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Growth Configuration of Invention-based Entrepreneurial Start-up

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ABSTRACT

This research studies an important question of configurational change of entrepreneurial growth. More precisely, it explores the question of post-start-up configurations in invention-based ventures and aims to improve our understanding of how and why aspects of start-ups transition from one stage to another. A case study method enables us to see what happens when a start-up tries to move from product invention to its commercialization stage, why specific actions occur, and how they impact the venture. Our findings show the importance of enabling the organizational emergence process through two complementary mechanisms, changes in entrepreneurs' sense- and decision-making logic and using temporal or similar pressure as a motivational tool.

Keywords: *Start-up, Entrepreneurial growth stages, Transition, Configuration studies, Invention, Commercialization*

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გამოგონებაზე დაფუძნებული სამეწარმეო სტარტაპის ზრდის კონფიგურაცია

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კვლევა შეისწავლის სამეწარმეო ზრდის კონფიგურაციული ცვლილების მნიშვნელოვან საკითხებს. კონკრეტულად ის იკვლევს პოსტ-სტარტაპული ეტაპის კონფიგურაციას გამოგონებაზე დაფუძნებულ საწარმოეო ტიპის სტარტაპში და მიზნად ისახავს გააუმჯობესოს ჩვენი ცოდნა სტარტაპის განვითარების ერთი ეტაპიდან მეორეზე გადასვლის პროცესის შესახებ. ქეისის თვისობრივი შესწავლის საფუძველზე საშუალება გვეძლევა დეტალურად გავაანალიზოთ თუ რა ხდება, როდესაც სტარტაპი ცდილობს გადავიდეს პროდუქტის გამოგონებიდან მის კომერციალიზაციის ეტაპზე, რატომ ხდება გარკვეული ქმედებები და როგორ მოქმედებს ისინი საწარმოზე. კვლევის შედეგები აჩვენებს, რომ გამოგონებაზე დაფუძნებული სტარტაპების ზრდის პროცესისასთვის განსაკუთრებით მნიშვნელოვანია ორი ურთიერთშემავსებელი მექანიზმის არსებობა: მეწარმეების შეხედულებებისა და გადაწყვეტილების მიღების ლოგიკის ცვლილება და დროის ზეწოლის ან სხვა პასუხისმგებლობების გამოყენება, როგორც სამოტივაციო ინსტრუმენტი.

საკვანძო სიტყვები: *სტარტაპი, სამეწარმეო ზრდის ეტაპები, გარდასვლა, კონფიგურაციის თეორია, გამოგონება, კომერციალიზაცია.*

1. Introduction

New venture growth has been a central point in entrepreneurship literature for a few decades. Prior studies have generated a rich material to describe typical configurations of different dimensions which are necessary to achieve growth. However, little attention has been paid to the identification of post-start-up configurations (Witmeur & Fayolle, 2011) while this remains the main concern for invention-based start-ups as the survival rate remains relatively low for this type of ventures (Kehbila, 2021; Heirman & Clarysse, 2004). How can an invention be successfully commercialized is still a key question that needs to be addressed. Numerous studies have shown even when the necessary conditions are met, not every start-up goes to the second stage of its life cycle.

Despite the importance of the topic, past research has mostly focused on a narrow subset of strategies and environmental conditions, rather than holistically evaluating the multiple drivers which may lead to start-ups' growth. Scholars seem to agree that despite abandoned literature on the topic, further qualitative studies are needed to improve our understanding of how and why start-ups transition from product invention to the commercialization stage (Gersick et al., 1999; Naumes et al., 2006; Marullo et al., 2018). Indeed, as growth is a "multidimensional and complex phenomenon", it can take "very different forms and time frames" (Witmeur & Fayolle, 2011). That is why previous studies have observed important heterogeneity of growth patterns (Gilbert et al., 2006; Witmeur & Fayolle, 2011).

The aim of this research is to shed further light on the transition period of a post-start-up configuration of invention-based ventures. One exciting way to explore this question is by linking the life cycle approach of entrepreneurial growth to the theory of configurations (Watson, Jansen & Chandler, 1993; Witmeur & Fayolle, 2011). According to the life cycle model of entrepreneurial growth, there are common sets of elements at different stages of the entrepreneurial life cycle (Churchill & Lewis, 1983; Eggers et al., 1994; Naumes et al., 2006; Stayton & Mangematin, 2016). These dimensions are resources and assets on the one hand, and certain issues and managerial skills, on the other hand (Tandilashvili, 2017). In this view, growth can happen when the issues, typical for each stage, are successfully solved. The configuration theory allows to holistically analyze the complexity of the entrepreneurial journeys from one growth stage to another and explore why some actions occur for invention-driven start-ups and how these actions impact the growth.

To better understand the process of configurational change and the passage from product invention to commercialization, this research is interested in the transition period from growth stage one to stage two. This transition period, or the processes of a "Take-off" (Marullo et al., 2018) is the most critical for invention-based start-ups as it marks the transition of the start-up into a viable business. At the same time, it is the most uncertain and vulnerable process.

We investigate these issues through a qualitative, inductive process study of one invention-based Georgian start-up, using in-depth, semi-structured interviews with the founders of the start-up, company internal documents, and notes of the observant participant. By employing a single case study approach, we analyze what happens when a start-up tries to move from the invention to the commercialization stage, why certain actions happen, and how they impact the venture (Yin, 2009). We go further and

explore what are the main challenges and tensions that entrepreneurs have to overcome and how exactly they make decisions that may lead to entrepreneurial growth when it comes to invention-based start-ups.

Our findings reveal that the transition from a successful product invention to its commercialization can not be taken for granted even when the necessary conditions are met: entrepreneurs' willingness to grow and learning pattern, high-demand market, support from external stakeholders… Our research confirms previous findings on the importance of contributing and managing organizational emergence right after product development. Not having temporal pressure can be a blocking issue as it implies the lack of a powerful motivator. We contribute to the existing literature by showing that temporal pressure can be replaced by a sense of accountability to external stakeholders or to oneself. We also contribute to the literature by demonstrating that organizational emergence should happen in parallel with changes in entrepreneurs's sense- and decision-making as well as behavioral patterns. We argue that the Complementary means-driven and goal-driven logic can be mobilized to do so.

2. Literature review

2.1. Entrepreneurial growth from the prism of configurational change

Understanding entrepreneurial growth includes understanding its origins, modalities, impacts and outcomes (Hlady-Rispal et al., 2021). Since growth is the critical question for entrepreneurship, there is a wide literature studying this aspect with multiple theoretical perspectives (Gilbert et al., 2006). Fundamental works have identified the "conditions" or dimensions that are necessary to achieve a nascent venture's growth. Sandberg (1986) developed a new model for the performance of new ventures, arguing that a new venture's performance depends on three dimensions: the entrepreneur himself, the structure of the industry, and the adopted strategy. Chrisman, Bauerschmidt, and Hofer (1998) extended Sandberg's model to also include resources, organizational structure, processes, and systems. Thakur (1999) added the elements of an entrepreneur's access to resources, opportunity choice, and managerial capability. For Box, White, & Barr (1993), psychological characteristics and the background of the entrepreneur, as well as the scanning intensity and industry dynamics, are the key dimensions of growth. Later, a systematic literature review allowed Gilbert, McDougall & Audretsch (2006) to conclude that the most important predictors of new venture's growth are the following dimensions: **entrepreneur characteristics, resources, strategy, industry,** and **organizational structure and systems**.

These perspectives can be grouped into five main schools of thought which study the question of entrepreneurial growth (Witmeur & Fayolle, 2011).

- **"Traits approach"** (willingness of the entrepreneur to grow or stay stable) analyzes the characteristics, motivations, and behavior of entrepreneurs and argues that different entrepreneurial profiles explain the difference of growth willingness and aptitudes (Ettinger, 1983; Delmar & Wiklund, 2003; Baum & Locke, 2004; Dvalidze & Markopoulos, 2020).
- **Strategic management approach** (strategic orientation of the venture and the entrepreneur) identifies strategic behavior and strategic content which leads to competitive advantage and superior business performance (Miles & Snow, 1978; Ireland, Hitt & Sirmon, 2003).

- **Ecology of population approach** (an evolutionary process of market acceptance) suggests the importance of the environment in the selection of survivors (Hannan & Freeman, 1977). In contrast with the first two, this approach reduces the role and impact of the entrepreneur and strategic decision-making in the venture's performance.
- **Resources-based view** (the role of available resources) explains the growth pattern and venture's performance with the existing resources and the venture's capacity to transform the resources into dynamic capabilities (Brush, Greene & Hart, 2001; Zahra, Sapienza & Davidsson, 2006).
- **Lifecycle or stage-based model** (single evolution paths) proposes a complementarity of other models and suggests that the above-listed dimensions are all needed at different stages of the venture's life cycle but with different configurations, in order to achieve the growth (Churchill & Lewis, 1983; Eggers et al., 1994; Naumes et al., 2006; Stayton & Mangematin, 2016).

The lifecycle model typically divides the lifespan of an entrepreneurial venture into 3 to 6 stages of development. Each stage is characterized by a set of necessary elements or key dimensions. These elements are financial and human resources, and some other tangible and intangible assets, such as entrepreneurs' know-how, intellectual property rights, relationships with stakeholders, etc. At the same time, there are certain managerial skills needed at each stage as there are inevitable crises, the resolution of which is the key to the evolution of the venture from one stage to another. Based on the original work of Churchill & Lewis (1983) and Eggers et al. (1994), Naumes et al. (2006) proposed revised six steps of entrepreneurial growth. They identified the key issues and crises which take place at each stage on the one hand, and the managerial skills needed to resolve these issues on the other hand. Even if ventures can skip a stage of growth, they need to follow these steps in the following order:

Table 1: Entrepreneurial Growth Stages By Naumes et al. (2006)

Growth stages	Key issues	Managerial skills
Stage 1: Existence as a viable business Business is created and first customers served. Product development may continue.	Obtaining customers. Finding (enough) cash to reach viability. Balance between the owner's personal and business goals.	Owner's operating ability. Access to financial resources. Ability to develop the processes.
Stage 2: Survival Business has established a market niche.	Manage the difference between revenues and expenses. Generate enough cash to grow. Balance between the owner's personal and business goals.	
Stage 3: Stabilization Business is returning profit and has a functional structure, with some professional managers.	Possible disagreement on what to do next. Possible other disengagements between the owners.	Owner's operational abilities. Development of business resources and relationships.

Stage 4: Growth Orientation Business goal is to become a big(er) company.	Acquiring the (necessary) financial resources and developing the systems to enable the growth.	Owner's strategic & operation ability. Owner's management skills.
Stage 5: Take-off/Rapid Growth Business is growing rapidly.	Focus on how to grow and how to finance it. Delegation and development of control systems.	
Stage 6: Resource Maturity Business has reached its full potential. Owner and business are usually now separate entities operationally and financially.	Consolidation and control of the results. Maintaining "entrepreneurial spirit," despite the company's increased size.	Owner's strategic ability & managerial skills. Management of financial resources.

The lifecycle approach of entrepreneurial growth can be assimilated with the configuration approach of firms' performance (Miller & Mintzberg, 1983). The theory of configurations has emerged as an alternative to the existing theories of organizational performance, suggesting that instead of reviewing all the possible relationships between dimensions, it is more useful to limit the scope of analysis to a limited number of coherent configurations. To do so, researchers can identify common sets of attributes related to strategy, organizational structure, and environment in order to understand firm performance. Witmeur & Fayolle (2011) argue that the configurational theory is more suitable than other similar approaches to fully capture the complexities of the entrepreneurial journey. For example, contrary to the contingency theory (which looks for one unidirectional and linear law to explain incremental changes), the configuration studies take a more holistic and nonlinear system view of the changes occurring in organizations (Meyer, Tsui & Hinings, 1993). Thus, studying entrepreneurial growth from the perspective of configuration theory allows us to holistically explore the complexity of the entrepreneurial journey from one stage to another rather than focusing on a narrow subset of entrepreneurial strategies or environmental conditions (Turcan & Juho, 2014; Witmeur & Fayolle, 2011).

Similarly to the life-cycle model of entrepreneurial growth, in configuration theory, the elements of the configuration are coherent, and change in one attribute may predict changes in others. These configurations, called gestalts, represent mutually supportive organizational system elements that are combined with appropriate resources and behavioral patterns (Turcan & Juho, 2014). These configurations are stable and are modified only by major changes (Miller & Mintzberg, 1983). After some time, the configurations achieve a "made-it point" (Turcan & Juho, 2014) which creates inevitable tensions between the key dimensions of a configuration. Reducing these tensions is the key to entrepreneurial growth (Churchill & Lewis, 1983; Eggers et al., 1994; Naumes et al., 2006; Witmeur & Fayolle, 2011; Galkina et al., 2021). "To get to a made-it point or pass the entrepreneurial threshold, entrepreneurs constantly create, and re-create, conceptualize and re-conceptualize, and contextualize and re-contextualize the type and the state of elements in their ventures' organizational gestalt" (Turcan & Juho, 2014, p. 131).

2.2. Start-ups' take-off. The transition from the stage of product invention to the stage of commercialization

According to the life cycle model, the key dimensions of a venture should evolve from one stage to another. At each stage, there are different inevitable issues that need to be resolved. Successfully solving the issues and tensions at each stage (called crisis) is necessary in order to achieve the growth and go to the next stage of the life cycle (Churchill & Lewis, 1983; Eggers et al., 1994; Naumes et al., 2006; Witmeur & Fayolle, 2011; Galkina et al., 2021).

According to Eggers et al. (1994), five critical skills which need to be addressed in low-growth start-up companies in order to move to the second stage of their life cycle are: financial management, relationship building, motivating self, time management, ethics, and organizational culture. In the case of a high-growth start-up company, the five critical management skills are: financial management, motivating others, vision/direction/focus, motivating self, and planning and goal setting. Additionally, to survive, nascent ventures need to reach a legitimacy threshold at three levels of organizational gestalt: goal (vision), decision (strategic), and behavioral (tactical) in order to achieve growth (Lichtenstein et al. 2006). Turcan & Juho (2014) argue that it is the dynamic capabilities that contribute to attaining such thresholds at all levels of the venture's gestalt, and managing them enables growth from one stage to the next.

Prior studies have shown some contradictory results on what enables the transition from invention to the second stage of entrepreneurship. In terms of resources, **financial capital** is one of the most tangible resources influencing start-up success, but for the start-up's successful take-off, the link to venture capital investors (VC) is more important (Marullo et al., 2018). Some empirical evidence has identified the relevance of **patenting** activities for the commercialization of product innovations (Andries & Faems, 2013). On the contrary, some recent studies argue that patenting might not act as an efficient appropriation mechanism (Marullo et al., 2018). For Marullo et al. (2018), **market impact** at entry, rather than the strength of the technology, represents the crucial factor driving start-up success. Similarly, rather than having an A-list team of technology professionals, one of the crucial prerequisites for 'Take-off' is the **diversity of teams'** knowledge and complementarity of their skills.

The diversity of results is expected as a configuration change is a "complex multi-motor process" type of event (Witmeur & Fayolle, 2011). Based on the original work of Van de Ven & Englemen (2004) and Miller (1987) Witmeur & Fayolle (2011) propose 5 processes that may lead to a configuration change:

- **"Traits approach"** is the willingness of the entrepreneur to grow or stay stable.
- **Ecology of population approach** is the evolutionary process of market acceptance.
- **Technology adoption cycle** refers to the evolutionary process of investor acceptance.
- **Organisational changes** refer to the need for organizational structuring and professionalization (managerial & processes).

- **Strategic management and Resource-based view** refer to teleological processes in which, first of all, resource acquisition and transformation (Lichtenstein & Brush, 2001) and, secondly, comparison between expected and actual performance (Gersick, 1994) play a central role.

Witmeur & Fayolle (2011) argue that the willingness to grow and 'market acceptance' are the most important processes. Organization structuring and strategic planning are also important, but only at later stages of start-up development, and are only useful if the willingness to grow and market acceptance are confirmed. Investor acceptance is important only for the product development stage.

Thus, the transition from the first stage of growth to the next one can not be taken for granted (Gersick et al., 1999; Marullo et al., 2018). It is a complex combination of various elements. Studies have shown that even when the necessary conditions are met (managerial skill, problem-solving), not every start-up goes to the second stage of its life cycle (Kehbila, 2021). That is why, the question of growth mechanism remains the primary concern for nascent ventures. This is particularly sensitive for invention-based start-ups where some additional difficulties are to be overcome, such as protecting intellectual property (Somaya & Teece, 2021).

Insufficient financial resources is one of the primary causes of the failure of new high-technology ventures (Marullo et al., 2018). However, start-ups may still fail to "take-off" even in case of important funds. Sometimes, to avoid failure, new ventures have to "pivot" from their original activity (Hampel et al., 2020). Indeed, in current dynamic environments, a start-up's initial plans can be obsolete by the time of a product launch (Blank, 2013). Pivoting from the original invention is very costly for technological ventures, if not impossible.

In some industries, the life cycle is relatively short after the product development. For IT-based start-ups, for example, the successful growth pattern is to be bought by established companies. In some technology fields, it is a strategic partnership that is considered the most convenient growth strategy. For example, in the field of biotechnology, after new start-ups are established as variable businesses, they often form a strategic partnership with established pharmaceutical companies in order to get additional funding and/or to incorporate needed later stage development knowledge (Lamb,2019). However, in the case of invention-based start-ups, strategic partnership brings an additional danger of losing control on the invention. When possible, they use patents to shelter their intellectual assets against partners and competition (Kultti et al., 2006; Peeters & Potterie, 2006; Cohen, et al., 2000). In some minor cases, such as in family-owned inventions, intellectual property protection can even be perceived as risk-taking because of the danger of losing socioemotional wealth (Gomez-Mejia et al., 2018), such as disclosing tacit knowledge, increasing reputational risks, and creating dependence on external sources (Chirico, et al., 2020).

Another pathway is rapid internationalization. Previous studies have shown a growing tendency of rapid internationalization of early-stage technology start-ups (Linan et al., 2020; Madsen, 2013). International New Ventures and "born-global" ventures attain a higher success rate thanks to rationalizing its resources

from the early stages (Stayton & Mangematin, 2016; Turcan & Juho, 2014)[4]. However, some scholars have demonstrated that, on the contrary, new and small ventures, such as start-ups, may suffer liabilities of newness, smallness, and foreignness (Zimmerman & Zeitz, 2002).

Given these findings of prior studies, the question of how a configurational change can be achieved in an invention-based start-up to enable the desired pattern of growth remains critical.

2.3. Managing tensions in order to grow

Some recent studies have identified the importance of managing tensions that arise between different configurational elements at each stage of a start-up's life cycle to enable growth (Witmeur & Fayolle, 2011; Turcan & Juho, 2014; Stayton & Mangematin, 2016; Galkina et al., 2021). The tensions are inevitable and vary per growth stage. At the product development and launching stages, these tensions arise, for example, because of conflicting priorities, perceptions, and behavioral logics of entrepreneurs.

These tensions may occur at **three levels**: individual, organizational and interorganizational. At an inter-organizational level, there can be tension between the entrepreneurs and external stakeholders (such as investors) due to different priorities and even logic (Sarasvathy, 2001). For example, sometimes tensions arise between founders' effectuation logic and investors' or other external stakeholders' causal reasoning (Galkina et al., 2021).

Tensions at the organizational level are mostly due to tensions between different types of resources: financial, human, and technology (invention). Stayton & Mangematin (2016) summarize the tension into a triangle of temporal, financial, and human resource tensions. The tension between temporal and financial resources occurs when additional time is needed for product development and/or market entry, which requires additional financial resources. The tension between financial and human resources rises when the start-up needs to hire skilled workforces for both technology development and commercialization. Last, the tensions between temporal and human resources occur when there is a rush to hire the right candidates. Delays in hiring key employees into the firm may preclude a venture's ability to continue growing at a healthy pace (Gilbert et al., 2006, p. 942). At the same level, tensions may arise between co-founding entrepreneurs because of different priorities and logic on how to plan and develop the venture.

Ultimately, at the individual level, tension may arise in decision-making or when juggling between primary occupation and product invention. For example, when entrepreneurs are satisfied with their primary occupations (working conditions, sense of personal accomplishment), they tend to be less devoted to the start-up process. On the opposite side, those who are not satisfied with their salaried jobs, will be more invested. Laffineur et al. (2020) also found that individuals who have high-level managerial experience tend to put more effort into the new venture.

[4]Entrepreneurial firms are more international compared to family-owned or sole-entrepreneur start-ups (Denicolai et al., 2015), because internationalization requires significant financial and human resources (Turcan & Juho (2014; Andersson & Evers, 2015).

Managing the tensions between different elements allows entrepreneurs to succeed and thus, move to the next stage of the start-up lifecycle. Managing tensions between the founders' salaried occupations and their dedication to the start-up activities entirely depends on the founders' willingness to succeed or on their ability to attract sufficient resources and thus concentrate their efforts on the nascent venture. Thus, there is a little guideline proposed by prior studies on how to overcome this type of tension. As for the tensions between other elements, studies have proposed different "solutions". Stayton & Mangematin (2016) argue that the inevitable tensions between different types of resources can be managed internally by using time as a key strategic variable. In this view, time is not only a source of tension. A compression of time can be seen as a motivational tool, more than a managerial one. For example, the authors argue that the scarcity of financial resources speeds up the launch of technology, but reducing start-up time decreases the chances of success for organizational emergence. Thus, the "[international] technology ventures startup most quickly with the minimum funding required to remain viable" (Stayton & Mangematin, 2016, p. 397). Similarly, quick commercialization of an invention reduces tensions between different resources by saving scarce resources and thus allows more favorable investments and decision-making (Stayton & Mangematin, 2016). On the other hand, delaying the launch of the invention raises the need for additional external funding and boosts the tension between temporal and financial resources.

Recent works have demonstrated a positive impact of open innovation and social networks on start-ups' performance by decreasing tensions between different resources (see. Danarahmanto et al., 2020). For example, according to Marullo et al. (2018) 'open approach' to new venture creation can help the founding teams to overcome internal resources constraints and thus avoid or decrease the tensions between different types of resources. Iglesias-Sanchez et al. (2022) argue that higher stakeholder involvement (as a part of an open innovation approach) gives rise to novel entrepreneurial opportunities that allow start-ups to better face tensions. Gilbert et al. (2006)'s literature review showed a strong consensus that a venture's connections to outsider competencies, such as incubator resources, and external consultants, were beneficial for the growth of start-ups. By working with partners or leveraging the productivity and efficiency of current workers, a venture may grow without increasing the number of individuals it employs (Gilbert et al. (2006). Yet another solution to manage the tensions between start-up resources is an early internationalization of its activities. The International New Ventures, "from inception, seek to derive significant competitive advantage from the use of resources and the sale of outputs in multiple countries" (Oviatt and McDougall, 1994).

The review of literature on the growth patterns of invention-based start-ups shows what are the necessary dimensions that need to be considered to move from the invention stage to product commercialization. It also shows the main challenges and tensions that arrive at these stages and the coping mechanisms. We believe that our understanding of the question can be improved by exploring how exactly entrepreneurs make decisions at this point of entrepreneurial crossroad (Witmeur & Fayolle, 2011; Stayton & Mangematin, 2016; Marullo et al., 2018; Kehbila, 2021).

3. Research Methodology

Understanding entrepreneurial growth requires understating its origins, modalities, impacts, and outcomes and can be revealed in a reflexivity exercise of entrepreneurs' sensemaking (Hlady-Rispal et al., 2021). With the aim to explore the sequences of events, entrepreneurs' decisions and intentions, different actions, and the consequences of these actions at the early stage of invention-based ventures, we adopt a single case study strategy (Hampel et al., 2020; Turcan & Juho, 2014, Yin, 2009).

Case studies can be used for both exploratory and explanatory research (Naumes et al., 2006). As suggested by Yin (2009), this method leads to a more in-depth understanding of the interactions and complexities of the situation and is recommended for studies asking what, why and how questions. Using case-based research allowed us to explore the sequence of events and the role of entrepreneurs by direct observation (Miles & Huberman, 1994).

We conducted an in-depth case study of an early-stage Georgian technological start-up. We purposefully selected an information-rich case that manifests the studied phenomenon intensely (Miles and Huberman 1994). The choice of the case was determined by four criteria. First, and because of the research objective, we wanted to study a start-up struggling to move from the product development to the commercialization stage. Second, we wanted to explore a real-time case of an early-stage start-up to avoid the problems of retrospective biases and identify the relatively fresh sense-making of entrepreneurs (Turcan & Juho, 2014; Lichtenstein & Brush, 2001). Third, we wanted to study an invention-based start-up to see the particularity of start-up processes which take place in the case of technological invention and commercialization. Fourth, following the recommendations of Hlady-Rispal et al. (2021) on the need to use innovative approaches for entrepreneurial growth studies, we selected a start-up that allowed us to take the role of an observant participant.

3.1. Data collection

To answer our research questions and triangulate our findings, we collected three types of qualitative data set: interviews, start-up documentations, and notes of participant observation. Triangulation of data sources allowed us to analyze the decisions that the entrepreneur made during different stages of the start-up process and the consequences of these decisions (Naumes et al., 2006).

The primary source of the empirical data is the six interviews with the main actors of the start-up: two interviews with each co-founder. Semi-structured interviews allowed deeper questioning on pertinent topics of conversations. We employed the critical incident technique (Flanagan, 1954; Miles and Huberman, 1994) to identify important events in the discourse of the respondents, the way they were managed, and the perceived effects of these actions. The interview guide included six topics that emerged from the literature review: *Entrepreneurs' background and primary occupations; Product invention and patenting; Role repartition; Grants & other Fundings; Stakeholders;* and the first steps of *Commercialization.*

To triangulate information, additional data were requested during the process, including documents such as technical descriptions of the technology, patents, grant proposals, journals, business plans, financial projections, market studies, and competitor analyses. These documents helped us to better understand founders' decisions and actions, beyond their own judgment. Additionally, to understand how external stakeholders perceived the start-up, we analyzed press articles and online publications mentioning the venture.

The opportunity for the researcher to observe and even participate in certain actions allowed to fill in the missing data for an in-depth and complete understanding of the start-up processes. One of the authors was engaged in various activities, such as communicating with external stakeholders, analyzing potential foreign markets, and gathering information about global competitors. He kept a notebook and recorded observations, mainly on his interaction with the founders. The role of observant participation allowed us to gain a rich and granular understanding of the research case (Yin 2009). Just like a participant observation, which allows a researcher to gain an intuitive and intellectual grasp of the ways that the start-up is organized and how people relate to each other (Schensul & Le Compte, 2013), the position of observant participation allowed us to gain a unique understanding of the start-up's processes, entrepreneurs decisions, priorities, and strategy, relation between co-founders, their roles and responsibilities. It also reduced the bias of our own experiences and subjective judgment, which may occur in case of participant observation.

3.2. Data analysis

With the aim to gain a better understanding of why some actions occur at the first stages of invention-driven start-up and how these actions impact growth, we opted for a naturalistic inquiry to conduct a qualitative process study (Glaser & Strauss, 2009; Lincoln & Guba, 1985). To do so, we followed the strategy of sensemaking (Langley, 1999) in order to ground, organize, and replicate the information emerging from the data (Hampel et al., 2020).

Transcribed interviews and other textual data were coded within the NVivo software using an abductive approach. The seven main topics of the interviews were detected from the literature review and the researchers identified them in the data set. However, their observations and semi-structured nature of interviews allowed some grounded themes to emerge empirically. We created the first-order codes by coding at the level of sentences and small paragraphs.

These initial codes were grouped into the second order codes with the aim to find meaningful patterns in the data and to create theoretical constructs. To do so, we analysed relationships between the first-order codes and organised them into more general themes. The second-order themes capture what was important within the data in relation to our research question and represent some level of patterned response (Braun & Clarke, 2006).

3.3. Research context. Presentation of the start-up

Technogreen[5] was founded in 2005 in Georgia after a technological invention made by one of its founders. The invention consists of a unique technology to clean the oil spill. Generally, there are two main methods of cleaning an oil spill. First, and the most widespread, is a chemical approach, which enables very quick remediation of the pollution but has the downside of being unsustainable with more or less important side effects. The second method is bioremediation, or cleaning the pollution with a biologically cleaner approach, which allows a more sustainable and ecologically clean solution; however, it has the downside of very diverse results. Technogreen technology is part of this second method, but its unique approach combines the strengths of the two methods. It allows for achieving quick and successful effects, as in the case of chemical methods, but has sustainable and ecological results, as in the case of the bioremediation approach. Additionally, the technology has the competitive advantages of being cheaper than competitors' services and being a universal solution, as can be applied to any type of landscape.

Since 2005, the start-up has served over 10 clients in Georgia. The bioremediation market is a niche activity that consists of providing bioremediation technology and services to industries, governments, and organizations seeking to clean an oil spill in a relatively clean and less offensive manner. The global bioremediation market is projected to grow from US$ 11.90 billion in 2021 to US$ 20.95 billion by 2028 and to grow at a CAGR of 8.4% during 2021-2028. The growth is due to three complementary reasons: fast industrial development in recent years which leads to important environmental pollution, mismanagement of plastic waste, and government regulations and funding for research & development activities in bioremediation globally. Despite the increasing demand, the number of bioremediation service providers remains limited on the global scale. In 2023, Technogreen applied for a European patent as a prerequisite for entering the global market. Despite multiple attempts and different collaborations, the commercialization has been unsuccessful. The founders tried different approaches and attracted different types of external resources, including one author of the present article, in the function of the observant participant. Today, the start-up counts three full-time members who also have managerial and leadership functions and 15 part-time members, field employees who only collaborate when providing service to clients.

4. Main findings

The case study shows a start-up that is struggling to find a way to move to the next stage of growth despite a 'ready-to-launch' product destined for a high-demand market. Following the configurational approach of the lifecycle model, we tried to explore the configuration of different elements, such as resources, behavioral patterns and tensions on the one hand, and critical events and actions on the other hand. Exploring these elements would lead us to understand the activities that the founders pursued in order to develop the start-up and how the start-up transitioned from one growth stage to another. The findings will be presented in two steps. First we will explore the product development and organizational emergence processes through the analysis of the critical events (Flanagan, 1954; Miles & Huberman,

[5] The real name of the start-up is disguised in this paper.

1994). Then we will explore the configuration of different elements and tensions observed within the start-up.

4.1. Chronology of critical events

To gain an overview of the progression of the start-up, we first established a timeline or "chronology" of the start-up's critical events. Following Stayton & Mangematin (2016) we will present these events within the two processes of a nascent technology startup: product development and organizational emergence. The figure 1 below illustrates the main events.

4.1.1. Product development process

For Technogreen, the product development was a particularly long process that lasted over two decades. All started with the academic research of a post-doctoral student in the 1990s who saw potential in her work. She studied different ways to clean the oil spills in liquid surfaces. With the industrial development she expected the oil-spills to happen more often and on larger scales. At the same time, a chemical remediation approach, widely used at that time, was showing more and more negative long-term impacts on the environment. The researcher saw potential in bioremediation methods. With insufficient support from her research institution, she decided to work on the technology on her own.

The first step was to build a laboratory to develop the technology. Without any financial support, this step became very difficult and time-consuming. The first investor and associate of the project was the husband of the scientist, who shared her vision of the potential of the invention and invested some money and a lot of time to build the laboratory from scratch. The laboratory was completed only after several years. The scientific research was undergoing in parallel, but only advanced in a significant manner with the creation of the fully functioning laboratory.

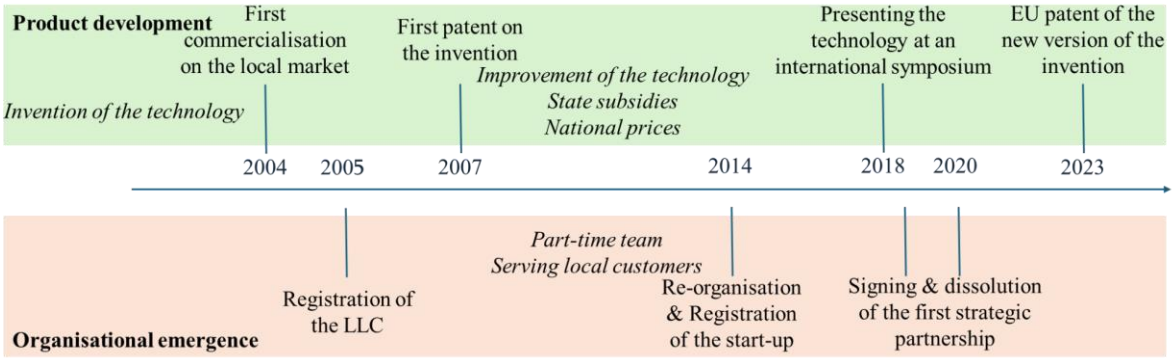
In 2004 Georgia experienced its first important oil spill. 41 hectares of land was contaminated because of a massive ecological disaster resulting from an oil well blowout. The contamination was particularly difficult to clean because it had spread over different landscapes: forest-covered hills, ravines and a river. The Technogreen technology development was not completed at that time. However, the entrepreneurs saw a possibility to test the first version of their technology. The results were very positive. For the entrepreneurs the success of their first commercial project was an important step to legitimize the invention.

The first (local) patent was obtained in 2007 after which the entrepreneurs still continued working on the technology. The development was fragmented and highly dependent on the obtaining of external funds. Between 2007 and 2015 a dozen other clients were successfully served in Georgia. This was very important for the product development process, as the technology was tested for different situations. However, these experiences were also a trigger for the entrepreneurs to realize that the invention was destined for a larger market than Georgia. With the Intellectual property rights in question, they applied for an international (EU) patent in 2023 before reaching international customers.

Thus, the product development process for Technogreen was purely product driven and not market driven. The main guideline behind it was product perfection at the expense of product launching time. The main motivator elements, mentioned by the entrepreneurs on various occasions, are the following in this order of importance: Creation of a perfect technology; 2. Environmental protection and sustainable products; 3. Revenue (Seeking return on personal investment - "too much time and money invested not to obtain a result"). Temporal pressure or competition were never mentioned as motivators. On the contrary, the product development process was guided by the guideline that "it takes as long as needed".

The entrepreneurs used nearly all the financial resources they obtained in product development. The only other action that they funded from a state grant was to present the invention at an international symposium. The aim was to make their technology known among professionals of the field. More than a commercial goal, even this event was perceived as a legitimation tool for the entrepreneurs. "We were very surprised and proud to see how the public was interested in our presentation. One organizer came to talk to us after the symposium to ask more questions about how Technogreen works" (Technical director). For the entrepreneurs this event was clearly an opportunity to make their product known but did not pursue any immediate actions in order to advance the commercialization of the product. Only after a few years the CEO took the initiative to contact the organizer of the symposium to see if she was interested in a certain form of partnership.

Figure 1: C**hronology of critical events**



4.1.2. Organisational emergence process

The process of organizational emergence includes creating formal organizational structure and management, agreements and relations, and power and responsibility repartition… It usually happens once product development is completed or when the first viable version of the product is launched into the market. The timeline of this process can be very diverse and depends on the configuration of multiple elements.

For Technogreen, the need for organizational emergence arrived in 2004-2005 when the entrepreneurs successfully tested their first viable product on a commercial project. However, this process was limited to officially registering the venture to serve customers and gain legitimacy on the market.

Registration of a new venture is particularly quick and easy in Georgia, where the government has put in place several initiatives that allow a new venture to be registered within 24 hours. This offers a number of administrative and financial advantages to local start-ups. Thus, with very little effort Technogreen was registered first as a Limited Liability Company in 2005. Once the venture registered, the entrepreneur continued working on the improvement of the technology and serving a few customers without dedicating efforts to organizational development.

The first step after the venture's registration was to gather a part-time team of fieldworkers. At this point, Technogreen did not consider formalizing its agreements, management, or structure as the two founders and the part-time team were handling the few customers' demands efficiently because of their high professionalism and knowledge of the technology. Generally, trust is an important element of decision-making in the organizational emergence process. As suggested by previous studies, to start-up quickly, entrepreneurs need to work with people they trust. Similarly, the founders of Technogreen surrounded themselves with the field workers they personally knew and had experience of working with. This allowed higher service quality. However, these early relations were ambiguous in terms of boundaries and responsibilities and did not end in format agreements and documentation. The decision-making was ad-hoc so that the results could be achieved quickly.

In 2014 with some commercial experience, the entrepreneurs saw a need to reorganise the venture as none of the entrepreneurs had the appropriate skills and experience to lead the organisational emergence process. Without sufficient resources to hire an external workforce, they decided to invite another member of the family, a postgraduate student, to take charge of the operational side of the venture. At that time came along an opportunity to develop the start-up with a strategic partnership. In 2018 a business consultant from the USA contacted Technogreen with a very attractive proposition: to commercialize the technology to the global market. With no experience of commercial partnership, the entrepreneurs accepted the propositions nearly without any negotiations. The World pandemic due to Covid-19 put aside the attempts of commercialization for a couple of years. Once the negotiations reopened, the business consultant proposed a possible solution to sign a strategic partnership with a French company specialized in oil spill clean-up. The partnership was not acceptable for the entrepreneurs as proposed, as it involved revealing some important aspects of the invention to the partner company. The entrepreneurs decided to stop the collaboration with the external consultant and pursue the commercialization steps alone.

Since 2022, the start-up has been managed by three co-founders: the CEO, the technical director, and the operational director. Now, when the product development is completed and the desired growth pattern identified, i.e. point for finding foreign partners. Established international firms do not trust an unknown start-up from a developing country without international experience and an official structure and management. One contact person from one European company confirmed over the phone having received the commercial proposition but thought it was spam and did not give it any further thought. Another company representative asked a lot of questions about the entrepreneurs and their experience to the Technogreen representative on the phone following the email reception.

4.2. Existing challenges and tensions

The most significant challenge is **confronting the co-founders' personal and business goals**. At a personal level, all three entrepreneurs have more and more responsibilities at their salaried jobs, which leaves less time for their entrepreneurial activities. Whereas the business goal of Technogreen, to obtain new (international) customers, is particularly time consuming and requires reactivity and implication from the management team. The managing team has difficulties finding the time and even space for other tasks. The scientific laboratory is the only working space for Technogreen. Now as the product development is completed, all non-product-related tasks are performed from home during weekends and other free time. This temporal tension is accentuated when there is pressure to fulfill an analytical task requested by a state agency delivering financial aid for local start-ups.

The second challenge observed in our analysis is that the decision-making is uncertain, ad-hoc, **and often delayed.** For example, even if the ultimate goal is clear (i.e., entering a European market), it has low specificities on how to do that. The management team has not decided on the market entry strategy nor on the product positioning and pricing. The decision-making is also dependent on external funds as the entrepreneurs tend to accomplish some pending activities once they receive some financing without planning the expenses ahead.

This brings to the third significant challenge of **dependence on external resources**. Availability of subventions has largely guided the product development process and is still the key trigger of important commercialization actions. At this point, the start-up is expected to use more intangible resources, such as social and organizational capital, negotiation and making deals with potential strategic partners to move to the commercialization stage. Whereas Technogreen's growth is entirely dependent on obtaining external financial resources, the absence of which delays the product launching process.

Another challenge is observed with **effectual reasoning**, which creates additional tensions with external stakeholders. If this mode of functioning is well established for start-up processes, it can become problematic for later stages of the life cycle, when start-ups are expected to have more causal decision-making as new resources and stakeholders are supposed to come on board. Whereas at Technogreen, all critical events are managed depending on the available means and resources and under temporal pressure. For example, to apply for a state subsidy with the Georgian Innovation and Technologies Agency, Technogreen has to make certain analyses, such as market study, competitive analysis, financial forecast… For the entrepreneurs, these tasks are perceived as obligatory work to obtain funding and more or less a loss of valuable resources - and time; they do not take advantage of the studies made for the agency.

At Technogreen, the future is not planned ahead but co-created with different stakeholders as they appear along with new opportunities. For example, the most important activity for the commercialization took place only because an external party contacted the start-up. The entrepreneurs did not consider this type of partnership prior to this opportunity. The partnership created an important tension (for the first time) within the start-up. The founders felt a mismatch of their role with this new partnership as they had different ideas on the organizational emergence. This tension was caused by two different reasons. On

the one hand, the founders felt they were losing control of the product and the venture. This was particularly scary as there is the question of property rights behind the technology. On the other hand, the founders felt that they had to stay disciplined and engage in routine work, while the new partners had to make all the strategic decisions.

Uncertainly, off-the-record decisions and informal relations also create tensions **at the organizational level.** More than the absence of formal management, structure, and relationships described above, there is also uncertainty in terms of the roles of the three managing members. Being members of a family before being a member of the same venture, enables mutual understanding, respect and conflict-less relationship. There is not much to be said and expressed officially as they share the same ultimate goal for the start-up: successful commercialization and do their best in this direction. Even if there is no conflict between the co-founders and even if they share the same vision and work ethics, there are some differences in terms of future direction. The CEO and the operational manager both expect the other to succeed in finding international partners. Even if both agreed later on the importance of hiring a specialized person, they disagreed on how to do that. The CEO, considering the cost, argued for a part-time, result-based remuneration. The operational manager preferred hiring a full-time experienced profile, given the importance of the results at stake.

The challenges faced by Technogreen are typical for the early-stage start-ups. Delaying their resolution creates additional tensions at different levels. In contrast, when managed successfully, these challenges can trigger an important growth action.

5. Discussion and conclusion

The main objective of this research was to improve our understanding of how entrepreneurial decisions and behaviors contribute to the growth of invention-based start-ups. Our findings respond to previous findings that stages of development are non-linear and timelines are idiosyncratic to companies (Vohora et al. 2004). The time a start-up takes to move to the next stage of growth depends on the existing configuration of different key elements and on a compromise between different internal and external tensions, reinforced by the entrepreneurs' ability to manage the resources (Stayton & Mangematin, 2016).

Our research shows a start-up struggling to move from product invention (stage one) to its commercialization (stage two). Difficulties are observed in all five key skills typical for early stage slow growing start-ups (Eggers, et al., 1994). Financial management, relationship building, motivating self, time management, ethics and organizational culture.

Financial management is fragmented due to high dependence on external financial resources. After acquiring a grant and or a subsidy, the start-up finances some pending actions and the financial management stops at this point, without any projections and expense planning. Whereas, at this point of growth, start-ups are expected to use more intangible resources, such as social and organizational capital, negotiation, and making deals with potential strategic partners (like Lichtenstein & Brush, 2001), to move to the commercialization stage.

Relationship building is also uncertain. Internally, Technogreen has not formalized any agreements and documents. The three co-founders have mutual understanding on what needs to be done and they do it together as a team (when they find available time) without official repartition of roles and responsibilities. Externally, the only stakeholder with more or less structured relation is the state agency for start-up funding. But even this relationship is fragmented and is limited to reporting back when Technogreen is held accountable to do so.

Difficulties in **self-motivation and time managemen**t are interconnected. Confirming previous studies, our research shows that successful **primary occupation** of entrepreneurs impacts their level of commitment to the start-up (Laffineur et al. 2020). Moreover, now that the product development is completed, there is high uncertainty about what needs to be done next, which also decreases self-motivation.

Last, **organizational culture** is inexistent due to the problem of organizational emergence. More than having an official registration, in order to gain credibility and successfully emerge as a viable organization, start-ups are expected to have formalized agreements and relations. "Once a minimum viable product is completed and ready to introduce to prospective customers, the organization needs to shift to become more professional, enabling legally compliant and mutually satisfactory domestic and international customer relations, supplier relations, employee relations, and future investor relations. To make this shift (the organizational formation pivot), roles, ownership agreements, and compensation packages need to be formalized." (Stayton & Mangematin, 2016, p. 399). Technogreen did not consider formalizing its agreements, management, or structure as the co-founders and the part-time team handle the (few) customers demands efficiently because of their high professionalism and knowledge of the technology.

Organisational emergence also requires relying on the **right skill and competences**. When the entrepreneurs do not have the appropriate skills and experience to accomplish the new roles that emerge as the start-up grows, it is important to hire the new specialized workforce. (Tandilashvili, 2017; Stayton & Mangematin, 2016; Gilbert et al., 2006). Filling key positions and the right type of employees define the start-up growth pace. In contrast, delaying hiring the needed competencies precludes the start-up's ability to grow. Technogreen's founder prioritized technology perfection over hiring commercial profile employees, and this delayed the organizational emergence and commercialization of the invention.

These challenges and difficulties are typical for slow growing start-ups at their early stages. successfully solving them is supposed to enable the transition to the next stage. On the other hand, delays in their resolution may create additional tensions. Our findings confirm the tensions observed by Stayton & Mangematin (2016) between financial and human resources and between temporal pressure and human resources, but not the **tension between financial and temporal elements.** This particularly of the case, also explains the delay in the product launch. Prior studies have shown that a "scarcity of financial resources speeds up technology venture launch" (Stayton & Mangematin, 2016, p. 397). For Technogreen, financial resources have always been scarce, but there has never been an actual temporal pressure as the external funds were mainly obtained from the state subsidies holding start-ups less accountable for their commercial results (compared to other financial investors). Stayton & Mangematin

(2016) argue that time is an enabling mechanism for invention-based ventures to accelerate product development, launching, and internationalization as it defines the pace of these processes by impacting other resources. Time seems to be particularly valuable for young ventures and start-ups as it has the particularity to be the only resource that can not be acquired, and the pace of its consumption can not be controlled (Stayton & Mangematin, 2016, p.402). The only way to get more time is to have more financial and human resources.

Another explanation of the delay in product launch, can be found in the type of invention itself. Because of the sensitive nature of the invention authorship rights protection, the founders tried to retain o**wnership and control** of the technology and the start-up by avoiding risky partnerships and delaying business investment. However, contrary to prior findings, the need to maintain control did not accelerate the product launch process. For example, Stayton & Mangematin (2016) found that to keep control of the invention, start-ups were eager to launch the product as quickly as possible using only personal funding and support from family and friends. Similarly, Gartner et al. (2012) observed that founders with more personal resources sought financing only at later stages.

Additionally, at Technogreen there is also the question of protecting socioemotional wealth (SEW). This is typical for family-owned start-ups where entrepreneurs try to maintain control over the invention until a threshold level of family ownership, beyond which the family's SEW is secured and a greater focus on prospective financial gains attainable through patents is possible (Chirico et al., 2020). Prior studies have shown that this "win/win" situation happens when the family has a secure majority ownership position—in which both future financial and SEW goals are aligned and compatible and thus work in tandem (Chirico et al., 2020; Gomez-Mejia et al., 2018). Similarly, the Technogreen CEO expresses a dilemma between reconciling financial and non-financial goals.

Finally, another reason for the delay in growth is found in an inability of the entrepreneur to change their behavioral and decision-making pattern from means-driven, non-predictive logic of entrepreneurial reasoning to more professional, goal-driven causal logic (Sarasvathy, 2001; Mintzberg, 1973). Studies often argue on the superiority of one logic over another. Some argue that the two logics co-exist and both add certain value despite a tension between them (Galkina et al., 2021). Our findings confirm the opinion that both logics are useful but at different stages of entrepreneurial growth. At later stages, new resources and stakeholders come on board, start-ups are expected to have more causal decision-making (Read & Sarasvathy, 2005; Sarasvathy & Dew, 2005; Mintzberg, 1973).

Thus, our study shows some unresolved tensions which delay the growth of the studied start-up. The tensions are unresolved for two reasons. Most of them are not perceived by the entrepreneurs, while others are due to the lack of resources. Galkina et al. (2021) argue that the inevitable tensions at the early stages of a nascent venture need to be solved at all levels in order to achieve growth. For them, if a venture solves the tensions with external stakeholders but neglects them internally, the development of the venture will be short term. Tensions at the level of individual decision-making or between founding members "may lead to poor results no matter how well the tensions are resolved among multiple founding entrepreneurs. Also, if the founding entrepreneurs effectively reconcile given knowledge with leveraging the unexpected, but fail to harmonize goal-setting and acting upon the means at hand, the full synergy

will not be attained" (Galika et al., p.21). For the authors, the long-term solution is to achieve a synergy between different tensions at different levels.

Thus, our case study shows that the international commercialization stage is delayed because of a constant trade-off between personal achievement (namely with primary employment), resource collection, the need to maintain control of the invention, and the inability to change logic undermining the entrepreneurial actions. This situation creates tensions between different types of resources (Stayton & Mangematin, 2016).

Based on our findings, we believe that temporal pressure can take different forms. A few occasions when Technogreen achieved an interesting breakthrough in the commercialization process happened when the co-founders were held accountable to report on the progress of their activities (namely, to report back to the funding state agency). The most significant business decision was also made under certain pressure. For example, during the collaboration with the business consultants, the entrepreneurs felt pressure to advance on the important business decision on the future of the start-up as they feared that the current partnership was leading towards revealing the invention to external parties. This pressure motivated the entrepreneurs to advance on their own and had a very useful outcome. It made clear that it would be very hard to enter as an independent competitor to the global market. Also, the international patent could not protect the technology from being reproduced by future partners, as using the technology would require diffusing the invention. Thus, the only optimal solution would be to enter the market as a service provider for existing oil spill cleaning companies.

That is why we argue that temporal pressure can be replaced by a sense of accountability and even without financial accountability, entrepreneurs may find motivation from other sources of pressure, such as personal achievement, socioemotional wealth (SEW), and seeking feedback for personal investment of time, money and energy.

Growth stages are unique configurations of a number of dimensions, and the literature suggests that there is an important (linear) relationship between these dimensions. Changes in one can cause a change in others. We argue that these relationships need to be viewed more like circular or triangle processes than like linear connections, where pressure to achieve results and the ability to adopt the appropriate behavioral and decision-making logic define the nature of the relationship between other dimensions. If there is no sense of pressure, even if the necessary managerial skills are present, the passage to the next growth stage will be delayed or will be more costly. Likewise, even under pressure, without changes in behavioral and decision-making patterns, growth can be delayed. Thus, pressure and the need to change behavioral and decision-making logic, can be seen as powerful motivational tools.

As with all studies, there are certain limitations. Since we adopted a single-case study methodology, our results are limited in scope. Whether our results and conjectures apply to invention-based start-ups is a question future research needs to address. More explanatory but comparative studies could confirm the findings of this research.

Contributor roles

All authors have contributed in multiple roles. Additionally, the corresponding author wrote the original draft and took the role of observant participant.

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