HOW ENTREPRENEURS MANAGE COLLECTIVE UNCERTAINTIES IN THE INNOVATION ECOSYSTEM

Leonardo Augusto de Vasconcelos Gomes[a*], Mario Sergio Salerno[a], Robert Phaal[b], David R. Probert[b]

WORKING PAPER EPUSP-PRO-LGI 001/2016

DOI 10.13140/RG.2.2.31815.91044

August 2016

[a] University of São Paulo, Polytechnic School, Production Engineering Department, Innovation Management Laboratory, Av.Prof.Almeida Prado, travessa 2, n.128, 05508-070 São Paulo, SP, Brazil.

[b] Department of Engineering, University of Cambridge, Mill Lane, Cambridge, CB2 1RX, UK

How entrepreneurs manage collective uncertainties in the innovation ecosystem

Leonardo Augusto de Vasconcelos Gomes[a*], Mario Sergio Salerno[a], Robert Phaal[b], David R. Probert[b]

[a] University of São Paulo, Polytechnic School, Production Engineering Department, Innovation Management Laboratory, Av.Prof.Almeida Prado, travessa 2, n.128, 05508-070 São Paulo,SP, Brazil.

[b] Department of Engineering, University of Cambridge, Mill Lane, Cambridge, CB2 1RX, UK

*Corresponding author: lavgomes@usp.br

Abstract

This paper argues that an entrepreneurial innovation ecosystem may be described as a network of individual uncertainties (i.e. uncertainties that affect a specific actor) and collective uncertainties (i.e. uncertainties that affect a group of actors). We examine the role of entrepreneurs in managing and coping with individual and collective uncertainties at the ecosystem level in new markets through an inductive, longitudinal study of six entrepreneurial ecosystems. Our central contribution is a framework that describes how entrepreneurs may proactively manage collective uncertainties using two processes: bridging uncertainties and mitigating uncertainty propagation effects. We suggest that, if managed properly, uncertainty could become a value source and a competitive advantage for entrepreneurial firms and ecosystems. Overall, we develop a holistic view of uncertainty and adopt a subjective approach to offer insights into uncertainty management at the ecosystem level. Our paper contributes to the reinvigoration of the study of uncertainty and strategic management in new firms.

Keywords: uncertainty management, entrepreneurial ecosystem, planning, startups

1. Introduction

Uncertainty has been regarded as the most important challenge faced by entrepreneurs and managers for centuries (Chawla et al., 2012). In the entrepreneurship field, uncertainty has been given center stage (McKelvie et al., 2011), and has constituted a "conceptual cornerstone in most theories of the entrepreneur" (McMullen and Shepherd, 2006). Knight (1921), one of the pioneers in recognizing the importance of this concept, described entrepreneurs as economic actors who earn profits from bearing uncertainty. Since Knight's works, numerous scholars have acknowledged the key role that uncertainty plays in entrepreneurship, exploring the relationship between uncertainty and a wide variety of antecedents and consequences of entrepreneurial activities. Studies have covered a vast agenda of subjects, such as the impact of environmental hostility on corporate entrepreneurship and firm performance (Zahara and Garvis, 2000); the role of technological uncertainty in technological partnership (Steensma et al., 2000), the entrepreneurial willingness to act and uncertain environments (Bhide, 1999), the use of contingency managerial approaches for uncertainty management (Pich et al., 2002), entrepreneurial behavior and actions when the conditions are uncertain (Saravasthy, 2001), the impact of environmental dynamism on the

relationship between entrepreneurial leadership and new venture performance (Ensley et al., 2006), the relationship between strategic choice under uncertainty and entrepreneurial performance (Loch et al., 2008), the relationship between different types of uncertainty and the willingness to act (Mckelvie et al., 2011), and the risk interdependence in corporate ecosystems (Adner, 2012) .

These studies reveal that the notion of uncertainty appears prominently in the entrepreneurship and managerial fields. However, different authors have adopted competing and often disparate conceptualizations of uncertainty. Some researchers consider uncertainty as the "inability to assign probabilities as to the likelihood of future events" (e.g. Duncan, 1972), while others define uncertainty as "the inability to recognize the relevant influence variables and their functional relationships" (e.g. Sommer and Loch, 2004). Mckelvie et al. (2011) suggested that these definitions of uncertainty are generally positioned within a context and there tends to be both theoretical and empirical ambiguity as to the impact of uncertainty on action. In in addition, they argue that "this ambiguity around entrepreneurship is the fact that practitioners and scholars often describe entrepreneurial environments as risky, ambiguous, dynamic, and turbulent and often imply that these terms are synonymous with uncertainty".

These misconceptions have resulted in inconclusive and contradictory empirical results. Take for example the debate around the importance of planning activities for entrepreneurial firm performance. Historically, this debate has been developing on two fronts. On one hand, some authors have argued that planning activities in uncertainty environments may produce non-desirable or insignificant impacts on firm performance (Mintzberg, 1994; Wiltbank et al., 2006). In such contexts, they argue, entrepreneurs should not spend their scarce resources, including time and financial, to conceive plans; instead, they should concentrate on action, improving firm's capabilities, and so on. In contrast, other authors have suggested that planning is important to clarify concepts, identify lack of information and knowledge gaps, and eliminate uncertainties (Brinckmann et al., 2010; Delmar and Shane, 2003). Nevertheless, in both cases the uncertainty construct is not examined in detail; it tends to be broad, unclear and in some cases ambiguous. Consequently, academics have not been able to offer decisive insights into how entrepreneurs cope with uncertainties and have failed to build robust theories and propose toolsets to support the entrepreneurial activity. Chawla et al. (2012) argue that "fundamental epistemological mistakes concerning uncertainties compromise an organization's ability to adapt and survive when environmental turbulence exceeds certain threshold levels".

Another point that has been criticized by some scholars is the narrow focus often adopted by entrepreneurship studies with regard to uncertainty. Firstly, theoretical research has primarily focused on the influences of risk-taking, while less attention has been devoted to the role of uncertainty (Alvarez, 2007). According to some authors, entrepreneurs are mainly faced with uncertainty (not measurable) rather than risk (understood as measurable uncertainty) (e.g. Knight, 1921; Dew et al., 2009). Secondly, Trigeorgis (1996) suggests that some authors have been biased in that they only consider the negative side of uncertainty. In other words, they have largely ignored that uncertainties could also be associated with opportunities (McGrath and MacMillan, 2000) and that they could also be a source of value for innovation projects (Huchzermeier and Loch, 2001).

Moreover, scholars have mainly focused on the firm level, overlooking the fact that entrepreneurs are part of a system (e.g. value-chain). Indeed, entrepreneurs typically face the challenge of creating and managing an ecosystem in order to develop and diffuse innovations in the market. In addition, current approaches for uncertainty management tend to focus on the project and firm levels (e.g. Rice et al., 2008; Loch et al., 2008; Mcgrath and Macmillan, 1995), paying less attention to the role of collective strategies to cope with uncertainties. Some authors have argued that using collective perspectives could provide a better understanding about the creation and capture of value in ecosystems (e.g. Adner and Kapoor 2010). Hence, Marino et al., (2010) have pointed out that the relationship between the performance of the entrepreneurial firm and the environment remains an important research gap for the entrepreneurship field.

This paper seeks to address these gaps by focusing on the role of entrepreneurs in managing and coping with uncertainties at the ecosystem level. We employ a mix of methodological strategies, including literature review and inductive longitudinal case studies in six new entrepreneurial ecosystems. Our inquiry focuses on the initials phases of the entrepreneurial firm, ecosystems and their markets; we seek to explore cases in which entrepreneurs are facing the challenge of developing and delivering various innovations at early stages of the market. Our theoretical framework considers that uncertainty is a construct that can be understood across multiple dimensions: degrees, types, areas, behaviors, and extensions, relationships with value, paradigms, and nature. Managerial approaches for uncertainty have considered one or a combination of these dimensions, but not all simultaneously. We argue that the uncertainty management field has largely adopted a positivist approach to uncertainty, failing to uncover some challenges that entrepreneurs face in practice. Positivist approaches to uncertainty might be adequate for physical and natural systems, while subjective ones are useful for the analysis of social systems (involving human action).

2. The construct of uncertainty

2.1. Overview

The construct of uncertainty has a rich and vast history in the economics, sociological and managerial fields. The way that the researches across different disciplines have understood and used it has evolved over time (Chawla et al., 2012). However, extant conceptualizations of uncertainty commonly tend to be broad and in some cases biased, failing to distinguish between the different dimensions involved in a comprehensive characterization of uncertainty. Take for example the table 1, which illustrates the richness of taxonomies related to the concept as well as a lack of consensus among the researchers.

2.2. Approaches to uncertainty

A theoretical formulation widely accepted by scholars across different domains of knowledge (e.g. Saravasthy, 2001; Loch et al., 2008) is that uncertainty is different from risk. Knight (1921) points

out that risk implies probabilities of future outcomes that are "knowable", whereas uncertainty implies that they are "unknowable". As useful as the concept of probability as differentiation criterion might be, a variety of approaches to it (and discrepancies among them) can be observed in the literature (Dequect, 2004). In this way, Von Mises (1963) and Chawla et al. (2012) suggested a distinction between class probabilities and case probabilities. Class probabilities are instances of probability, typically employed in the natural sciences, where we have sufficient information about the class of events or phenomena of interest (historical data), and we allow generalizing to singular events that we know fit in a specific class (Chawla et al., 2012). While case probabilities refer to phenomena involving humans, which may or not be reducible to particular classes and should be treated as unique happenings (Chawla et al., 2012). In addition, Chawla et al. argue that positivist management is associated to class probabilities while subjective approaches are related to case probabilities. Positivist management, dependent on historical data is bound to fail in many cases, as historical data about economic and social events are an example of case not class probability: they can tell us the past, not the future (Von Mises, 1963; Taleb, 2007). Conversely, a subjective approach to management involves making sense from historic events and creating a meaningful future.

For the purposes of this paper, we consider that the uncertainty is different from risk in social situations, and we clearly adopt a subjective and interpretative approach. Therefore, we use the concept of case probabilities for distinguishing between risk and uncertainty. We also consider that social actors, such as entrepreneurs, might not be able to differentiate in the real world whether their decisions are affected by risk or uncertainty. In doing so, we attempt to shed light on aspects that have been ignored by scholars in investigating how entrepreneurs manage uncertainties in practice.

However, as table 1 shows, the uncertainty construct is not confined to degree (differences between risk and uncertainty); it contains other dimensions. In the next sections, we explore other dimensions of uncertainty.

2.3. Types of uncertainty

According to Loch et al.(2008), risk is the simplest manifestation and lowest degree of uncertainty. However, Dequect (2006) explains that the literature distinguishes not only between degrees but also between types of uncertainty. Dosi and Egidi (1991) propose a distinction between substantive and procedural uncertainty. Substantive uncertainty corresponds to "the lack of all the information which would be necessary to make decisions with certain outcomes"; on the other hand, procedural uncertainty emerges from "limitations on the computational and cognitive capabilities of the agents to pursue unambiguously their objectives, given the available information" (p. 145). Dequech (1997) suggests the concept of strong uncertainty, which, in contrast to Knight's risk, is "characterized by the absence of unique, additive and fully reliable probability distributions". Dequech (2000) offers a clearer definition for ambiguity and fundamental uncertainty. According to him, ambiguity concerns the uncertainty about probability, "created by missing information that is relevant and could be known" (Dequech, 2000). In contrast, fundamental uncertainty is characterized by "the possibility of creativity and non-predetermined structural change". The list of

possible events is not predetermined or "knowable ex ante, as the future is yet to be created" (Dequect, 2000).

Milliken (1987) argues that the construct of uncertainty "has generally yielded inconsistent and difficult to interpret results due to poor reliability and validity of measurement instruments" (Milliken, 1987). Consequently, research on entrepreneurship has largely provided inconclusive, limited and often contradictory empirical results. Milliken (1987) and Mckelvie et al., (2011) distinguishes between three types of uncertainty at the level of the decision maker: state uncertainty, effect uncertainty, and response uncertainty. State uncertainty refers to uncertainty about the external environment caused by an individual's inability to "predict how environmental components are changing" (Mckelvie et al., 2011). Effect uncertainty relates to an individual's inability to predict how changes in the environment will impact a firm (Mckelvie et al., 2011). And response uncertainty refers to uncertainty caused by an individual's lack of "insight into response options given a changing environment and his/her inability to predict the likely consequences of a response choice" (Mckelvie et al., 2011). While Milliken's and Mckelvie et al.'s (2011) works represent an important advance in terms of building a construct of uncertainty, their definitions are focused on the firm's external environment rather than the internal aspects of the firm or innovation project (e.g. the choice between different technology options). Therefore, these conceptualizations do not capture another important feature of uncertainty: its emergence, in different types and degrees, throughout the life-cycle of a project or a firm.

To complement the above definitions, we refer to Sommer and Loch's (2004) works. They define unforeseeable uncertainty as an individual's inability to map in advance all variables that impact on project performance and their function relationships. Theses authors propose that unforeseeable uncertainties do not allow entrepreneurs to plan ahead. Although Sommer and Loch (2004) are not explicit as to whether unforeseeable uncertainty refers to state, effect or response, they bring uncertainty at the innovation project level and they recognize that uncertainties might emerge during the life-cycle of an innovation project.

This paper aims to make a contribution by building on, and combing, different perspectives of uncertainty. We consider that effect uncertainty also concerns an individual's inability to predict how certain variables (e.g. the current performance of the technology or the product features) of an innovation project may impact the ecosystem, the firm and the innovation itself. Secondly, we argue that response uncertainty is also caused by an individual's lack of insight options given changing project features and his/her inability to predict the consequence of his response or other actors situated in same context. Thirdly, we consider the emergence of uncertainty thorough an innovation project lifecycle. Finally, we adopt Dosi and Egidi's (1991) types of uncertainty, because it offers important insights into how different actors are affected by uncertainties at ecosystem level.

2.5. Origin and extension

Dixit and Pindyck (1994) point out that the origin or source of uncertainty could be endogenous or exogenous, i.e. its origin may be found either inside of the firm or in its environment. Moreover, uncertainty also has an extension, i.e., a particular uncertainty may affect different actors in

ecosystem. Both building blocks provide an important complement to types and degrees of uncertainty.

2.6. Management approaches

Historically, two managerial approaches have been proposed to managing and coping with uncertainty at the project and firm levels. The first approach consists of adopting a flexible style to plan and cope with changes (Wernerfelt and Karnami, 1987). The second one refers to pursuing several options in parallel (Sommer and Loch, 2004). Pich et al., (2002) argue that both approaches can be considered as types of contingency approaches to project management as neither of them is based on rigid planning. In addition, Sommer et al. (2008) demonstrate with empirical data that firms had better performance when adopting both approaches in uncertainty contexts.

Some authors have developed classifications suggesting that certain tools or frameworks are more adequate to high uncertainty contexts. For example, Rice et al. (2008) suggested that certain approaches such as the stage-system (Cooper, 1994) or milestones (Block and MacMillan, 1985) are recommended for projects with low-level of uncertainty (risk), while other approaches are adequate for projects with higher level of uncertainty, such as discovery-driven planning (e.g. Mcgrath and MacMillan, 1995), and, most of all, they propose the learning plan to cope with the highest level of uncertainty. However, these authors are not explicit as to which uncertainty approach (positivism or interpretative) they employ. They fail to recognize that entrepreneurs may not be able to distinguish whether they face risk or uncertainty conditions. Consequently, they do not give indications about what the most appropriated tools for entrepreneurs might be.

And finally, an important limitation of these studies is their narrow focus on firm and project level, largely ignoring that entrepreneurs are part of an ecosystem.

2.7. Relationship with value creation and value capture

Traditionally, uncertainty has been associated decreasing of value. Scholars have mostly focused on response to uncertainty (e.g. Teece 2007; Thompson, 1967). Few studies have recognized that uncertainty might also be associated to opportunities (e.g. Mcgrath and MacMillan, 1990).

Real thinking authors suggest that methods of project evaluation, such as Net Present Value (NVP) capture the negative nature of uncertainty, leading to decrease of the project's value (Mcgrath, 1999). In contrast, these authors argue that uncertainties might provide managerial flexibility, enhancing the value of project as whole (e.g. (Huchzermeier and Loch, 2001).

In the entrepreneurship field, Saravasthy (2001) puts emphasis on the idea that entrepreneurs are better able to navigate in uncertainty environments than other economic actors. This argument is widely accepted and it has built on the idea that entrepreneurs have low risk aversion (Bhide, 1999).

Even those studies that consider uncertainty as a potential source of opportunities present limited explanations about how uncertainty might enhance value, which kind of value and when this might happen. McKelvie et al. (2011) suggest these statements could be not true for every type of

uncertainty in all contexts. These scholars found that entrepreneurs have high wiliness to act when they are under state uncertainties, but this wiliness tends to decrease on the presence of other types of uncertainties (e.g. response and effect). Mainly, when entrepreneurs are not able to judge the effect of their actions (Mckelvie et al., 2011).

3.0 Research methodology

Building theory from case studies is a research strategy that involves using one or more cases to build theoretical constructs, propositions and theory from empirical evidences (Eisenhardt and Graebner, 2007; Eisenhardt, 1989). This paper adopts this strategy in order to understand how entrepreneurs manage uncertainties in the level of ecosystems. The case study approach used is predominantly inductive, since the main goal is to produce a new theory from empirical data.

The initial phase of research was the development of a more comprehensive framework for uncertainty and more suited for social situations. Our framework considers that uncertainty is a multidimensional construct, and may involve, step, type, extent, area and managerial approach. This framework is presented in Table 2. To operationalize the concept of ecosystems, we adopt the approach developed by Li and Garnsey (2011), which considers the ecosystem taken as the context in which the entrepreneur creates and captures value. According to the author, it consists of complementary innovators, suppliers, customers and other partners.

In all cases, we adopt a longitudinal approach, conducting interviews and other approaches to data collection at different times of development of the firm and its ecosystem (see table 2). The process of scientific research has followed a similar pattern in all cases. First, it developed a plan, including a script for the semi-structured interviews and for the implementation of the cases. The script was based on the literature review and preliminary case studies. This script was tested in two pilot cases. This pilot phase has improved the research protocols, which culminated in the drafting of a guide as they should be carried out case studies. The unit of analysis was defined as "decisions" and "the consequences of each decision," both related to the development of the firm, the innovation proposed by the firm, and the ecosystem. In each case, the first interview, conducted with entrepreneurs, aimed to understand the relationship between innovation, the firm and the ecosystem. It also allowed us to identify the critical uncertainties and design a network of relationships among these uncertainties. The subsequent interviews involving other partners in the venture and sought to improve the network of uncertainties, including how it has developed and how the uncertainties were being resolved collectively and individually. To complement the information collected, we made use of a series of documents such as business plans, technical reports, roadmaps, and websites.

4.0. Results

From our case studies, we identify two different perceptions about the effect of uncertainties upon the firm and ecosystem trajectories. First, some entrepreneurs were disappointed with firm progress and the value delivered by the ecosystem, even though they had favorable initials conditions in

terms of resources, including financial and technology. For example in the bio plastic ecosystem, the entrepreneur manifested that the actors in the ecosystem was not able to address the challenges imposed by marketing and technological uncertainties appropriately. According to him, the ecosystem could not explore the different available options and failed to create a favorable space for learning: "an increased environment of misconceptions about the market needs and technology progress, and distrust feelings contaminated the individual's plans and actions. Even though actors were able to solve some individual uncertainties, the ecosystem could not benefit from individual learning". In contrast, entrepreneurs, even if they had scarce of resources at the beginning, argued the ecosystem created was able to properly address managerial responses to many challenges. In both cases, the uncertainties may have shaped the way that entrepreneurs create, develop and manage the entrepreneurial ecosystem. The difference between them is how they manage the collective uncertainty.

We identified two distinct patterns that may be described as processes and could offer insights into how entrepreneurs strategically manage uncertainties at the ecosystem level. The first process, called by "bridging uncertainties", occurs when entrepreneurs connect individual and collective uncertainties that affecting different actors in the ecosystem in order to mitigate these uncertainties or/and create and capture value from solving uncertainties. Complementarily, we associated the "bridging uncertainties" with the situation in which entrepreneurs connect different actions in order to solve collective uncertainties. Analyzing our empirical data, we draw upon a set of steps that describe how entrepreneurs bridge uncertainties.

The second process consists of mitigating or amplifying the effects of a phenomenon identified in our cases: the propagation of uncertainties. This phenomenon occurs when an uncertainty propagates throughout of an ecosystem. We identify different causes, patterns of propagations, effects and strategies adopted by entrepreneurs in order to avoid or intensify this phenomenon. In the following sections, we describe each process as well as provide the idea, concepts, building blocks and sources of evidence for both processes. The way that entrepreneurs manage both processes may have important impacts on the firm and ecosystem performance.

4.1. Bridging uncertainties

We argue that an entrepreneurial ecosystem may be described as a network of uncertainties affecting individuals and groups. This network may be more complex according to the type and nature of the innovation as well as the extension of ecosystem. For example in the algae biofuel case, the entrepreneur faced the challenge of coordinating innovations in different domains of this emergent value-chain: algae feature selection (which involves genetic and biochemical manipulation); algae production method in farms; equipment and other products for algae production; equipment for converting algae in biofuel; market infrastructure, etc. Thus, the entrepreneur faced the challenge of managing and coping with complex networks of uncertainties in different dimensions such as areas, types, degrees, and extension. An important role of entrepreneurs in this ecosystem was to navigate in this network of uncertainties, connect these uncertainties and developing strategies in order to mitigate and capture value from them. Figure 1 represents an ecosystem of uncertainty affecting individuals and groups. This picture emphasizes

that uncertainties are related to each other and may shape the development of the entrepreneurial firm and the ecosystem.

We refer to this process of connecting uncertainties in order to mitigate them, thereby capturing value from them (and building a desirable future), as “bridging uncertainties”. We use additional insights from the algae biofuel case to illustrate this process. To develop a specific equipment to convert algae into a special kind of gas, the entrepreneur had to coordinate seven different actors, with different views and understandings about the technology readiness level (state uncertainty) and equipment features (response uncertainty). These different understandings caused non-desirable initial reactions such as low willingness to act by some actors; isolated learning experiments; and misconceptions about the technology. Consequently, these results caused an increasing feeling of disappointment among some actors about the capacity of the ecosystem for creating and delivering value. In order to accelerate the development of this specific equipment, the entrepreneur undertook initiatives to bridge the uncertainties among these different actors by promoting dialogue and information sharing, and collective experimentations. These initiatives help them align their different market and technology understanding, and to share learning. This bridging also allowed the actors to elaborate more accurate plans regarding the technology evolution and improved the understanding about the different options for this evolution.

As this network of uncertainties affecting individuals and group of actors co-evolves, the entrepreneur needs to take different types of actions for “bridging uncertainties”. This means that the stages of development of the firm, ecosystem, technology trajectory and market needs shape the way in which entrepreneurs bridge uncertainties.

From the case above, it is possible to identify that the first step in the process of bridging uncertainties is projecting the future and sense making of actions. These, in turn, involves: understanding the extent of each uncertainty; building a network of allies; conducting experimentations to solve uncertainties; creating intermediate objects between different loops in the process of bridging uncertainties in order to earn benefits from solving uncertainties; developing ways to capture value from these objects. Figure 2 shows this the main steps of what we call the bridging uncertainties loop.

Starting point of bridging: projecting the future and making sense of actions

Investigating the entrepreneurial actions in six cases, we perceive that starting points of bridging uncertainties may be projecting a desirable future and sensemaking of uncertainties.

In the early stage of a firm and an ecosystem or transitions moments (gates), entrepreneurs project the future need clearer definition of desirable and incomplete goals from their own resources and a particular known reality. The uncertainties are related in different ways to this projected future. The projected future means the “questions” or “challenges” existing in a certain context, such as market or industry, in which established firms ignore or are not encouraged to respond (response uncertainty). Uncertainties might also emerge as lack of knowledge about how to build this projected future. In all cases investigated, as the entrepreneur as to be able to build this particular

vision of future or fill all knowledge gaps alone he needed to shape the preferences and beliefs of other actors and persuade them to invest in this future configuration. These acts of persuading and convincing involve to sharing uncertainties among these actors as well as to understand which uncertainties may be shaping their decisions about the allocation of resources. Connecting entrepreneurial firm's uncertainties and other ecosystem's actors' uncertainties to build a desirable future seems to be associated with initials stages of the innovation process or stage gate points such as prototypes of technology and products, and different generations of product.

The second reason for bridging uncertainties comes from a sensemaking process of which uncertainties may be shaping some actions and behaviors of ecosystem's actors. Literatrure offers different definitions of sensemaking process. We consider sensemaking as "the ongoing retrospective development of plausible images that rationalize what people are doing" (Weick, Sutcliffe and Obstfeld, 2005). Here, the aim could be mainly associated with solving some specific problem or bottlenecks. In the social network ecosystem, the entrepreneur did not fully understand the reason in which complementary innovators and customer did not embrace the technology proposed. Thus, the entrepreneur undertook a sensemaking process in order to understand which uncertainties were shaping their views and decision processes. However identified these uncertainties, the entrepreneurs connected them and coordinate a series of actions to improve the acceptance of the technology. This second pattern or type of bridging appeared in later moments of entrepreneurial ecosystem development.

Finally, new emergent uncertainties, such as new information about customer change and an action of competitor, could start the process of bridging uncertainties.

The extent of uncertainties: understanding their boundaries

After projecting the future and sensemaking of uncertainties, entrepreneurs are faced with the challenge of understanding the extent of the uncertainty and how they may be connected.

The algae ecosystem may offer some insights into the first point. The entrepreneurial firm had coordinated the development of the value-chain from the raw-materials to the market infra-structure. Instead of following a sequential and linear way, entrepreneurs and other actors undertook a parallel approach to address the uncertainties. This approach was employed in both directions of the value-chains – upstream and downstream. For example, the features of algae (e.g. specie, life-cycle, and resistance) affect the production of algae (downstream) as well as the equipment to convert algae in biofuel or biogas. The firms in both parts of value-chains were under state uncertainty about the future of algae development. Similarly, firms were not able to predict the effect of their investments (response uncertainty). Consequently, the firms adopted different strategic behaviors, such as waiting for the best moment to invest or conducting different approaches in parallel. Recognizing that there was a network of uncertainties affecting different firms, the entrepreneurial firm, concerned to develop the genetic characteristics of algae, decided to sensemaking of uncertainties, answering: a) Which uncertainties do firms face? b) What is the extent of each uncertainty?

Answering these questions allowed the entrepreneur to draw the space of uncertainty by understanding which actors are affected by uncertainties. The next challenge was related to how to connect these uncertainties affecting different actors, how to share them, and how to address a proper managerial approach.

Space of solution: building a network of allies

Building on the understanding of the uncertainty extension, the next step emerged from empirical cases is creating a network of allies to address these uncertainties. Network of allies means a group of actors dedicated to solve a particular uncertainty or set of them affecting a number of actors in the ecosystem.

Entrepreneurs develop different strategies to connect different actors. For example, dengue treatment, the entrepreneur sought to show that the individuals' uncertainties had a collective dimension, mutually affecting different actors. For that, the entrepreneur organized workshops involving the government, suppliers and customers. After these workshops, the actors were able to visualize the network of uncertainties and enforce the ties to address each uncertainty. Thus, these ties did not only concern social relationship but they also included as well: informal and formal partnerships (contracts), projects, and joint ventures. Table 3 offers some examples of how firms in case studies building a network of allies.

Defining a proper strategic action and managerial approach

After drawing the space of uncertainty and the space of solution, the following step adopted by entrepreneurs was to define a suitable managerial approach for each uncertainty. Our cases reveal that these approaches are not restricted to adopting learning by trial-and-error or selectionism approaches as proposed by Pich et al. (2002). We also identify three complementary approaches employed by entrepreneurs. These approaches may be changed according to the type of uncertainty and which may shape the way in which learning by trial-and-error and selectionism are undertaken by the firms at the ecosystem level.

The first approach consists of building a common template. As we present earled, in the social network ecosystem, the firms were hesitant to adopt a certain technology. The firms were not able to predict which technology would be the dominant design in this industry. Similarly, they had different predictions about technology trajectory and these predictions produced a significant and non-desirable set of results. In order to align these actors, the entrepreneur built a series of stories to explain what the technology is and how it will look like. These stories are transmitted by business plans, technology roadmaps, presentations and workshops.

Building a common template was also employed for coping with response uncertainty. In the bio plastics case, the firms had different visions about the market needs. Again, these distinct forecasts led to a variety of behaviors, including betting in opposing value propositions in relation to the ecosystem's bet. To allow the firms to keep investing resources into entrepreneurial value proposition and decrease the search of space for addressing this uncertainty, the entrepreneur organized a series of workshops with the ecosystem patterns. In this workshop, the entrepreneur

emphasized how the market will look like and which directions the ecosystem should allocate their resources.

Building a common template could offer an explanation for why entrepreneurs are more able to navigate under state uncertainty than established firms. It is important to note that the template may evolve from schemes and plans to habits, routine, and, eventually, capabilities. The common template is also associated with procedural uncertainties. And the content of common template could be strategic and business information.

The second managerial approach, building communications platforms, is related to response and effect uncertainties. In the algae ecosystem, the firms created an online platform to share and integrate the evolution of experiments in development of key-technology. Firms were able to simulate in real-time the consequences of these decisions and collectively draw new strategies for following steps. We observed the same approach in the social network ecosystem in which the firms employed blogs and online communities to share knowledge and improve the capacity of actors in evaluating the effect of theirs decisions on ecosystem.

Finally, we identify that the entrepreneurs conducted learning experiments, involving different actors in order to address specific uncertainties. An experiment might be a project or a workshop and it may include trying different options in parallel in order to select the ones worked better or experiment into a specific option.

An important strategic action associated to learning experiments consists of organizing events to present concept proofs. These events are organized to reduce collective uncertainties.

Creating intermediate artifacts to capture value from uncertainty

In our case studies, entrepreneurs and firms tended to be engaged in solving some specific uncertainties when they were able to envision and design ways to create and capture value from uncertainty solving. We identify a list of different artifacts, each type of which can be associated to a particular kind of value from uncertainty. We call these artifacts as intermediate artifacts because they represent a part of value created in given bridging uncertainty loop.

In early stages of the entrepreneurial ecosystem, the most traditional outcomes of bridging uncertainties are proof of concepts, patents and prototypes. Later, the artifacts tend to be final products, reports, production procedures, so on. These objects may be commercialized, allowing the entrepreneur and other actors to capture the value from uncertainty solving. Other objects, largely ignored by literature that could be developed in order to capture the other types of value associated with solving uncertainties include reports, books and tools that summarize the learning obtained. These objects may allow entrepreneurs and other ecosystem actors to have a clearer understanding about the future (e.g. market needs and technological trajectory) and conceive more accurate plans.

Trajectories of bridging uncertainties

We observed that entrepreneurs execute several bridging uncertainty loops in order to answer current and emergent uncertainties. Overall, these various loops may describe a trajectory of the ecosystem and entrepreneurial firm across different generations of technologies and products. Thus, these loops could offer insights into how a small market and technology niche co-evolves, from a small group of actors with weak ties to a mature value-chain, with an established market and technology infra-structures, and stable institutions (e.g. market needs). It is also important to recognize that bridging uncertainty loops may present different characteristics according to the stage of development of the ecosystem.

In the early stages of ecosystems, the entrepreneurs may project the firm and ecosystem future with different, sometimes contradictory, value propositions. In the bio plastic case, this meant that the entrepreneur bridged uncertainties in different market niche opportunities. A similar process could be identified in the network ecosystem, in which the entrepreneur placed bets on different market opportunities in an *ex post* decision process. As a specific bridging uncertainty option started to provide more interesting intermediate objects or positive feedbacks, the entrepreneurs were able to focus these efforts on a specific direction.

Another aspect detected in the phase of ecosystem development is that the lack of legitimacy and credibility of the entrepreneur could impact on the effect of bridging complementary bridging loop.. This is associated to the resistance of the actors to become allies of ecosystem's organizations or accept the entrepreneurial template. In the dengue treatment ecosystem, the entrepreneur spent a considerable amount of resources to convince universities and influential scientists to support his value proposition. The entrepreneur use these formal and informal supports to legitimacy his template.

In later phases of the ecosystem evolution, the need for bridging uncertainties decreased for several reasons. First and most expected, the number of uncertainties tends to decrease according to the progress of innovation. Second, as the market and technology templates become accepted by ecosystems actors, the need and possibility of projecting a desirable future in a different way tend to decrease as well: it is developed a kind of "path dependency". The function of the template suffers a subtle alteration. It serves more to help predicting the future than creating it. We further discuss this point in the implications for theory and practice section.

5.0. Uncertainty propagation

Empirical evidence identified in our cases studies suggests that uncertainty may "propagate" throughout an ecosystem. Analyzing uncertainties present in the portfolio of decisions of different actors in one ecosystem and conducting cross analysis in different ecosystems, we identify this set of important observations which help to understand the ecosystem development:

1) **Similar uncertainties (type, and area) appeared in the decision portfolio of different actors in a particular ecosystem**. For example, in the diabetes treatment case, the entrepreneurs

and other firms developed a variety of strategies to cope with a regulatory uncertainty. Table 5 shows the number of decisions involved in similar uncertainties present in each ecosystem;

2) **The number of uncertainties (types and areas) increased in particular moments of the ecosystem trajectory**. In some cases, a particular uncertainty had an initial locus (an actor) and, then, different actors faced decisions associated with this particular uncertainty;

3) **An action or behavior of one actor could not be fully understood by other actors** and it became an uncertainty for them. Consequently, they **developed strategies** to cope with this uncertainty;

4) **The actors in ecosystems had different knowledge basis about technologies and markets**. Propagation of knowledge is notably recognized by several authors. However, authors have not paid attention that the knowledge propagates in a non-equal way, causing important lacks of knowledge (a type of uncertainty). The **asymmetric** distribution **of knowledge** was a powerful **source of uncertainty**. The heterogeneous individual knowledge base led to a variety of assumptions, which shaped their strategic actions, including the resource allocation.

5) Related to this last point, **when a particular information spreads out an ecosystem, it suffers a process of distortion, caused by different knowledge basis and the fact that actors add assumptions to this particular information**. This distortion may increase some particular types of uncertainties (e.g. response uncertainty or effect uncertainty), making it difficult to predict the future of ecosystem.

The next step was characterizing this set of aspects as meaningful concepts. We sought to relate these aspects to a phenomenon of *propagation of uncertainties*. Traditionally, the concept of propagation is associated with engineering systems. In this field of knowledge, propagation occurs when a particular material or substance propagates in way, through a process in which is possible to identify: the source, the way, the material, the effect, and the trajectory.

Recognizing that there are important differences between an engineering system and a social system, we propose that uncertainty propagation occurs when particular information is perceived as uncertainty (e.g. state uncertainty) or as a source of uncertainty by different actors in an ecosystem. As observed in our case studies, this means that particular information, perceived as uncertainty, is incorporated into the portfolio of decisions of different actors. This information could be an event or problem such as the launch of new product by a competitors, a change in the institutional environment, etc. Finally, we identify that uncertainty propagation has different sources, trajectories and effects (figure 3).

In the following sections, we explore the different patterns of uncertainty propagation its possible effects; while trying to recognize strategies developed by entrepreneurs to cope with this phenomenon.

Patterns of propagation

The first aspect identified is that uncertainty propagation may have different sources and might be associated to different areas, degrees and types of uncertainty.

Source: Environment

As expected, the first source identified was the environment. We consider environment as the context outside an entrepreneurial ecosystem and could be other ecosystems as well as the market, or other industries. In the bio plastics ecosystem, the firms were faced with the uncertainty around "what a green plastic should look like" (state uncertainty); and "what are the product requirements" (response). These uncertainties led to different reactions. A first group of firms conceived that the green plastic would be degradable. The second group of firms invested their resources in the development of plastic using renewable raw-material, replacing the traditional fossil fuel sources. The bio plastic ecosystem investigated belongs to the second group. However, the entrepreneur and his patterns did not have a full understanding about the effects of their response (effect uncertainty).

Source: Inside the ecosystem

The actions of members of the ecosystem could also be a meaningful source of uncertainty. For example, miscommunications or lack of communications may cause propagation of uncertainties among different actors. In the dengue ecosystem, we identify that different firms claimed the absence of a clear official position as to whether the regulatory environment will be favorable to the ecosystem's product (as it involved mosquitoes with genetic modifications). Also in this ecosystem, the firms claimed that the entrepreneur did not share important information about "how he was projecting the evolution of the product and the scale up process". This behavior contributed to raising the state, effect and response uncertainties in different actors of the ecosystem. In the intelligent surfaces ecosystem, a variety of predictions about the initial production announced by the entrepreneur with different patterns increased state and response uncertainties. This resulted in a failure to supply in producing and delivering the product during the scale up process.

Different expectations about particular points may be associated with two important implications for the entrepreneurial ecosystem development: a cause of uncertainty propagation and an effect. The former examples brought a case of distinct interpretations around the end-states of the production scaling up. These different end-state expectations are related to market or technology uncertainties. For example, in the bio plastic ecosystem, the actors had distinct assumptions about the timing of the market (when the market will take of).

Trajectory: Reconfiguring uncertainty

As we stressed in previous sections, uncertainty propagation is related to different types and areas of uncertainty. Uncertainties may recombine with other different uncertainties and assumptions in the sensemaking process. We call this kind of uncertainty propagation as recombinant uncertainty. A recombinant uncertainty makes it difficult for entrepreneurs and other players to draw the track of its propagation.

Effects

Our cases show that uncertainty propagation could be associated with different effects, defined as reactions adopted by actors in order to respond to a specific uncertainty and the consequences of

these reactions. Most obviously, uncertainty propagation increases the number of uncertainties that each actor faces in an ecosystem. As we have argued, unpredictable events come from outside of the ecosystem or unexpected reactions by ecosystem actors may increase the number and intensity of uncertainties. Entrepreneurs and other players of each ecosystem suggested that their initial portfolio of uncertainties increased throughout the ecosystem development. These new uncertainties produced a relevant set of non-desirable results (table 6), namely of the need to re-plan activities; delays; loss of windows of opportunities; increment of costs, including transactions costs (e.g. negotiations); reworks; development of wrong capabilities; misconceptions about the important aspects of innovation (e.g. market focus and market needs); and, in more extreme cases, new uncertainty bridging loops. Less obviously, a specific uncertainty could lead to a variety of reactions in an ecosystem. We identified that certain uncertainties led to a decreased willingness by some actors to act while they were perceived as opportunity by other actors.

Furthermore, a propagation of the uncertainties might affect the value delivered by the ecosystem as whole. In the bio plastic ecosystem, the entrepreneur revealed that he was disappointed with the last three products developed: “the ecosystem was not able to properly address several marketing uncertainties which emerged during the diverse generations of products”. According to him, they received a lot of contradictory and incomplete information about market needs and competitors moves.

“In my view, we were a network of uncertainties producing misconceptions. Each actor had a completely different view about the technology and market. As we were not really integrated, we started to move into a completely different value proposition. We accumulated no useful resources and had more difficulties changing our direction.”

Strategies: mitigating and amplifying uncertainty propagation effects

From our cases, entrepreneurs spent important resources before recognizing that actors in the ecosystem have different knowledge bases and distinct willingness to act under uncertainty. Entrepreneurs tend to focus on their own uncertainties. According to an entrepreneur, “each partner focused on solving his own uncertainties, ignoring his actions could be a powerful source of uncertainty.” We identify that most used mechanism to mitigate uncertainties is “building a common template”.

According to an entrepreneur in the intelligent surface ecosystem, “it is not possible to avoid new uncertainties emerging. Nevertheless, creating the right conditions, we can control the collective reactions”. In addition, this entrepreneur commented on the importance of this template: “we need to know about how the other companies will react to certain events. Notably, it’s impossible to communicate whenever a new event emerges. We need to develop a similar base of knowledge.”

Indeed, the content of this template seems to be crucial to control collective actions. An entrepreneur in the algae ecosystem suggested: “the true uncertainties come from lack of information about how the companies are seeing the future. It’s not enough to open your innovation

process. It's just the first step. It is not only about technology and technical requirements. We ignore that innovation is shaped by business strategy".

Not only is the content of this template important, but also the process of revitalizing it plays an important role. In the diabetes treatment case, the entrepreneur suggested that "plans could be helpful to other actors to respond to certain uncertainties. However, we might run faster to the wrong solution. We need also to understand when it is necessary to be flexible."

Another side of uncertainty could be used as strategic instrument for competition. We identify that entrepreneurs with their allies develop strategies to create uncertainties and propagate them in competitor ecosystems. For example, in the algae ecosystem, the entrepreneur produces a series of reports suggesting that solution pursued by other ecosystem would have a non-desirable environment results."

6.0. Implications for theory, practice and further research

Santos and Eisenhardt (2009) argue that the final step of an inductive methodology is to show how the findings may contribute to the current deductive knowledge body. In this section, we explain how our findings may provide new insights for addressing some specific gaps found in the literature.

Recently, there has been an increased interest in the importance of planning for new venture performance. A number of authors advocate that planning activities have a limited impact on firm performance in uncertain environments (e.g. Mintzberg, 1994; Wiltbank et al., 2006). An influential author in this line of thinking is Savarathy, who proposed a radical approach for entrepreneurs in which they should prioritize action and take the control of critical resources. In highly uncertain environments, Saravasthy argues that entrepreneurs tend to adopt the logic of effectuation in place of the logic of prediction.

Our findings provide an alternative explanation about the relevance of planning activities for entrepreneurs. Planning allows firms to better understand the effect of their actions on other players and vice-versa. As we stressed earlier, entrepreneurs' actions may represent a powerful source of uncertainties, mainly when entrepreneurs do not properly consider the effect of their own actions on the ecosystem. Moreover, planning could help entrepreneurs to make sense of their individual and collective uncertainties, shedding light on which of those uncertainties are shaping the ecosystem development and how to address them. In addition, plans, presentations and roadmaps are important instruments to reduce collective uncertainties, as they help create a common template to guide collective planning and actions.

In the early stages of an ecosystem, common templates may be used as ways to predict the future. Even if entrepreneurs adopt the effectuation logic and decided do not undertake planning activities, their arguments, written down in plans and presentations, are used by actors as ways to predict the future. Their arguments serve as input for forecast exercises and evaluation techniques, these being real options, NET, etc. Later, when the ecosystem accumulates a significant bundle of resources and

capabilities, the entrepreneur's template is gradually replaced by a collective template or technology trajectory, built on past experiences, historical data, and stories of success and failure.

The important of planning for early stages of an entrepreneurial ecosystem is also related to uncertainty management approaches. As we emphasized, entrepreneurs who use learning and selectionism approaches (Pich et al., 2002) in isolation might be increasing uncertainties in the ecosystem, consequently contributing to uncertainty propagation. Stressing this point, approaches for uncertainty management (e.g. Rice et al., 2008) do not either pay attention to collective uncertainties and how uncertainty solving is associated with the creation and capture of value. In addition, these approaches implicitly use a positivist approach for uncertainty management. We suggest an approach built on the idea that uncertainties comes from a sense making process as well as a projecting process. Finally, both process, bridging uncertainties and mitigating and amplifying uncertainty propagation, complement these approaches for uncertainty management.

Building a common template also offers insight into open innovation theory (Chesbrough, 2003) in terms of the degree of openness. As our findings showed, sharing technological information and knowledge could not be enough for the entrepreneurial ecosystem development. Firms have difficulties to share strategic information, related to the way they project or predict the market and business future. This point calls for a more open strategic process, in which the firm tries to build collective strategies to address opportunities and respond to uncertainties. Hence, sharing this level of strategic information may lead the research in entrepreneurship and entrepreneurial ecosystem to try to develop an open approach for strategy.

In addition, our framework offers some insights into the cognitive approach for entrepreneurship. We complement the results of Santos and Eisenhardt (2009), showing an important function of common templates for mitigating collective uncertainties. We also show how this template offers a way to cope with procedural uncertainties and other types of uncertainties. Finally, the evolution of this template is associated with how plans and presentations evolve to habits, routines and capabilities, complementing the approach proposed by Dosi (1982).

Our framework provides a guide for entrepreneurial action, specifically in relationship to the creation and management of an entrepreneurial ecosystem. Bridging uncertainties help entrepreneurs project the future and shape it throughout collective action. This process also provides insights into how entrepreneurs may create and capture value from uncertainty solving. Our framework also sheds light on the phenomenon which we refer to as 'uncertainty propagation', and warns entrepreneurs about how their actions may drive this phenomenon while offering potential mitigation options. Figure 4 summarizes some possible actions to manage uncertainties at the firm and ecosystem levels.

These both processes also offer considerable challenges for entrepreneurs. The first point that emerges from our results is how to conduct collective experiments and how to share success and failures at the collective level. Additionally, building a common template could not only reduce collective uncertainty, but also contribute to increase cognitive rigidity.

Of course, further research is required to better deeply understand bridging uncertainty and managing uncertainty propagation. At least three themes deserve further investigation: how bridging uncertainty shapes new entrepreneurial ecosystem development; how, why and when entrepreneurs try to amplify uncertainty propagation; how these processes are related to competitive advantage at the ecosystem level.

7.0. Acknowledgments

The research was founded by Fapesp; we would like to thank Elizabeth Garnsey for her precious help and patience.

8.0. References

Adner, R., 2012. The wide lens: A new strategy for innovation. Penguin Books, New York.

Adner, R. R., Kapoor, R., 2010. Value creation in innovation ecosystems: how the structure of technological interdependence affects firm performance in new technology generations. Strategic Management Journal 30 (3), 306-333.

Aldrich, H., McKelvey, B., Ulrich, D., 1984. Design strategy from the population perspective. Journal of Management 10 (1), 67-86.

Alvarez, S., 2007. Entrepreneurial rents and the theory of the firm. Journal of Business Venturing 22 (3), 427-442.

Bhide, A., 1999. The Origin and Evolution of New Businesses. The Oxford University Press: Oxford.

Huchzermeier, A., Loch, C. H., 2001. Project Management Under Risk: Using the Real Options Approach to Evaluate Flexibility in R&D. Management Science 47 (1), 85–101.

Block, Z., MacMillan, I. C., 1985. Milestones for successful venture planning. Harvard Business Review 63 (5), 184-196.

Brinckmann, J., Grichnik, D., Kapsa, D., 2010. Should entrepreneurs plan or just storm the castle? A meta-analysis on contextual factors impacting the business planning performance relationship in small firms. Journal of Business Venturing 25 (1), 24–40.

Chesbrough, H.,2003. Open Innovation: The New Imperative for Creating and Profiting from Technology. Harvard Business School Press, Boston.

Chawla, C., Mangaliso, M., Knipes, B., Gauthier, J., 2012. Antecedents and implications of uncertainty in management: A historical perspective. Journal of Management History 18 (2) 200 – 218.

Cooper, R.G., 1994. Perspective - Third generation new product processes. Journal of Product Innovation Management 11 (1), 3-14.

Courtney, H., 1999. 20/20 Foresight: Crafting Strategy in an Uncertain World (Hardcover). Harvard Business School Press, Boston.

De Meyer, A., Loch, C.H., Pich, M.T., 2002. From Variation to Chaos. Sloan Management Review 43(2), 60–67.

Delmar, F., Shane, S.A., 2003. Does business planning facilitate the development of new ventures? Strategic Management Journal 24 (1), 1165–1185.

Dequech, D., 2006. The new institutional economics and the theory of behaviour under uncertainty. Journal of Economic Behavior and Organization 59 (1), 109-31.

Dequech, D., 1997. Uncertainty in a strong sense: meaning and sources. Economic Issues 2 (2), 21–43.

Dequech, D., 2000. Fundamental uncertainty and ambiguity. Eastern Economic Journal 26 (1), 41–60.

Dequech, D., 2004. Uncertainty: individuals, institutions and technology. Cambridge Journal of Economics 28, 365–378.

Dew, N., Read, S., Sarasvathy, S.D., & Wiltbank, R., 2009. Effectual versus predictive logics in entrepreneurial decision-making: Differences between experts and novices. Journal of Business Venturing 24(4), 287–309.

Dixit, A.K., Pindyck, R.S., Davis, G.A., 1994. Investment Under Uncertainty. Princeton University Press, Princeton.

Dosi, G., 1982. Technological paradigms and technological trajectories. Research Policy 11, 147–62.

Dosi, G., Egidi, M., 1991. Substantive and procedural uncertainty—an exploration of economic behaviour in changing environments. Journal of Evolutionary Economics 1 (2).

Duncan, R. B. 1972. Characteristics of Organizational Environment and and Perceived Environmental Uncertainty. Administrative Science Quarterly, 17, 313-327.

Eisenhardt, K., 1989. Building theory from case study research. Academy of Management Review 14 (4), 532-556.

Eisenhardt, K. M., Graebner, M. E., 2007. Theory building from cases: Opportunities and challenges. Academy of Management Journal 50 (1), 25–32.

Huchzermeier, A., Loch, C. H., 2001. Project management under risk: Using the real option approach to evaluate flexibility in R&D. Management Science 47 (1), 85– 101.

Jauch, L.R., Kraft, K.L., 1986. Strategic management of uncertainty. Academy of Management Review, 11 (4), 777-90.

Kim, J., Wilemon, D., 2003. Sources and assessment of complexity in NPD. R&D Management 33 (1), 15-30.

Knight, F.H., 1921. Risk, uncertainty and profit. Houghton Mifflin, New York.

Li, J.F., Garnsey, E., 2011. Entrepreneurship and Global Health: Catalyzing the Ecosystem Centre for Technology Management Working Paper Series.

Loch, C.H., Solt, M.E., Bailey, E.M., 2008. Diagnosing Unforeseeable Uncertainty in a New Venture, Journal of Product Innovation Management 25 (1), 28–46.

Mangaliso, M.P., 2010. Strategic Choice under Uncertainty: Multinational Corporations and the Pressure to Disinvest from South Africa. UPA/Rowman & Littlefield, Lanham.

Marino, L., Kresier, P., Robinson, A., 2010. Environmental uncertainty and firm-level entrepreneurship, in: H. Lanström et F. Lohrke (dir.), Historical Foundations of Entrepreneurship Research. Edward Elgar, Cheltenham, pp. , 81-97.

McCann, J.E., Selsky, J., 1984. Hyperturbulence and the emergence of type 5 environments. The Academy of Management Review 9 (3), 460-70.

McGrath, R.G., 1999. Falling forward: real options reasoning and entrepreneurial failure. Academy of Management Review 24(1), 13–30.

McGrath, R.G., MacMillan, I.C., 1995. Discovery driven planning. Wharton School, Snider Entrepreneurial Center.

McGrath, R.G., MacMillan, L., 2000. The Entrepreneurial Mindset. Harvard Business School, Boston.

Mckelvie, A., Haynie, M., J., Gustavsson, V., 2011. Unpacking the uncertainty construct: Implications for entrepreneurial action. Journal of Business Venturing 26 (1), 273–292.

McMullen, J.S., Shepherd, D.A., 2006. Entrepreneurial action and the role of uncertainty in the theory of the entrepreneur. Academy of Management Review 31 (1), 132–152.

Mercer, D., 2001. Fear of the future – a new management approach. Management Decision 39 (8), 654-60.

Ensley, M.D., Pearce, C.L., Hmieleski, K.M., 2006. The moderating effect of environmental dynamism on the relationship between entrepreneur leadership behavior and new venture performance. Journal of Business Venturing 21 (2), 243–263.

Miller, D., Shamsie, J., 1999. Strategic responses to three kinds of uncertainty: product line simplicity at the Hollywood film studios. Journal of Management 25 (1), 97-116.

Milliken, F.J., 1987. Three types of perceived uncertainty about the environment: state, effect, and response uncertainty. The Academy of Management Review 12 (1), 133-43.

Mintzberg, H., 1994. The rise and fall of strategic planning. The Free Press, New York.

Panayi, S.; Trigeogis, L., 1998. Multi-stage Real Options: the cases of information technology infrastrucuture and international bank expansion. The Quarterly Review of Economics and Finance 38, 675-692.

Pich, M., Loch., C.H., De Meyer, H.A., 2002. On uncertainty, ambiguity and complexity in project management. Management Science 48 (8), 1008-1023.

Rice, M.P., O'Connor, G.C., Pierantozzi, R., 2008. Implementing a learning plan to counter project uncertainty. MIT Sloan Management Review 49 (2), 53-62.

Santos, F.M., Eisenhardt, K.M., 2009. Constructing markets and shaping boundaries: Entrepreneurial power in nascent fields. Academy of Management Journal 52 (4), 643–671.

Saravasthy, S.D., 2001. Causation and effectuation: towards a theoretical shift from economic inevitability to entrepreneurial contingency. Academy of Management Review 26 (2), 243–263, 2001.

Sommer, S.C., Loch, C.H., 2004. Selectionism and learning in projects with complexity and unforeseeable uncertainty. Management Science 50 (10), 1334-1347.

Sommer, S.C., Loch, C.H., Dong, J., 2009. Managing complexity and unforeseeable uncertainty in startup companies: an empirical study. Organization Science 20 (1), 118-133.

Steensma, H.K.L., Marino, K.M., Weaver, P.H., Dickson, 2000. The influence of national culture on the formation of technology alliances by entrepreneurial. Academy of Management Journal 43 (5), 951-973.

Sutcliffe, K.M., Zaheer, A., 1998. Uncertainty in the transaction environment: an empirical test. Strategic Management Journal 19 (1), 1-23.

Sutcliffe, K.M., Zaheer, A., 1998. Uncertainty in the transaction environment: an empirical test. Strategic Management Journal 19 (1), 1-23.

Taleb, N., 2007. The Black Swan: The Impact of the Highly Improbable, Random House, New York.

Teece, D. J., 2007. Explicating dynamic capabilities: The nature and microfoundations of (sustainable) enterprise performance. Strategic Management Journal, 28 (13), 1319-1350.

Thompson, J.D., 1967. Organizations in Action: Social Science Bases of Administrative Theory. McGraw-Hill, New York.

Trigeorgis, L., 1996. Real Options: Managerial Flexibility and Strategy in Resource Allocation. MIT Press, Cambridge.

Von Mises, L., 1963. Human Action: A Treatise on Economics. Yale University Press, New Haven.

Wernerfelt, B., Karnani, A., 1987. Competitive strategy under uncertainty. Strategic Management Journal 8 (2), 187-94.

Wiltbank, R., Dew, N., Read, S., Sarasvathy, S. D., 2006. What to do next? The case for non-predictive strategy. Strategic Management 27 (10), 981-998.

Zahara, S. A., Garvis, D. M., 2000. International Corporate entrepreneurship and firm performance: moderating effect of international environmental hostility. Journal of Business Venturing 15 (2), 135 – 173.