex patterns (sequences of steps) of operations decision-making were inductively identified. Finally, the author developed a decision-making framework and suggested various research propositions to be tested in the following parts of this thesis. The framework details

how operations decisions made by managers during growth periods can contribute to sustainable growth.

This thesis complements existing theory on business growth by adding to it the concept of sustainability, and exploring its implications on operations-related decision-making processes. The propositions in this framework contribute to the practice of growth management by providing valuable insights that may support growing firms in getting through these kinds of complex transition phases.

Understanding which steps the decision-maker has to pass through while making a decision also adds to the decision-making theory and contributes to helping managers of SMEs better support their CEO (decision-maker). While being aware of the complexity of the patterns and of the risk of endless loops, managers might skilfully provide support if the necessity to make decisions more rapidly becomes apparent.

The classification framework highlights the necessity to consider operations decisions on all dimensions of the TBL in order to achieve sustainable growth. By contributing to the use of the TBL concept in the understanding of business growth, this observation also provides SMEs with practical and easy to use tools to verify their growth considers a sufficient number of its multi-aspects.

7.2 Contribution of research study 2: observing a whole period of growth

At this stage of research (end of research study one), there was still a need to identify the connection that might exist between different decisions made during periods of growth, in order to understand how decisions interrelate with and impact each other. After having gained some deeper understanding on decisions themselves, it was time to investigate their global influence during growth. To achieve this, it was necessary to zoom out in order to observe a complete period of growth and to investigate links between decisions. For this aim, the following research questions have been investigated in the second research study:

- (4) What is the impact of decisions on the growth trajectory of the SME?
- (5) Which cycles (series of different decisions) appear during a period of growth?

This thesis adds to the theory of capacity expansion strategies by stressing the effectiveness of the managerial decision-making process as an important contingency factor. By considering all decisions made during the five years of intense growth of the company in a longitudinal study, the author provides a new approach for improving the understanding of high-growth firms and therefore answers the call of Brown and Mawson (2013) who assert that monitoring firms

closely is crucial to examine the dynamic nature and consequences of growth trigger points (i.e., decisions in our case).

Overall, the author has observed that a growing company has the opportunity to take advantage of its growth not only to “do more things”, but also to “do things better”. In terms of improving its efficiency, a growing company might learn how to make a larger number of decisions during a similar period of time, without diminishing their quality. Organizational learning can be observed among managers of the company who learn how to support each other during the decision-making process. Both of these results are related to the theories of organizational learning and knowledge creation. By using the “option to learn”, the company uses the waiting time to observe the impact of its previous decisions and eventually make better decisions afterwards. This fully complies with real options theory and Bayesian theorem by giving rise to this additional strategy of managers for influencing the future outcome by a delayed interventionist action.

Regarding the gain in social responsibility, the results of this study show that the company considers more social than environmental aspects. This can also help with filling an important gap pinpointed by several researchers in this field. By following this new approach that focuses on decisions and considers growth as a dynamic process, one might distinguish social aspects more clearly than with other approaches. By considering a continuously increasing variety of decisions during growth, the company responds to new stakeholder demands. This result improves the general understanding of how a company integrates more parameters over time and therefore reaches a better – and more holistic – performance achievement afterwards.

On the managerial impact side, this research advises managers on how top management may use growth to improve the efficiency and responsibility of the company. By promoting organizational learning, supporting and encouraging each other to consider different types of decisions, managers of a growing firm can positively influence the outcome of this complex transition phase. Indeed, this study highlights that the decision-making process influences crucially sustainable business growth, positively or negatively. It is therefore critical for managers to understand the importance of an effective decision-making process, as well as the necessity to support the company in its learning process on how to become efficient during growth periods.

Observing the time-dependency and type-dependency of decisions has led to the identification of interesting patterns over time (cycles of decisions). This identification of cycles of decisions fosters the acceptance that growth periods imply nothing but deciding, which might disturb

managers at first. The pace at which decisions have to be made can become very rapid during growth periods and while being aware of it, managers will feel comfortable with that. The identification of cycles of decisions also enabled an understanding of the connections between different decisions made during periods of growth, in order to better understand how decisions impact each other. Alongside these results, the empirical identification of a pattern might also contribute to theory building in the field of business growth.

7.3 Contribution of research study 3: creating the model representing a period of growth

The development of the model representing the operations of a growing company has been achieved thanks to the raw and analysed data that were provided during research studies one and two of this thesis. The objective of the presented empirical quantitative research study was to deal with the following research questions:

- (6) How can the risk of bankruptcy during growth be measured?
- (7) How can the decision-making process of growing SME managers be supported in order to sustain the growth of their firm? And more precisely:
 - a. What is the impact of the efficiency to make decisions on the growth trajectory of the firm?
 - b. What is the impact of the sensitivity towards well-being and environment on the growth trajectory of the firm?
 - c. Which key performance indicators (KPI) can be monitored in order to increase the probability of a sustainable business growth?

One of the major contributions of this thesis is the precise measure of bankruptcy risk; which shows that the percentage of risk of business failure during growth is extremely high; even for companies, which might create – with the same combinations of initial parameters values – relatively outstanding trajectories in terms of performance. By providing the possibility to measure the risk of bankruptcy, this research contributes to the field of research investigating how business failure can be predicted. Moreover, this result contributes to the theory of capacity expansion strategies (Slack and Lewis, 2002) by shedding light on the narrow frontier between runs that lead to bankruptcy and runs that ensure sustainable growth. The use of a simulation model to represent the dynamics of growth strongly contributes to the understanding of the concept of business growth. The combination of qualitative and quantitative methods will help with the general understanding of the concept of business growth (Achtenhagen et al., 2010).

In terms of theory development, this research helped in identifying growth processes that are linked to sustainable business growth and in understanding the major causes of success or failure of growing firms under specific circumstances.

In order to go one-step further and to foster the development of theory of bankruptcy causes and impact, this research identified major KPIs that highly influence the probability of going bankrupt. The sensitivity analyses allowed for observing which parameters deeply impact the trajectory of a company during a growth phase. This revealed different reasons for bankruptcy and helped with shedding light on some of the major risks and elements to track cautiously during growth periods. Main KPIs themselves contribute to theory testing; the influence of the sensitivity of the decision-maker towards well-being and environment somehow contributes to research made on Corporate Social Responsibility activities and their impact on firm performance. The way the use of temporary workers affects the performance contributes to researches on temporary employees and agencies, while demonstrating the positive impact of using them during growth periods; financial KPIs important influence provides useful insights for the research about several financial fields, such as the impact of new banking restrictions on SMEs (such as BASEL III regulations) and the relationship between SMEs and their bank.

The necessity of prioritizing decisions within identical categories –with spending more time on decisions, which have bigger impact; such as the investment in infrastructure compared to investment in collective material - also provides a new application of the use of heuristics during the decision-making process.

In terms of practical insights, this study aims to practically assist managers of growing firms during their transition journey. Being aware of the high risk of bankruptcy might not necessarily scare SMEs' CEO and discourage them to seize growing opportunities but might instead encourage them to grow intensively only for limited periods. Moreover, the resulting outcomes of the “best set of values” might also incite them to benefit from growth periods, while monitoring precisely just a few appropriate parameters, namely the rapidity at which clients pay, the efficiency to make diverse decisions rapidly and the proportion between temporary and permanent employees. Monitoring a countless number of parameters might not be worthwhile.

Banks and other investors might also benefit from the results of this study. The support provided by financial partners is tremendous during growth periods, especially in terms of limit credit allowed. The external control provided by banks and other financial institutions during growth periods is of course positive and necessary. Many companies would grow at a dangerous pace without it and the risk of failure would even be higher. On the other hand, the risk of bankruptcy

is highly impacted by financial constraints; as financial institutions share the responsibility of the clients to fail or to succeed, it might be in their best interest to be aware of decisions when it comes to defining credit limits.

Globally, this research advises managers and financial service providers who support growing firms, on how to evaluate risky situations and shortly afterwards to take corrective actions by effective decision-making. This model shows that tactical and strategic decisions made during a growth phase may severely affect the company's liquidity level and its survival altogether. By observing simulations outputs in detail, the interlinked effects of any parts of the model showed how strong any phenomenon would influence the performance of the company positively or negatively. Upward and downward spirals are observed at any time during the simulation, while the company continuously tries to restore equilibrium. Lasting downwards spirals almost always lead to business failure.

The model developed during this thesis could in the future be used as a tool to support the decision-making process of growing firms' managers; it might also be useful for banks to draw scenarios depending on the support they deliver. As mentioned already, growing firms often feel lost and not supported during growth periods, without knowing how to maximize their chances of achieving sustainable business growth. By developing an efficient decision-making process related to growth periods, this study helps managers with making decisions and determining what their impact will be, thus guiding the transition journey of growing firms towards sustainable business growth. Support received by banks during growth periods might also encourage SMEs to seize growing opportunities, while at the same time reinforcing their relationship and the loyalty they might feel towards their financial partner.

By adapting initial values of the model in order to make it match any company operating in the same industry, it would be possible to measure the risk of bankruptcy according to several criteria defined with the partner company. Managers could therefore understand and observe visually how the growth trajectory of their firm might be influenced in the future and how they could increase their chances of success. In terms of managerial contribution, this approach could really give practical advice to growing firms' managers in OM but also in financial departments, in order for them to address growth periods more serenely right from the start.

8 Conclusion

The ultimate objective of this study was to investigate how SMEs face intense periods of growth; the decision-making process during growth has been examined and the risk of bankruptcy for companies that have to continuously reorganize their operations and adapt their capability has been measured. Considering and representing business growth as a process, it was investigated how decisions made by managers during periods of growth influence how firms grow and which elements should be closely monitored in order to increase the probability of success. Rising extremely fast and failing as fast has been observed in many SMEs, therefore the topic of business growth had been handled with a broad range of perspectives and approaches for decades. This study answers the request of several researchers who had called for a focus on growth as a process while studying this phenomenon; therefore seizing the multidimensionality and complexity of the concept. Moreover, it contributes to business growth literature by integrating the concept of sustainability and it also adds to the understanding of operations management theory by providing a nuanced picture of operations-related decision-making processes during business growth—exceeding the current operations management focus on strategic decisions relating to capacity (Olhager et al., 2001).

The study was organized into three main research studies; naturally following each other and building upon the previous one. The study subject was a Swiss growing SME, which faced an intense period of growth during five consecutive years; a longitudinal case study allowed for studying the process of growth as the company was evolving. In the first research study of the thesis, the territory of operations decisions during a growth period was mapped with the aim of a classification framework, based upon the dimensions of the triple bottom line (economic, social and environmental); therefore this framework could now totally be extended to any sector or industry. Different sequences of complex decisions were investigated and three inherent patterns were identified; these patterns improve the understanding of the decision-making process during growth periods and explain why sometimes decisions require an excessive amount of time before being made. In the second research study of the thesis, five consecutive years of intense growth were investigated in order to understand how the case-company evolved during this transition period. All decisions that impacted the company were collected and analysed referring to the framework of research study one. It was observed that growing firms could take advantage of their growth to make things better while improving their efficiency at making decisions, considering more stakeholders and focusing especially on the well-being of their employees. By collecting decisions but also internal processes empirical data, the second

research study of the thesis allowed to build a simulation model that represents a company's operations and its expansion during a growth phase. Research study three was entirely dedicated to simulation modelling and to sensitivity analyses that could be computed with different parts of the model. Through a compare runs analysis, the risk of bankruptcy of a growing SME was precisely measured. Sensitivity analyses allowed for identifying seven KPIs, which should be closely monitored during growth; their ideal values –which would maximise the probability of achieving a sustainable growth – were also tested and discussed in order to advise growing firms' managers.

Presenting the results in the form of monography highlights the fact that each research study of the thesis, taken individually, does not result in the same insights. Moreover, the last research study of the thesis could not have been completed without the two preliminary research studies.

Thanks to this study, several interesting results arise. First, once computed with the simulation model, it appears that the risk of failure during growth period is extremely high – much higher than expected – and this applies even to companies, which might present the same initial values as firms performing outstandingly after a period of growth. It therefore means that besides the efforts made by the growing firm, luck remains to be an inevitable part of the equation. Even though it is likely that the case-company has been close to failure from time to time, such a high risk of bankruptcy was not imaginable. Second, it is possible to reduce drastically the risk of bankruptcy while monitoring a few appropriate KPIs closely and from the beginning of a growth period. Combining all of them and maintaining ideal values for each of them will positively influence the probability of achieving sustainable growth. The majority of these KPIs are internal and therefore the operations and financial managers might engage in tracking them carefully. The KPI that presents the most significant impact on the growth trajectory of growing firms among all tested KPIs is external – the credit limit allowed by the bank. Obtaining a higher credit limit than what standard banking systems allow for today requires therefore negotiating power from the company. However, this result might concern not only managers of SMEs but also bankers who finance companies and who are directly affected by the failure of their clients. Indeed the results of this study show that the higher the credit limit allowed by the bank, the higher the probability of success of the growing company. Therefore, this result finally suggests that, by restraining the credit limit for growing firms, banks have not followed the most optimal approach ever since 2009 and that they would also personally benefit from increasing credit limits during growth periods.

With this research, it has been confirmed that decisions made during growth periods positively influence the growth trajectory and that their impact can be quantified; the number of decisions during growth periods has also been depicted as being extremely high, which might give CEOs the impression of doing nothing but deciding. Therefore, the proposition that the numerous operations decisions that have to be made during growth periods have substantial repercussion on the overall financial health of the company was confirmed. Moreover, the probability of sustainable business growth has been precisely measured in different situations and KPIs to monitor closely in order to improve this probability have been identified. Almost all KPIs have a strong impact on the probability of achieving sustainable business growth; therefore, the majority of propositions formulated in this research were not rejected.

Outcomes of this study contribute to theory building and add to the understanding of the concept of business growth; future avenues of research might also engage researchers in investigating this phenomenon further. The general understanding of the concept of growth has also been improved thanks to the combination of qualitative and quantitative approach.

In terms of practical implications, this study contributes by supporting the decision-making process of growing firms' managers. Specific advice on how to monitor influencing KPIs has been given and recommendations have been formulated. Finally, the results might also implicate banks and other financial institutions, which are directly affected by the success or failure of their clients along the journey of growth. Results of this study show that moving to a supportive strategy towards growing firms – at least in terms of credit limit computation – might benefit both investors and their clients.

This study is the first of its kind that models in detail the entire operations of a company and their evolution during periods of growth. Computing precisely the risk of bankruptcy depending on several combinations of parameters values is innovative and helpful for growing firms' managers who seek out support during intensive growth periods. By supporting growing firms, this study also aims to sustain the economic development that needs to be fostered both in terms of employment opportunities and in terms of different firms' performance.

In terms of limitations, one might consider the following elements. First, the results are essentially based on one company, and consequently on one sector: the construction business in Switzerland. By choosing a longitudinal case-study methodology, the author has answered the call of several researchers investigating the concept of business growth. However, in order to further investigate the generalizability of the results of this thesis, data collection and analysis could be repeated in other high-growth firms (of different sizes and belonging to different

industries). Complementing the current data by several more years of observations would enhance the validity of the current results and complement their scope.

In terms of modelling, some rare aspects could have been modelled into more detail such as the production programming in the mid-term; the process as it is now is correct, it could only be more detailed. Some elements (listed below) could also have been added to the model; however, they would have increased essentially the complexity of the model and would probably have increased the risk of bankruptcy even more. It is worthwhile to mention the left out category of decisions “develop new activities”, which would have required another complete sub-model for integrating the whole logic standing behind. The credit limit in the model can always either be increased or blocked at its current level; modelling the fact that credit limit could also be reduced in critical cases – e.g., when the company does not pay amortization on a regular basis – could have been modelled; however this would again have only increased the risk of bankruptcy. Besides the use of temporary workers, subcontracting could have been another option for the company when it starts to be overloaded by new projects. The author decided not to model it because the case-company hardly ever relies on this option – probably because of the high degree of specific knowledge that its products require. However, modelling subcontracting would be interesting for future studies in the field. As mentioned in the discussion part already, adding other sources of financing besides the bank in the model would allow the growing firm to increase the possibilities to find a financial partner, depending on the specificities of the growth period and of the company itself (Hsu et al., 2014). To add more complexity to the model, insolvent clients could be introduced. The author neglected this aspect because this phenomenon only has a minor impact on the case-company; however, it would be interesting to integrate especially if the model is tested in sectors where insolvency is much higher (e.g. exporting companies). As mentioned previously, adding competitors would allow observing how growth might be influenced by the development of competition in the global market.

Many interesting axes of development open up from the results of this research. Follow-up research may critically examine, corroborate or modify the given framework by analysing further cases of growing SMEs’ decision-making and by testing propositions derived from the research propositions. Follow-up investigation may also take an in-depth look at specific issues that have been omitted in the present research, as it was beyond its scope. For example, the benefits, drawbacks and application of decision-making by heuristics (Katsikopoulos and Gigerenzer, 2013) could be scrutinized in more depth and thus further strengthen the research area of behavioural operations management. It might also be interesting to transpose this

analysis to large firms which follow other types of strategies to grow. One could consider adapting some processes of the model or creating a simulation with a multiplication of companies – e.g. while splitting large firms in several sub-entities and considering each entity as a different SME in order to observe the global impact of growth on the large firm.

As mentioned in regards to the limitations in the previous section, several aspects could be introduced in the simulation model to enhance its accuracy and design quality. As suggested by Roig-Tierno et al. (2015), combining the use of infrastructures supporting business growth such as incubators, technology centers, and universities can positively affect young innovate companies' growth. This dynamic could be integrated in the model in order to see its positive impact on the probability of sustainable growth. A better understanding of the link between alternative sources of finance and sustained growth should also be studied (Fraser et al., 2015); alternative sources of finance could be integrated in the model in order to measure their impact on the risk of bankruptcy and to finally choose relevant modes of financing during growth periods. In terms of financial accuracy, one might consider to decompose the real options theory in small steps and to model them precisely. This logic, added to the model, would allow observing some subtle mechanisms of the decision-making process when it comes to mixing strategic and financial aspects.

Several sensitivity analyses could also be further conducted. Regarding the sensitivity of the market, several elements could be tested throughout the sensitivity analyses (e.g. the initial number of clients, the percentage of repeating clients, the rate at which new clients are added in the model and the amount of money invested in marketing necessary to gain one new client, etc.). In terms of internal processes, it would be interesting to observe if changing the maximum number of permanent employees who could be hired at the same time would affect the growth trajectory. This number was set according to the company habits, but maybe another way to manage this aspect of growth would benefit the company even more. As a last example, the author would like to mention the level of performance associated with permanent employees who are critically busy; maybe this value would influence the trajectory as well.

In terms of practical implications, the model created during this thesis could potentially be further developed in order to be used for counselling of growing SMEs in Switzerland. According to Widerstedt and Månsson (2015), business counselling has a positive impact on firm growth; therefore this model could represent an interesting tool to help companies reduce their risk of bankruptcy while fully benefitting from growth. Developing a user-friendly version of the model in order for managers to use it is also an interesting option that will be considered.

9 References

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10 Appendices

10.1 Results of data analysis of the research study 2

All tables below that are presented in this appendix refer to the analyses conducted in research study 2, mentioned in the section 5.1.1 - Data Analysis.

10.1.1 ANOVA one factor split by level of decision

ANOVA à 1 facteur						
		Somme des carrés	ddl	Moyenne des carrés	F	Signification
Duration for making the decision in days	Inter-groupes	932951.187	4	233237.797	2.971	.019
	Intra-groupes	32261688.930	411	78495.593		
	Total	33194640.120	415			
Duration for applying the decision in days	Inter-groupes	3040922.408	4	760230.602	23.036	.000
	Intra-groupes	13563987.580	411	33002.403		
	Total	16604909.990	415			

10.1.2 ANOVA one factor split by category

ANOVA à 1 facteur						
		Somme des carrés	ddl	Moyenne des carrés	F	Signification
Duration for making the decision in days	Inter-groupes	3231970.163	2	1615985.082	22.274	.000
	Intra-groupes	29962669.950	413	72548.838		
	Total	33194640.120	415			
Duration for applying the decision in days	Inter-groupes	457532.074	2	228766.037	5.851	.003
	Intra-groupes	16147377.920	413	39097.767		
	Total	16604909.990	415			

10.1.3 *Chi-square test for Sequence and Matrix cell*

Tests du Khi-deux

	Valeur	ddl	Signification asymptotique (bilatérale)
Khi-deux de Pearson	129.975 ^a	42	.000
Rapport de vraisemblance	125.009	42	.000
Association linéaire par linéaire	43.296	1	.000
Nombre d'observations valides	416		

a. 46 cellules (69.7%) ont un effectif théorique inférieur à 5. L'effectif théorique minimum est de .15.

10.1.4 *Chi-square test for Sequence and Level of decision*

Tests du Khi-deux

	Valeur	ddl	Signification asymptotique (bilatérale)
Khi-deux de Pearson	69.951 ^a	4	.000
Rapport de vraisemblance	58.333	4	.000
Association linéaire par linéaire	42.509	1	.000
Nombre d'observations valides	416		

a. 0 cellules (.0%) ont un effectif théorique inférieur à 5. L'effectif théorique minimum est de 9.68.

10.1.5 *Chi-square test for Sequence and Category of decision*

Tests du Khi-deux

	Valeur	ddl	Signification asymptotique (bilatérale)
Khi-deux de Pearson	78.112 ^a	14	.000
Rapport de vraisemblance	84.942	14	.000
Association linéaire par linéaire	35.697	1	.000
Nombre d'observations valides	416		

a. 6 cellules (25.0%) ont un effectif théorique inférieur à 5. L'effectif théorique minimum est de 1.61.

10.1.6 Kolmogorof-Smirnov test

Test 3 de Kolmogorov-Smirnov à un échantillon

Year only for the date of making the decision		Date when the decision was made	
2010	N	33	
	Paramètre de Poisson ^{a,b}	Moyenne 15.06.2010	
	Différences les plus extrêmes	Absolue	.455
		Positive	.455
		Négative	-.455
	Z de Kolmogorov-Smirnov	2.611	
	Signification asymptotique (bilatérale)	.000 ^c	
2011	N	28	
	Paramètre de Poisson ^{a,b}	Moyenne 04.06.2011	
	Différences les plus extrêmes	Absolue	.571
		Positive	.571
		Négative	-.429
	Z de Kolmogorov-Smirnov	3.024	
	Signification asymptotique (bilatérale)	.000 ^c	
2012	N	66	
	Paramètre de Poisson ^{a,b}	Moyenne 05.07.2012	
	Différences les plus extrêmes	Absolue	.515
		Positive	.515
		Négative	-.470
	Z de Kolmogorov-Smirnov	4.183	
	Signification asymptotique (bilatérale)	.000 ^c	
2013	N	127	
	Paramètre de Poisson ^{a,b}	Moyenne 24.07.2013	
	Différences les plus extrêmes	Absolue	.567
		Positive	.433
		Négative	-.567
	Z de Kolmogorov-Smirnov	6.389	
	Signification asymptotique (bilatérale)	.000 ^c	
2014	N	162	
	Paramètre de Poisson ^{a,b}	Moyenne 12.07.2014	
	Différences les plus extrêmes	Absolue	.500
		Positive	.500
		Négative	-.481
	Z de Kolmogorov-Smirnov	6.364	
	Signification asymptotique (bilatérale)	.000 ^c	

10.2 List of empirical data used in the model

DYNAMIC OBSERVED	AGENT	PARAMETER	ELEMENT TO EVALUATE	UNIT
Initial situation	Company	initialNumOfPerm	Number of employees at the beginning of simulation period	# of employees
Initial situation	Company	initialNumOfTemp	Number of temporary employees at the beginning of simulation period	# of employees
Initial situation	Company	initialNumOfManager	Number of managers at the beginning of simulation period	# of employees
Initial situation	Company	infrastructureCapacity	Value of infrastructure at the beginning of simulation period	CHF
Initial situation	Company	organizationLevel	Quality of organization at the beginning of simulation period	%
Initial situation	Company	respectOfEnvironment	Initial value at the beginning of simulation period	Boolean
Initial situation	Company	sensitivityToEnvironment	Initial value at the beginning of simulation period	%
Initial situation	Company	sensitivityToWellbeing	Initial value at the beginning of simulation period	%
Initial situation	Company	liquidity	Initial value at the beginning of simulation period	CHF
Initial situation	Company	creditLimit	Initial value at the beginning of simulation period	CHF
Initial situation	Company	debtLevel	Initial value at the beginning of simulation period	CHF
Initial situation	Company	date of start of simulation	Date of start of period of growth	date
Initial situation	Company	turnoverRealizedIn2009	Initial value at the beginning of simulation period	CHF
Project completion	Company	workingHourPrice	Price charged per hour of work	CHF

DYNAMIC OBSERVED	AGENT	PARAMETER	ELEMENT TO EVALUATE	UNIT
Project completion	Project	workload + main.workloadMaxSensitivityValue	Workload by project	Days
Project completion	Project	workload + main.workloadModeSensitivityValue	Workload by project	Days)
Project completion	Project	startWorkingOnProject (statechart transition)	After how many days does the company start working on project once it is accepted	days
Project completion	Company	function acceptProjectImpact	Condition for accepting projects: percentage of global workload	%
Project completion	Company	function acceptProjectImpact	Condition for accepting projects: maximum 6 months full	workload
Project completion	Abstract Employee	resistanceToStress	Level of stressResistance of a permanent employee	%
Project completion	Abstract Employee	performance - initial value	Level of performance of a permanent employee	%
Project completion	Permanent Employee	function onBusyState	% of occupation fraction where qualityOfWork decreases because employee is critically busy	%
Project completion	Temporary Employee	performance	Level of performance	%
Project completion	Company	function allocateResources	Number of employees (P + T) who work on the same project together	# of employees
Project completion	Company	function allocateResources	# of permanent employees BY project	# of employees
Project completion	Company	function allocateResources	# of temporary employees BY project	# of employees

DYNAMIC OBSERVED	AGENT	PARAMETER	ELEMENT TO EVALUATE	UNIT
Project completion	Main	event <code>allocateMorning</code>	Call function <code>allocateResources</code> when employees come back to work	Timeout, Cyclic
Project completion	Main	event <code>allocateAfternoon</code>	Call function <code>allocateResources</code> when employees come back to work	Timeout, Cyclic
Project completion	Company	function <code>putToRest</code>	# of deadlines unmet necessary to put somebody to rest	# of deadlines
Project completion	Company	function <code>putToRest</code>	<code>globalOccupationFraction</code> where <code>putToRest</code> is required	%
Project completion	Company	function <code>putToRest</code>	# of permanent employees to put to rest	# of employees
Project completion	Main	event <code>putToRestMorning</code>	Call function <code>chooseNumberToPutToRest</code> when employees come back to work	Timeout, Cyclic
Project completion	Main	event <code>putToRestAfternoon</code>	Call function <code>chooseNumberToPutToRest</code> when employees come back to work	Timeout, Cyclic
Liquidity level	Project	event <code>payAdvancePayment</code> + fluid <code>remainingWorkload</code> + statechart <code>cashied</code>	Division of payments during project completion	
Liquidity level	Abstract Employee	<code>salary</code>	Permanent employee salary	CHF
Liquidity level	Manager	<code>salaryManager</code>	Manager salary	CHF
Liquidity level	Temporary Employee	<code>salary</code> + <code>main.salaryTSensitivityValue</code>	Temporary employee salary	CHF
Liquidity level	Company	function <code>investStaffImpact</code>	Quantity of investment for common goods (each 4th new employee)	CHF

DYNAMIC OBSERVED	AGENT	PARAMETER	ELEMENT TO EVALUATE	UNIT
Liquidity level	Company	function <code>investStaffImpact</code> -risky part of leasing (inside)	Part of leasing considered risky by the bank	%
Liquidity level	Company	function <code>investInfrastructure</code> -variable <code>amountOfInvestmentInfrastructure</code> inside	Quantity of investment for the infrastructure	CHF
Liquidity level	Company	function <code>isLeasing</code> -max amount that can be taken by leasing (inside)	Quantity of liquidity necessary to invest in infrastructure (related to the amount of investment)	CHF
Liquidity level	Company	function <code>investInfrastructureImpact</code> -liquidityNecessary (inside)	Quantity of liquidity necessary to invest in infrastructure (related to the amount of investment)	%
Liquidity level	Company	function <code>marketingDoImpact</code> -variable <code>amountOfCampaign</code> inside	Cost of a marketing action	CHF
Liquidity level	Company	event <code>payWages</code>	Recurrence of wages payment	Timeout, Cyclic
Liquidity level	Company	event <code>collectTemporaryWages</code>	Recurrence of temporary wages collection	Timeout, Cyclic
Liquidity level	Company	event <code>payTemporaryWages</code>	Recurrence of temporary wages payment	Timeout, Cyclic
Liquidity level	Company	- <code>monthlyamortization</code> - <code>quarterlyamortization</code>	Quantity of amortization based on investment made by debt	CHF
Liquidity level	Company	event <code>payMonthlyAmortization</code>	Recurrence of monthly amo payment	Timeout, Cyclic
Liquidity level	Company	event <code>payDelayedWages</code>	Available amount of liquidity necessary to pay a part of delayedWages	CHF
Liquidity level	Company	event <code>payDelayedWages</code>	Recurrence of event	Timeout, Cyclic
Liquidity level	Company	event <code>payQuarterlyAmortization</code>	Recurrence of quarterly amo payment	Timeout, Cyclic

DYNAMIC OBSERVED	AGENT	PARAMETER	ELEMENT TO EVALUATE	UNIT
Liquidity level	Company	event payDelayedAmortization	Available amount of liquidity necessary to pay a part of delayedAmortization	CHF
Liquidity level	Company	event payDelayedAmortization	Reccurence of event	Timeout, Cyclic
Liquidity level	Company	event payDelayedInvestment	Available amount of PREDICTED liquidity necessary to pay a part of delayedInvestmentStaff	CHF
Liquidity level	Company	event payDelayedInvestment	Reccurence of event	Timeout, Cyclic
Liquidity level	Company	event payDelayedTemporaryWages	Available amount of liquidity necessary to pay a part of delayed temporaryWages	CHF
Liquidity level	Company	event payDelayedTemporaryWages	Rate at which delayedTemporaryWages is checked	Timeout, Cyclic
Liquidity level	Company	- workloadEvolutionChart - scale - historyWorkloadForCL - keep up to x samples	Period during which globalWorkload is observed in order to define if it is growing or not.	Days
Liquidity level	Company	event checkWorkloadEvolution	After how long the workload evolution is firstly checked	month
Liquidity level	Company	event checkWorkloadEvolution	Rate at which evolution of workload is checked	Timeout, Cyclic
Liquidity level	Company	event checkDelayBetweenIncrease	Period minimal to allow creditLimit to be adapted again	Days

DYNAMIC OBSERVED	AGENT	PARAMETER	ELEMENT TO EVALUATE	UNIT
Liquidity level	Company	event <code>checkPossibilityToIncreaseCL</code>	Period during which globalWorkload keeps increasing to allow creditLimit to be adapted	Days
Liquidity level	Company	function <code>askCreditLimit</code>	How much increase of creditLimit is allowed	CHF
Liquidity level	Company	event <code>checkIfReachingCL</code>	Difference between CL and current level of liquidity in order to ask for increasing CL again.	CHF
Liquidity level	Company	event <code>checkIfReachingCL</code>	Amount maximum asked to increase CL without a precise need	CHF
Liquidity level	Company	event <code>stopLiquidity</code>	Amount of delayed wages that makes the company go bankrupt	CHF
Liquidity level	Company	event <code>stopLiquidity</code>	Amount of delayed amortization that makes the company go bankrupt	CHF
Liquidity level	Company	event <code>stopLiquidity</code>	Amount of delayed temporary Wages that makes the company go bankrupt	CHF
Client satisfaction	Client	satisfactionLevel - initial value	Initial level of satisfaction of a new client	%
Client satisfaction	Client	event <code>checkSatisfactionAndAdaptWOM</code>	% of satisfaction where WOM is set on POSITIVE	%
Client satisfaction	Client	event <code>checkSatisfactionAndAdaptWOM</code>	% of satisfaction where WOM is set on neutral	%
Client satisfaction	Client	event <code>checkSatisfactionAndAdaptWOM</code>	% of satisfaction where WOM is set on NEGATIVE	%
Client satisfaction	Company	function <code>environmentProtectImpact</code> variable <code>positiveImpactForClients</code> inside	% of increase of clientSatisfaction when a D environment (E) is made	%

DYNAMIC OBSERVED	AGENT	PARAMETER	ELEMENT TO EVALUATE	UNIT
Client satisfaction	DecisionEnvironment	function <code>checkAcceptance</code>	% of decrease of clientSatisfaction when a D environment (E) is rejected	%
Client satisfaction	Company	function <code>decreaseSatisfactionBecauseOfFiring</code> - variable <code>negativeImpactOfFiring</code> inside	Decrease of satisfaction of client when an employee is fired by the company	%
Market development	Client	<code>repeatingProfile</code> (Boolean) + <code>main.repeatingProfileValue</code>	% of clients that might repeat orders	%
Market development	Client	event <code>orderRepeatingProject</code>	% of satisfaction below which repeatingClient will never order again (stops a currently waiting project)	%
Market development	Company	function <code>marketingImpactDo</code> -variable <code>isAccepted</code> inside	Probability to accept D (based on empirical data)	
Market development	Client	delay <code>delayNuisanceStopping</code>	Time after which client with negative WOM stops injuring the company	years
Environment	Company	event <code>stopNegativeEffectOnBanker</code> + <code>main.timeoutStopNegEffectBankValue</code>	Duration during which the bank does not want to increase credit limit because of environment D that were rejected.	Days
Organization	Company	<code>organizeRejectRate</code>	Probability to refuse D (based on empirical data)	%
Organization	Company	function <code>investStaffImpact</code>	% of decrease according to each CHF delayed (investStaff)	%
Organization	Company	event <code>payDelayedInvestment</code>	% of increase according to each CHF paid	%
Organization	Company	function <code>newEmployeeStarts</code>	% of decrease of organizationLevel when a permanent employee is hired	%
Organization	Company	function <code>hireTemporary</code>	% of decrease of organizationLevel when a temporary employee is hired	%

DYNAMIC OBSERVED	AGENT	PARAMETER	ELEMENT TO EVALUATE	UNIT
Happiness level	Permanent Employee	happiness level (SD) - initial value	Initial level of happiness of a new employee	%
Happiness level	Permanent Employee	appropriateWorkload (SD)	% of occupation fraction between which the happiness remains stable or increases	%
Happiness level	Permanent Employee	appropriateWorkload (SD)	Flow (rhythm) at which happiness increases while being in-between ideal %	rate
Happiness level	Permanent Employee	notEnoughWorkload (SD)	% of occupation fraction below which the happiness decreases	%
Happiness level	Permanent Employee	notEnoughWorkload (SD)	Flow (rhythm) at which happiness decreases while below %	rate
Happiness level	Permanent Employee	tooMuchWorkload (SD)	% of occupation fraction above which the happiness decreases	%
Happiness level	Permanent Employee	tooMuchWorkload (SD)	Flow (rhythm) at which happiness decreases while above %	rate
Decisions	Main	amountToMakeD	Minimum price of project in order to generate a decision to make	price
Liquidity level	Main	clientsRapiditiyToPay	Numbers of days before clients pay advance and final amounts for projects.	days
Project completion	Company	function acceptProjectImpact + main.daysToDeadlineValue	Condition for accepting projects: Number of days before deadline necessary	Days
Project completion	Project	deadline + main.deadlineMaxSensitivityValue	Deadlines of projects	days converted in LocalDate

DYNAMIC OBSERVED	AGENT	PARAMETER	ELEMENT TO EVALUATE	UNIT
Project completion	Project	deadline + main.deadlineMinSensitivityValue	Deadlines of projects	days converted in LocalDate
Client satisfaction	Client	connection myProjects - decrease of satisfaction + main.decreaseSatWhenProjectAbandonedValue	Decrease of satisfaction of client when a project is abandoned by the client because the company did not make the decision quick enough	%
Client satisfaction	Client	connection myProjects - decrease of satisfaction + main.decreaseSatWhenProjectRefusedValue	Decrease of satisfaction of client when a project is refused by the company	%
Initial situation	Company	efficiencyInSupportingTheDecisionMaker	Efficiency in supporting decision-maker	%
Initial situation	Company	efficiencyToMakeDecision	Efficiency in making decisions	%
Client satisfaction	Client	event checkDelaysAndAdaptSatisfaction + main.formulaFlowSatisfDecreaseDelay	Flow (rhythm) at which satisfaction decreases according to the delay of project completion	amount / day
Decisions	Main	formulaGlobalWorkloadMaxToAcceptProj	Criteria to refuse project: if global workload is bigger than capacity of the next months: 1= 6 months full, 0.5 = 3 months full, 2 = 12 months full, etc.	%
Project completion	Company	main.formulaNumDelaysMaxForFiringT	Condition for accepting projects: Number of days before deadline necessary	Days
Hiring	Company	event checkNeedTemporary + main.formulaNumProjMinToAcceptHValue	Number of projects necessary to accept to hire a new permanent when number of temp already reached	# projects

DYNAMIC OBSERVED	AGENT	PARAMETER	ELEMENT TO EVALUATE	UNIT
Hiring	Company	event checkNeedTemporary + main.formulaNumWaitingProjForHiringTValue	Number of projects waiting necessary to accept to hire temporary (compared to number of permanent employees)	# projects
Hiring	Company	event checkNeedTemporary + main.globalOccForHiringTValue	Average level of occupation of employees (globalOccupation) above which hireTemporary is made <i>/ below which fireTemporary is made</i>	%
Initial situation	Main	initialNumOfClients	Number of clients at the beginning of simulation period	# of clients
Liquidity level	Company	function investOneEmployee -variable amountOfInvestmentOneE inside + main.investOneESensitivityValue	Quantity of investment for a new employee	CHF
Happiness level	Company	event checkGlobalHappiness + main.level1HappinessValue	Level of global happiness / # of employees who are above unhappy % in order for the D well-being (W) to appear	%
Happiness level	Company	event checkGlobalHappiness + main.level2HappinessValue	Level of global happiness / # of employees who are above unhappy % in order for the D well-being (W) to appear	%
Market development	Company	function marketingImpactDo + main.marketingAmountToCreateNewClient	Amount of marketing campaign that have to be done to add 1 client	CHF
Market development	Company	marketingDoRate + main.marketingDoRateValue	Rate at which opportunities of doing marketing appear	rate
Decisions	Company	maxDelaysToAcceptProject		

DYNAMIC OBSERVED	AGENT	PARAMETER	ELEMENT TO EVALUATE	UNIT
Decisions	Company	function <code>callHireOrInvestInfra</code> + <code>main.maxDInvestInfraPendingValue</code>	Number of decisions max that can be considered at the same time for investing in infrastructure	number of decisions pending max
Hiring	Company	<code>maxNumberTempPossible</code> + <code>main.maxPropoTempValue</code>	Proportion max of temporary workers compared to permanent employees in order to be allowed to hire more temporary workers.	# temporary / permanent
Client satisfaction	Company	event <code>checkGlobalSatisfaction</code> + <code>main.minLevelSatisfactionValue</code>	Level of global satisfaction above which the D organize (O) appears	%
Liquidity level	Company	event <code>checkNeedInvestStaff</code> + <code>main.numEmpForInvestStaffValue</code>	Number of new employees after which investStaff has to be done	# of employees
Organization	Company	event <code>checknumberHireFireForOrg</code> (action) + <code>main.numEmpForOrganizeValue</code>	Rate at which a D organize (O) appears	rate
Project completion	Permanent Employee	function <code>onBusyState</code> + <code>main.perfWhenCriticallyBusyValue</code>	Level of performance of a permanent employee when critically busy	%
Organization	Company	function <code>environmentProtectImpact</code> -variable <code>positiveImpactOfE</code> inside + <code>main.positiveImpactOfEMaxValue</code>	% of increase of organizationLevel when a D environment (E) is made	%
Organization	Company	function <code>environmentProtectImpact</code> -variable <code>positiveImpactOfE</code> inside + <code>main.positiveImpactOfEMinValue</code>	% of increase of organizationLevel when a D environment (E) is made	%
Organization	Company	function <code>environmentProtectImpact</code> -variable <code>positiveImpactOfE</code> inside + <code>main.positiveImpactOfEModeValue</code>	% of increase of organizationLevel when a D environment (E) is made	%

DYNAMIC OBSERVED	AGENT	PARAMETER	ELEMENT TO EVALUATE	UNIT
Organization	Company	function organizeImpact -variable positiveImpactOfO inside + main.positiveImpactOfOMaxValue	% of increase of organizationLevel when a D organize (O) is made	%
Organization	Company	function organizeImpact -variable positiveImpactOfO inside + main.positiveImpactOfOMinValue	% of increase of organizationLevel when a D organize (O) is made	%
Organization	Company	function organizeImpact -variable positiveImpactOfO inside + main.positiveImpactOfOModeValue	% of increase of organizationLevel when a D organize (O) is made	%
Happiness level	Company	function wellbeingImproveImpact -variable positiveImpactOfAction inside + main.positiveImpactOfWMaxValue	% of increase of each employee happinessLevel when a D well-being (W) is made	%
Happiness level	Company	function wellbeingImproveImpact -variable positiveImpactOfAction inside + main.positiveImpactOfWMinValue	% of increase of each employee happinessLevel when a D well-being (W) is made	%
Happiness level	Company	function wellbeingImproveImpact -variable positiveImpactOfAction inside + main.positiveImpactOfWModeValue	% of increase of each employee happinessLevel when a D well-being (W) is made	%

DYNAMIC OBSERVED	AGENT	PARAMETER	ELEMENT TO EVALUATE	UNIT
Market development	Main	event addClientRandomly + main.rateAddingClientRandomlyValue	Rate at which a new client is randomly added.	rate
Market development	Client	event createNewClient + main.rateCreatingClientValue	Rate at which a client is added when WOM is set on +	rate
Market development	Client	event removePotentialClient + main.rateDeletingClientValue	Rate at which a client is deleted when WOM is set on - (and no ongoing project)	rate
Environment	Company	event environmentProtect + main.rateEnvironmentProtectValue	Rate at which opportunities to take care of environment appear	rate
Market development	Client	event orderRepeatingProject + main.rateRepeatingOrderValue	Rate at which a repeating client order new projects	rate
Client satisfaction	Company	event checkGlobalSatisfaction + main.reccurenceCheckClientSatisfactionValue	Rate at which globalSatisfaction is checked	rate
Happiness level	Company	event checkGlobalHappiness + main.reccurenceCheckHappinessValue	Rate at which globalHappiness is checked	rate
Happiness level	Permanent Employee	event checkSelfHappiness - action	% of happiness below which an employee decides to quit the company	%
Happiness level	Permanent Employee	function defineMyDateOfLeaving	Delay for really having the person leaving when resigned (last day of month)	Days
Happiness level	Company	function fireImpact -variable impactOnEmployee inside	% of decrease of happiness of each remaining employee when someone is fired	%

DYNAMIC OBSERVED	AGENT	PARAMETER	ELEMENT TO EVALUATE	UNIT
Hiring	Company	database equilibrium infrastructure (related to -currentInfrastructureStep -maxNumberPermPossible -checkInfrastructureCapacity)	Quantity of Infrastructure necessary to be able to hire	CHF
Hiring	Company	-workloadEvolutionChart - scale -historyWorkloadForHiring - keep up to x samples	Period during which globalWorkload is observed in order to define if it is growing or not.	Days
Hiring	Company	event checkNeedHiring + main.reccurrenceNeedPermanentValue	Rate at which the minimum number of temporary workers is checked in order to decide hiring this minimal number	Timeout, Cyclic
Hiring	Company	event checkNeedHiring + event checkNeedTemporary + function hireImpact	Period during which globalWorkload keeps increasing to decide Hiring	Days
Hiring	Company	-temporaryEvolutionChart - scale -historyTemporary - keep up to x samples	Period observed to define what was the minimum number of temporary hired during that period	Days
Hiring	Company	function determineNumberToHire	Period observed to define what should be the right number of permanent employees to hire based on the minimum number of temporary hired	Days
Hiring	Company	function determineNumberToHire	Number of employees hired when check is done	# employees
Hiring	Company	function defineDateOfStart - variable nextDateForComputation inside	Delay for really having the person starting (1st day of month)	Days
Hiring	Company	event checkNeedTemporary + main.reccurrenceNeedTemporaryValue	Rate at which the necessity to hire / fire temporaries is checked	Timeout, Cyclic

DYNAMIC OBSERVED	AGENT	PARAMETER	ELEMENT TO EVALUATE	UNIT
Hiring	Company	event <code>checkNeedTemporary</code>	Number of deadlines unmet necessary to hireTemporary	# of projects
Hiring	Company	function <code>newManagerIsNeeded</code>	Proportion max of permanent employees compared to managers.	# permanent / manager
Firing	Company	event <code>checkNeedFiring</code>	Rate at which firing permanent employee need is checked.	Timeout, Cyclic
Firing	Company	event <code>checkNeedFiring</code> + event <code>checkNeedTemporary</code> + function <code>fireImpact</code>	Period during which globalWorkload keeps decreasing to decide Firing	Days
Firing	Company	event <code>checkNeedFiring</code>	Number of people fired each time <code>checkNeedFiring</code> is called	# employees
Firing	Company	event <code>checkNeedFiring</code> + function <code>fireImpact</code>	Level of globalOccupationFraction below which the decision to fire is made.	%
Firing	Company	function <code>defineDateOfLeaving</code> -variable <code>nextDateForComputation</code> inside	Delay for really having the person leaving (last day of month)	Days
Decisions	Company	event <code>checkGrowthRate</code>	Number of decisions that define intensity of growth STABLE	# of D
Decisions	Company	event <code>checkGrowthRate</code>	Number of decisions that define intensity of growth LIGHT	# of D
Decisions	Company	event <code>checkGrowthRate</code>	Number of decisions that define intensity of growth INTENSE	# of D

DYNAMIC OBSERVED	AGENT	PARAMETER	ELEMENT TO EVALUATE	UNIT
Decisions	Company	event checkGrowthRate	Number of decisions that define intensity of growth VERY INTENSE	# of D
Decisions	Company	event checkGrowthRate	Number of decisions that define intensity of growth EXTREME	# of D
Decisions	Abstract Decision	event checkInstantaneity	Maximum number of days for making a decision that makes it be instantaneous	
Decisions	Decision Project Accept	correctionFactor	Correction applied to reduce timeInProcess	
Decisions	Decision Environment	correctionFactor	Correction applied to reduce timeInProcess	
Decisions	Decision Marketing Do	correctionFactor	Correction applied to reduce timeInProcess	
Decisions	Company	function acceptProject	Value of price below which decision is considered as operational	CHF
Decisions	Company	efficiencyToMakeDecision	Efficiency of decision-maker to make decisions	%
Decisions	Decision Invest	timeBetweenMadeAndApplied	Time to apply the decision of I	days
Decisions	Decision Organize	timeBetweenMadeAndApplied	Time to apply the decision of O	days
Decisions	Decision Environment	timeBetweenMadeAndApplied	Time to apply the decision of E	days
Decisions	Decision Wellbeing Improve	timeBetweenMadeAndApplied	Time to apply the decision of W	days
Managers	Manager	levelOfExperience	Level of experience to support decision-making process when they join the company	%

DYNAMIC OBSERVED	AGENT	PARAMETER	ELEMENT TO EVALUATE	UNIT
Managers	Abstract Decision	function <code>disconnectFromManager</code> -variable <code>impactOnExperience</code> inside	Increase of level of experience of a manager each time a decision is made thanks to him/her	%
Decisions	Company	<code>efficiencyInSupportingTheDecisionMaker</code>	Efficiency of managers in supporting the decision maker to make decisions	%
Managers	Manager	statechart - rate of <code>startingMeeting</code> transition	How many times a week the manager enters a meeting with the decision-maker	rate
Managers	Manager	statechart - rate of <code>supportingDecisionMaker</code> transition	Quantity of messages that are sent to the DM in order to convince him per hour	rate
Managers	Manager	statechart - timeout of <code>meetingOver</code> transition	Duration of a meeting with the decision-maker	Hours

10.3 Development and construction of the model: details

10.3.1 Main level: logic

The main level constitutes of a management dashboard. From this level, the model user can 1) adapt the values of some parameters while the model is running, 2) observe charts that relay most important information from all parts of the model, 3) define what detailed information should be written in the console as the model is running (using the `traceln` function described above).

Figure 20 shows the main level view.

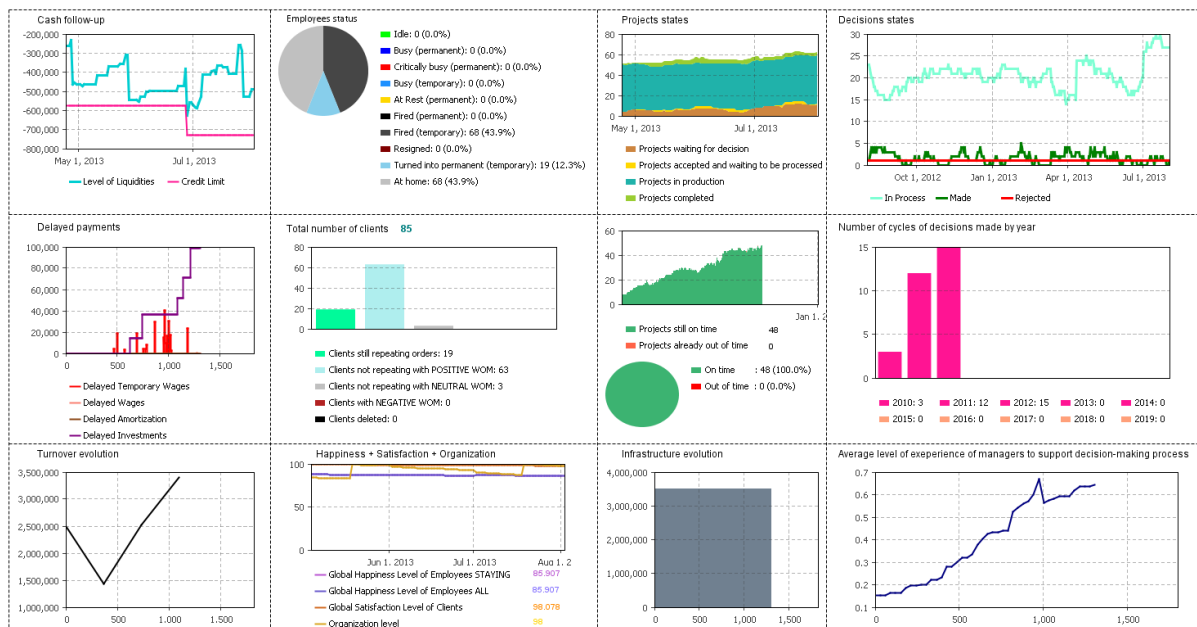


Figure 20 – Main page during simulation

10.3.2 Clients population: logic and behavior

All clients in the model can be identified by their name. 25% of them (percentage precisely stipulated during calibration - see section 6.1.5, calibration of the model) present a repeating profile, which means they will order projects on a repeating basis. While investigating repeating business in the construction industry, Sims and Anderson (2003) propose a series of steps for meeting the customers' expectations and maintaining a good relationship. Based on the longitudinal case study data, it is clear at which rhythm clients contact the company for new projects and the author sharpened this value (1,021 times per year) during calibration process. Non-repeating clients order only one project when they start their relationship with the company. Therefore, each time a new client file is created, s/he will order a first project. If the

client has a repeating profile, s/he will order more projects in the future – e.g. a high school might order several projects of auditorium within a year, on the other hand a private client will probably order just one house and nothing else during many years. Each time a project is ordered, the model creates a new project within the projects population (developed in next section). The client connects to the project by sending a message “I’m your mandator”; while receiving the message, the project will instantaneously connect back to the client. The model constantly checks the current status of the relationship of the client with the company. As long as a client has one or several projects that are currently processed by the company, he/she is considered as a current client. As soon as all projects have been completed and there is no project connected to the client anymore and the client does not have a repeating profile, the relationship is over.

All clients also have a certain level of satisfaction. A system dynamics process represents this level of satisfaction:

$$d(\text{satisfactionLevel}) / dt = \text{satisfactionIncrease} - \text{satisfactionDecrease} \quad (1)$$

When clients start the relationship with the company, their satisfaction is at 80%. As long as the relationship with the company develops positively, satisfaction increases slowly up to 100% - meaning that the client is entirely satisfied by his/her relationship with the company. Perceived and actual performance of the company are important predictors of customer satisfaction and behavioural intention of purchasing again in the future (Burton et al., 2003). Several elements related to the company behaviour might also positively affect the satisfaction of the client, such as seizing opportunities to support the environment. On the contrary, as soon as one (or several) project is delayed, satisfaction will start to decrease. The more projects connected to the clients are delayed, the more rapidly his/her satisfaction will decrease. Several studies demonstrate the negative impact of delays on customers (Casado Diaz and Más Ruíz, 2002, Bielen and Demoulin, 2007, Anderson et al., 2009). Rapidity at which satisfaction decreases was also precisely set during the calibration phase. Moreover, if the company refuses some projects (because of a lack of capacity), takes disproportionate time to accept projects ordered by the company (because of lack of efficiency in the decision-making process), fires employees, or rejects opportunities to support the environment, satisfaction will also decrease by a certain amount (that lies, depending on the circumstances, between 1% and 20%).

All clients also have a certain level of word-of-mouth (WOM) power, which is directly linked to their level of satisfaction. The Word-of-Mouth Marketing Association (2009)¹ defined word-of-mouth as “the passing of information from person to person by oral communication” (Tsai et al., 2014). When clients start the relationship with the company, their WOM is set on neutral. Depending on how their level of satisfaction increases or decreases, WOM will change to positive or to negative. As long as WOM is set on positive or neutral, a repeating client will order new projects for him/herself as they have satisfactory experience with the product or service (Lau and Ng, 2001). If WOM is strictly set on positive, a client will also create new clients at a rate of 0,336 per year (value resulting from the calibration process) - which means approximately one new client each 36 months. Positive WOM has a great effect on people’s willingness to use a service (even more than negative WOM according to Sweeney, Soutar and Mazzarol, 2012) and has been assessed as a powerful marketing tool for organizations (Lo, 2012, Chesney, 2017). Conversely, a client with a negative WOM will remove some repeating clients at a rate of 1,934 per year (value resulting from the calibration process) - which means approximately one client removed every 6 months. One might see that this rate is much higher than the rate that creates new clients but several studies show that negative WOM is communicated to more people than positive WOM – with the first one of this kind being Richins (1984). Negative WOM might influence negatively firm cash flows (Luo, 2009). Lau and Ng (2001) have shown that purchase decision involvement is an important determinant of negative WOM behaviour – which is especially true for the construction industry. In case the company refuses three consecutive times a project from the same client, the WOM will also be set on negative.

If the relationship between the client and the company is over (as explained above), the model will keep active only the current WOM-related events (order new projects and create new clients if WOM is positive, remove repeating clients if WOM is negative). Former clients with WOM set on negative will stop harming the company after five years (the model will simply delete them).

New clients are created according to three possibilities. The first one is described above and is related to positive WOM. Marketing actions that are taken by the company (developed in detail below) will also create new clients each time a certain amount of money invested is reached. Finally, clients can also be created on a random basis at a rate of 1,983 per year (value resulting from the calibration process).

¹ Retrieved from <http://www.womma.org/>

10.3.3 *Projects population: logic and behavior*

As clients order projects from the company, this section will present the projects population of agents. Briefly, each project that appears belongs to an identified client and consists of a deadline (specified by the client), an amount of workload (depending on the type of project and estimated by the company), a price (calculated according to the relative workload), and a level of satisfaction (directly linked to the client it belongs to). The author would like to add more details about all of these elements. As mentioned in the previous section, clients order one or several projects and connect to their respective projects, which then connect back to them. As a result, each project has one parameter that is called “client” and that represents the client who actually ordered the project agent. At its creation, a workload will be chosen for the project. Based on the company data, the workload is a stochastic value expressed in days, based on a triangular distribution with minimum = 3 days, mode = 47 days and maximum = 294 days (this triangular distribution has been verified during the calibration process). Each project that is created will present a workload somewhere between those values. The deadline at which the project expires is also a stochastic value calculated in respect to the respective workload according to the following expression:

```
LocalDate deadline =  
date().toInstant().atZone(ZoneId.systemDefault()).toLocalDate().  
plus(uniform_discr((roundToInt((workload/4)+main.deadlineMinSensitivityValue)),  
roundToInt(workload+main.deadlineMaxSensitivityValue)),ChronoUnit.DAYS)      (2)
```

This means that the shortest deadline computed would be the number of days required by the workload, divided by four, to which a certain amount of days (coming out from the calibration process) is added. Logic for the longest deadline value is similar. The price of the project is also computed based on the workload, according to the hourly cost of the company-case, and according to the number of hours worked by day (8,2 hours):

```
double price = workload * main.company.workingHourPrice * 8.2      (3)
```

In order to be able to define what project has to be completed first by the company, a degree of urgency is computed and associated to each project. Projects that have the earliest deadlines and the biggest amount of remaining workload have the highest level of urgency and are therefore started first. When a new project appears, the deadline of other already accepted projects (using the queuing agent comparison method) is checked and the order is then placed in the right place according to its level of urgency in the queue.

Statistics are collected on projects status and are shown at the main level of the model. Projects that are not terminated yet and for which deadlines have not yet been exceeded present the

status “In progress”. Projects that have been completed before the deadline expires present the status “In time”; projects delayed present the status “Out of time” even if they are not completed yet.

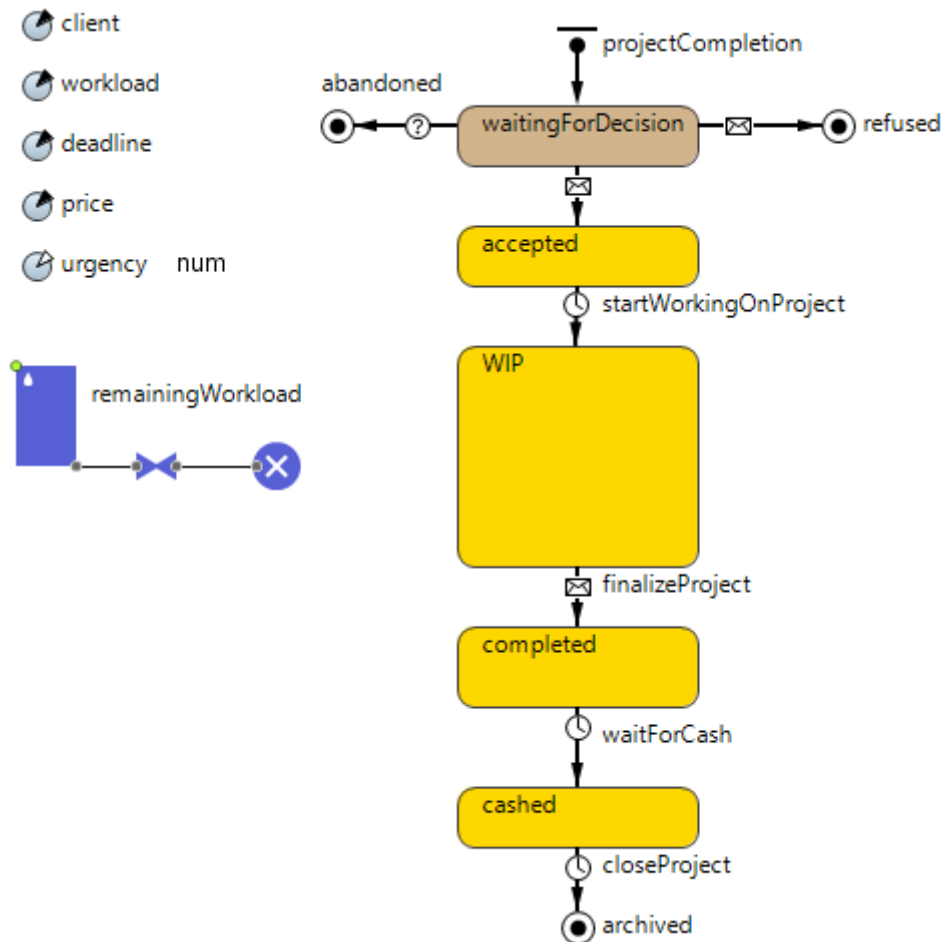


Figure 21 - Statechart of projects

In order to represent visually the remaining workload of each project, a Tank-Valve-Dissolve Fluid logic has been integrated in the model (refer to medium slate blue elements on the left hand-side of Figure 21). The logic works like this: a tank represents a certain volume of fluid contained and blocked. As soon as the valve connected to the tank opens, the fluid contained in the tank starts to dissolve and the level of fluid remaining in the tank decreases at the rate of the valve – this can be seen visually during simulation. The valve can be closed and opened again at any time during simulation. As soon as there is no more fluid in the tank, the flow stops. Fluid can represent anything e.g. a liquid, a workload, etc. In this model, fluids represent workload; when the project appears, its tank is full – meaning that the whole workload is remaining. As soon as the project starts out, the valve opens and decreases the fluid level at the same rate at which employees complete the project. As soon as the tank is empty, the project is completed.

A project completion statechart might be observed on Figure 21. In AB modelling, statecharts are used as the building blocks to model an agent as well as transitions from state to state of the agent existence. In this case, the statechart sets out the main steps a project eventually follows. While popping up, the project will wait until the company decides to integrate it in its global workload or not. In other words, this means that the company will receive the client's request to achieve his/her project, and it will make the decision to accept it or not. If the company refuses the project (for several reasons that will be discussed later on), the project moves to the state "refused" (see top right corner of Figure 21). If the company takes excessive time to make the decision to accept the project, the client might abandon the project and therefore it will move to the left state "abandoned" (decision-making progress will be seen in detail later on in this thesis). As soon as the project is accepted, it moves to the first yellow state "accepted" and waits until the company can start working on it. A transition is achieved through a message received by the project from the company, confirming the project has been accepted. As soon as the company allocates resources to the project, it moves to the state WIP (work-in-process) and will stay in that state until it is fully completed. The client is contacted twice for proceeding to payment when the project is in the WIP state. First, when employees start working on the project, 40% of the price is asked of the client. Second, when only half of the workload remains, another 40% of the price is demanded. Once completed, the project sends a message back to the company, in order to free the current employees working on it and to move to the completed state where it will wait until the connected client pays the remaining 20% of the total price. Once the amount of money is received by the company, the project moves to the cashed state and waits a few more days before being closed and archived. The days in receivables on the cash-to-cash cycle time (the average customer payment time) is defined by the model user with a default value of 30 days. Each new project (using new agent action field) increases the "predicted turnover" variable (at company level) by the price of the project. Each time an advance or final payment is received by the company, it increases the "realized turnover" variable (at company level) by the amount paid. It also directly allocates the turnover to the current year of simulation and increases "realized turnover in 20xx" by the same amount – e.g. if current year in simulation is year 2012, it increases the variable "realized turnover in 2012".

At the company level in the model, projects visualization shows the current state of each project. WIP projects can either be waiting to be seized or currently seized – depending on their level of urgency (refer to Figure 22). Each small tree represents one project. Right next to each tree, one might see the digit of the project, the remaining workload (vertical rectangle) which is green if project is still in time and red if project is out of time already, and how many employees work

on it - dark blue cells represent permanent workers, up to four; light blue cells represent temporary workers, up to five, with a maximum number of six employees per project. Once the project is over, the small tree is cut and falls (refer to Figure 22) and it waits until being cashed. Once the project is closed, it disappears from the company page.

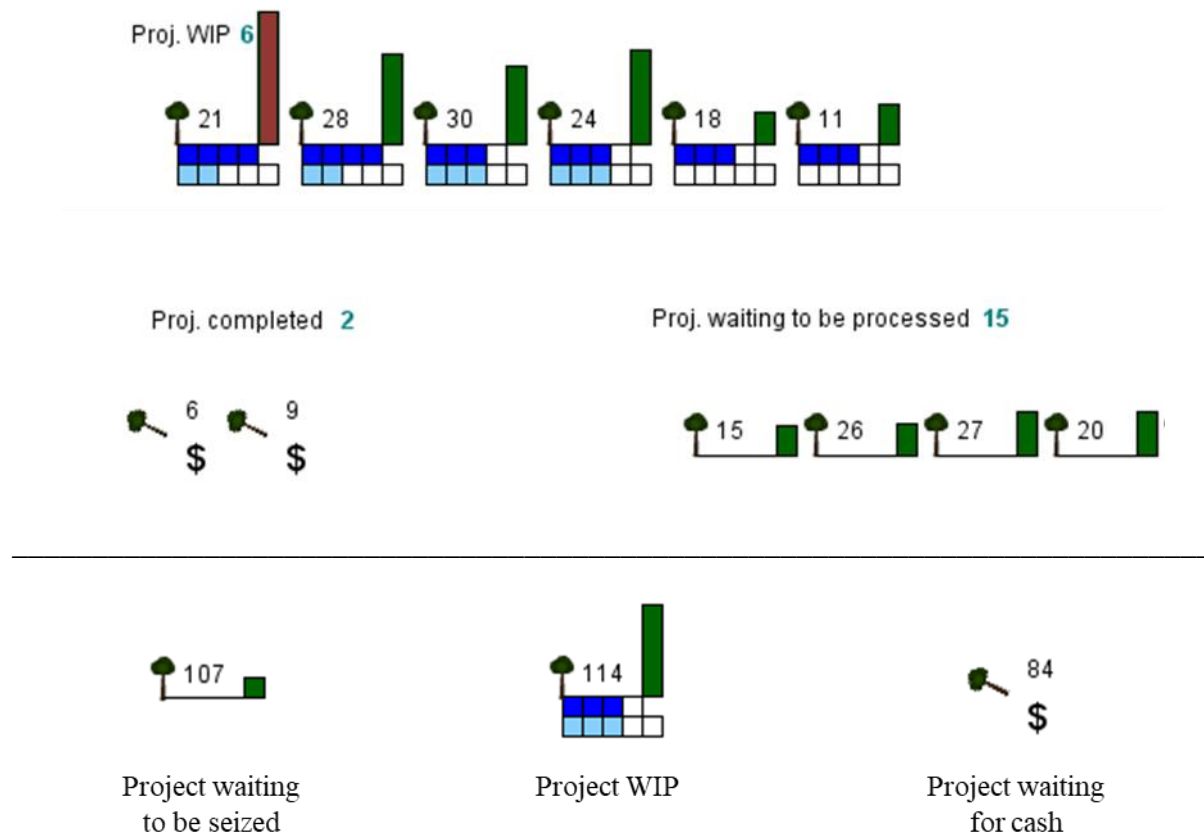


Figure 22 – Project states visualization

So far, clients and projects populations have been introduced. Clients order projects that will then follow a series of steps until being closed and archived. As explained in this section, projects are completed by employees of the company. Therefore, the following sections are dedicated to the presentation of employees’ populations – populations that are embedded in the single-agent company.

10.3.4 Employees population: logic and behavior

There are two main populations of employees: permanent and temporary workers. Both of them share some common characteristics so they do present some differences. The author will first elaborate on the common characteristics of populations. The next focus will be on each population to provide specific details about each of them. As the two populations share several features, the author has first created what is called “an abstract type” of population in AnyLogic.

Abstract populations have the benefit that they can share all their characteristics with other populations of agents that extend abstract populations – in this case permanent and temporary employees’ populations. It is therefore possible to specify in only one agent the main features shared by similar populations; if any modification is required, it has to be done only once at the abstract level and not several times in all similar populations of agents. As shown by Haden et al. (2011), commitment, trust, and fairness are values shared by both temporary and permanent employee groups; therefore according to the authors they are more similar than customarily perceived.



Figure 23 – Employee visualization

Figure 23 represents an employee as it appears in the model. The same shape is used for all employees. They are then differentiated by their colour according to their state.

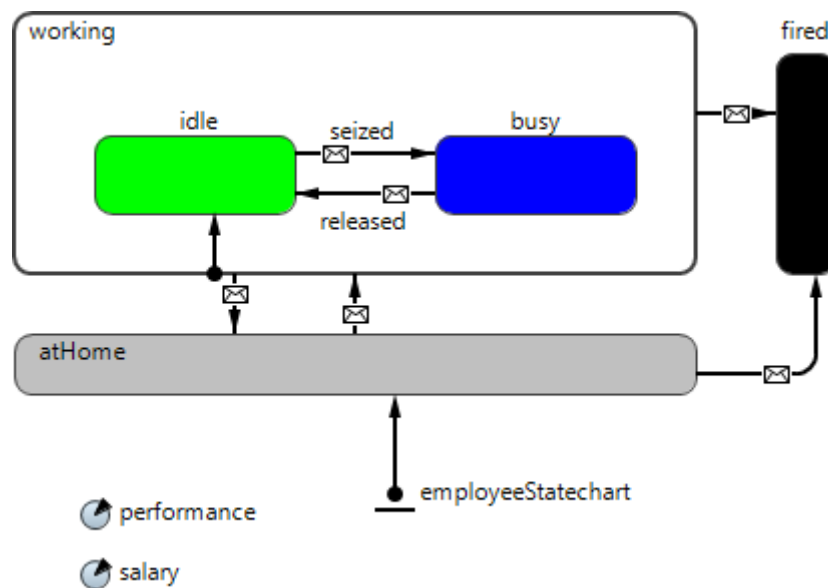


Figure 24 - Abstract employee statechart

Employees of the company also behave according to a statechart (see Figure 24). Figure 24 shows the states and parameters that are shared by both populations of employees.

While entering the statechart, each employee enters the grey “at home” state. The employee will then go back and forth between the working state (being either idle or busy) and the “at home” state. Changes between states are regulated by a schedule at company level (refer to Figure 25). This schedule is of the type on/off and defines all the working hours of the company.

When the schedule is on, employees are working. When the schedule is off, employees go back home. The entire schedule is provided below. Each week is repeated with the same schedule. The Monday to Friday 07:00 am to 12:00 am with one-hour break and 01:00 pm to 5:00 pm schedule with Friday afternoons off is quite common in the construction sector in Switzerland. It also totally corresponds to the company-case schedule. Introducing such a schedule was necessary to match as closely as possible with the reality of the case-company in terms of dates achieving projects and time necessary to complete them. Without a schedule, the model company would work day and night, weekend days included, without breaks. Projects would therefore be completed very early compared to reality. When the schedule turns to on or to off, it sends a message to all employees agents saying either “Working time” or “Go home”. All employees instantaneously change their state to the one corresponding to the schedule state.

workingHours - Schedule

Name: workingHours Show name Ignore

Visible: yes

Data

Type: on/off

The schedule defines: Intervals (Start, End) Moments

Duration type: Week Days/Weeks Custom (no calendar mapping)

Default value: on off

Repeat schedule weekly:

Mon	Tue	Wed	Thu	Fri	Sat	Sun	Start	End	Value
✓	✓	✓	✓	✓	☐	☐	07:00	12:00	<input checked="" type="radio"/> on
✓	✓	✓	✓	☐	☐	☐	13:00	17:00	<input checked="" type="radio"/> on

Figure 25 - Schedule regulating working hours of the company

While working, employees can either be busy – when they are seized by a project that needs resources – or idle – if there are not enough projects to allocate all the resources of the company. The allocation process will be described in detail in the section 10.3.9. Last state shared by both populations is the fired state. If the company needs to reduce its team size, it will have to fire one or several employees. Temporary employees will be fired first, followed by permanent employees. The firing process will be explained later on. When an employee receives the message “You are fired”, s/he will move to the fired state on his/her date of leaving and his/her salary will be set to zero. At abstract employee level, a time-colour-chart allows visualizing the last three-month states of an employee. While putting a chart at that level, each employee owns its chart and can be tracked by the model user. Figure 26 shows an example of this time-colour-

chart. One might see on that chart that the employee was busy (blue colour, which corresponds to busy state) most of the time.

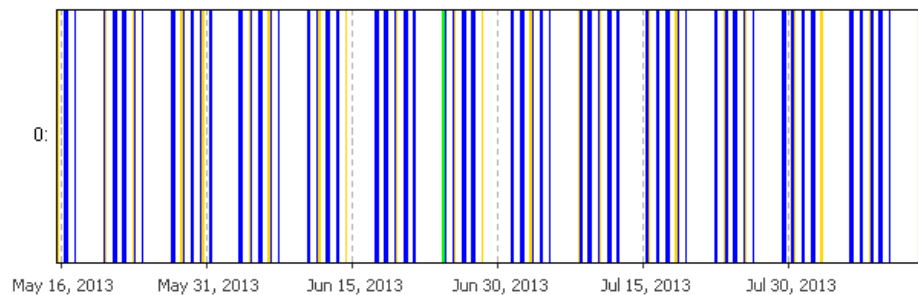


Figure 26 – Time-colour-chart of a permanent employee

Employees' populations share two parameters; salary and performance (refer to Figure 24). All agents being permanent or temporary employee are set with a salary and a certain level of performance. Permanent fully qualified workers have a salary triangulated within the following values (min, max, mode, expressed in Swiss francs): `triangular (4900, 7500, 5200)`. Temporary workers with an equivalent level of competences have an on-average higher salary (because placement agencies keep some part of it for the service provided) with the following values (min, max, mode, expressed in Swiss francs): `triangular (7200, 8250, 7700)`. However, as it is not always possible to hire qualified workers, the average temporary salary in the model was reduced by a variable set during calibration process to reach a level similar to permanent workers' salaries. In terms of performance, the model is designed so that permanent employees' performance always starts at 100%. Temporary workers' performance is a stochastic value with the following distribution:

$$\text{double performance} = \text{uniform}(0.7, 1) \quad (4)$$

This distribution means that there is an equivalent probability that the temporary employee's performance will equal any value between 70% and 100%. Temporary workers present in some cases a lower performance because of the qualifications level mentioned above.

At the abstract employee level, the author has built statistics that collect how much time is spent in statechart states in order to compute the average occupation of an employee. Time spent in the busy state is continuously compared to time spent in the working state and a percentage is adapted as time passes. Thanks to this computation, it is possible to calculate the occupation of a permanent employee and to verify s/he is not over or under-utilized.

This section showed the common characteristics of populations of permanent and temporary employees. Next section explains specific characteristics of permanent employees.

10.3.5 *Permanent employees population: features*

Permanent employees include all the features presented in the previous section. However, they also contain some specific characteristics that will be presented below. Figure 27 shows the complete statechart, with additional states “at rest” and “resigned” that are specific to permanent employees.

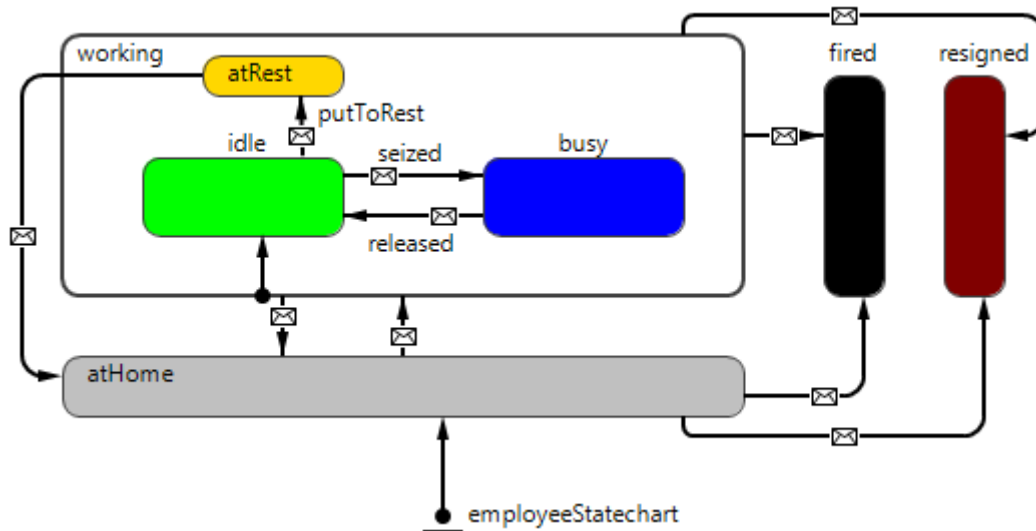


Figure 27 – Permanent employee statechart

Occupation fraction (computation explained in previous section) of permanent workers has to be measured and controlled on a regular basis. If occupation fraction is too high (excessive work) or too low (not enough work) it will negatively affect the happiness of the permanent employees. Occupational stress of employees is directly related to their intention to leave the company (Villanueva and Djurkovic, 2009). Happiness level is the most important feature specific to permanent employees and is presented in Figure 28.

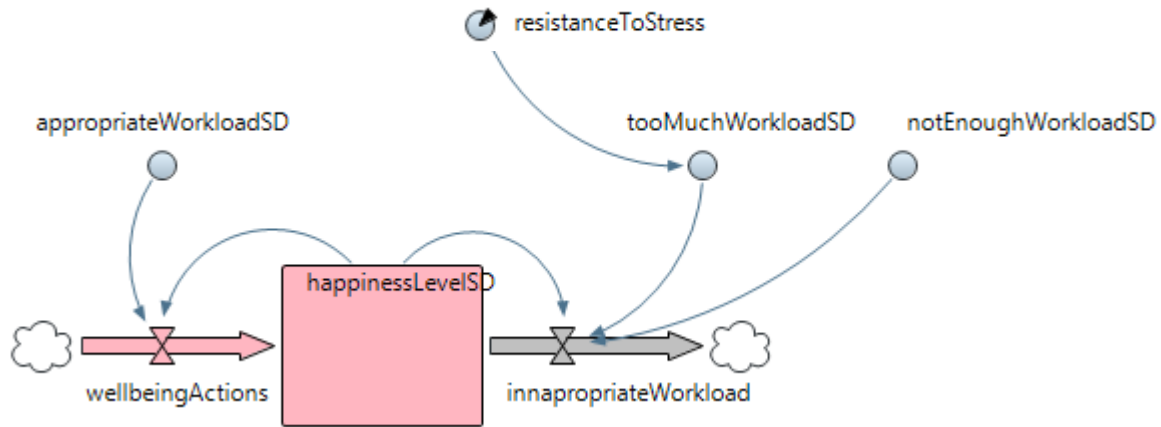


Figure 28 - Happiness level of permanent employee

As it evolves continuously, the happiness level has been modelled through system dynamics. As one might see, the happiness level is a stock (with a maximum amount of 1 = 100%) from which flows go in and out. The entering flow increases happiness and the exiting flow decreases happiness level with:

$$d(\text{happinessLevel}) / dt = \text{wellbeingActions} - \text{innapropriateWorkload} \quad (5)$$

$$\begin{aligned} \text{wellbeingActions} = & \text{inState}(\text{fired}) \ || \ \text{inState}(\text{resigned}) \ || \\ & \text{inState}(\text{atHome}) ? 0 : \text{happinessLevel} \geq 100 ? 0 : \text{appropriateWorkload} \end{aligned} \quad (6)$$

$$\begin{aligned} \text{innapropriateWorkload} = & \text{inState}(\text{fired}) \ || \ \text{inState}(\text{resigned}) \ || \\ & \text{inState}(\text{atHome}) ? 0 : \text{happinessLevelSD} \leq 0 ? 0 : \text{tooMuchWorkloadSD} + \\ & \text{notEnoughWorkloadSD} \end{aligned} \quad (7)$$

$$\begin{aligned} \text{appropriateWorkload} = & \text{occupationFraction} < 0.75 \ \&\& \ \text{occupationFraction} \\ & > 0.6 ? 1 : 0 \end{aligned} \quad (8)$$

$$\begin{aligned} \text{notEnoughWorkload} = & \text{occupationFraction} < 0.1 ? 12 : \text{occupationFraction} \\ & < 0.6 ? ((1 - (\text{occupationFraction})) / \\ & \text{pow}(\text{occupationFraction}, (1.085/1.91))) * 2.9 : 0 \end{aligned} \quad (9)$$

$$\begin{aligned} \text{tooMuchWorkload} = & \text{occupationFraction} > 0.75 ? \text{occupationFraction} * \text{pow} \\ & (\text{occupationFraction} / 1.085), 4) * (1/\text{resistanceToStress}) * 0.34 : 0 \end{aligned} \quad (10)$$

The numbers of equations (9) and (10) have been identified thanks to company data and with computations trials. The objective was to build a function that was able to shorten or lengthen the time passed before an employee resigned according to its occupation fraction and level of stress. The company data provided evidence of the time spent before an employee decided to resign after a long period of high or low occupation. The number chosen in the equations allow reproducing what happens in reality.

If occupation fraction remains between some acceptable boundaries, 80% to 100% of occupation per week spent on projects – which represents 60% to 75% in the model configuration (refer to conversion Table 18) -, the happiness remains stable or increases slowly up to 100% at a rate of 1% per day. As job satisfaction is linked to firm value (Edmans, 2012); the company might want to maintain global happiness within these boundaries. However, as soon as the average occupation fraction overtakes 100% or decreases below 80% (refer to column of percentages in reality in Table 18) happiness starts to decrease at the rate stated above.

% in model	% in reality	weekly hours
100	133	60
90	120	54
85	113	51
80	107	48
75	100	45
60	80	36
50	67	30
40	53	24
30	40	18
20	27	12

Table 18- Conversion table for occupation fraction

Resistance to stress is a parameter that moderates happiness decrease when occupation fraction is too high, the higher the resistance to stress, the slower the rate at which happiness decreases when an employee is critically busy. This phenomenon was studied by Bowling and Eschleman (2010) who show that employee personality moderates the relationship between stress and counterproductive behaviour. This means that, if critically busy, an employee with a high resistance to stress will remain happier longer than an employee with a low resistance to stress. The latter will become unhappy more rapidly. This tendency was observed among the employees of the case-company. Resistance to stress is a stochastic parameter with the following triangulated distribution (min, max, mode):

$$\text{double resistanceToStress} = \text{triangular}(0.2, 1, 0.7) \quad (11)$$

If too busy (100% in the model), an employee with a very low resistance to stress will resign after two and a half month approximately; an employee with a resistance to stress at 100% will resign after one full year. Stress resistance therefore contributes to keeping happiness high for a longer period if the workload increases.

On the contrary, one might see that happiness decreases at an always-faster rate when occupation fraction drops. Resistance to stress does not moderate this effect. If the happiness decreases to the level of 30% or lower, the employee will resign – which means s/he will decide to quit the company. Job anxiety is linked to intention to leave (Glazer and Kruse, 2008). An employee who is too idle (around 50% in reality) will make the decision to quit the company after approximately three months. If occupation is even lower, the employee will resign earlier (after one month in the worst-case scenario) – regardless of his/her resistance to stress.

During simulation, one will recognize visually employees who decide to resign because a small palm tree appears above their head (resigned employees dream about being somewhere else than in the company e.g. on a beach). Resigning will not occur instantaneously; indeed, in Switzerland, someone that resigns will have to work at least until the end of the following month (sometimes even longer but this is not taken into consideration in the model). Therefore, the date of leaving is defined according to the following function:

```
Date nextDate = timeToDate( time() + 31*day() );
Calendar cal = Calendar.getInstance();
cal.setTime(nextDate); //define date of leaving for next month
cal.set( Calendar.DAY_OF_MONTH, 28 ); //define precise day of month
cal.set( Calendar.HOUR_OF_DAY, 6 ); //define hour of day (6 AM)
cal.set( Calendar.MINUTE, 0 ); //define minute (00)
create_LetMeLeaveOnTheLast( dateToTime( cal.getTime() ) - time() );//create
a dynamic event that will occur on the leaving date defined (12)
```

When the date of leaving is reached, the employee moves to the state “resigned” in the statechart; salary is set to zero; flows in system dynamics stop.

In order to avoid happiness to decrease dramatically, the company can take different actions. The company should try to reduce permanent employee overload because permanent employees’ satisfaction will be negatively impacted by perceived workload imbalances (Galup et al., 2008). Specifically, in order to avoid an unbearably high occupation fraction, the company can put employees “at rest” (refer to yellow state on Figure 27). Employees that are put at rest have time to work on parallel tasks (and not only on projects) which means that they have time to achieve some daily-business tasks that are necessary but which are the first ones

that are left aside when the workload becomes excessive. Turnover is used to put at rest in priority employees who have the higher occupation fraction according to the following function:

```
List<PermanentEmployee> workingPermanent = filter (permanentEmployees,
    e -> !e.inState(PermanentEmployee.fired)
    && !e.inState(PermanentEmployee.resigned)
    && e.atRestAlready==false);

if (workingPermanent.size() != 0) {
    double occupationMax = max(workingPermanent, e -> e.occupationFraction);
    PermanentEmployee occupiedMax = permanentEmployees.findFirst(e ->
    e.occupationFraction == occupationMax
    && !e.inState(PermanentEmployee.fired)
    && !e.inState(PermanentEmployee.resigned)
    && e.atRestAlready==false);

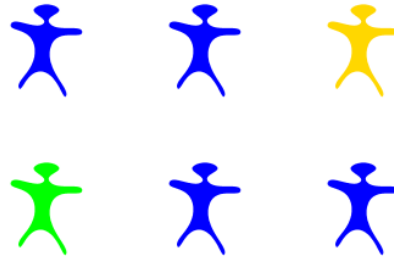
    if (occupiedMax != null) {
        deliver("You need some rest", occupiedMax );
        occupiedMax.atRestAlready=true;
        //For console
        if (main.checkboxPutToRest.isSelected()==true) {
            println("    Put to rest: " + occupiedMax.toString()
                + " with occupation of " +
                format(occupiedMax.occupationFraction) );
        }
    }
}
```

(13)

Wellbeing actions achieved by the company will also occasionally increase the happiness level of all employees. Details regarding those actions will be provided in the section 10.3.19 (Decision-making process: Wellbeing).

Besides decreasing happiness level, too high occupation fraction also results in a loss of performance. This logic addresses Yang et al. (2015) results, who claim that employees' well-being mediates the relationship between job satisfaction and service quality. Critically busy employees (with occupation fraction equivalent to or higher than 90%) will have a performance of only 80% (and not 100% anymore). As the performance of employees directly influences their rapidity to complete projects correctly, a lower performance results in a higher amount of time necessary to complete a client's project. In other words, a lower performance could also mean that a percentage of the project workload will have to be partly redone, which needs in the end more time as well. As soon as occupation fraction reaches again a reasonable level, performance increases to 100%.

In terms of simulation visualization, permanent employees' shapes might present the following colours: green = idle; blue = busy; red = critically busy; dark red = resigned; black = fired, yellow = at rest.



Legend

blue = busy yellow = at rest green = idle

Figure 29 – Permanent employees' visualization

10.3.6 Temporary employees population: features

Modelling a company in the construction sector with only permanent workers would not have been realistic (at least in the Swiss market) Fluctuations in terms of global workload can be rather important because of seasonality, administrative procedures related to projects starts and client's choices. Consequently, nearly all construction companies resort to use placement agencies. Temporary employees are employed to compensate for fluctuations. Since the 1990s, the use of temporary workers has doubled across Europe (Drury, 2016) and worldwide (Peck et al., 2005) and keeps increasing. Academics have investigated many reasons for which companies tend to use temporary workers. In the construction industry, employers mainly use temporary workers to meet short-term peaks in demand (Forde et al., 2008). Internationally, construction companies also hire temporary workers to allocate them to remote construction projects (Lin, 2011). The main inconvenience of this policy is to hire workers who are not permeated by the culture of the company and who do not share the same values, norms and working habits of permanent employees. Their level of qualifications might also be lower and therefore for high-skill workers, companies are less likely to use temporary workers (Ono and Sullivan, 2013). However, one of the main advantages of this policy is to avoid firing permanent employees when workload fluctuates downwards, which has a very positive impact on the global happiness of the permanent team. In manufacturing in general, temporary workers are used to accommodate output fluctuations and to facilitate firms' flexibility (Ono and Sullivan, 2013). As other companies in the sector, the case-company SCHWAB-SYSTEM employs temporary employees on a regular and continuous basis.

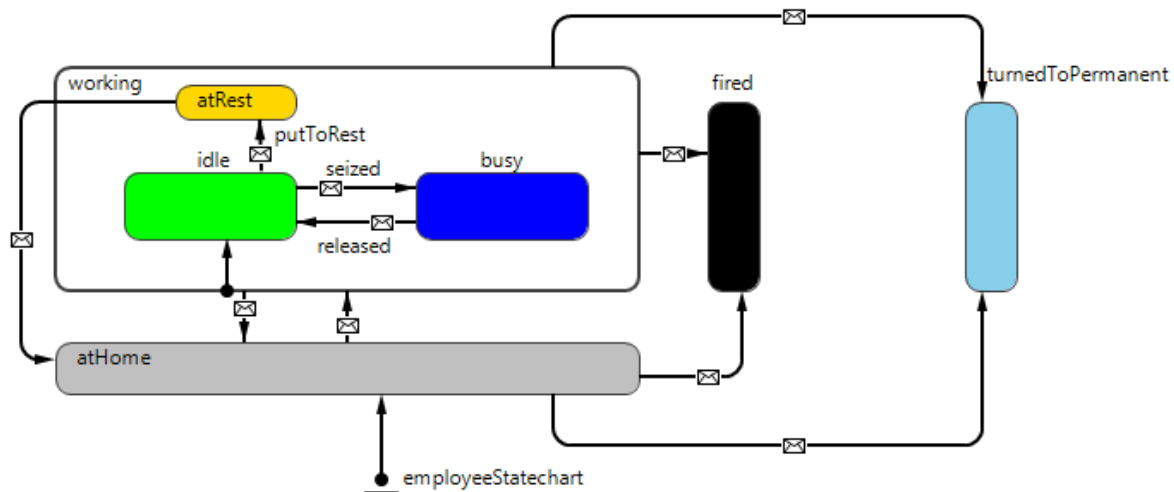
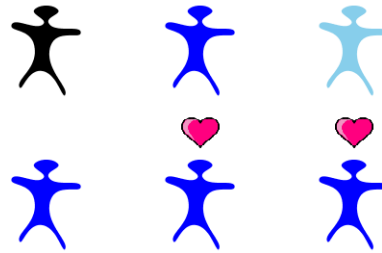


Figure 30 – Temporary employee statechart

Muzzolon et al. (2015) developed a scale of reasons for which employees might prefer temporary contract. Temporary employees behave slightly differently than permanent employees. First, the happiness level of temporary employees is not measured because occupation fraction does not affect them the same way it influences permanent employees. It has been demonstrated that temporary workforce displays overall higher job satisfaction than does the permanent workforce (Galup et al., 2008). Temporary employees only have to focus on projects (no parallel task is assigned to them) and the higher the workload, the happier they are (with a high workload they are more likely to stay hired by the company for an extended period). Consequently, temporary employees cannot resign and therefore this state is not used in their statechart - in reality, a temporary employee could hypothetically resign but this hardly happens and another temporary would instantaneously replace him/her, therefore this case is not taken into consideration in the model. However, temporary employees can be turned into permanent ones if the company needs to hire new fixed employees and if the performance of the temporary is high enough. Figure 30 shows the light blue sky “turned to permanent” state that is specific to temporary employees. Temporary employees that are designated to be hired (hiring process will be presented in detail in the dedicated section) are recognized during the simulation because a small heart appears upon their head. Following the same logic as for resigning process presented previously, they cannot instantaneously be integrated into the permanent team and will therefore have to wait until the end of the following month to be definitely turned into permanent.



Legend

black = fired blue = busy light blue = turned to permanent
blue with heart = designated for being turned to permanent

Figure 31 – Temporary employees’ visualization

As one might see on the figure below, when the model is running, all employees are represented visually as individuals. Even fired employees (in black on the figure) or temporary turned to permanent (in light blue on the figure) remain visible during simulation – so that the model user knows how many of them have been hired or fired already. However, the number indicated next to the name of the population indicates the number of currently working employees.

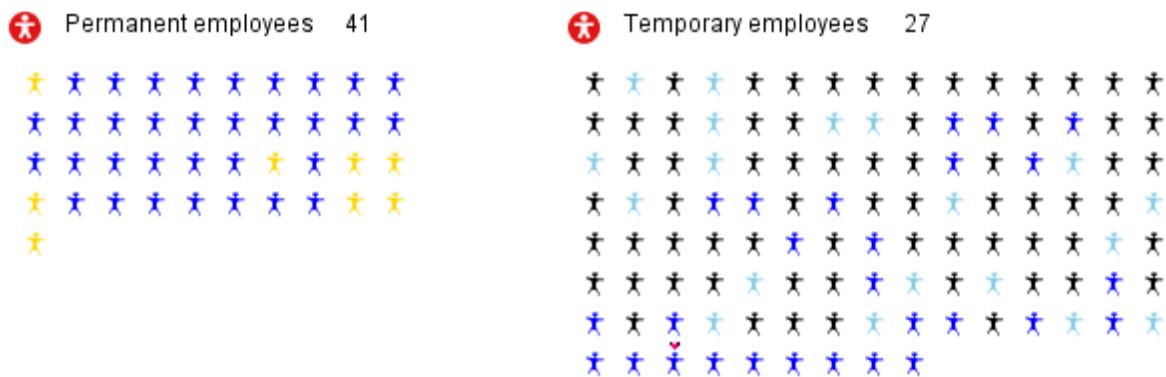


Figure 32 – Employees population visualization when model is running

The model user might choose to delete inactive employees (fired, permanently hired for temporaries and resigned for permanent workers) at any time during simulation, by using specific buttons. S/he might also want to delete them automatically from then on by simply ticking the related boxes.

10.3.7 Managers population: logic and behavior

After permanent and temporary employees, last embedded population of agents is the manager population. Managers behave differently than other employees in the model. For this reason, they do not extend the same abstract agent and are a completely separate population of agents. Managers have two main roles in the model. First, they have to manage teams of employees. The proportion of one manager for ten permanent employees (proportion applied by the case-company) has to be respected. Therefore, each time it is required, a new manager is added to the managers' population. It is assumed that managers help maintain a good level of organization within the company. Second and more importantly, managers contribute to the decision-making process of the company. As seen in the first research study, in 29% of the cases, the decision will follow a pattern where a triggering event is required for the decision-maker to eventually make his/her decision (patterns 2 and 3). This event has to be triggered by a manager, while discussing with the decision-maker (in the model, the company itself). This dynamic is represented in the model by a statechart (refer to Figure 33), where managers are either idle (which means they manage their teams and therefore do not discuss with the decision-maker) or busy (in discussion with the decision-maker).

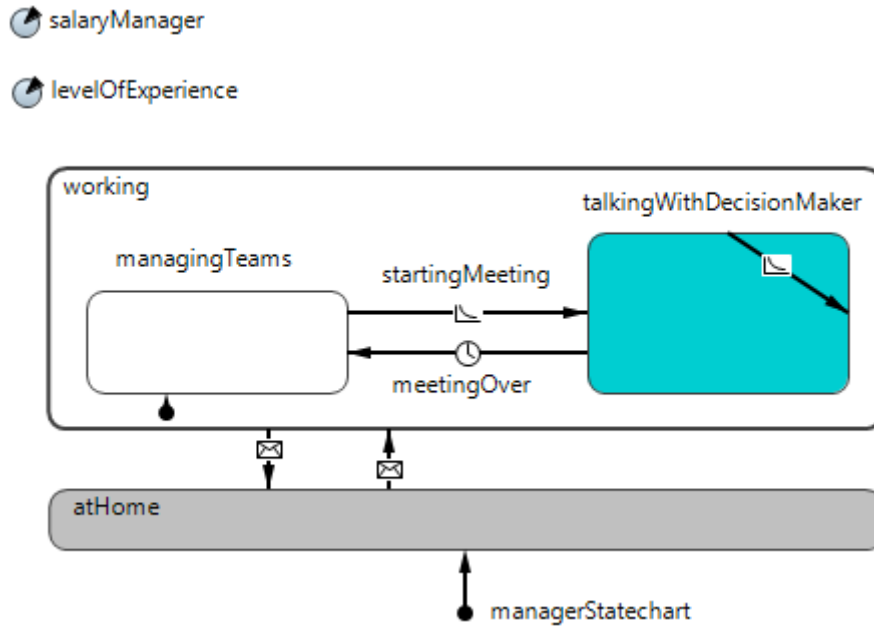


Figure 33 – Manager statechart and parameters

They enter in discussion with the decision-maker on a regular basis, based on the number of decisions they currently cover. When decisions appear in the model (the process will be described in detail in section that presents decisions population), they automatically connect with one of the managers (the manager is chosen on a random basis). Connecting a decision

with a manager symbolically, means that the manager is responsible for this decision – s/he has to make sure the decision-maker will be able to make the decision and s/he might need to support the decision-maker in his/her process of making the decision. Therefore, the more decisions a manager is in charge of, the higher the rate at which s/he will call a meeting with the decision-maker for the purpose of discussing the currently pending decisions. However, a second element moderates this rate: the efficiency of the managers' team to support the decision-maker. As observed in research study two of this thesis, the support of managers is crucial in helping the decision-maker getting out of his/her endless loops. The more managers are aware of the role they play in this process, the more efficient they will be in organizing meetings for discussions with the decision-maker. Therefore, the rate at which managers call a meeting with the decision maker is computed according to the following formula:

$$\text{Rate} = \text{myDecisions.getConnectionsNumber}() * \text{company.} \text{efficiencyInSupportingTheDecisionmaker} \quad (14)$$

This equation literally means that a manager “counts” how many decisions s/he currently covers and this number is multiplied by the efficiency of the team of managers (measured in percent, from 0% to 100%). Efficiency can also be compared to the willingness of the management team to support the company's growth. As managers behave as a team, the same value is applied to all managers.

One variable “level of experience” (going from 5% to 100%) takes into consideration the experience gained by managers while supporting the decision-making process. This value is individual (different for each manager). There is a positive relationship between the level of experience of managers (including the CEO) and the firm performance (Stone and Tudor, 2005). The more decisions are made thanks to a manager, the higher his/her level of experience will be – this means that the manager knows well how to approach the subject related to the decision s/he is in charge of and s/he also knows how to support the decision-maker in his/her process of deciding. When they join the company, the level of experience of managers can be quite low and is triangulated between the values of 5% (min), 30% (max), and 15% (mode). A manager can already have experience in the process of supporting a decision-maker, however s/he will still have to adapt to his/her new CEO and there is therefore room for improvement in all cases.

During each meeting managers have with the decision-maker, they send at an hourly rate (based on their level of experience) a message to the decision-maker that encourages him/her to make the decision. If the message reaches the decision-maker, s/he finally makes the decision. Otherwise, the decision remains pending. A meeting lasts a maximum of two hours. The higher

the level of experience of the decision-maker, the higher the probability s/he will be able to send messages to the decision-maker in order to finalize the decision-making process of connected decisions. Moreover, while studying the experience of influencing, it was observed that being influenced once tends to be positively related to being influenced during the following times as well (Chesney et al., 2017a). On the contrary, if the level of decision is still quite low, almost no message will reach the decision-maker. If a decision reaches the decision-maker, the decision will finally be made. The decision will then disconnect from the manager and increase his/her level of experience according to the following code:

```
//For console
if (main.checkboxSupportManagers.isSelected() == true) {
    println( toString() + ". "
        + myManager.getConnectedAgent().toString()
        + " made me move on.");
}

/*Adapt the level of experience of the manager
because of the decision that was made thanks to him/her. */
double impactOnExperience = triangular(0.01, 0.1, 0.02);
if (myManager.getConnectedAgent().levelOfExperience+impactOnExperience<=1)
    myManager.getConnectedAgent().levelOfExperience +=
        impactOnExperience;
else myManager.getConnectedAgent().levelOfExperience = 1;

/*Disconnect from manager because the decision is made.*/
myManager.disconnect();
```

 (15)

As a result, the more decisions are made thanks to a manager, the higher his/her level of experience.

In brief, the more experienced managers are and the more they want to help (efficiency in supporting the decision-maker), the more rapidly they will understand that they have to support the decision-maker and therefore they will multiply the number of contacts with him/her and the number of messages sent.

Besides this, managers do share some common characteristics with other employees. They follow the same schedule, thus they go home and come back to work at the same time as other employees. They also have a “salary” parameter with a value triangulated between CHF 6’000.- (min), CHF 9’000.- (max) and CHF 7’500.- (mode).

10.3.8 Company fundamental operations: global computations and values

Before introducing sub-models of the complete growth model, some global values and computations of the company fundamental operations will be introduced.

Regarding each population that has been presented up to that point (clients, projects and employees) the company collects information on a regular basis and aggregates values collected for single agents of each population. First, the company verifies the satisfaction of each client and computes the variable “global client satisfaction”. This computation is made up of the system dynamic stock “client satisfaction” at client level. A function iterates over each client-agent and calculates then the average level of satisfaction. Following the same logic, the company computes the average of all working permanent employees’ occupation in the variable “global occupation fraction”. Based on the system dynamic level of happiness stock at employee level, the company also verifies the “global happiness level” of all working employees. Global satisfaction of clients and global happiness of employees are shown on a chart at main level.

Regarding projects, the company checks daily the amount of global workload out of the remaining workload of all projects that are in states “WIP” or “accepted” only – projects that have not been accepted yet are not taken into consideration in this computation. Moreover, a data set collects the history of the variable “global workload” and shows it on a time plot chart. The company observes once a month if the last amount collected by data set is bigger or smaller than the amount of 90 days before to determine if the workload is growing or decreasing. Boolean variable “workload growing for company” is set on TRUE if workload has a tendency to grow and is set on FALSE otherwise. This variable is used as a mid-term prevision for the company and has an important impact on the hiring and firing processes that are computed by the company (and that will be presented later on). The same logic is applied for determining if the workload grows or not with regard to the banker perception. For the variable “workload growing for banker”, to be set on TRUE, the workload has to be growing for the last 180 days before. This financial variable is then used to set the credit limit level (explained later on).

The single-agent company also has its own characteristics. Two parameters will be described here. First, the company has a parameter called “organization level” which evolves continuously and represents the quality of organization within the company production teams. This value varies from 20% to 100%, with 100% being a very high quality of organization – meaning that the company is very efficient when completing projects. The more the value decreases, the longer it will be for teams to achieve projects. At the beginning of the growth period, the value is set at 100%. It decreases each time a new employee (permanent or temporary) is hired. The increase of the parameter organization level depends on the decisions of category “organize” that are made by the company and will be introduced in detail in the section 10.3.16 – Decision-making process: Organize.

Second, the company also has a certain level of infrastructure, which corresponds to the value of its property assets (plant, machines, etc.). The level of infrastructure is expressed in Swiss francs. If the company makes investments in machines or plant capacity, the level of infrastructure will increase by the same amount. This parameter is directly linked to the capability of the company to hire more permanent employees. The higher the level of infrastructure, the more permanent employees can be hired by the company. This process will be described in more details in section 10.3.14 – Decision-making process: Hire. Few studies discuss the capacity utilization of companies; but for example Sun and Wong (2010) have decomposed the relationship between capacity utilization and jobs-to-sales; Oliva et al. (2003) pointed that developing the infrastructure is required to serve and keep the masses of customers attracted.

Temporary employees' number however is not connected to the infrastructure capacity, because most of them work outside of the plant, directly on the construction sites; consequently, infrastructure does not have to increase in order to hire them. The number of permanent employees who can be hired according to the current level of infrastructure is indicated by the variable “maximum number of permanent possible”. The value of this number is monitored by a database in the model. The function “check infrastructure capacity” constantly verifies what stage has been reached by the infrastructure –stocked in the parameter “current infrastructure step” - and determines how many employees can be hired:

```
currentInfrastructureStep = selectUniqueValue(  
    "SELECT MAX(equilibrium_infra_anylogic.infrastructure) FROM  
equilibrium_infra_anylogic WHERE equilibrium_infra_anylogic.infrastructure  
<= ?",  
    infrastructureCapacity);  
  
maxNumberPermPossible = (int) selectFrom(equilibrium_infra_anylogic)  
    .where(equilibrium_infra_anylogic.infrastructure  
    .eq(currentInfrastructureStep))  
    .uniqueResult(equilibrium_infra_anylogic.number_of_employees);    (16)
```

Each time the variable of infrastructure increases, it might reach a new level and allow for hiring more employees. Figure 34 below indicates the relationship between the level of infrastructure and the number of employees who can be hired. Blue cell indicates the capacity level at the beginning of the growth period – this number was used as the initial value in the model simulation settings. Maximum value was set at CHF 81 million - a bigger company (more than five hundred employees) would not be considered as an SME anymore.

	infrastructure	number_of_employees		infrastructure	number_of_employees
1	100,000	1	18	5,200,000	57
2	162,000	2	19	6,250,000	66
3	234,000	3	20	7,500,000	97
4	280,000	4	21	9,000,000	117
5	335,000	5	22	10,800,000	122
6	400,000	7	23	13,000,000	127
7	479,000	9	24	15,600,000	146
8	830,000	13	25	18,720,000	205
9	1,000,000	15	26	22,500,000	245
10	1,200,000	21	27	27,000,000	256
11	1,440,000	26	28	32,400,000	267
12	1,730,000	27	29	39,000,000	308
13	2,080,000	28	30	46,800,000	430
14	2,500,000	30	31	56,200,000	515
15	3,000,000	44	32	67,500,000	535
16	3,600,000	53	33	81,000,000	555
17	4,320,000	55	*		

Figure 34 – Relationship between infrastructure capacity and maximum number of permanent employees.

This table was created based on the company-case data. Historic of the company was scrutinized to create a relationship between the number of employees hired and the investments made in infrastructure. Relationship concerns the number of permanent employees and indirectly the number of projects (because the number of projects that can be accomplished is directly linked to the number of employees). This logic is necessary because several times during its growth, the case-company could not hire permanent employees anymore because it was lacking capacity. Without it, the model could potentially hire an infinite number of permanent employees, regardless of the capacity of the company, which is not realistic.

This section presented some of the main loops that are computed on a regular basis by the company, in order to collect important information about its performance towards clients, employees and projects populations. Some general variables that describe the company were also introduced.

10.3.9 Company fundamental operations: projects completion

Now that general variables are introduced, some company fundamental operations will be presented. The first sub-model contains the major operations that any company has to achieve in order to play a role on the market: create and deliver value to its customers by means of a product or a service. The case-company creates value when its employees complete projects

that are ordered by clients. This section therefore provides details on how employees are allocated to projects and on how projects are completed. In AnyLogic, if different populations of agents need to communicate with each other or exchange information, a connection (single or collection of links) has to be created between them. A bidirectional connection exists between employees and projects populations. The connection at project level is a collection of links – meaning that several employees can work on the same project. On the other hand, connection at employees' level is a single link – each employee can work only on one project at a time.

As mentioned in detail in section 10.3.3 (projects population), after popping up, a project waits until it is accepted, enters the WIP stage, is completed, waits to be cashed and is then archived. This section focuses on what happens when the project enters the WIP state. It is important to remember that each project can seize a maximum of six resources and that there has to be at least one permanent employee per project - a team entirely composed of temporary workers cannot complete a project. Moreover, a maximum of four permanent workers will be seized by a project – two free places either will be used by temporary workers or will remain empty. Allocation is carried out by the “allocate resources” function; the logic is the following: there are available employees and projects in work (WIP). Each time employees go back to work (morning and afternoon, except for weekend days); projects are sorted according to their priority (urgency parameter). Then, the function defines how many projects must seize resources based on (a) the current number of permanent employees and (b) the total number of employees (temporary + permanent employees). The selected projects – the ones that need to get resources - are virtually placed in a sub list (“tree set” in AnyLogic). The first project of this list – with highest priority - takes a full set of workers; the same does the second, and so on. Permanent employees are allocated first; the function iterates over selected projects and adds only one permanent employee to each of them in the first round, then a second, then a third, up to a maximum of four permanent per project. Temporary employees are allocated in a second time, project after project, fulfilling the free places up to six employees by project. The function is designed so that the selected number of projects will always offer places to all employees (permanent and temporary) according to the acceptable combinations of people. Figure 35 shows how combinations of workers are created according to different number of permanent, temporary workers and projects.

Permanent	Temporary	Total	Proportion T / P	Project	Project	Project	Project	Project
				1	2	3	4	5
4	0	4	-	4 P				
4	1	5	0.25	4 P 1 T				
4	2	6	0.50	4 P 2 T				
4	3	7	0.75	2 P 3 T	2 P			
4	4	8	1.00	2 P 4 T	2 P			
4	5	9	1.25	2 P 4 T	2 P 1 T			
4	6	10	1.50	2 P 4 T	2 P 2 T			
4	7	11	1.75	2 P 4 T	2 P 3 T			
4	8	12	2.00	2 P 4 T	2 P 4 T			
4	9	13	2.25	2 P 4 T	1 P 5 T	1 P		
4	10	14	2.50	2 P 4 T	1 P 5 T	1 P 1 T		
4	11	15	2.75	2 P 4 T	1 P 5 T	1 P 2 T		
4	12	16	3.00	2 P 4 T	1 P 5 T	1 P 3 T		
4	13	17	3.25	2 P 4 T	1 P 5 T	1 P 4 T		
4	14	18	3.50	2 P 4 T	1 P 5 T	1 P 5 T		
4	15	19	3.75	1 P 5 T	1 P 5 T	1 P 5 T	1 P	
4	16	20	4.00	1 P 5 T	1 P 5 T	1 P 5 T	1 P 1 T	
4	17	21	4.25	1 P 5 T	1 P 5 T	1 P 5 T	1 P 2 T	
4	18	22	4.50	1 P 5 T	1 P 5 T	1 P 5 T	1 P 3 T	
4	19	23	4.75	1 P 5 T	1 P 5 T	1 P 5 T	1 P 4 T	
4	20	24	5.00	1 P 5 T	1 P 5 T	1 P 5 T	1 P 5 T	

Figure 35 – Allocation of resources to projects

When the schedule turns to off, projects release employees and wait until the next working period starts. If there are many projects in the WIP state, many of them will have to wait - some for short periods and some for longer - before being able to seize employees.

Another function called “join allocated projects” works somewhat differently and deals with employees that are released by finished projects during working hours. Completed projects release employees; immediately after that, “join allocated projects” function takes over, it checks if there are free places in current WIP projects and makes employees join them if they have free places (employees first join projects with highest priority). If there is no or not enough place left, a new project will be selected towards the list of WIP-waiting projects (from the “tree set”) and released employees will join it all together. Most of the time, permanent employees join a new project and temporary employees fulfil places left in all projects that are the most urgent.

One of the prime advantages of the “put at rest” logic that was presented in the permanent employees’ population section is that allocation of resources is made in an equal manner. It is

not always the same employee who will have to work on a project first. By default, the model would have wrongly seized always the first employee of the population, creating disequilibrium in terms of occupation fraction of all employees.

Calling “allocate resources” function twice a day (each time employees go back to work) allows for reacting rapidly if a new project joins the WIP group and presents a degree of urgency that is higher than projects currently completed. Resources that work on a less urgent project will set aside this project for a while, complete the most urgent one and go back to the other project afterwards. Consequently, projects are continuously allocated differently if one of them is more urgent than previously. This means that employees can work on “project A” for a few hours, days or weeks, might then switch to “project B” for a while and then come back to A as long as nothing more urgent appeared in-between. Modelling this flexibility was done based on observations of how the case-company deals with the urgency of projects.

When a project has seized resources and when employees are currently completing it, the rapidity at which the work is accomplished depends on 1) the number of employees, which have been seized to work on the project 2) the performance of all employees working on it and 3) the current quality of organization of the company. The previous section presented the parameter organization level— as a reminder, the higher it is, and the more rapid the completion of projects will be executed.

The complete code of “allocate resources” function is presented below:

```
LocalDate currentDate =
date().toInstant().atZone(ZoneId.systemDefault()).toLocalDate();

    //For console
    if (main.checkboxAllocate.isSelected() == true)
        println ("CALL ALLOCATE: " + currentDate);

/*
1) Re-sort projects according to their level of urgency */
if (sortedProjects.size() != 0) {
    sortedProjects.forEach(p -> p.projectPresWIP.setVisible(false) );
    Collections.sort(sortedProjects);
    queueProjectsWaiting.sortEntities();
}

    //For console
    if (main.checkboxAllocate.isSelected() == true) {
        println ("    Sorted projects = ");
        sortedProjects.forEach( p -> println( "        Project " +
            p.getIndex() + " Urgency = " + format(p.urgency()) ) );
    }
}
```

```
/*
2) Define how many projects must seize resources based on
  a) number of permanent employees)
    --> define MIN and MAX
  b) total number of employees (T + P)
    --> choose correct number of projects*/
int numPermanent = permanentEmployees.size()
    -permanentEmployees.numberPermanentFired()
    -permanentEmployees.numberPermanentResigned()
    -permanentEmployees.numberPermanentAtRest();

int numTemporary = temporaryEmployees.size()
    -temporaryEmployees.numberTemporaryFired()
    -temporaryEmployees.numberTemporaryTurnedToPermanent();

int numTotal = numPermanent + numTemporary;

int numCurrentProjects = sortedProjects.size();

/*Define minimum and maximum number of projects to allocate*/
int minNum = (numPermanent / 4);
int rest = numPermanent % 4;
if (rest!=0)
    minNum = (numPermanent / 4 ) + 1 ;

int maxNum = numPermanent;

/*Check if there is enough current projects, otherwise reduce to that number*/
if (minNum > numCurrentProjects)
    minNum = numCurrentProjects ;

if (maxNum > numCurrentProjects)
    maxNum = numCurrentProjects ;

//For console
if (main.checkboxAllocate.isSelected() == true) {
    traceln("  Min number of projects to allocate = " + minNum);
    traceln ("  Max number of projects to allocate = " + maxNum);
}

/*Define right number of projects to allocate*/
int rightNum = maxNum;

for (int i = minNum ; i <= maxNum ; i++ ) {
    if (i*6 > numTotal) {
        rightNum = i ;
        break;
    }
}

//For console
if (main.checkboxAllocate.isSelected() == true) {
    traceln ("  Right number of projects = " + rightNum);
}
}
```

```
/*Create a sublist only with the projects selected for allocation.*/
projectsToAllocate.forEach(p -> queueProjectsAllocated.remove(p));
projectsToAllocate.clear();

Project[] sortedArray = sortedProjects.toArray(new Project[]{});
Arrays.sort(sortedArray);
sortedArray = Arrays.copyOf(sortedArray, rightNum);
projectsToAllocate.addAll(Arrays.asList(sortedArray));

//For console
if (main.checkboxAllocate.isSelected() == true) {
    println("    Projects to allocate = ");
    projectsToAllocate.forEach(p -> println(p.getIndex() ));
}

projectsToAllocate.forEach(p -> queueProjectsWaiting.remove(p));
projectsToAllocate.forEach(p -> enterProjectsAllocated.take(p));
projectsToAllocate.forEach(p -> p.projectPresWIP.setVisible(true) );
queueProjectsAllocated.sortEntities();

/*
3) Allocate permanent resources
(only one employee by project per round) */

for (int i=0; i< numPermanent; i++) {

for (Project p: projectsToAllocate) {
    if (p.myEmployees.size()< 4) {

        for (PermanentEmployee e: permanentEmployees) {
            if ( e.inState(PermanentEmployee.idle)
                && e.myProject.isConnected()==false
                && e.atRestAlready==false) {
                e.myProject.connectTo(p);
                //For console
                if (main.checkboxAllocate.isSelected() == true) {
                    println("    P" + e.getIndex() + " connects to
                        project " + p.getIndex());
                }
                p.myEmployees.connectTo(e);
                e.myProject.deliver("Here I Am");
                break;
            }
        }
    }
}

}

/*
4) Allocate temporary resources to complete projects with permanent
(project after project, up to 6 people,
until there is no temporary left) */
```

```

for (Project p: projectsToAllocate) {

    for (TemporaryEmployee e: temporaryEmployees) {

        if (p.myEmployees.size()>0) {
            if ( p.myEmployees.size() <6) {
                if (e.inState(TemporaryEmployee.idle) &&
                    e.myProject.isConnected()==false) {
                    e.myProject.connectTo(p);
                //For console
                if (main.checkboxAllocate.isSelected() == true) {
                    println("  T" + e.getIndex() + " connects to
                        project " + p.getIndex());
                }
                p.myEmployees.connectTo(e);
                e.myProject.deliver("Here I Am");
            }
        }
    }
}

/*Connect all seized employees to project*/
for (Project p: projectsToAllocate) {
    p.myEmployees.deliverToAllConnected("New Project");
}

```

(17)

This section closes the first sub-model that was created: the model performs basic operations that create value for the clients of the company by allocating resources to projects. The following sections focus on another sub-model that is also mandatory to represent a company: the financial processes that include liquidity and credit limit logic as well as the global payment processes.

10.3.10 Company fundamental operations: liquidity and credit limit logic

As observed in the literature as well as in this study's preliminary results, the most critical indicator during a growth period is not the sales level but the liquidity level. Indeed, running out of liquidities is a very common problem—and often a fatal threat—for growing firms (Shirur, 2013), even if the sales level remains very high. Hence, the level of liquidity is an important variable in the company. It collects any transactions that are performed in the operations of the company, such as receiving money once a project is completed, paying wages, paying interests, investing in infrastructure or material, etc. The liquidity variable is therefore constantly changing over time. Liquidity level can be increased only when clients pay an advance or final invoices they receive while their projects are completed. As mentioned already,

clients will pay based on the average time indicated by the parameter “clients’ rapidity to pay” which is set on 30 days by default. The model user can play with this value thanks to a slider and sets it from 0 to 90 days. Impact of changing this value will be discussed in the analyses section of the thesis. On the contrary, many reasons might decrease the liquidity level. All of them will be explained in detail in the next section, throughout the presentation of the payment process.

Liquidity variable is directly linked to the credit limit variable. Both of them appear on the same central chart at the main level of the model. As all initial values of the model are based on the case-company data, the initial value of the credit limit is very low - set at CHF (- 75'000).- Even if this level remains much below what would have been a reasonable level of credit limit, there is a simple explanation which is that, historically, the company never needed to increase it. As one will see, this was changing drastically during the upcoming growth period.

The computation of the level of credit limit is quite complex (as it is in real life) and will therefore be detailed here. First, a Boolean parameter is linked to it: “possibility to increase credit limit” (at the company level). If this parameter is set on FALSE (for several reasons that will be explained later on), it is not even possible for the company to ask the bank to increase its credit limit. Otherwise, this parameter is set on TRUE if the parameter “workload growing for banker” (presented in previous section, giving a mid-term prevision about the global workload) is set on TRUE as well. The value of the parameter “possibility to increase credit limit” is constantly checked by the event “check possibility to increase credit limit”. Complexity comes from the fact that even if it might be theoretically possible to increase the credit limit, the bank will then make a very restrictive computation to determine what the maximum amount available is. The function that returns the maximum amount of credit limit authorized is called “ask credit limit” and operates as follows: the function chooses the correct turnover according to the current date in simulation. Correct turnover is always the turnover of the previous year – if current simulation date is 2012-12-04, the correct turnover chosen is the turnover of year 2011. The reason for this is that it is the only turnover, which is reported, reviewed and published already; thus, the only turnover the bank can rely on, waiting for the next turnover to be consolidated, reviewed and finally made available to the banker. The maximum available credit limit represents 25% of this turnover. Then, the bank has to define the amount of money that it has already borrowed to the company and which is considered “risky” for the bank. The risky part involves precisely 20% of the global amount of leasing that the company contracted and that have not been fully refunded yet. This risky part is deducted from the maximum amount based on turnover (25% of turnover). Finally, the level of credit limit can be computed

according to the following formula: credit limit level = (25% of turnover of previous year) – (20% of all running leasing). The function that returns the potential increase of credit limit in the model presents the following code:

```
/* Start function by setting a null increase potential*/

double increasePotential=0;

/* Define the maximum level possible, which is 25% of potential
annual turnover minus 20% of all leasings (risky part for the bank) */

double maxLevelBasedOnTurnover = chooseCorrectTurnover()*0.25; //select
turnover of previous year with function chooseCorrectTurnover
double currentlyRiskyPart = 0.2*monthlyAmortization; //risky part
double maxLevelOfCreditLimit = (maxLevelBasedOnTurnover-currentlyRiskyPart)
* (-1);

/* Check if possible to increase credit limit. And if yes, by how much.
Conditions:
-possibility set on true AND
-current CL level + 20% of leasing does not reach the maximum amount
potential of CL. */

if (workloadGrowingForBanker==true && respectOfEnvironment==true &&
    creditLimit > maxLevelOfCreditLimit ) {

    increasePotential = creditLimit - maxLevelOfCreditLimit ;
}
else {
    increasePotential=0;
}

return increasePotential; (18)
```

While being the heart of the system of the growing company, liquidity and credit limit both play a significant role in all the following sections, and especially in the very next section that will introduce the payment processes of the company.

10.3.11 Company fundamental operations: payment processes

A sub-model totally partitioned from the growth model has been developed in order to model the payment processes of the company. Once this model was fully completed and under control, it was simply integrated into the main growth model and connected to the corresponding variables and parameters. The full payment process in the model includes 29 variables, 17

events and 16 functions. It follows for an agent-based logic. AB has already been used to model financial processes such as accounting (Chesney et al., 2017b) and will therefore be perfectly suited to modelling the payment process of the company. The author will summarize the main principles of the logic in this section.

There are several types of payment that have been grouped into four categories; namely wages (permanent employees + managers), suppliers (temporary wages), investments (divided in three sub-categories), amortization, and marketing actions. All of those payments decrease the level of liquidity of the company. At first, the author will present the different categories of payments and then explain the whole payment process. One might notice that there are no supplier payments included in this list (except for placement agencies that supply temporary employees). Even though material costs represent an important part of the turnover in the construction sector and in the case-company as well, they are not the main source of profitability. In many cases, materials are bought at a cost very similar to the price at which they are resold to the clients. Therefore, it was decided that they would not be added to the payment process, as they do not provide any interesting insights in terms of value created by the company. What is called “turnover” in the model thus refers to the “value added” computed between the turnover and the EBITDA in a classical profit and loss statement.

As explained when introducing employees’ populations, each employee has a salary parameter. The model contains a variable called “monthly wages” which, through a function once a month, collects and sums all individual salaries of permanent employees and managers. On the 28th of each month, the event “pay wages” reduces the liquidity level by the amount of the variable “monthly wages”. Temporary salaries are collected on a daily basis (because some of the temporary employees might work less than one month or even less than one week) and are paid each Thursday - payment is transferred to the placement agencies with which the company collaborates and which is in charge of paying wages directly to the temporary workers. Therefore, paying temporary wages is more similar to paying a supplier than to paying permanent wages.

Investments are split into three categories. The first type of investment concerns individual investments that are made by the company each time a new employee is hired - basic equipment that each employee has to get in order to be able to work efficiently. The amount is between CHF 2500.- and 3000.- by person. The second type concerns collective investments that are made for each fifth employee hired (n. b. employees who quit the company count for minus one person in this logic). A vehicle typically falls within this category of investments. The amount

of collective investment is triangulated between CHF 10'000.- and 30'000.- with a mode of CHF 150'000.- by equipment. For this category of payments, the company might try to obtain a leasing option, which will be granted if the conditions explained in the credit limit presentation are met. Leasings are generally gladly granted by banks as they would not be affected by potential defaults of customers (Bülül et al., 2014) and because leasing has a lower associated bankruptcy costs (Krishnan and Moyer, 1994). If the conditions are not met, the company will have to use its liquidity to pay the equipment. The third type of investments concerns the infrastructure. The company regularly has to invest in new machines; increasing plant capacity also forms part of infrastructure investments. The amount for this category of investments is higher and lies between CHF 100'000.- and 2'000'000.-. For this type of investment, the company requires the support of the bank and will therefore try to obtain a loan. For industrial activities, the bank agrees to support 50% of the total amount. The company has to bring the remaining 50% of the value. There is no limit in terms of global amount of loan accepted by the bank in this category of investments (contrary to the credit limit or the leasing). When an investment of this category is made, it will increase the "infrastructure" variable of the company by the amount invested. As mentioned already, the "infrastructure" variable plays an important role in the hiring process of the company and will be presented in more detail later on.

As some investments increase the debt level of the company towards its financial institution, the debt has to be paid back on a monthly or quarterly basis. This category of payments is called amortization in the model. Monthly and quarterly amortization are automatically computed based on the level of debt (infrastructure and leasing) and are paid the 2nd of the month for the monthly amortization and four times a year, at the end of the concerned months for the quarterly amortization. Each time an amortization is paid, the debt level is decreased by the corresponding amount. Next amortization is calculated based on the remaining debt level with a declining balance method (digressive amortization).

The last category of payments concerns the marketing actions realized by the company. A marketing action will cost an amount lying between CHF 100 and 15'000.- and will directly decrease the level of liquidity.

If the company has sufficient liquidity to fulfil all types of payments each month, it will pay related amounts with no delay. However, if the company starts to run out of liquidity, it will have to delay some payments - or all of them - temporarily. Therefore, the company will start to prioritize payments to make instantaneously or to delay, according to their category. The order of importance appears in the following table; starting from the most critical payments (no

delay should occur at any time) to the less critical payments (a delay might be acceptable for a reasonable period):

	Category	Criticality of delay	Explanation
1	Wages of permanent employees and managers	Extremely critical	The company cannot create value and answer customer's request without permanent employees. If they are not paid, they might want to quit the company very rapidly or stop working. Therefore, delaying wages should be avoided at all costs.
2	Amortization (monthly and quarterly)	Very critical	Repayment ability is directly linked to the relationship between the company and the bank. If amortization is not paid when it is supposed to, the bank might become upset and, as a consequence, increasingly restrictive. Therefore, amortization is part of the highest payment priorities.
3	Wages of temporary employees	Very critical	Wages of temporaries are paid to the placement agencies, which can be considered as suppliers of the company. If maintaining good relationship with the company, suppliers might agree for some time that their invoices are delayed. After what there is a risk of legal proceedings. The delay thus has to remain reasonable.
4	Collective investments	Moderately critical	Delaying investments will not affect directly the solvency of the company but rather its organization level. If numerous investments are delayed, the level of organization will drop; projects will not be achieved efficiently anymore, which might eventually lead to a dissatisfaction of clients and a decrease of workload.
5	Infrastructure investments	Moderately critical	Renouncing top investing opportunities in infrastructure will not affect the company in the short-term. However, in the long run, it will block the growth of the company. If the capacity cannot be increased, no more employees can be hired and growth will stall.
6	Marketing actions	Slightly critical	Refusing a marketing proposal has no important consequence except if the global workload is currently decreasing, in which case marketing actions would be very profitable or even essential for the company in order to gain new clients.

Table 19 – Payments priority

A certain number of rules determine how payments are made or delayed. Permanent and managers wages have the priority. Thus, when they have to be paid, the function will check the current level of liquidity. If it is sufficient, wages are paid. Otherwise, the function will check if it is possible to increase credit limit via the function “increase credit limit”. If function returns TRUE (YES), credit limit is increased and all wages can be paid. Otherwise, the function pays only what is possible according to liquidity and stock the remaining wages in the variable “delayed wages”. As soon as there are some delayed payments, an event constantly checks if the level of liquidity increases again. The moment it is possible, delayed wages are paid in full - and therefore this variables is set to zero again - or partially - and “delayed wages” variable is decreased by the identical amount.

The same logic is applied for the payment of amortization, except that the company will not ask for increasing credit limit when it is about to pay amortization. Amortization can therefore also be delayed and will be paid as soon as some liquidity is available again. According to Coad et al. (2013) loans that are repaid in a timely manner are positively linked with enterprise survival.

Temporary wages will be delayed if the level of liquidity is not sufficient to pay permanent and managers salaries as well as amortization at the end of the month. Therefore, variable “delayed temporary wages” is increased and the delayed amount is paid as soon as the level of liquidity increases again.

For investments (any type), the company first verifies that the remaining level of liquidity is sufficient to pay wages and amortization before deciding to invest. Consequently, if there is not enough liquidity while hiring a new employee, investment is not made, the variable “delayed investment” is increased and it might be paid when liquidity is available. For collective investments, the company will ask for a leasing. If the maximum amount taken by leasing is already reached, the same logic will be applied and investments will be delayed. Moreover, if there is any other payment already delayed, investments are completely delayed as well. As mentioned in Table 19, if an investment is delayed, it will decrease the organization level of the company. A negative impact is computed based on the amount that is delayed; the higher the amount delayed, the higher the negative impact on the organization level. If e.g. a vehicle would be necessary but cannot be bought, workers teams will suffer from this disorganization and will therefore be less efficient; which will decrease clients’ satisfaction level and eventually global workload. However, when a delayed investment is paid – because liquidity level has increased – organization level increases as well again.

For investments in infrastructure, the company needs to bring 50% of total (while remaining able to pay wages and amortization). If the company currently has not enough liquidity to invest, it will first check if it is possible to increase credit limit. If yes, credit limit level is adapted, company pays 50% of the investment and the other half increases debt level. If it is not possible – and thus the company cannot invest 50% of the global amount -, the investment is not made and the total amount is summed in the variable “lost investment opportunity”. Indeed, an opportunity to increase infrastructure (for example by buying another plant) cannot be delayed and paid back later. It is done or it is lost. If an opportunity is lost, the company will have to wait until the next opportunity appears.

Finally, for marketing actions, if there is no delayed wages or amortization, and if the level of liquidity is sufficient, marketing is invested in. Otherwise, marketing action does not take place and its relative amount increases variable “marketing not invested”. Here as well, opportunity to perform marketing is lost and the company will wait for the next one.

The complete logic of payments has been tabulated in an excel sheet, showing all types of payments (on time and delayed for each category), what functions are called, in which order, etc. The complete table is in appendix 4 (section 10.4). Table 20 below transcribed the process of payment of temporary wages. The table has to be read from top to bottom, with the logic of a decision tree. While paying temporary wages, the company first checks if there are delayed wages (as priority is given to permanent and managers wages). If yes (true), the totality of the amount is delayed. Same for delayed amortization (which has priority as well); if there is some (true), the global amount of temporary wages is delayed. If there are already some temporary wages delayed, the new amount that was supposed to be paid is added to the “delayed temporary wages” variable. However, if no wages and no amortization are delayed, the company will then check the predicted level of liquidity with function “calculate predicted liquidity”. If the predicted level of liquidity is sufficient for paying wages and amortization at the end of the month, all temporary wages are paid. Otherwise, only the available part of temporary wages – that will still allow permanent employees’ wages, managers’ wages and amortization to be paid at the end of the month – will be paid. The remaining part will be delayed.

	payTemporaryWages				
anyDelayedWages	false			true	
anyDelayedAmo	false		true		
anyDelayedTempWages	false	true			
anyDelayedInvestment					
checkIfLeasing					
calculatePredictedAmo					
calculateAvailableLiquidity					
askCreditLimit					
calculatePredictedLiquidity	enough	not enough			
increaseDebt					
increaseAmo					
<i>payORdelay (amount paid, amount delayed)</i>	<i>ALL, 0</i>	<i>available, remaining</i>	<i>0, ALL (because of delayed TempWages)</i>	<i>0, ALL (because of delayed Amo)</i>	<i>0, ALL (because of delayed Wages)</i>
decreaseDebt					
decreaseRemainingAmo					
reduceDelayedAmount					
increaseInfrastructure					
decreaseOrganizationLevel					
increaseOrganizationLevel					

Table 20 –Detailed payment process of temporary wages

In this table, all lines that remain completely grey (such as “check if there is any delayed investment”, “ask for increasing credit limit”, “increase / decrease debt”, “increase /decrease amortization”, “increase / decrease organizational level”, etc. are not used when paying temporary wages but are used in other payment processes (refer to appendix 4).

Fundamental company’s operations have been introduced. All other operations processes that will be presented in the following sections rely on decisions that are made by the company on a regular basis. Therefore, the next section will first present the different populations of decisions.

10.3.12 Decisions population: logic and behavior

This section introduces a new type of agent: the decisions. It was decided to model decisions as agents because all of them share common characteristics and behaviour, but each of them presents unique values of parameters and might be processed differently by the company. Agent-based modelling is perfectly suitable for this kind of modelling (North and Macal, 2007). Moreover, Elsayah et al. (2015) have showed that AB allows capturing the richness of decision-making.

In the two first parts of the thesis, the author has analysed that 1) decisions follow three patterns (sequences of steps) and are made on average after a known duration according to the pattern they follow, 2) decisions belong to a class (matrix cell) according to the classification framework that was developed in the first research study and 3) decisions belong to different categories, namely: (a) Accept projects (b) Hire / Fire employees (c) Invest (into infrastructure, equipment, vehicles, etc.) (d) Organize the management / the plant (e) Improve well-being (f) Support environment (g) Make marketing actions and (h) Develop business.

As mentioned previously, decisions arise when (1) disequilibrium appears between several parameters of the company or (2) a specific situation launches a decision. Situations that lead to the creation of a decision have been identified and transcribed into the model logic. Disequilibrium and situations that create decisions will be described in detail in the following sections.

In the model, the category “(b) Hire / Fire” has been split into two separate categories because the logic in the model while hiring or firing is different. Moreover, the last category identified “(h) Develop business” has finally not been integrated in the model logic. As this type of decisions was not directly affecting the current operations of the company (but was rather developing new sectors with other employees, other logic, other competences, etc.) it was decided to keep it as a subtle feature that could be integrated in a future version of the model.

So as far as employees populations are concerned, decisions population has been modelled as an abstract population of decisions and then each category of decisions has been modelled through a different population that extends the abstract population. This way, all populations share common elements – that were modelled only once – but their values are unique and they affect differently the company operations, once they are made.

Decision parameters and computation of time to make decision

When it pops up, a decision already gets (1) the pattern it will follow (parameter “pattern” in the model), (2) the matrix cell to which it belongs (split in three parameters namely “level of decision”, “supply chain” and “TBL”) and (3) the time it will spend in the decision-making process (“time in process”) which depends on the pattern it follows and is influenced by the efficiency of the decision-maker to make decisions.

The values of all of these parameters depend on several elements that were observed, collected and measured in the company-case and that have been transcribed in the model logic. The distribution of pattern – how the model defines which pattern a new decision will follow – depends on the category of the decision. So do the values of the matrix parameters. Each distribution values are based on what was observed within the case. For example, a decision of the type “improve well-being” will follow in 60,7% of the cases the pattern “easy with no work” (pattern 1), in 17,9% of the cases the pattern “difficult with no work” (pattern 2) and in 21,4% of the cases the pattern “difficult with work” (pattern 3). Same kind of distributions has been created for matrix cells, for all category types. In total, 32 distributions have been created (four parameters multiplied by eight categories of decisions) based on what was observed and measured during empirical data collection and analysis. As a result, the pattern and matrix cells selection is stochastic in the model and is therefore representative of what would happen in reality. Figure 36 below shows the complete list of distributions that were created in order to be applied when a decision pops up.

Distribution of parameters for each category of decisions

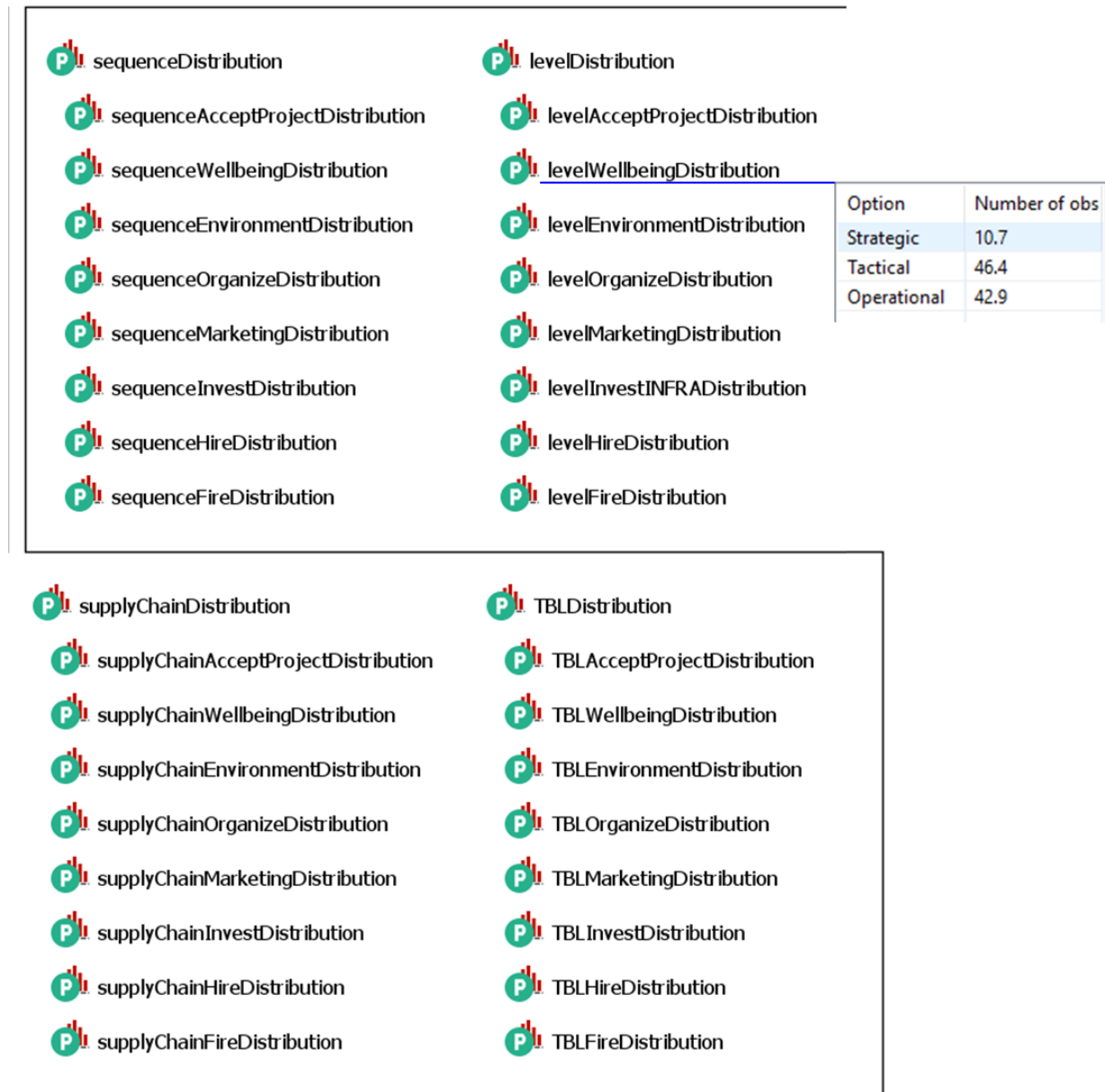


Figure 36 –List of distributions with example for well-being level of decision

The parameter “time in process” is the result of the computation between two elements: (1) predicted time necessary to make decision and (2) efficiency of the decision-maker to make decisions. The parameter “time predicted” always gets a value that is triangulated between a minimum, a maximum and a mode. Min, max and mode values are calculated based on the pattern the decision follows - if the pattern follows the simplest pattern (pattern 1 in the model) the predicted time will be much shorter than if it follows the most complex pattern (pattern 3 in the model). The time values in the model are based on average time that was measured in the case-company (time to make decisions). Moreover, min, max and mode values also depend on the number of decisions of the same pattern that were made already; as it was analysed in the

second research study, the more decisions of similar pattern have been made already, the shorter the time the decision-maker will spend before making the decision (gain in efficiency over time through the experience gained). Therefore, min, max and mode values are smaller for a decision that appears after several years of growth than for a decision that pops up at the very beginning of the period. Predicted time is also stochastic. Related parameter “time in process” is computed according to the following formula:

$$\text{double timeInProcess} = \text{timePredicted} / \text{efficiencyToMakeDecision} \quad (19)$$

Hence, “time in process” depends on the value of “time predicted” and on the efficiency of the decision-maker. Core values that are given to predicted time are based on a theoretical efficiency of the decision maker of 100%. This means that if a value of 10 days is set for the predicted time, if the decision maker has an efficiency of 100% to make decisions, it will take exactly 10 days to make the decision. However, if his/her efficiency is lower than 100%, the time to make the decision will be proportionally longer. Figure 37 shows what are the times necessary for making decisions when following the pattern “difficult with no work” (pattern 2) and depending on the level of efficiency of the CEO.

Pattern 2 - difficult with no work												
	<=20			<=40 OR >20			<=60 OR >40			>60		
Efficiency	Min	Max	Mode	Min	Max	Mode	Min	Max	Mode	Min	Max	Mode
100%	15	150	90	7	90	60	4	70	40	1	45	34
90%	17	167	100	8	100	67	4	78	44	1	50	38
80%	19	188	113	9	113	75	5	88	50	1	56	43
70%	21	214	129	10	129	86	6	100	57	1	64	49
60%	25	250	150	12	150	100	7	117	67	2	75	57
50%	29	300	180	14	180	119	7	140	80	1	90	68
40%	38	375	225	18	225	150	10	175	100	3	113	85
30%	50	500	300	23	300	200	13	233	133	3	150	113
20%	75	750	450	35	450	300	20	350	200	5	225	170
10%	150	1'500	900	70	900	600	40	700	400	10	450	340

Figure 37 – Time necessary to make decisions according to level of efficiency

As one might see, there is a positive evolution of time (time shortens) progressively as the number of decisions already made increases (reading Figure 37 from left to right). Finding the correct value range where an improvement could be observed (here 20 by 20 decisions) needed some analysis, using SPSS software. Different trials were made, with ranges going from 15 to 30 decisions, with an increment of 5 decisions. The objective was to find a significant time improvement between ranges. The range of 20 decisions was considered as the most significant in terms of time improvement. With an efficiency of 100%, the minimum time required for making a decision following pattern 2 starts with 15 days for the 20 first decisions, than reduces to 7 days for the next 20 decisions, reduces again to 4 days for the next 20 decisions and finally

reaches the value of 1 day for all other decisions following the primary 60. On the opposite, the maximum time required with an efficiency of only 20% starts at 750 days for the first 20 decisions, reduces to 450 days for the next 20 decisions, reduces again to 350 days for the next decisions and reaches the final value of 225 days for all decisions following the primary 60. In that case, the time necessary for making decisions remains very long, even after many decisions have been made. It was estimated that the CEO of SCHWAB-SYSTEM was about 60% efficient while making his decisions. Hence there was a possibility to reduce the time and to be more efficient than the case-company (the CEO recognized there was an important room for improvement) but there was also a risk to take more time than the case-company to make decisions. While presenting the results of this analysis to the CEO, 100% values seemed to be realistic. It was also decided to start efficiency level at 20% because a lower efficiency is probably unrealistic – it would represent a CEO that never decides anything, which is almost impossible. Efficiency of the decision-maker is a parameter with which the model user can play around with the aim of a slider going from 20% to 100%.

In brief, there are two elements that are combined in order to define the time that a decision will spend in the decision-making process (“time in process”); the efficiency of the decision-maker (that lies between 20% and 100%) and the improvement over time of the predicted time to make decisions which reduces whereas the number of decisions made increases. This second effect (gain in efficiency) was observed during research study two of this thesis and was transcribed in the model logic. It also means that even a less efficient decision-maker will gain some experience and shorten the time s/he needs to make decisions over the period of growth. However, the average time to make decisions will remain higher than for a decision-maker who is more efficient.

Decision statechart and impact of decisions

After popping up, each decision will follow the statechart presented on Figure 38 below.

Each decision is visually represented by a small cloud containing a letter (first letter of category name: (A) for accept project, (H) for hire, (F) for fire, (O) for organize, (I) for invest, (E) for support environment, (W) for improve well-being and (M) for make marketing). The colour of the cloud corresponds to the colour of the state in which the decision currently stands.

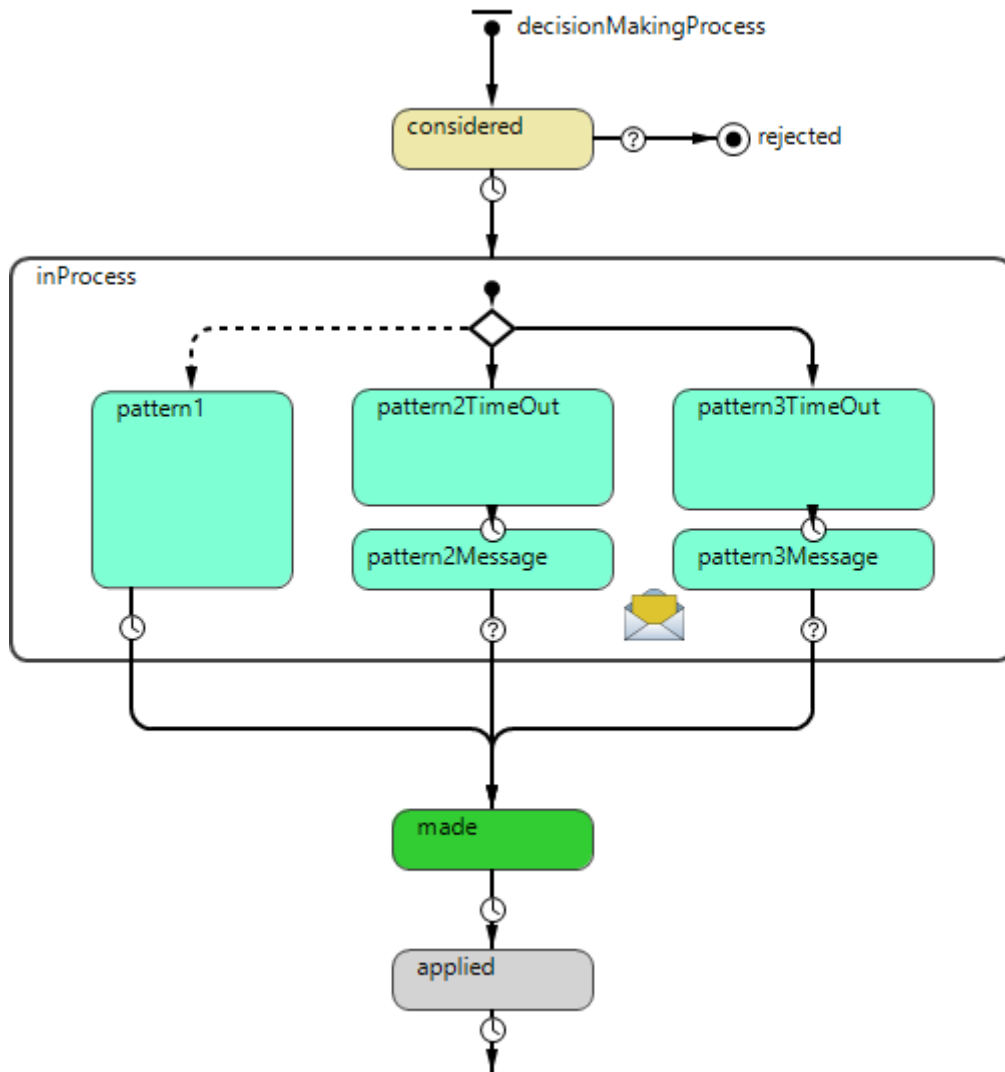


Figure 38 – Statechart of decisions

The decision first enters the state “considered”. At this stage, the decision might still be rejected – e.g. the decision-maker might decide not to consider it at all because s/he is not receptive / sensitive to this type of decision. There are only two types of decisions that might be rejected: support environment and improve well-being. All other decisions are 100% operations related and/or economic and do not require some sensitivity from the decision-maker. For example, a decision-maker who is absolutely not sensitive to supporting the environment might reject a decision of category environment instantly when the opportunity to take an action appears. The quantity of decisions rejected is related to the sensitivity of the decision-maker towards well-being and environment. A decision-maker who is 50% sensitive to the environment for example will reject on average one in two decisions of this category. If the decision is rejected by the decision-maker, it will move to the state “rejected” and will be destroyed. Its related cloud will become red. If the decision is not rejected, it will straightaway move on to entering the “in process” state and will go to the state that corresponds to the value of its parameter “pattern”

(1, 2 or 3). While going through pattern 1 (pattern easy-with-no-work) the decision will only have to wait until the required time to make it (parameter “time in process” presented above) is up. The time spent in the state “pattern 1” therefore represents the time necessary for the decision-maker to go through all steps of the pattern easy-with-no-work (pattern at the very top of Figure 5 presented in section 4.3.2 – identification of patterns). If the decision goes through pattern 2 or 3, it will also have to spend a certain amount of time in the process determined by the parameter “time in process”. However, a second element is required for the decision to get out of the “in process” state, the support of managers team towards the decision-maker. As presented in the second part of this thesis, managers play an important role in helping the decision-maker getting out of the loops in which s/he might be blocked when making a decision following difficult patterns (pattern 2 or 3) (refer to the middle and the bottom of Figure 5 of section 4.3.2). This support towards the decision-maker is reflected in the model by the receipt of messages that are sent on a regular basis by managers to the decision-maker (the whole process of how managers support the decision-maker is presented in the section 10.3.7). As a consequence, for a decision following pattern 2 or 3 to be made, both elements have to be combined – time in process has to be spent and support has to be given by one of the manager (message sent by the manager has to successfully reach the decision-maker). If one of the two elements is not achieved, the decision cannot move to the next state and will stay “in process” until both elements are attained.

Regardless which pattern is followed, when the time in process has run out - and support of manager has been received for patterns 2 and 3 -, the decision automatically moves to the state “made” and the corresponding cloud becomes green. The decision will remain a few more days in the made state, waiting to finally be applied and to influence the company operations. The time between “made” and “applied” states depends on the category of the decision and is based on data observed in the case-company. Some decisions can be applied immediately (such as accepting a project, making marketing, hiring and firing), some will take between 1 and 30 days (organizing the plant, improving well-being or supporting environment), and investing decisions will take up to 60 days. When the decision enters the “applied” state, it affects the company operations. Each category of decision has a different impact on operations:

- Accept project decision (A) will make the corresponding waiting project move from the state “waiting” to the state “accepted”; client owning the project will be informed that his/her project was accepted.

- Hire decision (H) will select the temporary who will be hired next. Turning to permanent will occur at the beginning of the following month only (on the 1st of the month), but the decision is considered as applied when the person is selected.
- Fire decision (F) will select the permanent employee who will be fired next. Firing will occur at the end of the following month only (on the 30th or 31st of the month), but the decision is considered as applied when the person is selected.
- Organize decision (O) will increase the level of organization of the company.
- Invest decision (I) will activate the invest functions of the company.
- Wellbeing decision (W) will increase the level of well-being of all employees.
- Environment decision (E) will increase the respect of environment of the company.
- Marketing decision (M) will increase the quantity of marketing actions already made by the company.

All of the decisions impacts are explained in detail in the following sections.

It is important to understand that for decisions that pop up when disequilibrium appears in the company's operations, as long as they do not reach the state "applied", the operations of the company remain in their current state—i.e. disequilibrium remains, during this entire period. If several decisions of the same or different categories appear together and take time to be made, disequilibrium will become incrementally important. It is only once the decision is applied that it will impact the company's operations and will restore equilibrium – at least for a while.

Aim of decision

The decision can be made and applied with a positive or a negative aim. The aim of the decision will be defined according to the current situation of the company when the decision is applied – e.g. if the company makes the decision to invest in the plant capacity but does not have the liquidity to pay for it, the decision will be refused (aim = NO) and will therefore impact the operations differently than if it is accepted (aim = YES). However, whatsoever its aim, each decision will go through the entire process of decision-making and will consequently take some time to the decision-maker – even if its aim is negative and if it does not positively impact the operations. Decisions with a negative aim see their letter (inside the cloud) becoming red. While tracking decisions information when simulation is running, the console always writes down the value of the amount of money related to the decision (if applicable), the aim of the decision and the reason why it has been refused if aim is negative.



Legend

- cloud filled green = decision made
- cloud filled grey = decision applied
- letters: category of decision
- black letter: decision accepted (aim = YES)
- red letter = decision refused (aim = NO)

Figure 39 – Decisions visualisation with clouds, colours and letters

On the figure above, one might see several decisions already made or applied. Two decisions have been refused so far- one of type “fire” and the other of type “make marketing”. Four decisions have not been made yet. The decisions are listed in order of appearance.

Statistics and visualization of decisions

Some functions collect statistics about all populations of decisions in order to know how many decisions (of all types) are in each state of the statechart – namely considered, in process, made, applied and rejected - ; how many decisions of each component of the matrix cell have been made already – namely social, environmental and economic, supplier, focal firm and client, operational, tactical and strategic -; and how many decision of each pattern (1, 2 or 3) have been made already. A dynamic parameter also collects the percentage of decisions that are made quite instantaneously (within maximum 10 days after they appear).

In terms of visualization of decisions number and states, numerous elements have been added to the model in order to see rapidly what is going on in the decision-making process when simulation is running. Each decision has a small tank which indicates the remaining time before the decision is made (based on “time in process” parameter), the lower the remaining time, the emptier the tank. At the company level, two charts show the number of decisions pending (considered or in process), as well as the number of decisions over (made or applied), split by category. One chart displays the number of decisions made according to their TBL aspect (matrix dimension). One chart shows how many decisions of each category have been made month after month, in order to indicate an evolution by category over time and one chart shows the current intensity of growth (refer to Figures 40 and 41).

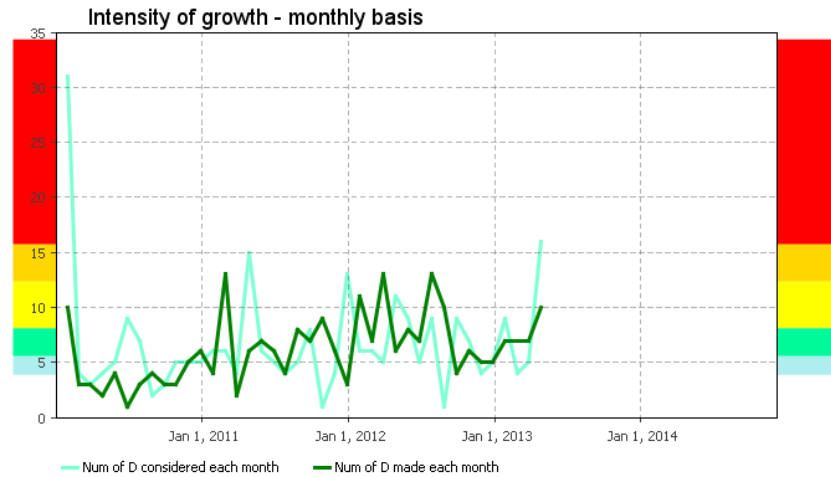


Figure 40 – Intensity of growth chart

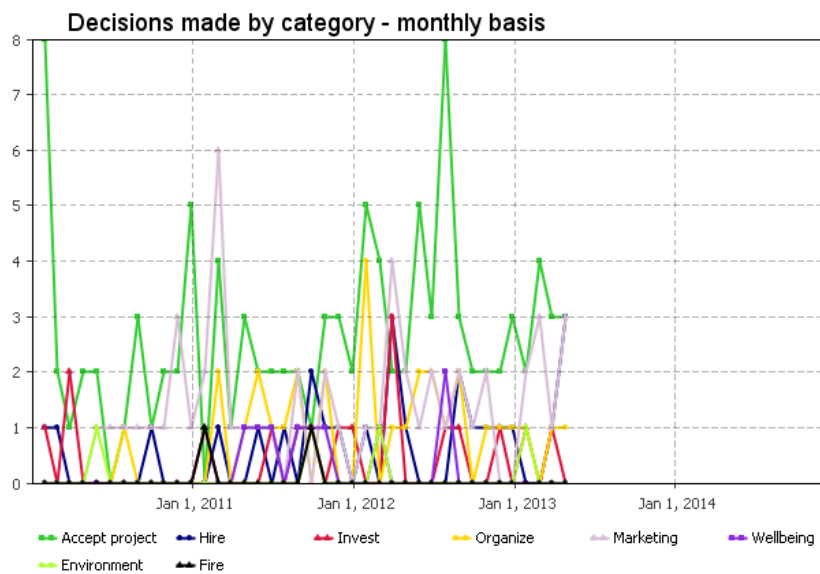


Figure 41 – Category of decisions chart

Cycles of decisions

In the last part of analyses of research study two of this thesis, cycles of decisions have been identified – a cycle is a combination of decisions that are made more or less at the same time; for a cycle to be completed, at least one decision of each category considered in the combination has to be made by the decision-maker.

Cycles in the model correspond to the “variants A-H-I-O” that were observed in the case-company – each time a decision of type “accept project”, “hire”, “invest” and “organize” has been made, a cycle is closed. In the model, four variables collect and sum the number of decisions of type A-H-I-O respectively. It is only once a decision enters the state “made” that it is added to its respective variable. When all variables get at least one decision (their value is

bigger or equivalent to 1), a cycle is achieved and all variables values are decreased by one. Consequently, the number of cycles made in the model can be compared to the number of cycles that were achieved in reality. Figure 43 reflects the four categories of decisions that are used for counting cycles; in this precise case, one decision of type hire or of type organize is missing in order to complete a cycle.

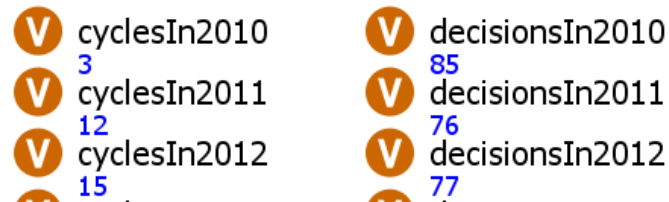


Figure 42 – Number of cycles and number of decisions made during the three first years of growth (simulation randomly selected)



Figure 43 – Variables used for counting cycles

This section about decisions behaviour and logic was completing the section presenting the population of managers – as managers play an important role in the decision-making process of the company. All agents have been presented now. The following sections will focus on precise processes from which decisions arise and on the impact the decisions have on the operations of the company. Each category of decisions will be detailed; situations where decisions pop up will be explained and impact of decisions once they are made on operations will be made explicit.

10.3.13 Decision-making process: Accept projects

Each time a new project is ordered by a client either because a new client is created (positive WOM of another client or random addition), or because of the high level of satisfaction of a repeating client, a decision of type “accept project” (A) will pop up – e.g. a new agent is created. The decision will automatically connect itself to the related project. Therefore, employees will not achieve the project as long as the company does not explicitly accept it. Depending on the price of the project (if lower than a certain amount), it will be considered as an operational decision; above a certain amount, it will be considered as tactical or even strategic – following

the corresponding distribution in the model - and therefore, average time required for making decision will be longer. When the decision reaches the state of being made, several conditions are checked in order to accept the project. If at least one of the following reasons becomes true, the project will be refused: (1) the deadline of the project is unrealistic - when checked, the deadline is considered as too short (precise value has been defined during calibration process), (2) the global workload already accepted by the company is higher than the maximum level of workload that the company normally agrees to accept according to the size of its permanent employees' team (equivalent to several months of work already full), and (3) there are already numerous projects delayed (precise value defined during calibration). If none of these reasons becomes true, the project is accepted. As soon as the decision is made, the connected project receives a message telling if it is accepted or rejected. According to the aim of the decision, the project will move to the next state in its statechart (rejected or accepted). At the same time, the client owning the project will be informed of the decision made by the company. If the project is rejected, the satisfaction of the connected client will decrease.

One special case might occur if a project already reaches its deadline while its connected decision is still not made – the decision of accepting the project is still “in process” and the decision-maker has not decided upon it yet. In this case, the project will be abandoned by the client (who will probably give it to another construction company) and the project in the model will move to the abandoned state (refer to Figure 21 in section 10.3.3 for seeing statechart of projects). In this case as well, the satisfaction of the connected client will decrease.

As soon as the project has moved to the accepted stage, it then follows the process described in section 10.3.3 (behavior of projects population).

Decisions of accepting projects therefore impact the global workload of the company, as well as the satisfaction of clients.

10.3.14 Decision-making process: Hire

Hiring is a quite complex process in the company for the different types of employees (permanent and temporary) who might be hired in different circumstances.

First, the company will never hire a permanent employee without first hiring temporary employees who will finally be turned to permanent. This is the way hiring is achieved in the construction industry in Switzerland –as well as in the case-company. Most companies consistently have a certain number of temporary workers. If they are confident enough they will need all of them for an extended period of time, they will turn one or some of them in permanent

employees. This process is also consistent with the results of Ono and Sullivan (2013) who found that temporary workers are always preferred when the expected output is about to fall or to fluctuate. This logic has been transcribed in the model, in order to stay close to what happens in reality. A primary version of the model was not considering temporary employees, but it was not realistic and was therefore not able to reproduce a growth period identical to the growth of the case-company.

In the current version of the model, a complete sub-model with hiring and firing process has been developed, tested and finally integrated; it includes temporary workers. 26 elements (functions, variables, events, dynamic events and parameters) fall within this sub-model. Two main events occur relating to this dynamics, the first one check if the company needs to hire or to fire some temporary workers, the second check if the company need to hire permanent employees. The author will first present the logic inherent to temporary employees and then details about the hiring process of permanent employees will be provided. The main difference between these processes is that hiring temporary workers does not require a decision made by the CEO of the company. Hiring and firing temporary workers is the responsibility of the middle-management team. Hence, this process is done in the company on a regular basis, without calling on the decision-maker. Hiring and firing permanent employees, on the contrary, rely on the decision-maker and related decisions will pop up in the model each time one of these processes is called.

Hiring temporary workers and creating decisions to hire permanent employees

The recurrence at which the required number of temporary workers is verified has been determined during the calibration process; its value had to fall within one day (the company checks every day if the number of temporary workers has to be adapted) and one week (the company only adapts once a week the number of temporary workers required) – weekend days are of course excluded. The event “check need temporary” is in charge of adding or removing one temporary worker each time it is called. Being called once a day, it means that a maximum of five temporary workers can be added to or removed from the team each week. The event checks if it is necessary to change the number of temporary employees, first by verifying if hiring is necessary, then if firing is required. In the model, the event occurs just before the schedule turns on in the morning, so changes in temporary teams are effective when the working day starts. For hiring temporary, the first prerequisite is that workload is considered growing (checked through the variable “growing workload” presented in section 10.3.8 – global computations). If it is not the case, no temporary will be hired. If the workload is growing,

additional conditions will be checked. Hiring temporary will be required if at least one of the following elements is true: (1) there is at least one project delayed, (2) global occupation fraction of permanent employees (presented in section 10.3.8) is above 78% (value determined in calibration), or (3) there is an important amount of projects waiting to be processed in the WIP state (precise amount computed based on number of permanent workers). If one of these additional conditions is verified, the event considers it necessary to hire temporary workers.

Next condition to be verified is if there are enough permanent workers to hire one more temporary employee. As mentioned previously, the proportion between temporary and permanent workers cannot exceed 25% (one permanent for five temporary workers). If the quota of temporary workers is not reached yet, the function “hire temporary” is called and it will simply add a new temporary worker to the population. If the quota has been reached already, the event will check if there might be a possibility to add a permanent employee first. If there are not enough projects currently, the event will inform the user (in the console) that it would be necessary to add a temporary worker but that there are not enough projects. If there are enough projects currently to increase the permanent team size, the event will call another function “determine number to hire” which will define how many permanent workers should be hired. This function observes, by the way of a data set, the minimum amount of temporary workers that were employed by the company during the last 3 months.

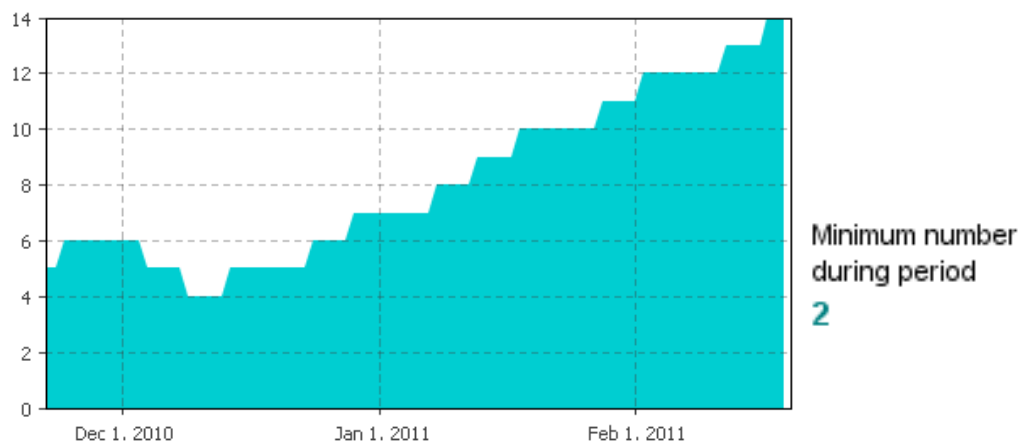


Figure 44 – Number of temporary employees chart

The function will then return a number from one to six corresponding to the number of permanent employees to hire. The table below shows how the conversion is made. If the data set minimum value equals 0, 1, 2 or 3, the function returns 1. If the data set minimum value is above 8, the function returns 6 (the case-company – and most SMEs in general - will not hire at the same time more than six employees).

Minimum number in data set	0, 1, 2, 3	4	5	6	7	8 and above
Number returned by the function (number to hire)	1	2	3	4	5	6

Table 21 – Function “determine number to hire” conversion

The final step executed when hiring temporary is to verify how many decisions of type “hiring” already exist in the model. The local variable “number of potential recruitment” is calculated as below:

```
int numberOfPotentialRecruitment = decisionsHire.numPendingDH() +
temporaryEmployees.numberTemporaryWhoWillBeHired();
```

 (20)

If this value is already higher than the number returned by function “determine number to hire”, no new decision of hiring will be made. However, if this number is null or lower, the event will call the function “call hire or invest in infrastructure” (refer to equation 21 below) several times - until the total of decisions to hire that are pending in the model equals the number of permanent employees who should be hired.

```
/*If hiring is required: check if capacity is high enough. If no, check how
many decisions to invest in Infrastructure are already in progress. If not
too much decisions, call investInfrastructure once and exit the loop.
Otherwise, call hire the required number of times.*/
```

```
for (double i = 0 ; i < idealNumberToHire; i++) {

    //For console
    if (main.checkboxHire.isSelected()==true) {
        println("Function that creates decisions HIRE called " + (i+1)
+ " time(s)");
    }

    if (currentNumberPerm() >= maxNumberPermPossible ) {
        //For console
        if (main.checkboxHire.isSelected()==true) {
            println("Not possible to hire because of limited
infrastructure.");
        }

        if (decisionsInvest.numPendingDInvestInfra() >=
main.maxDInvestInfraPendingValue ) {
            //For console
            if (main.checkboxInvestment.isSelected()==true) {
                println("      There are already enough DECISIONS in
process.");
            }
            break;
        }
    }

    investInfrastructure();
}
```

```
        break;
    }

    else {
        hire();
    }
}
(21)
```

The function “call hire or invest in infrastructure” has been created with an argument, which means that each time it is called, an argument has to be given to indicate how many times the function should occur successively. For example, if a data set indicates that the minimum number of temporary employees during the last three months was 10 (which is above 8); the function “determine number to hire” will return six. If there are already 2 decisions of hiring pending in the process, “call hire” function will be called 4 times ($6-2=4$). Function “call hire or invest in infrastructure” is created with a loop inside, which means that its content (actions it has to do) will be called and will occur several times if required. Each time the function is called, it will first check if the infrastructure capacity is high enough to hire new permanent employees (refer to Figure 34 in section 10.3.8 - global computations - to see the relationship between infrastructure and permanent employees’ number). If the infrastructure capacity is not sufficient to add new permanent employees, the function will call another function, “invest in infrastructure” (which will be presented later on) and will exit the loop – it will not call this function several times, which would not make sense. On the contrary, if the capacity is sufficient to hire new permanent employees, it will create several decisions of type “hire” until the right number is obtained. These new decisions will enter the state “considered” of their statechart and will follow the different states they need to go through until they are made. Next sub-section will explain what happens when these decisions reach the state “made”.

Impact on operations when hiring decisions are made

Whenever a certain amount of time has passed before the decision of hiring was created, once it is made, the company has to check one more time if conditions for hiring are still good (via function “hire impact”). It might happen in certain cases that conditions were conducive to hiring when the decision was created, but that the situation is less favourable a few weeks or months later – depending on how much time the decision-maker required to make his/her decision. If this is the case, the aim of the decision might eventually be negative. When conditions are checked again, if global workload is decreasing, if there is no more temporary workers (because they already all have been fired) or if there is not enough capacity in terms of infrastructure, decision to hire will be refused (aim = NO). In that case, no employee is selected for future hiring and the decision disappears. However, if the conditions are still good, the

function will set the aim of the decision to positive (aim = YES), and it will select the temporary employee with the best performance in order to turn him/her to permanent. Predicting which temporary will be turned to permanent depends on the individual differences including stress and performance (Bauer and Truxillo, 2000). As the hiring cannot happen instantaneously, the function will also calculate the date of start (through function “define date of start”) which will create a dynamic event happening only on the precise date that is set (the 1st day of month, two months later). On the day when the employee is finally hired, a new permanent employee is added to the population and the corresponding temporary worker moves to the state “turned to permanent” presented in section 10.3.6 – temporary populations. The effective start of the new employee happens just before working time so that s/he is allocated to projects the morning when s/he starts. At this time only, the company checks whether it needs one more manager to maintain a correct proportion. If it is the case, a new manager will be added to its population.

Creating decisions to hire permanent employees directly

With the logic introduced so far, hiring will happen only if the number of temporary reaches the maximum and that no new temporary worker can be added before hiring a permanent employee. However, this logic is not exhaustive because it might happen that a company will keep a quite large team of temporary workers for a long time, without reaching the maximum number required for creating a decision to hire a permanent employee. Therefore, another event was added in the model; this event checks, once a month (recurrence was defined during calibration process) if it is necessary to hire permanent employees, even if there is still room for new temporary workers – it is important to remember here that a permanent employee has a relative cost for the company lower than a temporary employee. Similarly as the event presented above, if this event observes that global workload is decreasing, it will not create the decision to hire a permanent employee. Otherwise, it will call the function “determine number to hire” and will follow exactly the same logic than presented above (observe minimum number of temporary workers over the last three months, define how many permanent employees to hire, check how many decisions are already pending, create the missing ones or call function to invest in infrastructure if capacity is too low).

This event is automatically rescheduled one month later once it occurred. However, if the event “check need temporary” occurs in-between and creates decision to hire permanent employees, it will change the next occurrence of the event “check need hiring” and set it one month later again.

This section explained how the company hires temporary and permanent employees and how hiring process is directly related to the infrastructure capacity of the company. The next section will present the opposite dynamics: the firing process.

10.3.15 Decision-making process: Fire

Following the same guidelines as the hiring process, the company will never fire permanent employees before having fired already all its temporary employees. Moreover, and still identically, the process of firing temporary employees does not create any decision to be made by the decision-maker, whereas the process of firing permanent employees does.

Firing temporary workers

The second part of code of the event presented previously “check need temporary” concerns the firing process of temporary employees. If the event finally does not find good conditions for hiring a temporary, it will then check if it needs to fire one. Reasons for firing temporary workers are the following: (1) there is at least one temporary to fire (this seems logical indeed) and (2) the global workload is decreasing and either (3) there is no delayed project currently, or (4) the global occupation fraction is low enough. Something to notice regarding reasons (3) and (4); when there is no project delayed anymore, but the global occupation fraction of permanent employees remains very high, temporary workers stay employed until global occupation fraction decreases. Permanent employees can therefore be put at rest until their occupation lowers. As soon as they are not critically busy anymore and if all other conditions mentioned above remain identical, temporary employees start to get fired.

If not all conditions are verified, the event will stop and nothing will happen – the current number of temporary workers will remained unchanged. If conditions are true, the function “fire temporary” is called. The function will select the temporary worker with the lowest performance and will fire him/her. In the model, the agent will simply move to the state fire on the statechart. The function of course considers temporary workers who are about to be hired as permanent (agents with a small heart above their head) and will never fire them.

Creating decisions to fire permanent employees

Every last day of the month, the event “check need firing” occurs. It verifies if there is enough workload for everyone. If it is not the case, it starts to fire permanent employees progressively. First, if there is only one permanent employee left, the event will do nothing otherwise company operations would immediately stop. Then the model checks conditions that have to be true for

firing to happen: similarly as before, if global workload is not growing or if the global occupation fraction is lower than 60%, firing will have to occur. The event will then define how many employees have to be fired. The local variable “number below 40” counts how many employees are occupied less than 50% in reality (which means 40% in model). If none of them has such a low occupation fraction, only one employee will be fired. If many of them have a low occupation fraction, the correct number of employees to fire has to be calculated - maximum 50% of employees can be fired together, even if more than 50% are unoccupied. The correct number is computed thanks to the following formula:

```
int numberToFireMax = ((currentNumberPerm() - numberOfPotentialLayOff) / 2);  
with  
int numberOfPotentialLayOff = permanentEmployees.numberWhoWillQuit() +  
decisionsFire.numPendingDF() (22)
```

With a logic slightly different as aforementioned it must be stated that if there are already decisions of type “fire” in process, additional decisions will still be created because the computation of the number of employees to fire takes into consideration the number of persons who might already be fired (if current decisions are finally made). Consequently, the event will call, with a loop, the “fire” function – which creates the decision to fire – as many times as it is required. Firing decisions enter the state “considered” and will go through the statechart until they are finally made. The next sub-section provides details about the impact of a decision “fire” once it is made.

Obviously, the firing process is relatively more aggressive than hiring process. This issue was discussed with the CEO of the Zuttion group who explained that if workload is critically decreasing, the only chance to survive is to fire quickly enough several employees – which is not pleasant. Otherwise, the company will run out of liquidity very rapidly - which is even worse. Therefore, between the ends of two consecutive months, if workload still drops, it is necessary to create new decisions of firing, even if some of them are already in process.

Impact on operations when firing decisions are made

As with hiring decisions, when a firing decision is finally made by the decision-maker (the decision enters the state “made” in the statechart), the company first verifies if firing is still necessary. If there is only one permanent employee left, firing will not occur and the aim of decision will be negative (aim = NO). The function “fire impact” will then check whether the conditions presented above (no temporary and low global occupation fraction) are still verified. If it is the case, the aim of the decision is positive (aim = YES). The function selects the

permanent employee with the lowest resistance to stress and designates him/her as the future fired employee. A small sword appears above the head of the selected employee in the model visualization. As firing does not happen instantaneously either, the date of leaving is computed (last day of month, two months later) and the related dynamic event “define date of leaving” is created. When it occurs, the selected employee moves to the fired state.

When a company announces an important permanent layoff, its reputation suffers among stakeholders such as employees (Goins and Gruca, 2008) and clients (Filbeck and Webb, 2001). This logic has been reproduced in the model as follows. When one employee is selected to be fired, the happiness of all remaining employees decreases by an amount triangulated between 1% (min), 10% (max) and 5% (mode). Their stock in system dynamics system is impacted. Happiness decreases because they become upset about being fired afterwards or because they appreciate employees who are currently fired. Following the same logic, satisfaction of clients might decrease as well, because they are upset about the health of the company; however, some of them might not be affected or might not know that firing will occur. Therefore, the negative impact of firing on clients is triangulated between the following values 0% (min), 5% (max) and 2% (mode). According to Goins and Gruca (2008), the negative impact of layoff announcement might even affect other companies of the same sector. However, this logic was not reproduced because the company is a single agent in the model.

If conditions are better when they are checked again, firing will not occur and the decision will have a negative aim (aim = NO).

The next process to be presented is directly linked to the hiring and firing processes. While changing the size of the team, the company needs to make sure employees remain efficient or become efficient if there are new. Therefore, the organizing process plays an important role.

10.3.16 Decision-making process: Organize

The variable “organization level”, presented in section 10.3.8 (global computations) represents the company capability to complete projects efficiently and rapidly, while keeping a high quality level. In other words, this variable shows continuously the current quality of organization in the company. As “organization level” is directly related to the computation that determines at which rate projects are completed, the higher it is, the more rapid projects will be realized and the more satisfied the clients will be.

At the beginning of the growth period, organization level is considered to be at its maximum value: 100%. Each time a new employee (permanent or temporary) is hired or fired, the level

will decrease by 1% per employee. This occurs because while the size of the team fluctuates, employees have to constantly adapt to more or less colleagues. They have to get used to each other. Asking temporary and permanent employees to work together has a significant impact on the social organization of the company (Drury, 2016). Temporary workers might not know how to behave at the beginning, etc. Thereby, if global workload varies importantly for some periods, the number of employees hired and fired might be significant. In that case, organization level will drop very rapidly. In order to keep a quality work environment, the company will have to manage effectively both temporary and permanent employees (Galup et al., 2008). A variable “number of employees for organization” collects all the variations and adds one to its current value each time an employees is hired or fired. Each time this variable reaches a certain number (defined during calibration phase), a decision of type “organize” is created and enters the state “considered”. This literally means that e.g. each fifth employee to be hired or fired, a decision “organize” will pop up. A decision of type “organize” will also be created when the global satisfaction of clients is checked; if its value is lower than 60%, a decision of type “organize” will appear, in order to reorganize things, to become more efficient again and to increase the clients’ satisfaction.

When a decision of type “organize” is created, it enters the state “considered”. When it is finally made, it might be refused (aim = NO) in some rare cases. Based on the company data, it was observed that a very low percentage of decisions of type organize have been refused by the decision-maker, who did not see the utility of applying them (about 2,5%). This element was modelled as a variable in order to easily increase it for making sensitivity analyses for example or if another decision-maker is maybe less sensitive to organization than the CEO of SCHWAB-SYSTEM. As long as the decision to organize is not refused, a positive impact will be computed – stochastic value – with a triangulation where min, max and mode values have been set during calibration process (1,9%, 35,1% and 16,2%); and the “organizational level” will increase again, which ensure a high quality of projects. By reorganizing the plant, the company enables teams to monitor and better adjust their behaviour in order to achieve high-quality products (Gibson et al., 2007). Wall (2015) has demonstrated that frequent organizational change is beneficial with respect to the performance of the company. Organizational change also induces an increase in labour productivity (Bertschek and Kaiser, 2004). Organizational decisions might also contribute to staffing and training the teams; which will have a positive effect on productivity (Kim and Ployhart, 2014).

The next section presents decisions of the type “invest”. When an investment is delayed, it also has a negative impact on the organization level of the company. Moreover, several other

elements do affect positively or negatively the organization level; they will be presented in the following sections.

10.3.17 Decision-making process: Invest

As previously mentioned, investments are split into three main categories, namely 1) individual investments, 2) collective investments, and 3) infrastructure investments. Individual investments are made each time a new employee (permanent or temporary) starts working in the company. They do not require a decision made by the decision-maker. With the same logic than when hiring temporary employees, the company makes this action automatically. Therefore, the model function “invest one employee” is called and an amount between CHF 3’000 and CHF 3’800 is invested if liquidity is sufficient and if there are not already delayed payments (wages or amortization). If liquidity is not sufficient, the whole investment is delayed. Collective investments are made on a regular basis, each time five new employees join the team. The variable “number of employees hired and fired” counts dynamically and continuously the variation in terms of number of employees. Starting at zero, the variable will add one unit each time a permanent or a temporary employee joins the team. On the contrary, the variable will decrease its total by one unit each time an employee is fired. The variable can thus occasionally present a negative value. The logic behind this is to consider that collective investment is necessary when a certain number of employees join the company (e.g. a new vehicle will be necessary when four or five new employees join the team); however, an employee who is fired creates one free place in terms of collective equipment that is required and the next one who will be hired replace him/her without creating additional need in terms of collective investment. On a daily basis, an event checks the value of the variable “number of employees hired and fired”. Each time the value of five is reached, the function “invest staff” is called and the variable “number of employees hired and fired” is set to zero again. The function “invest staff” creates automatically a decision of type “invest” that will enter the statechart of decision-making process. As long as the decision is created by the function “invest staff”, its level of decision will be operational. The decision is associated to a certain amount triangulated between CHF 10’000 (min), CHF 30’000 (max) and CHF 15’000 (mode) – realistic amount for a collective investment to be made. When the decision reaches the state “made”, some conditions are checked in order to verify if the investment can be made directly or if it has to be delayed. If there are some delayed wages or amortization, the complete investment will be delayed. If a collective investment is delayed, it will negatively impact the organizational level of the company - employees who cannot access collective material will be less efficient (e.g. a vehicle

would be required for a team to move rapidly from site to site; if the team does not have the vehicle, it will have to wait until another vehicle is available; or the team will need to share the vehicle that will serve several sites but then, a fewer employees can work on each site because the number of places in the vehicle is limited, etc.). The level of organization will be impacted according to the amount of money that is delayed; 10'000 CHF delayed represent a 5% impact on the organizational level:

```
double organizationLevel -= (amountToPay / 200'000); //The " - = "
stands for decreasing the computed value to the current value of
organizational level. (23)
```

The company will first check if it is possible to make a leasing based on the current level of credit limit. If there is a possibility to increase credit limit or if credit limit is high enough already to add a leasing – which represents the risky part for the bank, see section 10.3.10 for complete explanation – investment will be made via the bank; therefore it will increase the debt level and the corresponding monthly amortization variable. If the credit limit cannot be increased, the company will see if its level of liquidity is sufficient for paying the investment in cash. If it is not the case, again, investment will be delayed and organization level will decrease. The console will write progressively the different steps, the remaining liquidity, the impact on organization level if appropriate, and other relevant information. The aim of decision “invest staff” will always be positive even if the investment is delayed. When delayed investment can finally be paid, the relative level of organization will increase again with the same logic:

```
double organizationLevel += (amountPaid / 200'000); (24)
```

Delayed investment can be paid either totally or also partially only (if liquidity does not allow paying the entirety at one time). The organizational level will be impacted accordingly.

As explained in section 10.3.14 (hire process) and in section 10.3.8 (infrastructure variable), if the infrastructure capacity does not allow for hiring more permanent employees, the company will have to invest in infrastructure first, before hiring more people. In those cases, the function “invest infrastructure” is called and a decision of type “invest” is created. This decision will be either tactical (47% of the time) or strategic (53% of the time). After having gone through the entire process of decision-making, when the decision reaches the state “made”, conditions will be checked to see if the decision can be directly applied or if it has to be delayed. The related amount of investment is triangulated between CHF 100'000 (min), CHF 2'000'000 (max) and CHF 300'000 (mode) – some investments that were made by SCHWAB-SYSTEM were even higher, however they could have been split in several steps (for example three times CHF

2'000'000 rather than CHF 6'000'000 at one go). The amounts were discussed with the CEO and were fixed in accordance to what seemed realistic in terms of modelling. If there are payments delayed (wages, amortization or collective investments), the aim of the decision will be negative (aim = NO) and investment opportunity will be lost. The related amount will be summed up in the variable "lost investment opportunity" so that at the end of the growth period, the company knows how many investment opportunities were declined. If nothing is delayed, the company will check if the investment could be made by leasing. If the related amount is equal to or lower than CHF 250'000.- the function "invest staff" will be called again, receiving the precise amount as an argument. It was more efficient to develop the model like this as the steps that have to be followed when an amount is taken by leasing have been developed already in the function "invest staff". Both processes are wrapped in the same function. If the related amount is higher than CHF 250'000.- the company will check if current liquidity is sufficient to pay 50% of the investment. If current liquidity level is not sufficient, the company will ask the bank for increasing its credit limit. If it is not possible, the opportunity to invest will be lost. If the current level of liquidity is sufficient or if the credit limit can be increased and allows therefore to invest, the aim is positive (aim = YES), the debt is increased by 50% of the amount, quarterly amortization variable is increased by the same amount, remaining 50% are paid by the company and therefore level of liquidity decreases by this amount, and infrastructure capacity is increased by the total amount of the investment. When an investment in infrastructure is made, the function will check, at the end, the variables "maximum number possible" and "current infrastructure capacity". According to the new level of infrastructure capacity that is reached after the investment, more permanent employees can be hired.

This section presented how decisions of type "invest" are created and how they impact the operations of the company once they are made. The next section will explain how marketing decisions are developed in the model.

10.3.18 Decision-making process: make Marketing

For SMEs to achieve growth, they must possess, among other things, marketing capabilities (O'Cass and Sok, 2014, Foroudi et al., 2017). The author observed in the case-company that the more intense the growth was, the more the company received marketing opportunities. It was therefore decided that an event would create marketing decisions on a scalable rate. Intensity of growth was measured here according to the number of employees as advised by Abu Bakar et al. (2016). The parameter "marketing do rate" is dynamic – its value changes continuously over time – and is computed as follows:

```
double marketingDoRate = currentNumberPerm()/main.marketingDoRateValue (25)
```

Therefore, the event that creates decisions of type “marketing” occurs at the rate “marketing do rate” and the bigger the team of employees, the higher the rate. A decision of type marketing has a relative amount triangulated between CHF 100.- (min), CHF 15’000.- (max) and CHF 500.- (mode). Those values are based on what was observed in the case-company. Most of the marketing requests concern local sponsoring and therefore amounts might be very modest. The company received only very rarely propositions of campaigns with amounts close to the maximum presented here. Financial management of marketing opportunities might contribute to steady organic growth (Jenkins and Meer, 2005). Marketing decisions are never rejected; however, their aim can be positive or negative at the end of the decision-making process. The aim of the decision depends on the evolution of the global workload. If global workload is decreasing when the decision is made, the decision will always be accepted (aim = YES in 100% of the case). This means that the company will try to compensate for the decrease of workload by increasing its marketing efforts. Contrarily, if the workload is stable or increasing, the decision will be positive (aim = YES) only in 65% of the cases (this number was observed in the case-company data). If the aim of decision is positive, the company will check if there are no payments delayed. If not, it will pay the marketing campaign and the related amount of money will decrease the liquidity level. In addition, the variable “marketing invested”, which collects the total sum that was already invested in marketing actions, will be increased by the amount of the campaign made. If this value reaches or exceeds the value of CHF 10’000.- the model will create a new client. The model will also decrease the variable “marketing invested” by CHF 10’000.- Following part of code shows this logic:

```
if (marketingInvested >= main.marketingAmountToCreateNewClient) {  
    main.add_clients();  
    marketingInvested -= main.marketingAmountToCreateNewClient;  
    //For console  
    if (main.checkboxClients.isSelected() == true) {  
        println("MARKETING created a new client");  
    }  
}  
} (26)
```

Conversely, if the marketing campaign is not made – because of insufficient liquidity or because of delayed payments – the variable “marketing NOT invested” will add the campaign amount to its total. This allows for tracking how much money was not invested in marketing during the growth period. These data were also collected in the case-company and they allow therefore the comparison at the end of the growth period.

Marketing decisions therefore contribute to the creation of new clients. The rate at which they appear is dynamic and the more intense the growth is, the higher the number of decisions that appear. All decisions go through the entire process of decision-making and their aim can be negative only if global workload is evolving positively. Marketing decisions can thus be very time-consuming during intense periods of growth. As observed by Hanssens et al. (2016), resources have to be allocated quickly and the business environment has to be closely monitored when a marketing opportunity appears.

The two last types of decisions concern other pillar of the triple bottom line. Most of the decisions that were presented up to here concerned economic aspects. Wellbeing and environmental decisions concern directly social and environment aspects of the TBL. The two subsequent sections focus on their impact on operations.

10.3.19 Decision-making process: improve Well-fbeing

All variables and processes that have been presented up to now are probably part of any SME – at least in the construction sector. All companies have liquidity, organizational level, and infrastructure capacity, they all accept projects, make investments, payments and marketing campaigns, and they also all hire and fire employees. This section and the next one are slightly different as they present aspects that might be absolutely not reflected in some companies, depending on their sensitivity towards them. Erhemjamts et al. (2013) have observed that the CEO's sensitivity to corporate social responsibility moderates the effect of corporate social responsibility policy.

The first company variable of this kind is the “sensitivity to well-being”. The World Health Organization (1948)² defines well-being as a three-dimensional concept, composed of physical, psychological, and social aspects. The variable “sensitivity to well-being” goes from 0% to 100%. Its value determines how many decisions of type “improve well-being” will be rejected or considered by the decision-maker. A decision-maker with a very low sensitivity to well-being will reject the majority of decisions of type “improve well-being” that pop up. More precisely, the value of the variable represents the amount of decision that are not rejected – and therefore considered and made – by the decision-maker (100% if s/he is very sensitive, 0% if s/he is not sensitive at all to this type of problems). The model user, at the beginning of the

² WHO (1948). Preamble to the Constitution of the World Health Organization as adopted by the International Health Conference, New York, 19-22 June, 1946; signed on 22 July 1946 by the representatives of 61 States (Official Records of the World Health Organization No. 2, p. 100) and entered into force on 7 April 1948.

simulation, defines the value of the sensitivity to well-being. It can also be adapted during the simulation, in order to see its impact on growth trajectory.

At a frequency that was defined during the calibration process, starting after two weeks of simulation and every four weeks, when the global happiness of employees becomes too low (refer to sections 10.3.5 – permanent employees - and 10.3.8 – global computations), one or even two decisions of type “well-being improve” will appear in the model and enter the considered state. If global happiness is lower than 85%, one decision will pop up. If global happiness is even lower than 70%, two decisions will pop up at the same time. According to the sensitivity to well-being of the decision-maker, they will either be rejected directly or move into the “in process” state. If they are considered, they will go through all the steps of the statechart until being made by the decision-maker. When a decision of type “well-being improve” is made, it positively impacts the happiness of all permanent employees by a value that is stochastic and which lies between the triangulated values 2% (min), 24% (max) and 13% (mode). The impact values have been fine-tuned during the calibration process. The impact might hence be very important for all of them or much more modest. This phenomenon was observed in the case-company; some well-being actions had a very positive impact and some of them were much less useful. This phenomenon is in line with the observations of Russell (2014) who analyzed that well-being actions impact will be moderated by the current level of stress. Wellbeing actions might be of different types; for example, managers can take advantage of the growth for providing support towards employees’ career growth opportunities (Huang et al., 2017) or for tutoring younger co-workers by older adults and using skill development tools (Araújo and Pestana, 2017). It is important to note that employees’ happiness cannot exceed 100% even if the impact of the positive action would set it at a higher level. A positive impact is directly introduced into the stock of the system dynamic model representing happiness variation. As long as the decision is not rejected, its aim will always be positive (aim = YES). After the decision being applied and having impacted permanent employees’ population, global happiness will be recomputed. If global level is still too low, other well-being decisions will pop up in the model. As long as their happiness level is high enough, employees will stay in the company. On the contrary, if some employees are very unhappy and if the company does not make something against it – well-being actions such as providing high performance work systems in order to reduce the intention to leave of employees (García-Chas et al., 2014) or putting them at rest – they will choose to resign from the company. Resignations are directly linked to the decisions of types “hiring” and “firing” that were presented previously. First, an unhappy employee who decided to resign cannot be selected to be fired anymore. Moreover, if

a firing decision is pending when an employee decides to resign; the decision will automatically be cancelled. The objective of the company to release a certain number of staff members is reached whether this is achieved by firing or by resignations. However, if some employees have already been selected as being fired (decisions are made already) when another employee resigns, this will not cancel what will happen – this is also true in reality. On the opposite, fired employees cannot resign anymore even if their happiness becomes very low. If conditions are good for the company (global workload is growing) when an employee resigns, it will automatically create a decision of type hire in order to replace the future missing employee. Employees who resigned also impact the organization level – the variables which counts how many employees are added or removed take resignations into consideration: “number of employees for organization” increases and “number of employees hired and fired” decreases.

All the effects that are created when decisions of type well-being improve are made highly dependent on the sensitivity of the decision-maker. Nothing of which is described above will happen with decision-makers who are not sensitive at all to the well-being of employees. This is the reason why the model user can adapt this variable.

10.3.20 Decision-making process: support Environment

Under an identical logic to the one presented in previous section, the decision-maker also has to have certain sensitivity to the environment. The related variable “sensitivity to environment” goes from 0% to 100%, similarly to “sensitivity to well-being”. Its value determines how many decisions of type “support environment” will be rejected or considered by the decision-maker. A decision-maker with a very low sensitivity to environment will reject the majority of decisions of type “support environment” that pop up. More precisely, the value of the variable represents the amount of decision that are not rejected – and therefore considered and made – by the decision-maker (100% if s/he is very sensitive, 0% if s/he is not sensitive at all to this type of problems). Segarra-Oña et al. (2015) indicate that companies belong to different groups that are defined by their motivation towards environmental proactivity. A high sensitivity towards the environment would represent a company of the most proactive of the three groups. The model user defines the value of the sensitivity to environment at the beginning of the simulation. The model user can also play with it during the simulation, in order to see how it affects growth trajectory.

Decisions of type environment pop up at a random rate of 1,6 per year, which represents approximately the apparition of one decision every seven or eight months. This rate was confirmed during the calibration process. While popping up in the model, the decision will first

be accepted or rejected, depending on the sensitivity of the decision-maker (e.g. with a sensitivity of 70%, there are 30% of chance that the decision will be rejected). Both accepted and rejected decision impact the operations – in different ways. The author will first explain the positive impact of an accepted decision and then the negative impact of a rejected decision of type “support environment” (E).

If the decision is accepted, once it is made, it will impact the organization level of the company. Logic behind this simply means that while taking actions for supporting the environment, the company will organize some of its operations accordingly. It will therefore positively impact the organization level of the company. Better organizational performance is linked to the implementation of corporate social responsibility practices (Valmohammadi, 2013). The impact is stochastic and triangulated between the succeeding values: 2% (min), 11% (max) and 7% (mode). Values were sharpened during calibration process. An action taken towards the environment will also positively influence the clients’ perception of the company – values lying between 1% (min), 20% (max) and 5% (mode). A positive impact will directly be added to the satisfaction stocks in system dynamic of all current clients. Similarly as with employees’ happiness, clients’ satisfaction cannot exceed 100% even if the impact would be greater.

On the contrary, if a decision of the type environment is rejected, it will have negative consequences. First, it will negatively impact the possibility of the company to increase its credit limit. The logic goes like this: at the company level, the variable “respect of environment” is a Boolean variable, which is set on TRUE by default and will be changed to FALSE for a period of 30 days each time the company rejects a decision of type “environment”. During growth periods, the banker closely monitors the actions taken by the company – at any level - and as long as the company is not respectful of the environment or misses an opportunity to support it, the banker will know of it. The consequences might be that, for a short period, s/he will be less inclined to support the company development. In other words, environmental decisions made by the company will have an impact on the financial partner’s perception of the company. Moura-Leite and Padgett (2014) have shown this kind of negative action affect the company’s reputation and its stakeholders – including the financial partner. More specifically, Kim (2010) has shown that corporate social responsibility is positively correlated to financial performance. Therefore, when the variable is set on false, in the model, the banker will refuse to increase the credit limit, even if other parameters that are checked when asking for an increase would have been accepted. As long as the variable “respect of environment” stays on TRUE, only standards criteria presented in section 10.3.10 will be checked for increasing the credit

limit. Moreover, current clients of the company will see their satisfaction affected negatively by values equivalent to the impact presented above - 1% (min), 20% (max) and 5% (mode).

Environmental process presentation closes the series of sections that presented main processes involving decisions and their impact on operations. The following sections will present the finalization of the modelling part, which includes (1) the growth's measurement – how can the intensity of growth be measured and represented visually in the model, (2) the identification of bankruptcy - situations where the model has to stop because the company is considered as going bankrupt, and (3) the setting of initial values in the model.

10.3.21 Final model configuration: growth measurement and visualization

As suspected in the literature review and confirmed in the second research study, the number of decisions that a company has to make during a growth phase is closely related to the intensity of its growth. Therefore, a variable that measures growth rate was added at the company level. The number of decisions that are created defines the value of this “growth rate” variable. Each time a decision of any category pops up and is not rejected, it adds one unit to a variable called “number created current month”. At the end of each month, an event checks how many decisions were created during the month and defines the intensity of growth accordingly, based on the following code:

```
/*All visualization elements that show intensity of growth are hidden first*/
arrowStable.setVisible(false);
arrowLight.setVisible(false);
arrowIntense.setVisible(false);
arrowVeryIntense.setVisible(false);
arrowExtreme.setVisible(false);

/*According to the number of decisions that were created, intensity is defined and corresponding visualization arrow is set visible again*/

if (numCreatedCurrentMonth * 12 < 20) {
    growthRate="Stable";
    arrowStable.setVisible(true);
}

if (numCreatedCurrentMonth * 12 < 50) {
    growthRate="Light";
    arrowLight.setVisible(true);
}

else if (numCreatedCurrentMonth * 12 < 100) {
    growthRate="Intense";
    arrowIntense.setVisible(true);
}

else if (numCreatedCurrentMonth * 12 < 150) {
```

```
        growthRate="Very intense";  
        arrowVeryIntense.setVisible(true);  
    }  
    else {  
        growthRate="Extreme";  
        arrowExtreme.setVisible(true);  
    }  
  
    /*Variable used to determine the intensity of growth is set to zero again*/  
  
    numCreatedCurrentMonth = 0; (27)
```

Growth can be considered as stable, light, intense, very intense and extreme, depending on how many decisions were created. The number determining ranges is based on what was observed in the company. The following figure shows how growth is indicated visually when the model is running:



Figure 45 – Growth intensity visualization

Moreover, all decisions that were taken during one year are added to the corresponding variable in the model (decisions made in 2010, in 2011, in 2012, etc.). If the number of decisions decreases from one year to the other, the model automatically navigates to the company level and shows the values of those variables, with a text that indicates that there might be a sign of stabilization.

At the company level, several charts show indications about decisions such as the intensity of growth on a monthly basis, the decisions made by category on a monthly basis, the total number of decisions pending by category since the beginning of the growth period, the total number of decisions made by category since the beginning of the growth period, and the percentages of decisions according to the TBL pillars.

All these pieces of information can therefore easily be used by the model user to understand how intense growth is and therefore what difficulties the decision-maker has to face.

10.3.22 Final model configuration: bankruptcy identification and stop simulation

In order to make the model relevant, it was necessary to determine what situations would eventually cause bankruptcy. With no predefined reason to stop, the model would continue running infinitely, even long after the company would have stopped its activities. Jenkins and McKelvie (2016) suggest that failure should be viewed as a multi-faceted phenomenon. In the model, there were two main situations, which could lead to bankruptcy. The first one happens when the company runs out of liquidity. Running out of liquidity means that the delayed payments become too high for the company to catch up and fill the gap in a reasonable period and that the company cannot increase its credit limit anymore. Delayed payments that might lead to bankruptcy can be of three types: wages, temporary wages or amortization. Investments are not included in this logic because delayed investments disorganize the company – and disorganization leads to clients' dissatisfaction, which leads to a lack of projects, which finally leads again to running out of liquidity. The second possibility is that all employees resign from the company because they all are really unhappy – most of the time because of an excessive amount of work. Insufficient work will lead to running out of cash more rapidly than to the resignation of all employees. Any other ideas that were considered also lead to running out of cash or to the downfall of employees' happiness. Not supporting the environment at all will permanently prevent companies from the opportunity to receive an increased credit limit. Not investing will lead to the impossibility to hire more people and never hiring means keeping employees critically busy, which will eventually push employees to leave. Not firing quickly enough when workload is decreasing will lead to running out of liquidity. Accepting projects too slowly or rarely will decrease global workload and clients' satisfaction until no more clients order projects because WOM is globally negative. Moreover, if marketing actions are never made, new clients will never be created. Being insensitive to the well-being of employees will avoid increasing employees' individual happiness and will lead to resignations in the long run. It should be obvious by now that many situations will potentially create a downward spiral, which will – if no measure is taken to correct the situation –systematically lead to bankruptcy. Those situations were discussed with the case-company several times. It was jointly decided to keep an eye on bankruptcy reasons as discussed above.

When the model considers the company as going bankrupt, simulation stops and the model navigates automatically to the chart corresponding to the reason of failure, highlighting an explanatory text – either “liquidity will be missing” or “all permanent employees have resigned”. The model user can then go back to model details and check what happens to the

company. If the function “writing in console” is activated, it will give all explanations that finally lead to bankruptcy.

10.3.23 Final model configuration: initial values setting

While creating a simulation modelling, one important step is to adjust initial values that are used by the model when launching the simulation. Several methods have been used to define the initial values. First, known values defined precisely according to data collected in the company were fixed – e.g. the initial infrastructure capacity, the initial credit limit, the initial amount of liquidity available, the initial number of employees (permanent and temporary), etc. Second, values that were known approximately have been calibrated (the calibration phase is explained in detail in the section 6.1.5). In this case, the company data provided a range of acceptable values and calibration was used to define the precise values – e.g. the proportion of clients with a repeating profile, the initial number of clients, the rate at which clients are created, etc. Third, some values were selected to be tested as propositions for the sensitivity analyses in order to measure their impact on the growth trajectory (propositions and analyses will be presented in detail in the analysis section). Those values were therefore created with the aim of sliders, so that the model user can set their values at the beginning of simulation. The values can also be adapted when simulation is running from the main page. Default values were set based on the company data. The following figure shows what values can be set thanks to sliders when simulation is launched:

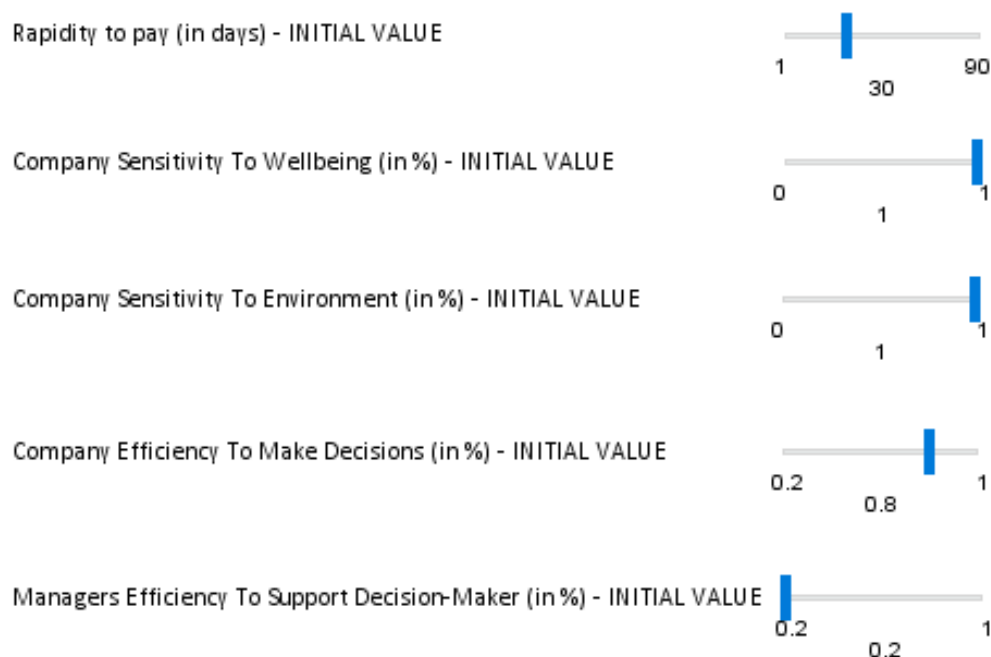


Figure 46 – Values with sliders

Sensitivity to well-being, sensitivity to environment, efficiency to support the decision-maker, efficiency to make decisions and clients' rapidity to pay are the five values that can be set by the model user at any time during simulation. Variables that might affect the growth trajectory but on which the company can only difficultly act on where left aside.

Regarding the decision-making process, several decisions were already "in process" at the beginning of the growth period observed. Similarly, several projects were already in the WIP state. For all those elements, the model was parametrized accordingly. At the model launch, 24 clients are created based on the company data. Thus, 24 decisions of type "accept projects" are automatically created. The model has been parametrized so that 16 decisions are instantaneously accepted and that related projects directly move to the state WIP - employees can seize them on the first morning already. The remaining eight decisions however follow the complete statechart before being made and therefore connected projects stay in the state "waiting for decisions". Similarly, three decisions of type hire, two decisions of type well-being, six decisions of type invest and two decisions of type organize are initialized with correct sequences, levels of decision, supply chain lever and triple bottom line pillar in order to correspond to the decisions that were in the company already. The following code shows what the event that initializes data does when model launches:

```
/*Create 3 D Hire*/
company.add_decisionsHire(Hire, Sequence1, Operational, 0, 5,
FocalFirmLever, Social, 1, 29, 29, 29);
company.add_decisionsHire(Hire, Sequence1, Operational, 0, 5,
FocalFirmLever, Social, 1, 30, 30, 30);
company.add_decisionsHire(Hire, Sequence1, Strategic, 0, 5, FocalFirmLever,
Social, 1, 1196, 1196, 1196); //Sequence2 in data

/*Create 2 D Wellbeing*/
company.add_decisionsWellbeingImprove(WellbeingImprove, Sequence1,
Operational, 0, 5, FocalFirmLever, Social, 1, 912, 912, 912);
company.add_decisionsWellbeingImprove(WellbeingImprove, Sequence1,
Tactical, 0, 5, FocalFirmLever, Social, 1, 912, 912, 912);

/*Create 6 D Invest, including 2 where isStaff is true*/
company.add_decisionsInvest(Invest, Sequence1, Operational, 0, 5,
FocalFirmLever, Economic, 1, 790, 790, 790);
company.add_decisionsInvest(Invest, Sequence1, Operational, 0, 5,
FocalFirmLever, Economic, 1, 790, 790, 790);
DecisionInvest dInvest1 = company.add_decisionsInvest(Invest, Sequence1,
Operational, 0, 5, FocalFirmLever, Economic, 1, 60, 60, 60); //Sequence2 in
data
dInvest1.isStaff=true;
DecisionInvest dInvest2 = company.add_decisionsInvest(Invest, Sequence1,
Operational, 0, 5, FocalFirmLever, Economic, 1, 60, 60, 60); //Sequence2 in
data
dInvest2.isStaff=true;
```

```
company.add_decisionsInvest(Invest, Sequence1, Tactical, 0, 5,  
FocalFirmLever, Economic, 1, 5, 5, 5);  
company.add_decisionsInvest(Invest, Sequence1, Tactical, 0, 5,  
FocalFirmLever, Economic, 1, 516, 516, 516);  
  
/*Create 2 D Organize*/  
company.add_decisionsOrganize(Organize, Sequence1, Tactical, 0, 5,  
SupplierLever, Economic, 1, 744, 744, 744);  
company.add_decisionsOrganize(Organize, Sequence1, Tactical, 0, 5,  
SupplierLever, Economic, 1, 744, 744, 744); (28)
```

For modelling reasons, it was overly complicated to create initial decisions that were following patterns 2 or 3. Therefore, all initial decisions were set with pattern 1 and therefore did not require connecting to a manager.

10.4 Payment logic

Pay wages logic

	payWages		
	false	true	
anyDelayedWages			
anyDelayedAmo			
anyDelayedTempWages			
anyDelayedInvestment			
checkIfLeasing			
calculatePredictedAmo			
calculateAvailableLiquidity	enough	not enough	
askCreditLimit		new level of CL	
calculatePredictedLiquidity			
increaseDebt			
increaseAmo			
<i>payORdelay (amount paid, amount delayed)</i>	<i>ALL, 0</i>	<i>available, remaining</i>	<i>0, ALL (because of delayedWage s)</i>
decreaseDebt			
decreaseRemainingAmo			
reduceDelayedAmount			
increaseInfrastructure			
decreaseOrganizationLevel			
increaseOrganizationLevel			

Pay temporary wages logic

	payTemporaryWages				
anyDelayedWages	false				true
anyDelayedAmo	false			true	
anyDelayedTempWages	false	true			
anyDelayedInvestment					
checkIfLeasing					
calculatePredictedAmo					
calculateAvailableLiquidity					
askCreditLimit					
calculatePredictedLiquidity	enough	not enough			
increaseDebt					
increaseAmo					
<i>payORdelay (amount paid, amount delayed)</i>	<i>ALL, 0</i>	<i>available, remaining</i>	<i>0, ALL (because of delayed TempWages)</i>	<i>0, ALL (because of delayed Amo)</i>	<i>0, ALL (because of delayed Wages)</i>
decreaseDebt					
decreaseRemainingAmo					
reduceDelayedAmount					
increaseInfrastructure					
decreaseOrganizationLevel					
increaseOrganizationLevel					

Pay amortization logic

	payAmo		
	false	true	
anyDelayedWages			
anyDelayedAmo	false	true	
anyDelayedTempWages			
anyDelayedInvestment			
checkIfLeasing			
calculatePredictedAmo	amo	amo	amo
calculateAvailableLiquidity	x		
askCreditLimit			
calculatePredictedLiquidity			
increaseDebt			
increaseAmo			
<i>payORdelay (amount paid, amount delayed)</i>	<i>available, remaining (because of liquidity)</i>	<i>0, ALL (because of delayed Amo)</i>	<i>0, ALL (because of delayed Wages)</i>
decreaseDebt	amount paid		
decreaseRemainingAmo	amount paid	ALL	ALL
reduceDelayedAmount			
increaseInfrastructure			
decreaseOrganizationLevel			
increaseOrganizationLevel			

Do Marketing logic

	doMarketing			
	false		true	
anyDelayedWages	false		true	
anyDelayedAmo	false	true		
anyDelayedTempWages				
anyDelayedInvestment				
checkIfLeasing				
calculatePredictedAmo				
calculateAvailableLiquidity	enough	not enough		
askCreditLimit				
calculatePredictedLiquidity				
increaseDebt				
increaseAmo				
<i>payORdelay (amount paid, amount delayed)</i>	amount + increase mktInvested	increase mktNOTinvested	<i>0, ALL (because of delayed Amo)</i>	<i>0, ALL (because of delayed Wages)</i>
decreaseDebt				
decreaseRemainingAmo				
reduceDelayedAmount				
increaseInfrastructure				
decreaseOrganizationLevel				
increaseOrganizationLevel				

Individual (employee) investment logic

	investOneE			
anyDelayedWages	false			true
anyDelayedAmo	false		true	
anyDelayedTempWages				
anyDelayedInvestment				
checkIfLeasing				
calculatePredictedAmo				
calculateAvailableLiquidity	enough	not		
askCreditLimit				
calculatePredictedLiquidity				
increaseDebt				
increaseAmo				
<i>payORdelay (amount paid, amount delayed)</i>	<i>ALL, 0</i>	<i>0, ALL (because of liquidity)</i>	<i>0, ALL (because of delayed Amo)</i>	<i>0, ALL (because of delayed Wages)</i>
decreaseDebt				
decreaseRemainingAmo				
reduceDelayedAmount				
increaseInfrastructure				
decreaseOrganizationLevel				
increaseOrganizationLevel				

Collective investment logic

	investStaff						
anyDelayedWages	false			true			
anyDelayedAmo	false			true			
anyDelayedTempWages							
anyDelayedInvestment							
checkIfLeasing							
calculatePredictedAmo	amo						
calculateAvailableLiquidity							
askCreditLimit	20% available	20% NOT available					
calculatePredictedLiquidity		enough	not enough				
increaseDebt	amount, 100%						
increaseAmo	monthly, amount, 100%						
payORdelay (amount paid, amount delayed)		ALL, 0	0, ALL (because of liquidity)		0, ALL (because of delayed Amo)	0, ALL (because of delayed Wages)	
decreaseDebt							
decreaseRemainingAmo							
reduceDelayedAmount							
increaseInfrastructure							
decreaseOrganizationLevel			amount/ 200'000			amount/ 200'000	amount/ 200'000
increaseOrganizationLevel	amount/ 200'000	amount/ 200'000					

Infrastructure investment logic

	investInfrastructure						
anyDelayedWages	false					true	
anyDelayedAmo	false				true		
anyDelayedTempWages							
anyDelayedInvestment	false			true			
checkIfLeasing	> 250'000		<= 250'000				
calculatePredictedAmo	amo		go to investStaff				
calculateAvailableLiquidity							
askCreditLimit							
calculatePredictedLiquidity	50% available	50% NOT available					
increaseDebt	amount, 50%	do nothing					
increaseAmo	quarterly, amount, 50%						
<i>payORdelay (amount paid, amount delayed)</i>	<i>50%, 0</i>				<i>0, 0 (because of delayed Investment)</i>	<i>0, 0 (because of delayed Amo)</i>	<i>0, 0 (because of delayed Wages)</i>
decreaseDebt							
decreaseRemainingAmo							
reduceDelayedAmount							
increaseInfrastructure	amount						
decreaseOrganizationLevel							
increaseOrganizationLevel							

Delayed payments logic

	payDelayedWages	payDelayedAmo	payDelayedTempWages	payDelayedInvestment
anyDelayedWages	true	false	false	false
anyDelayedAmo		true	false	false
anyDelayedTempWages			true	false
anyDelayedInvestment				true
checkIfLeasing				
calculatePredictedAmo				amo
calculateAvailableLiquidity	min 10'000	min 5'000	min 5'000	
askCreditLimit				
calculatePredictedLiquidity				x
increaseDebt				
increaseAmo				
<i>payORDelay (amount paid, amount delayed)</i>	<i>available, 0</i>	<i>available, 0</i>	<i>available, 0</i>	<i>available, 0</i>
decreaseDebt		amount paid		
decreaseRemainingAmo				
reduceDelayedAmount	amount paid	amount paid	amount paid	amount paid
increaseInfrastructure				amount paid
decreaseOrganizationLevel				
increaseOrganizationLevel				amount/ 200'000

10.5 Values emerging from calibration

DYNAMIC OBSERVED	AGENT	PARAMETER	ELEMENT TO EVALUATE	UNIT	Part concerned by Calibration	Min	Max	Step	Calibration result
Decisions	Main	amountToMakeD	Minimum price of project in order to generate a decision to make	price	# of D made A	50000	150000	5000	80'000
Liquidity level	Main	clientsRapidityToPay	Numbers of days before clients pay advance and final amounts for projects.	days	L	0	45	1	30
Project completion	Company	function acceptProjectImpact + main.daysToDeadlineValue	Condition for accepting projects: Number of days before deadline necessary	Days	Turnover	30	180	5	55
Project completion	Project	deadline + main.deadlineMaxSensitivityValue	Deadlines of projects	days converted in LocalDate	Turnover	100	1000	10	630
Project completion	Project	deadline + main.deadlineMinSensitivityValue	Deadlines of projects	days converted in LocalDate	Turnover	10	200	5	160
Client satisfaction	Client	connection myProjects - decrease of satisfaction + main.decreaseSatWhenProjectAbandonedValue	Decrease of satisfaction of client when a project is abandoned by the client because the company did not make the decision quick enough	%	Turnover	2	25	1	10.028
Client satisfaction	Client	connection myProjects - decrease of satisfaction + main.decreaseSatWhenProjectRefusedValue	Decrease of satisfaction of client when a project is refused by the company	%	Turnover	2	20	1	7.244
Initial situation	Company	efficiencyInSupportingTheDecisionMaker	Efficiency in supporting decision-maker	%	# of D made per year	0.2	0.6	0.1	0.445
Initial situation	Company	efficiencyToMakeDecision	Efficiency in making decisions	%	# of D made per year	0.4	1	0.1	0.756
Client satisfaction	Client	event checkDelaysAndAdaptSatisfaction + main.formulaFlowSatisfDecreaseDelay	Flow (rhythm) at which satisfaction decreases according to the delay of project completion	amount / day	Turnover	0.5	4	0.5	1.379
Decisions	Main	formulaGlobalWorkloadMaxToAcceptProject	Criteria to refuse project: if global workload is bigger than capacity of the next months: 1= 6 months full, 0.5 = 3 months full, 2 = 12 months full, etc.	%	# of D made A	0.2	2	0.1	0.329

DYNAMIC OBSERVED	AGENT	PARAMETER	ELEMENT TO EVALUATE	UNIT	Part concerned by Calibration	Min	Max	Step	Calibration result
Project completion	Company	main.formulaNumDelaysMaxForFiringT	Condition for accepting projects: Number of days before deadline necessary	Days	# of T	0	50	1	5
Hiring	Company	event checkNeedTemporary + main.formulaNumProjMinToAcceptHValue	Number of projects necessary to accept to hire a new permanent when number of temp already reached	# projects	# P	1	3	0.5	2.011
Hiring	Company	event checkNeedTemporary + main.formulaNumWaitingProjForHiringTValue	Number of projects waiting necessary to accept to hire temporary (compared to number of permanent employees)	# projects	# T	1	2	0.1	1.891
Hiring	Company	event checkNeedTemporary + main.globalOccForHiringTValue	Average level of occupation of employees (globalOccupation) above which hireTemporary is made / below which fireTemporary is made	%	# T	75	90	2	77.459
Initial situation	Main	initialNumOfClients	Number of clients at the beginning of simulation period	# of clients	Turnover	10	40	1	16
Liquidity level	Company	function investOneEmployee -variable amountOfInvestmentOneE inside + main.investOneESensitivityValue	Quantity of investment for a new employee	CHF	L	0.5	1.5	0.1	1.255
Happiness level	Company	event checkGlobalHappiness + main.level1HappinessValue	Level of global happiness / # of employees who are above unhappy % in order for the D wellbeing (W) to appear	%	# of D created W	L1: 50%	L1: 90%	L1: 10%	85
Happiness level	Company	event checkGlobalHappiness + main.level2HappinessValue	Level of global happiness / # of employees who are above unhappy % in order for the D wellbeing (W) to appear	%	# of D created W	L2: 40%	L2: 80%	L2: 10%	70

DYNAMIC OBSERVED	AGENT	PARAMETER	ELEMENT TO EVALUATE	UNIT	Part concerned by Calibration	Min	Max	Step	Calibration result
Market development	Company	function <code>marketingImpactDo</code> + <code>main.marketingAmountToCreateNewClient</code>	Amount of marketing campaign that have to be done to add 1 client	CHF	Turnover	8000	20000	500	18500
Market development	Company	<code>marketingDoRate</code> + <code>main.marketingDoRateValue</code>	Rate at which opportunities of doing marketing appear	rate	# of D created M	5	30	1	16.494
Decisions	Company	<code>maxDelaysToAcceptProject</code>			Turnover	0	150	1	64
Decisions	Company	function <code>callHireOrInvestInfra</code> + <code>main.maxDInvestInfraPendingValue</code>	Number of decisions max that can be considered at the same time for investing in infrastructure	number of decisions pending max	# of D created I	2	10	1	5
Hiring	Company	<code>maxNumberTempPossible</code> + <code>main.maxPropoTempValue</code>	Proportion max of temporary workers compared to permanent employees in order to be allowed to hire more temporary workers.	# temporary / permanent	# T	0.3	5	0.1	3.881
Client satisfaction	Company	event <code>checkGlobalSatisfaction</code> + <code>main.minLevelSatisfactionValue</code>	Level of global satisfaction above which the D organize (O) appears	%	# of D created O	50.00	85.00	5.00	60
Liquidity level	Company	event <code>checkNeedInvestStaff</code> + <code>main.numEmpForInvestStaffValue</code>	Number of new employees after which investStaff has to be done	# of employees	# of D created I	3	10	1	5
Organization	Company	event <code>checknumberHireFireForOrg</code> (action) + <code>main.numEmpForOrganizeValue</code>	Rate at which a D organize (O) appears	rate	# of D created O	3	20	1	5
Project completion	Permanent Employee	function <code>onBusyState</code> + <code>main.perfWhenCriticallyBusyValue</code>	Level of performance of a permanent employee when critically busy	%	Turnover	0.70	0.85	0.01	0.805

DYNAMIC OBSERVED	AGENT	PARAMETER	ELEMENT TO EVALUATE	UNIT	Part concerned by Calibration	Min	Max	Step	Calibration result
Organization	Company	function <code>environmentProtectImpact</code> - variable <code>positiveImpactOfE</code> inside + <code>main.positiveImpactOfEMaxValue</code>	% of increase of organizationLevel when a D environment (E) is made	%	# of D created O	0.10	0.20	0.05	0.112
Organization	Company	function <code>environmentProtectImpact</code> - variable <code>positiveImpactOfE</code> inside + <code>main.positiveImpactOfEMinValue</code>	% of increase of organizationLevel when a D environment (E) is made	%	# of D created O	0.01	0.03	0.01	0.022
Organization	Company	function <code>environmentProtectImpact</code> - variable <code>positiveImpactOfE</code> inside + <code>main.positiveImpactOfEModeValue</code>	% of increase of organizationLevel when a D environment (E) is made	%	# of D created O	0.03	0.10	0.02	0.074
Organization	Company	function <code>organizeImpact</code> -variable <code>positiveImpactOfO</code> inside + <code>main.positiveImpactOfOMaxValue</code>	% of increase of organizationLevel when a D organize (O) is made	%	# of D created O	0.20	0.50	0.10	0.351
Organization	Company	function <code>organizeImpact</code> -variable <code>positiveImpactOfO</code> inside + <code>main.positiveImpactOfOMinValue</code>	% of increase of organizationLevel when a D organize (O) is made	%	# of D created O	0.01	0.05	0.01	0.019
Organization	Company	function <code>organizeImpact</code> -variable <code>positiveImpactOfO</code> inside + <code>main.positiveImpactOfOModeValue</code>	% of increase of organizationLevel when a D organize (O) is made	%	# of D created O	0.05	0.20	0.05	0.162

DYNAMIC OBSERVED	AGENT	PARAMETER	ELEMENT TO EVALUATE	UNIT	Part concerned by Calibration	Min	Max	Step	Calibration result
Happiness level	Company	function wellbeingImproveImpact - variable positiveImpactOfAction inside + main.positiveImpactOfWMaxValue	% of increase of each employee happinessLevel when a D wellbeing (W) is made	%	# of D created W	15.00	30.00	5.00	24.099
Happiness level	Company	function wellbeingImproveImpact - variable positiveImpactOfAction inside + main.positiveImpactOfWMinValue	% of increase of each employee happinessLevel when a D wellbeing (W) is made	%	# of D created W	1.00	5.00	1.00	2.125
Happiness level	Company	function wellbeingImproveImpact - variable positiveImpactOfAction inside + main.positiveImpactOfWModeValue	% of increase of each employee happinessLevel when a D wellbeing (W) is made	%	# of D created W	5.00	15.00	2.00	12.53
Market development	Main	event addClientRandomly + main.rateAddingClientRandomlyValue	Rate at wich a new client is randomly added.	rate	Turnover	0	5	0.5	1.983
Market development	Client	event createNewClient + main.rateCreatingClientValue	Rate at which a client is added when WOM is set on +	rate	Turnover	0	2	0.1	0.336
Market development	Client	event removePotentialClient + main.rateDeletingClientValue	Rate at which a client is deleted when WOM is set on - (and no ongoing project)	rate	Turnover	0.5	3	0.5	1.934
Environment	Company	event environmentProtect + main.rateEnvironmentProtectValue	Rate at which opportunities to take care of environment appear	rate	# of D created E	0.5	7	0.5	1.631
Market development	Client	event orderRepeatingProject + main.rateRepeatingOrderValue	Rate at which a repeating client order new projects	rate	Turnover	0.1	2	0.1	1.021
Client satisfaction	Company	event checkGlobalSatisfaction + main.reccurenceCheckClientSatisfactionValue	Rate at which globalSatisfaction is checked	rate	# of D created O	1	4	0.5	1.5

DYNAMIC OBSERVED	AGENT	PARAMETER	ELEMENT TO EVALUATE	UNIT	Part concerned by Calibration	Min	Max	Step	Calibration result
Happiness level	Company	event <code>checkGlobalHappiness</code> + <code>main.reccurrenceCheckHappinessValue</code>	Rate at which globalHappiness is checked	rate	# of D created W	1	6	0.5	4
Hiring	Company	event <code>checkNeedHiring</code> + <code>main.reccurrenceNeedPermanentValue</code>	Rate at which the minimum number of temporary workers is checked in order to decide hiring this minimal number	Timeout, Cyclic	# P	1	6	1	1
Hiring	Company	event <code>checkNeedTemporary</code> + <code>main.reccurrenceNeedTemporaryValue</code>	Rate at which the necessity to hire / fire temporaries is checked	Timeout, Cyclic	# T	1	7	1	5
Market development	Client	<code>repeatingProfile</code> (boolean) + <code>main.repeatingProfileValue</code>	% of clients that might repeat orders	%	Turnover	0.01	0.3	0.05	0.247
Liquidity level	Temporary Employee	<code>salary</code> + <code>main.salaryTSensitivityValue</code>	Temporary employee salary	CHF	L	0.7	1.2	0.1	0.551
Initial situation	Company	<code>sensitivityToEnvironment</code>	Initial value at the beggining of simulation period	%	# of D made E	0.5	1	0.1	0.77
Initial situation	Company	<code>sensitivityToWellbeing</code>	Initial value at the beggining of simulation period	%	# of D made W	0.10	1	0.10	0.88
Environment	Company	event <code>stopNegativeEffectOnBanker</code> + <code>main.timeoutStopNegEffectBankValue</code>	Duration during which the bank does not want to increase credit limit because of environment D that were rejected.	Days	L	15	90	1	68
Project completion	Project	<code>workload</code> + <code>main.workloadMaxSensitivityValue</code>	Workload by project	Days (hours to convert in days)	Turnover	1	5	0.1	1.2
Project completion	Project	<code>workload</code> + <code>main.workloadModeSensitivityValue</code>	Workload by project	Days (hours to convert in days)	Turnover	1	5	0.1	3.9

10.6 Model documentation

The interested reader might refer to the separate PDF document “Annex 1 – model documentation” to see the complete model presentation.