Discovering entrepreneurial strategies : impact of strategic mechanisms in entrepreneurial decision makings on innovation performance of resource-constrained firms

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**DISCOVERING ENTREPRENEURIAL STRATEGIES:
IMPACT OF STRATEGIC MECHANISMS IN
ENTREPRENEURIAL DECISION MAKINGS ON
INNOVATION PERFORMANCE OF RESOURCE-
CONSTRAINED FIRMS**

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Abstract

In this dissertation, I explore entrepreneurial decision making processes to discover entrepreneurial strategies and study the impacts of these strategies on innovation performance of resource-constrained firms. The first essay tells the stories and subsequent analyses of 37 university spin-off technology start-ups in the United States to identify a set of strategic mechanisms that the start-ups adopt in order to move forward the tumultuous initial stage of technology commercialization. Longitudinal multiple cases study method is used to isolate a series of patterns in entrepreneurial decision makings, especially regarding strategic decisions that involve major changes in start-up goals, and to analyze commonalities and idiosyncrasies among these patterns between successfully progressing start-ups and unsuccessful ones. The start-ups that move forward successfully are found to be the ones that iteratively transform their goals using three strategic mechanisms of resource search and recombination, options generation, and contingency exploitation. Based on the strategic mechanisms identified in the first essay, the second essay reports the impact of these strategic mechanisms as well as start-up entrepreneurs' innovative behavioral and cognitive skills on innovation performance of 153 start-ups in Singapore by using survey questionnaire and face-to-face interview. A set of survey questionnaire is developed for options generation and contingency exploitation strategies based on the real options theory, effectuation theory, and strategic reactivity. The findings of this study (1) confirm that the strategic mechanisms identified in the first essay are indeed positively associated with more innovativeness of start-ups' new products or services, (2) empirically show that the options generation strategy and contingency exploitation strategy are used concurrently as the two gears of innovation to leverage uncertainty in a flexible, yet pre-planned way, and (3) elaborate on how certain innovative skills of entrepreneurs facilitate the identified strategic mechanisms.

Overview

How do entrepreneurs make decisions when the necessary information to make rational judgment is simply unavailable? The immediate solution in this situation would be to acquire relevant information as much as possible and try to extrapolate when historic probabilistic distributions are available, or estimate when analogous probabilistic distributions are available. However, for most entrepreneurs, even remotely relevant information can be non-existent, especially when they are trying to launch new products or create a whole new market. For this reason, entrepreneurial decision-making processes have been described as “scientifically unfathomable mystery” (Knight, 1921, p.227) or “untidy decision processes” (Baumol, 1993, p. 6). Entrepreneurial decision-making processes are scientifically unfathomable or untidy because no systematic method can be applied to calculate the optimal solution. This void of systematic methods to develop the rationale behind entrepreneurial decision-making has created an intellectual space for entrepreneurship researchers to introduce novel theories and challenge one another.

Due to this rather mysterious entrepreneurial decision-making processes, entrepreneurs have been described in such diverse ways that range from “fools” (Aldrich & Fiol, 1994, p. 645) to “prescient progenitors” (Dimov, 2010, p. 58, given as an example of conventional characterization of entrepreneurs). They are considered fools because they are destined to navigate a hostile, unknown terrain, over which they hardly have any control. They are described as sages because they somehow seem to be able to discover the unknown. These two characterizations appear to be polar opposites, yet the common denominator is the high level of uncertainty that entrepreneurs face inadvertently. Since it is simply impossible to forecast uncertainty by estimation, entrepreneurial successes have been understood as either incredible serendipity or as acts of divine prescience.

The external challenge of environmental uncertainty is not the only threat facing an entrepreneur. Internally, entrepreneurs suffer from lack of slack resources. Therefore, the very question on the potential drivers of entrepreneurial success can be rephrased as: how do successful entrepreneurs take advantage of uncertainty continuously while orchestrating limited resources? In

this dissertation, I aspire to answer the question by: (1) firstly, investigating entrepreneurial journeys of high-tech start-ups to identify a set of patterns in their streams of strategic decisions, and (2) secondly, testing the identified patterns with start-ups across multiple industries, to empirically show that the identified strategic mechanisms indeed positively influences the start-up performance. Therefore, this dissertation consists of two essays: the first essay builds theory on how start-up entrepreneurs make strategic decisions about their ventures, and the second essay tests the theory built in the first essay by surveying and interviewing start-up entrepreneurs.

In the first essay, I have identified entrepreneurial strategies by (1) investigating whether there exists any discernible pattern in start-up entrepreneurs' strategic decisions that entail major strategic changes, e.g., a decision to change a target product or market, and (2) identifying common decision patterns among successfully progressing start-ups. Since the level of uncertainty that a start-up faces is found to be highest for technology start-ups (Riolli-Saltzman & Luthans, 2001), university spin-off companies from seven top research universities in the United States, which are in the process of commercializing laboratory-developed breakthrough technologies, are interviewed face-to-face twice, 18 months apart, to collect longitudinal data. Technology commercialization process has a distinct characteristic, compared to entrepreneurial processes in general, because neither problem nor solution is established. Conventional characterization of an entrepreneurial process is that an alert entrepreneur identifies unmet market needs and creates a proper solution to address the needs (Kirzner, 2009). This process is reversed for start-ups with lab technologies, which create solutions first before problems are adequately defined. As a result, the level of uncertainty is even more significant for these start-ups, as they not only need to develop new technologies to commercially viable status, but also define problems that potential customers are willing to pay to fix them.

The dynamics between malleable solutions and undefined problems are aptly captured by the effectuation theory (Sarasvathy, 2001). Sarasvathy (2001) studied expert entrepreneurs to find that they effectuate, rather than plan, with what they have. Existing resources are creatively processed to identify multiple possible goals, and the entrepreneurs keep transforming their goals according to the

available resources and interested stakeholders' commitments. Technology entrepreneurs' journey to develop new technologies, and, simultaneously, apply the technologies by defining unarticulated problems is hypothesized to follow the effectuation process in this study. Responding to the call from prior research to further identify the techniques or strategic mechanisms underlying the effectuation process (Sarasvathy, Dew, Velamuri, & Venkataraman, 2003), this study identifies three strategic mechanisms that technology entrepreneurs repeatedly use to move forward under high levels of uncertainty: resource search and recombination, options generation, and contingency exploitation. Entrepreneurs search for new necessary resources, and, at the same time, recombine existing resources to put them into new uses, such as developing target applications in adjacent market by leveraging partners' relevant experiences. While recombining resources, entrepreneurs generate options, which are new ideas that are not feasible enough to be launched right away, but, at the same time, not bad enough to be discarded completely. Entrepreneurs keep an eye on the options by preserving them with minimal costs, until the relevant contingent events occur to be exploited in conjunction with the matched option. By having these options available, entrepreneurs are able to respond to pertinent contingencies in a pre-planned way, rather than mindlessly adapting to undifferentiated contingencies.

In the first essay, I find that the start-ups that progress successfully are the ones that adopt three strategic mechanisms consistently, whereas those that rely on either one or two of strategic mechanisms, or not at all, fail to move forward. The findings of the first essay show the specific strategic mechanisms that underlie an entrepreneur's effectuation process. However, rather a strict boundary condition of university spin-off, high-tech start-ups is bound to raise the question of generalizability. To answer this question, in the second essay, I test the theoretical model that was built in the first essay by studying start-ups across industry using survey and interview methodologies. 153 start-ups in Singapore, which are in the process of launching new products or services, are interviewed and asked to fill out the survey questionnaire face-to-face. Innovation strategies have been highlighting the importance of strategic flexibility to cope with high level of uncertainty (Van de Ven, 1986), yet lacks elaboration on how innovators make decisions flexibly but in a pre-planned way

(McGinn, 2012). The second essay identifies the structural alignment between the technology commercialization process of high-tech start-up entrepreneurs and the innovation commercialization process of start-up entrepreneurs in general. Therefore, the second essay hypothesizes that the strategic mechanisms identified in the first essay comprise individual entrepreneurs' strategy to leverage high level of uncertainty, and the entrepreneurs who actively adopt the strategy will show better innovation performance. Furthermore, following the recent discussions on the impact of an entrepreneur's behavioral and cognitive skills, a set of innovative behavioral and cognitive skills is hypothesized to be antecedents to the entrepreneurial strategy. A set of survey questionnaire is developed to measure the entrepreneurial strategy, either by adapting existing measures or developing new one based on theories. While the first essay studies high-tech start-ups which specifically start with their usually patented breakthrough technologies as starting resources, the second essay look into start-ups in general. As a result, effectuation theory is not expected to capture the full spectrum of resource recombination activities of the start-up entrepreneurs in the second study. Entrepreneurs in general recombine existing resources not only to come up with new goals, but also create new solutions to pre-defined goals. Resource bricolage, defined as an entrepreneurial action of creating something from nothing (Baker & Nelson, 2005), has been argued to capture the entire spectrum of resource recombination activities (Baker, Miner, & Eesley, 2003; Fisher, 2012). Therefore, the resource bricolage measure (Senyard, Baker, Steffens, & Davidsson, 2014) is adapted to measure resource search and recombination mechanism. The contingency exploitation measure is developed by adapting the experimentation items of effectuation (Chandler, DeTienne, McKelvie, & Mumford, 2011) as well as the strategic reactiveness measure (Green, Covin, & Slevin, 2008). The options generation measure is developed based on the real options theory (Klingebiel, 2012; McGrath, 1997). The five discovery skills measure (Dyer, Gregersen, & Christensen, 2008; Dyer, Gregersen, & Christensen, 2011) is used to assess entrepreneurs' innovative behavioral and cognitive skills.

The findings of the second essay confirm the positive impacts of entrepreneurial strategy: entrepreneurs who adopt the entrepreneurial strategy, especially those who use the options generation strategy and the contingency exploitation strategy as the two gears of product and service innovation,

are found to generate more innovativeness in their new products or services. Severe resource constraints usually prevent entrepreneurs to heavily invest in systematic market research and planning to launch new products or services. Reconfiguring available resources to come up with innovative ideas becomes a preferable approach for resource-constrained entrepreneurs. This internal search process of new ideas, rather than an external search that more established firms usually adopt, is likely to generate novel ideas that may not be feasible enough yet, which becomes strategic options for start-ups. This process of recombining existing resources into new configuration requires a systematic information processing exercise in order to identify the potential ideas. These options are cultivated either cognitively or in an iterative process of fast and frugal experimentation. They have not entered an entrepreneur's cognitive rifle range as a main target yet, but are stationed nearby so that the entrepreneur could switch targets flexibly whenever adequate ammunition becomes available. When entrepreneurs recognize relevant contingent events in their environments, they quickly map the contingencies into existing options and decide which one to exploit. This process of contingency exploitation is an exercise of heuristic information processing, by which time-pressured entrepreneurs are able to make fast decisions.

The options generation and contingency exploitation strategies explain how entrepreneurs balance complexity and simplicity: they use a set of options, which are carefully created by systematic recombinatory exercises, as a rule of thumb for their quick, heuristic decision on which contingency to exploit. Schema theory supports the dynamic use of the options generation and contingency exploitation strategies. According to the theory, individuals maintain multiple schemas, and when there is an environmental stimuli, they engage in pattern detection to match the stimuli to the information stored in an activated schema (Fiske & Taylor, 1991). Entrepreneurs who maintain more complex sets of schema, by generating and preserving strategic options, are expected to better recognize the relevant contingencies. Entrepreneurs' innovative skills, identified as the five behavioral and cognitive skills of questioning, observing, experimenting, networking, and associating, as antecedents to the entrepreneurial strategy are found to have mixed influences. As hypothesized, questioning, experimenting, and networking positively influence the options generation strategy,

either directly (i.e., questioning and networking) or indirectly through resource bricolage (i.e., experimenting), whereas associating negatively influences the options generation strategy. Two hypothesized relationships - (1) a positive association between associating and contingency exploitation, and (2) a positive association between observing and contingency exploitation - are not supported.

The findings of two essays contribute to both entrepreneurship and innovation research. First, the entrepreneurial strategy of options generation and contingency exploitation is qualitatively identified and quantitatively tested to elaborate on how entrepreneurs make strategic decisions in a flexible yet pre-planned way. This strategy acknowledges the duality of planning and adapting in entrepreneurial decision-makings, and explains how two seemingly conflicting approaches cohabit in the entrepreneurial processes. Second, by showing the behavioral and cognitive skills of an entrepreneur as antecedents to the entrepreneurial strategy, this study presents and explains the whole process of how individual skills affect strategy, and subsequently, influence firm performance in terms of the innovativeness of new products or services of the firm. Third, researchers have called for the need to study multi-level relationships between individual-level behavior and decisions and firm-level performance. By studying start-up entrepreneurs' behavior, decision patterns, and subsequent start-up performance measured by both self-report and interview transcript, this study responds to the call. Fourth, the findings of this dissertation elaborate on how innovators create new ideas and successfully implement them, not by simply having a Eureka moment of flashes of insights, but by investing in recombining available resources and continuously cultivating the innovative recombinations. This process supports the recent argument from the individual skills perspective that innovative capability can be learned and practiced by adopting a set of innovative behavioral and cognitive skills. Start-up entrepreneurs studied in this dissertation indeed confirm the positive association between individual skills and performance through the entrepreneurial strategy. Just like physical exercise helps to build muscles, entrepreneurs are found to train themselves to build cognitive muscles to balance complexity and simplicity.

Essay 1. Creating Opportunities: Understanding Strategic Mechanisms in Entrepreneurial Processes of Technology Start-ups

1. Introduction

U-Haul's website recounts the story of its founding.¹ At the end of World War II in 1945, L.S. "Sam" Shoen had just been discharged from the U. S. Navy. Sam and his wife tried but failed to rent a utility trailer for a one-way move from Los Angeles to Portland. Recognizing this prevalent need and a potential opportunity, the Shoens spent their \$5,000 savings to buy their first trailers from welding shops and private owners. They established a commission structure with service station managers who let them park the trailers on their premises and agreed to handle all rentals. Instead of spending on advertising, they painted the trailers with the U-Haul Logo and "\$2 Per Day" signs, so that the trailers would advertise themselves wherever they went. To overcome capital constraints, U-Haul established a unique financing plan: individuals could purchase U-Haul trailers and lease the trailer back to the company. This started as a way to obtain financing from friends and family, but it eventually became an established financing plan for all interested individuals.

Founding stories of companies such as U-Haul are powerful inspirations to potential entrepreneurs and have also intrigued researchers examining what makes entrepreneurs successful. Researchers have used the U-Haul story to illustrate an approach that entrepreneurs adopt to leverage existing resources to progress in a myopic way. Entrepreneurial bricolage, a concept described as making do with "whatever is at hand" (Lévi-Strauss, 1968, p. 17), describes how entrepreneurs create something from seemingly non-existent resources (Baker & Nelson, 2005). Entrepreneur bricoleurs interpret their resource environments in an idiosyncratic manner, such that the same resources can be used in different ways by different entrepreneurs. Rather than spending time pondering over a situation, wondering whether a workable outcome can result from entrepreneurial plans, they adopt actions to actively engage with problems and opportunities (Baker & Nelson, 2005). Sarasvathy (2001) presents a similar view known as an effectual process, wherein entrepreneurs start with the means that

¹<http://www.uhaul.com/About/History.aspx>. This story was highlighted in Sarasvathy (2001).

they have to enact outcomes that generate more resources that they can build upon, just as the Shoens did when they created U-Haul.

In addition to the prevalent entrepreneurial challenge of resource constraints, the U-Haul story also tells how the entrepreneur moves forward with environmental uncertainty. Prior studies in entrepreneurship research have focused on how entrepreneurs deal with uncertainty that poses both challenges and opportunities. This uncertainty makes entrepreneurs not only partially ignorant (Hayek, 1945) but also unable to fully define entrepreneurial opportunities *ex ante* due to the lack of information on future markets (Arrow, 1974). Entrepreneurs would rather act upon opportunities, without analyzing them systematically or comprehensively, and “make do” (Baker & Nelson, 2005; Lévi-Strauss, 1966) in an iterative and dynamic way. This image of an entrepreneur defies the conventional notion of a heroic entrepreneur who steadily marches through uncertainties without compromising, following the linear path of opportunity recognition and exploitation. Therefore, discussions in entrepreneurship research have recently called for needs to understand the whole, non-linear entrepreneurial journey from ideation to execution of entrepreneurial opportunities (Gaglio & Katz, 2001), with a specific focus on how entrepreneurs dynamically adopt different strategic logics according to the uncertain environments that entrepreneurs are facing (Wiltbank, Dew, Read, & Sarasvathy, 2006; Wiltbank, Read, Dew, & Sarasvathy, 2009).

Strategic management research, on the other hand, has largely focused on dynamic environments by studying how firms orchestrate limited resources to navigate along the shifting market boundaries while chasing a moving target (Eisenhardt, 1989b; Posen & Levinthal, 2012; Sirmon, Hitt, & Ireland, 2007; Sirmon, Hitt, Ireland, & Gilbert, 2011). Firm resources and capabilities are put under the microscope to be dissected and scrutinized in order to understand the successful mix of resources and capabilities to generate sustainable competitive advantage. What has been largely missing in this discussion is the role of managerial actions to create the process of accumulating and orchestrating resources (Sirmon et al., 2011). Strategic management literature has reached consensus on the argument that the firm strategy is based on resource strengths (Wernerfelt, 1997). Yet the questions remain on what if a firm has no resource strength, or even worse, no resources at all

especially as an emerging organization. Prior studies have pointed out the resource acquisition and orchestration process as an under-developed element in research on firm resources and capabilities (Barney & Arikan, 2001; Priem & Butler, 2001).

These emerging questions and discussions in entrepreneurship and strategic management research share similarities. What strategic management research describes as managerial actions to create and manage firm resources is managers' attempts to seek and exploit new opportunities, which are well aligned with entrepreneurial actions. Entrepreneurship theories about how entrepreneurs effectuate starting from highly limited resources at hands and manage uncertainty by proactively exploiting contingencies (Baker & Nelson, 2005; Sarasvathy, 2001; Wiltbank et al., 2006) seem to be appropriate tools to study the impact of managerial actions on resource accumulation and orchestration process. At the same time, what entrepreneurship research enquires about a specific mechanism behind successful entrepreneurs' decision logic is highly related to strategizing in uncertain or causally ambiguous environments. Strategic management theories about how to allocate resources while keeping flexibility or make efficient failures to explore (Adner & Levinthal, 2004; Klingebiel & Adner, 2015; Klingebiel & Rammer, 2014; McGrath & Boisot, 2005; Mosakowski, 1997) would offer a fitting theoretical lens to understand the entrepreneurs' decision makings. In addition, Venkataraman, Sarasvathy, Dew, and Forster (2012) have recently suggested to move away from the discussions about decision making under uncertainty, and shift toward understanding "problems of designing within constraints" (p. 30) by investigating how individual entrepreneurs interact with their endowments and environments. Venkataraman *et al.* (2012) particularly call for further research on specific mechanisms or techniques involved in these entrepreneurial actions.

However, there have been few attempts to explain how the entrepreneurs effectuate with existing resources in a designed, pre-planned way, rather than transforming liberally or merely adapting to environmental stimuli. Although it is difficult for entrepreneurs to systematically analyze an opportunity and plan accordingly in a complex setting, as "the forces shaping the future do not add up in a simple, system-wide manner" (Axelrod & Cohen, 1999, p. 14), entrepreneurs' actions do need to be guided by goals based on their resources and capabilities.

This study aims to address these calls from prior studies in both entrepreneurship and strategic management research by looking into how entrepreneurs leverage their limited resources and environmental contingencies to design an evolving goal. The goal of this study is two-fold: (1) to present a theoretical model explaining how entrepreneurs transform their goals in a structured way by leveraging available resources and environmental contingencies, and (2) to provide entrepreneurs with a set of strategic mechanisms for entrepreneurial successes. Various entrepreneurial journeys of high-tech start-ups are studied to discover a set of strategic mechanisms that underlie the entrepreneurial decision makings. The set of strategic mechanisms that are adopted by successfully progressing start-ups and those by failed ones are compared and contrasted to identify the common strategic mechanisms that are shared among successfully progressing start-ups.

2. Theory

In addition to common entrepreneurial challenges that entrepreneurs face while trying to articulate unmet market needs, entrepreneurs of high-tech start-ups share a burden of defining non-existent problems that could be solved with the technologies they develop. Therefore, the entrepreneurial processes of high-tech entrepreneurs have been depicted as identifying unsolved problems and creating proper solutions to generate entrepreneurial rents (e.g., Nickerson & Zenger, 2004).

The effectuation process adequately describes this entrepreneurial process of having solutions at hand first and trying to figure out what different types of problems that can be addressed to by existing solutions. According to effectuation theory, entrepreneurs review available resources first, rather than deciding upon a desirable goal, to figure out what kind of goals they can achieve using available resources (Sarasvathy, 2001). Once choosing a short-term goal based on the affordable loss, rather than expected returns, entrepreneurs iteratively transform the chosen goal with help of interested stakeholders and their resource bases. While trying to come up with various goals to

achieve, entrepreneurs recombine existing resources to generate new sets of resources. This resource recombination process of effectuating entrepreneurs is a subset of resource bricolage that Baker and Nelson (2005) define as "making do by applying combinations of the resources at hand to new problems and opportunities" (p.333). While effectuation focuses on available resources and flexible goals that can be achieved by leveraging available resources, resource bricolage focuses on leveraging available resources to solve new problems quickly or reach new goals. Therefore, in the context of high-tech start-ups in penurious environment, the concept of bricolage becomes more suitable to describe resource recombination activities of entrepreneurs, whereas the effectuation process more aptly describes the strategic changes that entrepreneurs make along their entrepreneurial journeys.

Recent studies have tried to compare and contrast the effectuation and bricolage concepts, in conjunction with other relevant concepts, such as improvisation or the opportunity creation perspective (Fisher, 2012; Welter, Mauer, & Wuebker, 2016). The consensus that has been reached so far is that effectuation, bricolage, and opportunity creation perspective are hardly separate, distinctive concepts, but, rather related concepts with overlapping meanings. Welter *et al* (2016) particularly highlights the different contexts by explaining that the main context for effectuation concept is the nonlinear, unpredictable environment that contains a significant level of uncertainty, whereas the primary context for the bricolage concept is an entrepreneur's perception of resource scarcity. The main context for the opportunity creation perspective becomes broader as it assumes an environment with Knightian uncertainty. Therefore, an entrepreneur, as an agent acting in the environment that he or she is embedded in, shows three different yet related types of actions: an effectuator relies on heuristic decision-making to create more means-ends relationships; a bricoleur recombine available resources to address new problem or opportunities; and an opportunity creator interacts with environment to create an opportunity in a form of market imperfection.

Therefore, an entrepreneur of a high-tech start-up, who face the multiple challenges of (1) resource constraints, (2) high levels of uncertainty due to the nature of new technologies, and (3) evangelical duty to articulate the most suitable market for the technology and to educate potential customers of the new solutions created by the technology, can be described as (1) a bricoleur to

interact with penurious environment, (2) an effectuator to create new means-ends relationships and to continuously transform goals accordingly, and (3) an opportunity creator to concretize market imperfections. Combining the effectuation, bricolage, and opportunity creation perspective, I propose a theoretical model, summarized in Figure 1, which suggests that the iterative combination of a set of actions combining and integrating opportunity discovery with opportunity creation generates a framework to illustrate how entrepreneurs both identify and create new opportunities. Later, I show the evolution of that initial model to a revised research model in Figure 3.

Opportunity and goal creation. Entrepreneurs either deliberately search for or stumble upon problems that exist in the form of market or customer needs. These generally result from market inefficiencies when entrepreneurs uncover customer needs that existing products do not meet. With the problems identified, entrepreneurs set a goal that defines the problem they aim to solve by searching for resources and creating solutions correspondingly. However, as noted earlier, analysis and planning about an uncertain future are not only difficult in a complex world but are also likely to produce useless information (Sarasvathy, 2001). Moreover, it is well recognized that entrepreneurs rarely possess all necessary information, making them partially ignorant (Hayek, 1945) and inherently myopic due to uncertainties in the entrepreneurial processes (Mosakowski, 1997). The inability to acquire necessary information as well as to clearly understand what types of actions result in either successes or failures requires entrepreneurs to remain flexible, to constantly update their goals and plans as they learn, and to obtain new information about the environment that surrounds the identified problems (Alvarez & Busenitz, 2001).

< Figure 1. Initial Theoretical Model >

Solution creation and resource search. To create solutions for the problems defined, entrepreneurs need to create resources and recombine them in creative ways. The solution that one can create depends on the resources that individuals bring on board. Entrepreneurs often begin with resources they have on hand to generate new resources (Baker & Nelson, 2005; Sarasvathy, 2001), through recombinations of existing resources, or by leveraging existing resources to create and obtain new resources. In the U-Haul example, Sam leveraged his personal contacts to obtain financing for additional trailers, thus creating new resources. Later, he established a financing plan where any individual could purchase U-Haul trailers and lease the trailer back to the company. Effectively, he recombined existing resources to obtain more trailers that they could rent to customers. Individuals' perceptions about the value of resources also influence how they leverage existing resources (Barney, Wright, & Ketchen Jr, 2001). For example, Sam realized the empty spaces of service stations, which currently served little purpose, were a resource he could leverage to park the rental trailers.

While entrepreneurs predominantly use the bricolage process to generate solutions, their actions need to be guided by goals and plans targeted at the identified opportunity. As highlighted by Baker and Nelson (2005, p.355), firms that are not guided by goals or focus, and who attempt to "create something from nothing across multiple domains," face suppressed growth, compared with firms that are guided by goals and areas of focus.

Iterations between opportunity identification and solution creation. For entrepreneurs to be successful there must be a meeting of the opportunities either identified or created and the solutions generated. The solutions generated must meet identified marketplace needs. The innovation literature often characterizes innovations as either technology push, where one starts with a solution and looks for the right problem in market needs, or market pull, where one starts with a market need and looks for the adequate solution (Brem & Voigt, 2009). Such characterization is an over-simplified and linear view of the matching of problems and solutions, because potential matching between problems and solutions is intricately intertwined in many ways. First, while initial goals guide resource creation and solution generation, predictions and goals are constantly changed and updated as organizations learn and uncover more information. Second, new resources created and solutions generated also provide

new information and constraints that have to be fed back into the opportunity discovery and goal setting process, to generate further information that needs to be considered when updating goals and predictions. Third, decisions and actions that entrepreneurs need to undertake to match the problems and solutions are far from clear, due to uncertain future consequences and the lack of complete information. It is not always clear to entrepreneurs *ex ante* which pieces of information deserve their attention and which do not (Sarasvathy & Dew, 2005). Hence, iterations in both the opportunity discovery process and the solution generation process, together, provide new and additional insights to guide entrepreneurs as to which pieces of information they should focus on.

3. Research Setting and Context

The objectives of this study are (1) to understand how and why opportunity discovery and opportunity creation processes complement each other in guiding entrepreneurial actions of effectuation and bricolage, and (2) to investigate how and why successful start-ups differ in their use of opportunity discovery and creation processes, compared with those that fail. In line with these objectives, I propose an initial theoretical model showing that opportunity discovery processes are important for opportunity identification, while opportunity creation processes are important for solution generation.

To examine the proposed theoretical model, I study the initial stages of technology start-ups, particularly those trying to commercialize technologies spun out of university laboratories. Many of Silicon Valley's most successful companies have grown from small start-ups that successfully commercialized technologies arising from ground-breaking research, including, for example, Intel and 3Com. However, many high technology start-ups do not survive to make a profit (Saxenian, 1996). Due to the 'liability of newness' originating from the novelty of their inventions, as well as to unproven track records of entrepreneurs or nascent organizations (Stinchcombe, 1965), technology start-ups face frequent barriers, especially in the early stages of growth, including lack of resources, skills, legitimacy, and a proven track record (Vohora, Wright, & Lockett, 2004).

While some may view technology start-ups as exemplifying the technology push model, they

do have to navigate an extremely complex process of matching solutions they create with opportunities they identify or create, especially in the initial stages of the start-up process. The entrepreneur faces significant ambiguity in identifying or creating markets and customer needs that are often not articulated or may be non-existent. Often, the lack of technological maturity and the foreignness of new technologies results in the need to educate the potential market about how the technologies relate to existing understandings and products, while simultaneously highlighting the novel aspects of their inventions (Hargadon & Douglas, 2001).

At the same time, the initial solutions generated are often far from complete. Technologies championed by start-ups are often embryonic, leading to significant challenges in generating proof of concepts, creating working prototypes, and establishing market feasibility. Moreover, the technology itself does not define the final solution. Different forms of solution can be generated from a single technology (Shane, 2000). In these initial stages, the goal is often to reduce the technological and market risk as far as possible in order to attract large companies or investors to finance further development of the technology into products. Yet technology entrepreneurs face significant difficulties commercializing their technologies in these embryonic stages, as the business is highly risky for potential investors as well as for potential employees or those holding key management positions.

4. Methodology

An exploratory longitudinal case study method is adopted to study technology start-ups in the United States. A case study, defined as an empirical inquiry that studies real-life phenomena (Yin, 1994), is particularly well-suited for "how" and "why" questions (Eisenhardt & Graebner, 2007), which aligns well with my objectives. Prior research emphasizes the importance of studying processes *in vivo* when studying individual decision making, because understanding actors' perceptions and contextual information in the environment is critical (Langley, Mintzberg, Pitcher, Posada, & Saint-Macary, 1995). Therefore, a longitudinal approach was thus taken to observe *in vivo* how the processes of technology commercialization unfolded.

4.1. Dataset

Due to my focus on technology start-ups, I examine start-ups that have been formed to

commercialize technological inventions generated from university laboratories. In this study, I focus primarily on early-stage start-ups, from idea inception to actual start-up. The literature classifies the start-up stages to include: idea inception, seed stage (where start-ups evaluate technical and market feasibility of their ideas), start-up stage (where start-ups are in late stages of product development and manufacturing and begin to attract initial customers), growth stage (where start-ups ramp up marketing of products, expand their product lines and production capacity and seek to expand the initial customer base), and exit stage (Wiltbank, 2005). Since resources are tightest and uncertainties are most significant in these early stages, I examine how technology entrepreneurs make strategic decisions during this period, in order to develop the clearest picture of how they discover or create opportunities. Once a company starts to generate stable revenue streams and moves into the growth stage, technology entrepreneurs' decision making is expected to focus more on generating and sustaining competitive advantage, an area that is more informed by literature in the strategic management domain (Ireland, Hitt, Camp, & Sexton, 2001).

I examined start-ups formed to commercialize technologies from the research laboratories of seven leading research universities in the U.S. The seven universities are actively developing new technologies with commercial potential and have had varying measures of success in the technology transfer arena. The Technology Transfer Offices (TTOs) or entrepreneurship centers of the chosen universities were contacted and asked to recommend a group of start-ups that agreed to participate in the study. During the first round of data collection, 48 co-founders from 38 start-ups were interviewed. The start-ups represent a wide range of industries: software, bio-technology, energy, wireless communications, material, aerospace, and agriculture. To understand the institutional context surrounding the start-ups, 53 key university personnel were interviewed, who were involved in helping the start-ups, including the directors and staff of TTOs, entrepreneurship center directors, managers of accelerators/incubators and mentoring services. To keep track of the progress of the start-ups, the second round of interviews were conducted 18 months later; 16 start-ups were interviewed in

that second round.²

Given the large number of cases that I have, I divided them into two groups, so that one group could be used to confirm or disconfirm findings derived from the other group, in line with the replication logic (Eisenhardt, 1989a; Yin, 1994). For this study, I conducted an in-depth analysis of the 16 start-ups with which I conducted follow-up interviews. I used the remaining cases as a secondary data set to validate the findings derived from the initial analysis. Prior research shows that multiple retrospective cases enhance external validity, while longitudinal cases enhance internal validity of the proposed model (Leonard-Barton, 1990). I designed the analysis accordingly by using both longitudinal cases and retrospective cases to increase the validity of my conceptualization.

16 primary, longitudinal cases consist of one software (text visualization engine), one laser technology (laser chip application), three energy (e.g., printable battery), and 11 bio-technology start-ups (e.g., protein-detecting micro-particle application). Bio-technology start-ups predominantly comprise the primary cases, partly because one of the research universities visited offer a technology commercialization program for scientists and engineers which specifically targets bio-technology-related ideas. While these start-ups are in various stages of progress, such as ideation, prototyping, beta-testing, or pitching, majority of them had reached or passed the prototyping stage. 22 secondary cases consist of one wireless communication, one material, one agriculture, two mechanical engineering, two energy, five software, six bio-technology, three medical device, and one medical service start-ups. All start-up participants are in various stages of commercialization. Table 1 and 2 show the list of start-ups which participated in both rounds of interviews, a description of the technologies they seek to commercialize, and their stages during the interviews. Pseudonyms were used for start-up names.

I acknowledge the limitations of interview data, such as retrospective sensemaking (Eisenhardt & Graebner, 2007). To minimize the effects of biases, where possible I interviewed more

² Among the 38 start-ups interviewed in the first round, 11 had already moved into the growth stage at the time of the first round interviews. These start-ups were thus not contacted for the second round of interviews, since necessary information on their commercialization processes during the early stages had already been captured during the first round of interviews. 5 start-ups had already been terminated at the point of the second round interview, and could not be contacted for the interviews. Among the remaining 22 start-ups, 6 companies did not respond to the invitation for the second round interview.

than one informant to triangulate facts and interpretations (Miller, Cardinal, & Glick, 1997; Schwenk, 1985). I were able to do so for eight of the 16 start-ups used for the main analysis, and two of the 22 start-ups used for the secondary analysis. Each interview lasted 60-90 minutes, and all were recorded and later transcribed in order to be coded and analyzed.

< Table 1. List of Primary Cases >

	Start-up	Industry	Product	Stage (1st interview)	Stage (2nd interview)	Success vs. Failure
1	BatteryCo	Energy	Battery technology that enables printable, form factor-free batteries	Incorporating	Seeking funding and fine-tuning business plan	Success
2	LaserCo	Laser	Laser application based on quantum cascade laser	Prototyping	Creating applications	Success
3	WindCo	Energy	Deployable airborne wind turbine	Pitching to VCs	Seeking strategic partners	Success
4	ProteinCo	Biotech	Microparticle application for multiplex detection of protein and nucleic acids	Beta-testing	Selling overseas	Success
5	EarCo	Biotech	3D ear canal imaging	Pitching to VCs	Going through FDA trial	Success
6	VeinCo	Biotech	Catheter-based device to treat chronic venous inefficiency in the legs	Submitting 510(k)	Applying clinical trials in Europe	Success
7	VentilatorCo	Biotech	Inexpensive, portable ventilator	Licensing out from TTO	Securing funding and moving to India	Success
8	SwitchCo	Biotech	Research tool to study how DNA switches work	Considering exiting	Exploring corporate partnership	Success
9	CellCo	Biotech	High performance assay method, cell therapy platform, and ultraminiature medical diagnostic instruments	Prototyping	Going through clinical trial	Success
10	VaccineCo	Biotech	Vaccine for valley fever	Prototyping	Looking for funding	Success
11	DialysisCo	Biotech	Medical device to treat hyperphosphataemia patients	Filing patents	Hiring CEO	Success
12	DrugCo	Biotech	Oncology drug discovery	Seeking research grants	Preparing for animal testing	Success
13	MicroscopeCo	Biotech	Automated microscopy	Designing product	Changing target market and strategy	Success
14	WebCo	Software	Software application to visualize opinions using collaborative filtering & recommendation	Selling beta	Co-founder leaving the firm to join another start-up	Failure
15	SniffCo	Biotech	Medical device to detect prostate cancer	Filing patent	Terminated	Failure
16	GrapheneCo	Energy	Graphene-based super capacitor	Licensing out from TTO	Terminated	Failure

< Table 2. List of Secondary Cases >

	Start-up	Industry	Product	Stage (1st interview)	Stage (2nd interview)	Success vs. Failure
1	ShoeCo	Software	shoe-shopping application using recognition technology	Generating revenue	Not contacted for interview	Success
2	PolymerCo	Energy	rechargeable lithium-ion battery based on nanostructured polymer electrolyte	Manufacturing	Not contacted for interview	Success
3	ElixirCo	Biotech	small molecule drugs that target sirtuins, a family of seven enzymes associated with disease of aging	Participating in clinical trials	Not contacted for interview	Success
4	TextCo	Software	software application to statistically analyze unstructured texts	Generating revenue	Not contacted for interview	Success
5	PrintingCo	Mechanical	3D printer	Generating revenue	Not contacted for interview	Success
6	PileCo	Medical device	medical device to treat severe hemorrhoidal disease quickly and inexpensively	Signed the deal with incubator	Not contacted for interview	Success
7	BackCo	Medical device	medical device to stabilize spine in a minimally invasive way	Manufacturing	Not contacted for interview	Success
8	WoundCo	Medical device	negative pressure wound therapy	Generating revenue	Not contacted for interview	Success
9	PlatformCo	Biotech	platform technology to screen for ADME properties of drug candidates	Generating revenue	Not contacted for interview	Success
10	EngineCo	Mechanical	rocket engine design with better thrust to weight ratio in lower costs	Ideation	Terminated	Failure
11	GraphicCo	Software	graph database technology	Licensing tech. from university	Terminated	Failure
12	SolarCo	Energy	solar heat collection technology using black fluid	Prototyping	Terminated	Failure
13	MobileCo	Wireless communication	self-optimizing wireless network technology	Licensing tech. from university	Terminated	Failure
14	HeatCo	Material	material with electro-thermal properties	Prototyping	Terminated	Failure
15	CallCo	Medical service	call center to provide consulting service on healthcare plans	Spinning out	Not contacted for interview	Failure
16	GreenCo	Agriculture	hydroponic technology to corrode plants quicker and cheaper	Generating revenue	Not contacted for interview	Failure
17	PathogenCo	Biotech	DNA sequencing technology for clinical diagnostics	Closing Series A	No response	-
18	TissueCo	Biotech	tissue imaging spectroscopy	Starting to generate revenue	No response	-
19	SensorCo	Biotech	miniaturized biosensor for optical detection	Licensing out technology from university	No response	-
20	RemedyCo	Biotech	sprayable foam to treat severe hemorrhage	Signing term sheet with angel investor	No response	-
21	ParallelCo	Software - computing	one-chip general-purpose parallel computing technology	Ideation	No response	-
22	SoundCo	Software	real-time sound synthesis	Prototyping	No response	-

	Start-up	Industry	Product	Stage (1st interview)	Stage (2nd interview)	Success vs. Failure
			technology			

4.2. Data collection

The first round of face-to-face, semi-structured interviews was conducted in Spring 2011. The second, follow-up round was done by telephone in Fall 2012. During the first round, interviewees walked through each step of their commercialization effort, discussing key decisions made and challenges faced during each step in chronological order. The second round of interviews tracked further developments experienced since the first round. Further information that was publicly available in news articles, start-up websites, university websites, or personal blogs was also collected to supplement the interview data. Appendix A lists the interview protocol used for the interviews.

4.3. Data analysis

I designed five stages to analyze the data. Table 3 summarizes the analytical goals, data, analytical procedure, outcome, and theory development for each stage (e.g., Rindova & Kotha, 2001). I started by developing a case write-up for each start-up: multiple interview transcripts and secondary data sources were synthesized to reconstruct chronologically the start-up's journey as accurately as possible. The case write-ups averaged 2,000 words, and each contained a detailed activity sequence diagram, representing a chain of interrelated events such as key decisions made by entrepreneurs, antecedents such as certain environmental contingencies that suddenly materialized, resources that served as inputs and outputs of the decisions, and decision consequences. This activity sequence diagram chronologically summarizes what has happened throughout a start-up's journey so far. Figure 2 shows an example of the event sequence diagram of one of the primary cases, MicroscopeCo, which will later be analyzed in detail in results section. MicroscopeCo's full-length case is provided in Appendix B.

From the case studies and activity sequence diagrams, I identified focal episodes involving major decisions, e.g., a decision to change target products or services, and the associated context, antecedents and outcomes of the decision. I then used each focal episode as the unit of analysis. Then

I open coded the interview transcripts by identifying the tactics or strategies that start-up entrepreneurs use to identify and create opportunities and grouped similar tactics into categories. As a next step, I did axial coding by searching for relationships among these categories, in order to assembly them into the second order concepts of strategic mechanisms. This process of coding was recursive as I had to go back and forth to strengthen or clarify the first and second order concepts.

Based on this analysis, I identified four strategic mechanisms that entrepreneurs used. I then used axial coding to define and generate the relationships between those strategic mechanisms, enabling me to propose a new theoretical model that explains how the different strategic mechanisms interrelate and represents actions that entrepreneurs take to match opportunities with solutions they develop. Finally, I used the replication logic to conduct further selective coding on the focal episodes identified in the additional 22 cases. This allowed me to verify whether the proposed theoretical model was also observed in these additional cases.

< Figure 2. MicroscopeCo's Activity Sequence Diagram >

< Table 3. Data Analysis Stages for Theory Development >

Analytical goal for stage	Raw data used	Theories & analytical procedure used	Analysis outcome	Theory development
Chronologically reconstruct each start-up's journey	Interview transcripts, news on the web, and company webpages	Process theory and stages of the start-up process	Case write-ups highlighting focal episodes. Sequence diagrams highlighting the triggers of changes, involved actors, and change outcomes	Entrepreneurs move and cycle between the opportunity and solution space iteratively. Evidence of opportunity discovery and creation appears throughout the start-up process.
Identify focal episodes and reconstruct them chronologically	Case write-ups and sequence diagrams	Data reorganization	6-10 focal episodes identified for each start-up	N/A
Identify key strategies in exploring problem and solution space	Focal episodes	Open Coding and Thematic Analysis	Identified strategies that are used by entrepreneurs	Four strategies: (1) resource search and recombination, (2) options generation, (3) contingency exploitation, and (4) goal transformation
Develop theoretical relationships between strategic mechanisms. Revise proposed theoretical model accordingly	Strategic mechanisms identified and activity sequence diagram	Axial coding	Revised theoretical model and propositions	Goals are continuously transformed while leveraging environmental contingencies, options generated and resources created.
Identifying commonalities and idiosyncrasies between successful and unsuccessful start-ups	Case write-ups (including secondary cases)	Replication logic and selective coding	Propositions	Successfully progressing start-ups transform their goals in such a way that existing resources are put into "good enough" use

5. Results

5.1. Four strategic mechanisms used in exploring the problem and solution spaces

Thematic analysis of the focal episodes generated four strategic mechanisms: (1) *resource search and recombination* mechanism through which start-ups seek new resources and recombine existing resources; (2) *options generation* mechanism through which start-ups carefully cultivate a set of options, to which they do not fully commit initially, but ensure that the options remain open for them to exercise when future environmental factors make it favorable to do so; (3) *contingency exploitation* mechanism through which start-ups devise corresponding solutions when they realize

environmental constraints or see the chance to exploit emergent opportunities; and (4) *goal transformation* mechanism through which start-ups not only continuously recalibrate their short-term goals but also take a creative leap to dramatically transform current goals into new ones.

< Table 4. Data Structure: Strategies that start-ups use, first-order categories, and second-order mechanisms >

Strategies	First-order categories	Second-order mechanisms
Start-ups pitch to potential investors, look for necessary talents, scavenge idle resources around them, or get access to inexpensively available resources.	Seeking and acquiring new resources including legitimacy	Resource search & recombination
Start-ups participate in business plan competitions, seek endorsement from reputable figures in target industry, or participate in projects with major corporations to gain legitimacy.		
Start-ups make use of co-founders' prior experience and knowledge of starting a business, such as leveraging personal acquaintances with necessary expertise.	Recombining existing resources and/or newly acquired ones	
Start-ups brainstorm possible applications of their technologies, and also set up criteria based on their prior experience and knowledge to prune out weak ideas.	Continuously expanding resources	
Start-ups continuously search for new information about potential markets by directly talking to relevant customers, working on small projects with major firms, or pitching to investors. They incorporate the information acquired into their current business plans.	Probing and experimenting	Options generation
Start-ups deliberately invest time and money to choose target product candidates. They either create stripped-down prototypes or seek third-party opinions to choose favorable candidates.	Creating technology roadmap with multiple routes	
Start-ups break down the initial goals into multiple short-term goals so that they can gradually pursue towards their long-term goals.	Cultivating opportunities	
Start-ups choose more than one target application. They either create back-up plans using applications in lower priority, or carefully align them with their top choice application to keep, or even develop them in parallel if possible, as viable opportunities.	Preserving opportunities	
Start-ups avoid engaging venture capital funding or top management personnel in early stage for fear of losing control and flexibility over future direction of the firms.	Sensing market information	Contingency exploitation
Start-ups try to stay vigilant on any change in market trends. They closely interact with industry people and participate in trade shows to become alert on potential opportunities.	Socially constructing peripheral environmental factors	
Start-ups actively seek like-minded entrepreneurs or start-ups to exchange information and explore partnership possibilities.	Converting constraints into new resources	
Start-ups sometimes face seemingly unsolvable challenges, such as no funding sources available in their current regions. They try to view the challenges as newly realized opportunities, such as an opportunity to venture into new geographical region.	Overcoming challenge	
Start-ups face difficulties in both technology development and new market creation. They try to overcome the challenges as quickly as possible using minimal resources.	Capturing serendipitous opportunities	
Start-ups act on favorable opportunities, such as newly available funding sources, expert personnel, or technological breakthrough, as quickly as possible.		

Strategies	First-order categories	Second-order mechanisms
Start-ups change their short-term goals when they create profitable applications so that they can take advantage of them.	Leveraging internal resources	Goal transformation
Start-ups change their short-term goals when they face significant challenge and their current plans are unlikely to pan out.	Leveraging cultivated/preserved options	
Start-ups change their short-term goals when they realize sudden opportunities.	Leveraging external opportunities	

I identified these strategies from the case studies using a three-step process. First, I conducted open coding on the focal episodes identified from the cases. These *in vivo* codes were then organized, and I then applied thematic analysis to identify applicable constructs. The first order constructs were further aggregated into second order constructs to form the four strategies identified above. Table 4 shows the summary of strategies based on the *in vivo* codes, first-order categories, and finally the second-order mechanisms that surfaced from the codes. I explain each of the strategies below.

Resource search & recombination. Resource search and recombination is a mechanism commonly used across all start-ups actively seeking new resources. As start-ups face a resource constrained environment, they have to actively search for new resources and recombine them in novel ways to utilize these resources or to gain additional resources. The vignette below illustrates how MicroscopeCo went about creating resources they can leverage.

MicroscopeCo has developed versions of a microscope that images the motion of magnetic beads inserted into a specimen. MicroscopeCo's technology was developed by Ryan and Ron, professors at a research university on the east coast. Royce, a recently graduated doctoral student at Ryan's lab, was brought in as a co-founder. While Ron had previous experience starting a company, Ryan and Royce had no prior start-up experience. Recognizing their lack of business knowledge, Ryan and Royce enrolled in a one-year entrepreneurship course at the university's business school. During the course, they were introduced to Dan, the head of the university's venture accelerator, who provided some seed funding for the venture and introduced the team to industry experts. Through these meetings, the team met Brian, an experienced entrepreneur in the medical diagnostics market with a technical background. Brian

started as a consultant for MicroscopeCo, with funding sponsored by the accelerator, but after talking to the team and studying the technology, he became interested in the technology and started advising the team on product development. Eventually, he became a member of MicroscopeCo's scientific advisory board. The accelerator also introduced Royce to the Kauffman Foundation, which provided funding for Royce's post-doctoral position, allowing him to spend time on advancing the idea to a product. Ryan explained:

"I think by far the biggest impact was meeting Dan... Dan has always been a source of "oh, meet this person and send materials to this person, and meet this person." ... But specifically regarding Dan's Venture Accelerator, it has funded a couple of consultant contracts with Brian. And that's been really important, you know, as you can have coaches spending an hour here and there, but in the end you really have to start paying people and spend a targeted time."

This vignette shows how a start-up obtained financial resources (research grants), human resources (a business expert who evolved from consultant to board member), and organizational resources (legitimacy and connections to potential partners). Other examples of strategies that technology entrepreneurs adopt to create new resources include: (1) entering business plan competitions to generate publicity and legitimacy by showing others' endorsement of the start-up's ideas; (2) securing high profile board members or seeking endorsement from respected figures in the target industry, to increase the legitimacy of one's ideas; and (3) conducting contract work with reputable organizations, sometimes even on a *pro bono* basis, to develop products and show proof of concept, which enhances legitimacy to other potential customers.

While resource creation is important for resource-scarce start-ups, researchers have had a hard time specifying what unique set of resources would lead to superior start-up performance. Instead, it has been argued that the ability to uniquely combine existing resources is likely to lead start-ups to be successful (Rasmussen, Mosey, & Wright, 2010). The analyses show that entrepreneurs need to iteratively cycle through processes that create and recombine resources in creative ways. In this process, entrepreneurs need to balance and manage multiple stakeholders, as different processes of creating and recombining resources are highly dependent on each other. The WindCo vignette below illustrates the intricacies involved in balancing between multiple resource search and recombination processes.

WindCo develops aerospace technology that lifts up an airborne wind turbine in a helium-filled, inflatable shell to harness the stronger and consistent winds over 1,000 feet high, and to produce low cost, renewable energy to be sent through a conductive tether. Due to the large-scaled nature of airborne wind turbines, WindCo faced a double bind: it needed a working prototype and evidence of customers' interest to pitch to investors, but developing a fully-functioning prototype required significant investment. In order to sustain momentum, WindCo decided to develop a limited version of a prototype to attract potential customers' interests, which could be done with the limited resources and funding they had on hand. To leverage the prototype to generate wider interest, WindCo uploaded a video of the successful demonstration of the stripped-down prototype, which created market buzz in the form of more than 20,000 YouTube views. WindCo subsequently leveraged that good publicity to pitch to potential investors. WindCo carefully combined existing and newly acquired resources and created an interim solution to seek funding sources. One co-founder of WindCo explained:

"With a start-up, it's this delicate dance...We have our prototype. We have customers, and we have investors. And every one of those wants to see the other two as far along as they can to get interested. So you do this iteration where I'm constantly ... whenever we have a new customer who is interested, I tell the investors. So if we get a new investor interested, I tell the customer. And when the prototype is further along, we tell everyone."

Options generation mechanism. While creating and recombining resources, technology entrepreneurs occasionally find themselves having certain ideas that are not developed or robust enough to be pursued right away but not weak enough to be discarded completely. Entrepreneurs often keep these ideas as options that they can exercise when environmental factors become favourable to the idea or when currently pursued goals do not pan out and the second best option is needed. I thus define a strategic mechanism that entrepreneurs use both to plan for the future and to actively create opportunities: options generation.

I observed that the strategic actions of options generation consist of two sub-strategies: (1) cultivating potential opportunities to generate options, so as to be able to exercise the option in the

future, and (2) avoiding premature commitments, so as to preserve options that the entrepreneur can take on in the future. The vignette below illustrates how LaserCo proactively planned for and cultivated options that turned out to be useful later.

LaserCo is a start-up that develops laser applications using quantum cascade laser technology. LaserCo initially relied on research grants from the federal government to develop their technology, but doing so required them to focus on applying their technology to the homeland security sector. Through their interactions with VCs, the co-founders learned that security-related products would attract limited interest from venture capitalists. While the team felt that government grants were the most appropriate source of funding at the initial stage, they knew they would need to migrate from research grants to private funding in the near future. Therefore, while the team focused on developing their technology for the security market, LaserCo also took into consideration that parallel developments were needed to apply their technology to the commercial sector of the spectroscopy market as well. One of co-founders of LaserCo said:

"In the earlier phases, we thought that we could get pretty good traction with markets in homeland security and relate it to the government and so on, which make sense. We started working on some possibility of commercial, things you would sell to other businesses that don't have defence and security uses."

This benefited the start-up, because when they needed to pitch to private investors, they were able to show working prototypes targeting a range of applications in private-sector markets.

Others in this sample tell the story of putting the initial breakthrough (and probably too foreign) idea on hold, but pursuing a more achievable short-term goal while retaining the option to pursue the more ambitious breakthrough product. Many do so by breaking down the original idea into multiple-staged interim goals to achieve gradually. In these cases, technology entrepreneurs neither pursue nor abandon the original idea, but cryopreserve it while waiting for the right time and environment to defrost it.

The underlying logic of the second sub-strategy of options generation—avoiding premature commitments—is to refrain from limiting future possibilities and to maintain the availability of certain options. This is necessary because some decisions made early in the venture creation process

may close certain doors or restrict actions later on. For example, many start-ups explicitly expressed their reluctance to receive funding from venture capitalists (VCs) too early in the commercialization process for fear of diluting the founders' equity and losing control of the start-up's development. As explained by Brian, co-founder of BatteryCo:

"... the opportunity to have an investor give us money at an early stage when Cindy and I were just getting started in the form of convertible debt allowed us to maintain some independence and determine how we were gonna grow and what we were gonna do without diluting the company significantly via issuing equity from the start and putting in place the growth expectations and pressure that often come with VC money."

Several start-ups also exhibited significant care with decisions to bring in new hires for the management team. There are so many possible directions that a start-up can go that it may not be clear what expertise a new management team would require early in the venture creation process. Bringing in a new management team prematurely may restrict growth or push the firm in a particular direction before sufficient consideration has been given to whether that is indeed the most feasible route.

The use of options generation allows companies to pro-actively plan for ways that they can retain strategic flexibility. Such flexibility is especially important for high-technology start-ups, due to the continuous state of flux of products, processes, markets and competitive boundaries (Evans, 1991).

Contingency exploitation mechanism. During the start-up journey, technology entrepreneurs often find themselves facing various contingencies, in the form of a constraint or opportunity. In contrast to generating options, with which start-ups proactively plan for the future, managing contingencies refers to coping with emergent events that are unpredictable and somewhat random (Garud, Kumaraswamy, & Karnøe, 2010). Negative events that technology entrepreneurs encounter, such as constraints that surface as entrepreneurs learn more about their technologies and markets, can be successfully converted into opportunities (Sarasvathy, 2008). On the other hand, contingencies may arrive in the form of newly uncovered information or serendipitous opportunities. As entrepreneurs learn more about the environment in which they operate, including characteristics of the market, customer needs, and regulatory requirements, their increased understanding may allow them to uncover new opportunities or contingencies. Technology entrepreneurs who successfully exploit these new opportunities are adept at leveraging emergent new opportunities that they did not

plan for. The VentilatorCo vignette below shows how a start-up did that.

VentilatorCo develops an inexpensive, portable ventilator, targeting niche markets in developing countries. From the start VentilatorCo was well aware of the difficulty of finding private funding sources in the U.S., mostly due to the target product's focus on humanitarian causes in emerging markets. While pitching to various groups of investors, VentilatorCo was introduced to an angel investor in India, who eventually agreed to invest. To seize the opportunity, VentilatorCo decided to close the U.S. office and move all operations to India, even though it had originally planned to target emerging markets while operating in the United States. VentilatorCo's co-founder explained the difficult choice he had to make:

"You have to recognize that sometimes you make a big change now in order to give yourself success later on. I think that was the hardest thing that you just got to totally let go of so much. You just have to say, 'Well, yes, I've put a lot of time and whatever the original plan was, it all ended up being, not worthless but call it a learning experience, and, or, sunk cost really'".

VentilatorCo hired a CEO from Bangalore, India, and changed the first target market to small clinics in India, with future plans to expand the target market to Southeast Asian countries.

Another vignette, on ProteinCo, further illustrates how an organization reacted to contingencies that surfaced in the form of constraints during the start-up process.

ProteinCo, a start-up producing a micro-particle application to detect multiplex protein and nucleic acids, initially set a goal to launch a whole system for planning, assaying, and analysing micro RNA levels. As ProteinCo kept interacting with pharmaceutical companies and angel investors, however, it learned that investing in an entire system required too much time and capital. As the co-founders learned what investors were looking for in start-ups, they also realized that building an entire system would be too risky, due to the inflexibility of product development, and would thus make them unattractive to VCs and angel investors. Instead, they decided to radically transform their business strategy to produce a series of plug-ins that would work with

existing instruments. This strategy would shorten time-to-market of the product for quick feedback from the customers. As highlighted by a co-founder:

“So before we had thought that we needed to build our own instrument... but it turns out we didn't feel like spending all the money to build the instrument and we didn't have the time to waste, so we just went with a razor blade model [where we make only the blade to plug into somebody else's razor] and so now we're using existing equipment to plug our technology into it. It was definitely a very important shift that we made maybe as of six months ago that changed the whole direction of the company and I think for the better.”

Goal transformation mechanism. Another important strategic mechanism that technology entrepreneurs used was the transformation of their goals based either on previously generated options that they decided to exercise or on their decision to exploit contingencies that arose. Each of the previous vignettes describing options generation and contingency exploitation included goal transformation as an outcome, after the start-up decided to pursue a different option or to exploit certain contingencies. LaserCo changed its target market from homeland security to the commercial sector. VentilationCo uprooted the whole company and moved it to India when they seized the funding opportunity created by the Indian VC. ProteinCo changed its business models as it recognized new constraints about the market. Start-ups also transform their goals based on resources that they have created or interim solutions they have developed. This vignette on EarCo provides an example.

EarCo developed a 3D ear canal scanning system. It was co-founded by David, a fluid dynamicist in an east-coast research university who works on experimental fluid mechanics and instrumentation of fluid flows. David previously co-founded ToothCo, a start-up producing a digital dental impression system, and successfully sold it. While interacting with executives from major corporations during the founding of ToothCo, David came up with an idea to apply the same technology for 3D ear canal scanning. David recounted:

“And then while we were working at ToothCo, the head of [major corporation] business development unit came in and said, “You're scanning teeth. Can you scan ear canals?” And I said, “Why would you want to do that?” And he explained that it's very similar to teeth, that in the sense that they would like to create 3D hearing aid fits that fit in the canal. But we were focused on teeth, so we didn't even want to talk about it [then].”

David did not initially pay much attention to the suggestion since he believed the technology would not work for scanning ears. It was only after David successfully sold ToothCo to a large corporation that he realized he might have the right technology to start another company, for 3D scanning of ear canals. David had a unique and award-winning technology from one of his labs that was initially thought to be useful for measuring the oil film thicknesses in engines and was never thought of as a 3D imaging system. David leveraged his network from ToothCo to set up a team of experts to incorporate EarCo to commercialize the technology.

Similar to MicroscopeCo’s decisions to transform their goals, almost all start-ups interviewed shared multiple episodes involving major goal transformations. Goal transformation is another key strategic mechanism that technology entrepreneurs engage in.

< Figure 3. Revised Research Model >

5.2. Relating the four strategic mechanisms

As noted earlier, technology start-ups have to iteratively navigate a complex process of aligning solutions they create with opportunities they identify. The four strategic mechanisms I

reported—resource search and recombination, options generation, contingency exploitation, and goal transformation—represent strategies technology entrepreneurs adopted to identify and create opportunities as well as to align solutions with opportunities. As a result, I revised my initial model to incorporate the four strategic mechanisms identified. The revised research model is presented in Figure 3, which represents a more developed version of my initial model in Figure 1, based on new insights from my analysis. Figure 3 shows how concurrent processes of opportunity identification and solution generation are iterative in nature and how they relate to each other. The research model shows how technology entrepreneurs iteratively and continuously explore the opportunity and solution spaces while ensuring that their goals are aligned with opportunities identified, resources generated, and contingencies that emerge.

As previously proposed in Figure 1, the findings confirm that technology start-ups recombine existing resources and generate new ones to explore and expand the solution space. Resources are critical for start-ups to make progress in creating interim solutions such as generating prototypes or solving technical issues. While entrepreneurs are guided by initial goals when starting the process of resource search and recombination, the process of generating new resources and solutions is highly emergent and dependent on existing and new resources that the entrepreneur brings on board.

However, the findings provided more insights into the opportunity identification processes originally proposed in Figure 1. In particular, I discovered that the opportunity identification process is more than spotting the right opportunities based on market and user needs. Rather, it consists of iterative processes involving options generation, contingency exploitation, and goal transformations. I found that entrepreneurs engage not so much in pure identification of opportunities, but rather generate multiple options about possible market opportunities they could pursue. As more information becomes available about the solutions they are generating and about exogenous constraints and opportunities in the market and environment, entrepreneurs then decide which option to exercise. In other words, the opportunity discovery and creation perspectives are complementary. Entrepreneurs engage in opportunity creation to generate various options, but opportunity discovery perspectives would need to be exercised to figure out, based on existing information, which option they should choose.

The decision to exercise an option or to exploit a contingency often results in a transformation of the start-up's existing goal. Most start-ups in this sample demonstrate more than one episode of goal transformation. The iterative nature of goal transformations shows how start-ups gradually define, probe and concretize potential opportunities. The MicroscopeCo vignette below provides an integrating illustration of how these different strategic mechanisms relate to one another.

After preliminary market research, MicroscopeCo decided there were three possible target markets for their product: the biofluid diagnostics market, the cancer diagnostics market, and the blood clotting market. The team initially decided to focus on cancer diagnostics, as they felt that they could be frontrunners in creating this market. In comparison, the blood clotting market was well established, and competition among incumbents was fairly high, whereas the biofluid diagnostics market lacked market potential. While the team focused their product development on the cancer diagnostics market, they did not abandon the possibility of pursuing the other two markets and ensured that their product development progress could also be applied peripherally to them. Their investigations later revealed significant challenges in the cancer diagnostics market. The team learned that the advantages involved in leading the market without any competitor do not necessarily outweigh the disadvantages associated with educating the market. In this situation, MicroscopeCo faced two contingencies. One in the form of a constraint—creating a cancer diagnostics market—was too challenging, but the other contingency took the form of an opportunity: a new advisory board member, who used to be the technology consultant for the start-up, happened to have extensive expertise and network in the blood clotting market. MicroscopeCo quickly decided to exploit this newly realized opportunity to respond to the constraint: it changed the target market to the blood clotting market so that the start-up could leverage in-house expert resources and network in that market, as Royce explained:

"We were focused on cancer for a long time. We're now focused on blood diagnostics... It came down to a good match between the core technology [and what] we have in the team."

Leveraging Brian's expertise and network in the blood diagnostics market, the team engaged in more in-depth research, which revealed that about 10 percent of patients with

uncontrolled bleeding die from trauma-induced coagulopathy. The team felt that if the patients' level of blood clotting could be accurately measured in the ambulance, hospitals could be notified earlier if patients needed transfusion and could have the blood bank ready when patients arrived at the hospital. After assessing their technology's feasibility, MicroscopeCo decided to produce a hand-held, blood clot measuring device for ambulances.

5.3. Comparison with unsuccessful start-ups

I also conducted an analysis comparing successful and unsuccessful start-ups in the following manner. I first coded all cases into those that had successfully progressed versus those that had progressed very little between the first and second interviews. Out of the 16 start-ups analysed, three turned out to be failure cases: two were terminated and one was put temporarily on hold (Table 1 and 2 provide more details about the stages of the start-ups). I also identified seven failure cases among the second pool of cases: start-ups that were interviewed once during the first wave of data collection but were verified to have stalled by the time of the first or second interview. I compared the successful and unsuccessful cases among all the 38 start-ups interviewed, which allowed us to compare the actions they took and to generate conclusions about successful versus unsuccessful start-up entrepreneurs. In order to compare and contrast the start-ups in a coherent way, the activity sequence diagrams that were created initially during within-case analysis were revised to incorporate the strategic mechanisms identified above.

The most distinctive difference between successful and unsuccessful start-ups is the existence of a series of goal transformations. Successful start-ups repeatedly transformed their goals by (1) incorporating developments in resource creation and subsequent solution generation, (2) exercising the appropriate options when the environment became favorable or when constraints arose limiting progress toward a previous goal, and (3) exploiting contingencies that arose either in the form of constraints or opportunities. In other words, successful start-ups are adept at managing all four strategic mechanisms of resource search and recombination, contingency exploitation, options generation, and goal transformation that I had identified earlier (Table 8 and 9 shows the number of

strategic mechanisms used for each start-up). As a result, these start-ups show quick and multiple cycles of goal transformations. Moreover, the technology entrepreneurs of successful start-ups are clearly free from the imprinting effect of strategizing (Lumpkin & Lichtenstein, 2005): the initial strategizing that led to initial goals rarely confined their cognitive capacity or restricted the boundaries of their actions when the situation called for an expansion of the boundaries. To explain the results in this section, I draw upon some previously-described examples to illustrate different types of goal transformation and use additional vignettes illustrating unsuccessful start-ups to present a contrast.

Goal transformation based on resources created. The previous vignette on EarCo illustrates a case in which a technology entrepreneur leveraged resources and ideas generated in a previous start-up to set a new goal: to transform a current technology into a product to be commercialized by a new start-up. In contrast, unsuccessful start-ups fail to transform their goals even when provided with opportunities created by new resources, as illustrated by WebCo below.

WebCo is a start-up developing a software application to visualize text contents using a collaborative filtering and recommendation algorithm. WebCo's technology helps online communities brainstorm and exchange ideas and opinions by using a graphical "map" to show patterns, trends, and the most impactful ideas, to "*enhance the wisdom of the crowds*". WebCo initially planned to develop a turnkey solution for the mass market, but switched to launching customized solutions in the short term, as they attracted interest from firms and learned how they could adapt a research-based system for commercial purposes. WebCo started generating a small amount of revenue after securing the first few customers. With the revenue stream, WebCo lost the urgency to seek funding sources, which eventually led them to stop developing a turnkey solution. A co-founder explained:

"In a way, we decided to keep it a smaller scale where we support, every now and then, consulting project or some sort of this spoken implementation of the software but we're not aggressively doing a company as was s the plan before [developing a product that can be sold as a turnkey solution]."

< Table 5. Illustrating goal transformations based on resources created >

<p>Examples illustrated in text:</p> <ul style="list-style-type: none">• Success: EarCo leveraged resources and ideas generated in a previous start-up to transform a current technology into a new product to be commercialized by a new start-up.• Failure: WebCo was so consumed with generating interim solutions that they failed to use their insights from servicing the initial clients to update their initial goal of developing a turnkey solution for customers.
<p>Other example of success:</p> <p>VeinCo develops a non-implantable, catheter-based medical device to treat chronic venous insufficiency in the deep veins of the legs. Frank, the founder of VeinCo, assigned 50% of his time to develop a prototype while working as a research fellow at university. Without many slack resources to start from, Frank used whatever was inexpensively available to him. He contacted the cadaver lab at the university and got approval to use human vein from varicose vein stripping cases to test his prototypes. He also leveraged his network with the animal test lab and tested his prototype on euthanized animals. These scavenging activities in the initial stage generated a series of interim solutions that would be compiled and provide sufficient validation for Frank to quit his other obligations and focus on VeinCo full time.</p>	<p>Other example of failure:</p> <p>SolarCo has a proprietary technology of biodegradable "black fluid," which consists of suspended particles running through clear tubing and storing up to 20% more solar energy than conventional metal solar panels with direct sunlight and 400% more in cloudy weather. SolarCo was certain that its technology would not only compete in the current regional market of solar energy, but also in other regions without year-round sunlight. SolarCo set a long-term goal to target the nationwide solar energy market and started with a heating system for swimming pools as the first target market. Although initial test-runs on both residential and commercial buildings received positive, three co-founders of SolarCo figured out the growth potential of the swimming pool market was not substantial. The gloomy growth forecasts discouraged the three co-founders from committing to SolarCo full time. They eventually decided to terminate SolarCo.</p>

The figure in Table 5 illustrates the pathway taken by firms that successfully transform their goals based on resources they generated and provides summaries and further examples of successful and unsuccessful cases.

Goal transformation based on the exercise of options. The earlier LaserCo vignette illustrated a firm that was successful in transforming its goals based on the exercise of options. On the other hand, I found that, none of the unsuccessful start-ups generated any options to be leveraged later in their journey, as illustrated by the GrapheneCo vignette below.

GrapheneCo was developing graphene-based electrodes for super-capacitors. GrapheneCo developed a technique that can potentially be used to manufacture graphene in a low cost and scalable manner. Due to the popularity of graphene as a research topic, the start-up was successful in securing government grants to fund the initial development of the technology. To be competitive in the market, the team needed to prove that their capacitor functioned much better than others, in order to warrant a higher price, but could be easily manufactured as well. However, the team developed only material technology and had no knowledge of capacitors. The co-founders found it difficult to bring in people with the required expertise, as there was no engineering school within the same university. The team also needed to raise funds but lacked hands-on experience in pitching to potential investors. While they recognized the need to hire someone with business experience, the requirements that GrapheneCo imposed—that this person must have business experience to sell the technology and also a doctoral degree in material science or in relevant fields to understand GrapheneCo's technology—made it difficult to get the right person. As explained by a co-founder:

“... that person must be able to bridge technology and have the passion and be motivated to sell this. ... I think really to get this going, I just need that kind of person.”

The team had limited success in seeking funds from venture capitalists, as they found increased competition from the rapidly increasing number of start-up companies with graphene-related technologies. Facing multiple challenges, the team decided to terminate GrapheneCo.

As shown in the vignette, GrapheneCo was continually stumped by challenges they encountered due to resource constraints. However, their search for resources was very limited in scope; they searched only locally and imposed strict requirements on the type of expertise they desired. Instead of cultivating options, changing their goals, or searching widely, the team chose to lament their lack of resources and eventually gave up due to the challenges they faced in obtaining funding. Unlike LaserCo, GrapheneCo did little to generate possible options to exercise further down the road. The figure in Table 6 illustrates the pathway taken by firms that successfully transform their

goals based on options they generated and summarizes the successful and unsuccessful cases.

< Table 6. Illustrating goal transformations based on the exercise of option >

<p>Examples illustrated in text:</p> <ul style="list-style-type: none">• Success: LaserCo cultivated the option of applying their technology to the commercial spectroscopy market while focusing their development on the security sector that provided available research funds.• Failure: GrapheneCo met with difficulties in obtaining engineering and business expertise due to their restricted local search, inability to change their goals and lack of options generation that might have allowed them to get round the problems in other ways.
<p>Other example of success: BatteryCo develops new energy storage devices using conventional printing equipment. BatteryCo’s initial conception of its core product was a printed microbattery with form factor flexibility. After investigating the traditional business models in the battery industry and realizing that the idea of printing batteries would be unfamiliar to most people in the industry, the team re-conceptualized the first product as a conventional microbattery module with the advantage of thin and flexible applications, better performance, and easier production. BatteryCo decided to keep the initial idea as an option, which would be exercised when the battery industry becomes familiar enough with the printable battery idea.</p>	<p>Other example of failure: SniffCo is a start-up that tries to commercialize a spectral analyzer using an ion mobility spectrometry to sniff out a particular type of prostate cancer. SniffCo initially targeted prostate cancer because it was the only target market that fit the criteria which SniffCo initially set up: the market should be big and the problem should be clear. During prototyping, the postdoctoral researcher who was the sole technology specialist had to leave upon termination of the contract. Without any other options to work on, the co-founders decided to terminate the project and move on.</p>

Goal transformation based on contingency exploitation. The earlier vignette on VentilatorCo illustrated how a start-up radically transformed its goal to exploit an opportunity that presented itself in the form of funding from India. The analysis shows that most start-ups in this sample met with some resource constraints or unexpected opportunities, but the successful start-ups were able to exploit contingencies to transform their goals. The unsuccessful start-ups, on the other hand, were often too focused on continuing on a particular path, such that they were unable to spot and exploit contingencies presented to them, as illustrated in the vignette below.

SmartCo has developed an electrically-conductive latex-based paint; it can be used to melt snow on outdoor surfaces, presenting a better alternative to shovelling. While the research generating the technology was done in a university, Matt, a co-founder of SmartCo, had the opportunity to own the patent after the university returned the intellectual property rights of the invention to the inventor. Partly due to this, Matt had a strong desire to control the start-up equity and was reluctant to dilute it. The team made a conscious decision to bootstrap as much as possible and not seek private funding until SmartCo had solid prototypes and business models. Matt was offered \$300,000 in funding from investors he met through the Entrepreneurship Center's business competition, but he declined the offer because he believed that SmartCo's technology was not mature enough to take private funding. In order to grow SmartCo without relying on outside investments, Matt and Aaron, the other co-founder, decided to target small scale marketed demand for simple products, so that SmartCo could start generating revenue to support further research and development. Matt explained:

"All investors want something. They want a stake in your company. My goal is to have the biggest portion of whatever we can without losing it to investors. I don't want to give away a third of my company and I certainly don't want to get down the road and be pushed out of my own business and lose everything. If I had it my way, I would have no investors... I would do it all on my own."

Due to the lack of funds, however, both Matt and Aaron continued with their full time jobs, working on SmartCo as a side project. As a result, both product development and marketing efforts saw slow progress. Two years after the company incorporated, it folded.

This vignette shows a start-up that was unable to exploit contingency, but insisted on a particular path that eventually led to its downfall. In other examples, when environmental constraints surfaced, unsuccessful start-ups were unable to exploit contingencies, but rather, responded to constraints by continuing to search for new resources. The figure in Table 7 illustrates the pathway taken by firms that successfully transformed their goals based on contingencies exploited. Table 7 also summarizes successful and unsuccessful cases.

< Table 7. Illustrating goal transformations based on contingency exploitation >

<p>Examples illustrated in text:</p> <ul style="list-style-type: none">• Success: VentilatorCo seized the opportunity to receive funding from an Indian VC firm, even though it meant the entire company had to move to India.• Failure: Co-Founders of SmartCo were excessively focused on retaining control of equity in the start-up, such that they forewent opportunities where investors offered to invest in the firm.
<p>Other example of success:</p> <p>SwitchCo is a start-up developing a research tool to investigate how DNA switches work. SwitchCo initially wanted to develop a turnkey solution to study a wide range of DNA switches, which end-users can learn to customize for themselves. As SwitchCo interacted with potential customers in the market, however, they realized that end-users wanted highly customized solutions so that minimal learning would be required for them to start to use the tool. SwitchCo then decided that their initial market strategy would be to cater to the fragmented, customized needs of pockets of researchers by offering smaller-scale, specialized products targeting different cancer genes. While this would make it difficult to sell in large volumes, SwitchCo felt that this would reduce the level of education and training required for customers, as their product was new in the market.</p>	<p>Other example of failure:</p> <p>EngineCo is a start-up developing a rocket engine that would outperform existing jet or gas engines. Faculty members in Aerospace Engineering evaluated EngineCo's design and confirmed its superiority to existing engines. EngineCo took this positive feedback as a green light to move forward to further develop the technology and pitch to potential investors. While developing a prototype, EngineCo was introduced by the Entrepreneurship Center to major corporations in the aerospace industry, such as Lockheed Martin or GE,. Due to the concern over the prototype being at too early a stage to be fully demonstrated to potential investors, EngineCo let the opportunities pass. At the same time, for fear of interfering with the Entrepreneurship Center's efforts to help EngineCo, the founder of EngineCo intentionally postponed leveraging his own network, such as his acquaintance in Pratt & Whitney. Without much development inside or out, EngineCo was terminated eventually.</p>

Table 8 and 9 show how many each of strategic mechanisms have been observed. Successful start-ups distinctively show greater number of goal transformations, whereas unsuccessful start-ups hardly transform their goals. With these numbers, I have made a number of interesting observations. First, majority of start-ups show greater number of resource search and recombination than those of options generation or contingency exploitation. However, this number of resource search and recombination is not related to the number of goal transformation. Rather, either options generation or contingency exploitation usages are highly related to the number of goal transformation. This observation highlights the relative importance of two paths to reach goal transformation, i.e., through options generation or contingency exploitation in Table 6 and 7, respectively. As a result, the number

of goal transformation is capped by the maximum number of options generation or contingency exploitation.

< Table 8. Number of Occurrence of Strategic Mechanisms – Primary Cases >

Start-up Information		No of Occurrences of Strategic Mechanisms				
	Start-up	Success vs. Failure	Resource Search & Recombination	Options generation	Contingency Exploitation	Goal Transformation
1	BatteryCo	Success	6	1	5	2
2	LaserCo	Success	4	1	3	1
3	WindCo	Success	5	2	2	1
4	ProteinCo	Success	5	1	1	2
5	EarCo	Success	4	1	2	3
6	VeinCo	Success	6	3	5	5
7	VentilatorCo	Success	3	1	2	2
8	SwitchCo	Success	5	2	5	5
9	CellCo	Success	6	2	2	3
10	VaccineCo	Success	3	1	4	4
11	DialysisCo	Success	5	1	2	3
12	DrugCo	Success	5	1	2	4
13	MicroscopeCo	Success	4	2	3	4
14	WebCo	Failure	6	0	0	0
15	SniffCo	Failure	3	0	1	1
16	GrapheneCo	Failure	1	0	0	0

< Table 9. Number of Occurrence of Strategic Mechanisms – Secondary Cases >

Start-up Information		No of Occurrences of Strategic Mechanisms				
	Start-up	Success vs. Failure	Resource Search & Recombination	Options Generation	Contingency Exploitation	Goal Transformation
1	ShoeCo	Success	3	1	3	3
2	PolymerCo	Success	4	1	2	3
3	ElixirCo	Success	3	1	5	3
4	TextCo	Success	2	0	1	1
5	PrintingCo	Success	4	1	4	5
6	PileCo	Success	3	1	3	2
7	BackCo	Success	5	1	1	3
8	WoundCo	Success	9	1	4	3
9	PlatformCo	Success	3	1	3	3
10	EngineCo	Failure	2	0	1	1
11	GraphicCo	Failure	2	0	1	0
12	SolarCo	Failure	6	1	0	1
13	MobileCo	Failure	2	0	0	0
14	HeatCo	Failure	5	3	1	0
15	CallCo	Failure	4	0	1	1
16	GreenCo	Failure	4	0	0	0
17	PathogenCo	-	2	0	0	1
18	TissueCo	-	5	0	1	2
19	SensorCo	-	1	0	0	0
20	RemedyCo	-	5	2	2	3
21	ParallelCo	-	3	0	0	0
22	SoundCo	-	2	0	0	0

Overall, the comparison of successful and unsuccessful start-ups generated the following propositions:

P1: Technology start-ups that are able to transform their goals by considering developments in resource creation and solution generation are more likely to succeed.

P2: Technology start-ups that are able to transform their goals by exercising the appropriate options when the environment becomes favorable, or when constraints arise limiting progress with a previous goal, are more likely to succeed.

P3: Technology start-ups that are able to transform their goals by exploiting contingencies that arise either in the form of constraints or opportunities are more likely to succeed.

6. Discussion

This study aims to clarify how the contrasting models of opportunity discovery versus opportunity creation relate to or complement each other in explaining entrepreneurial decision making. I also sought to explain what differentiates start-ups that exhibit strong progress in the early stages of their journey from those that are unsuccessful. To do so, I identified strategic mechanisms that technology entrepreneurs use to recognize and create opportunities and solutions. By interviewing 38 technology start-ups from seven U.S. universities that are commercializing university-developed breakthrough technologies, I identified four strategic mechanisms used to iteratively explore the opportunity and solution spaces: (1) resource search and recombination, (2) options generation, (3) contingency exploitation and (4) goal transformation.

Based on the analyses, I propose a theoretical model showing how these strategic mechanisms are used in an iterative manner and how they relate to each other. I also compared the strategic mechanisms used by successful versus unsuccessful technology start-ups. This analysis revealed that start-ups that progress successfully are adept at using all four strategic mechanisms to garner more resources and to complement the resources created with options generated and contingencies exploited to transform their goals. This process allows start-ups to flexibly react to unexpected developments that are bound to occur during the start-up process. These four mechanisms also show how entrepreneurs can actively create as well as discover new opportunities.

The findings of this study contribute to the strategic entrepreneurship literature in significant ways. As highlighted earlier, the opportunity creation perspective (e.g., Alvarez & Barney, 2007) is often contrasted with the opportunity discovery perspective (e.g., Ardichvili, Cardozo, & Ray, 2003). The latter perspective emphasizes the need for alertness, systematic analysis, accurate predictions and comprehensive planning on the part of entrepreneurs in order to evaluate and recognize profitable opportunities (Gaglio & Katz, 2001; Kirzner, 1973). On the other hand, the opportunity creation perspective emphasizes an action orientation, improvising with whatever resources one has on hand, and the importance of exerting control rather than making predictions (Baker & Nelson, 2005; Sarasvathy, 2001). I contribute to the literature in two ways: (1) by highlighting that the entrepreneurial process requires a hybrid of both perspectives, and (2) by identifying four strategic mechanisms that incorporate the competing ideas of opportunity creation and opportunity recognition. In short, I show that the two perspectives complement each other.

Resource search and recombination. I find that the resource search and recombination mechanism is predominantly improvisation-based and action-oriented: entrepreneurs recombine existing resources with those that they can get access to relatively easily. Prior research on resource management has observed that firms not only need to search for and create new resources, but managers must also undertake resource orchestration or other actions to effectively structure, bundle, and leverage firm resources (Sirmon et al., 2007; Sirmon et al., 2011). This literature notes that how a firm utilizes and leverages its resources is just as important as the unique resources it possesses. This stream of literature is strongly rooted in the resource-based view, and emphasizes two aspects: (1) assessing and identifying the resources that would allow the most returns, and (2) highlighting capability as a key mechanism through which firms bundle and leverage their resources. This study on technology entrepreneurs supplements this perspective by clarifying how technology start-ups acquire, create and recombine existing and newly acquired resources by improvising activities (Miner, Bassoff, & Moorman, 2001) or bricolaging in a routine manner (Baker & Nelson, 2005), so as to create interim solutions with the resources on hand. The findings underline the important role that action-oriented improvising and bricolaging activities play in creating and recombining resources, suggesting the need to update the views on resource structuring, bundling and leveraging to include a more creation-

oriented perspective that emphasizes both action and improvising, depending on what resources are secured.

Options generation. I find that the options generation mechanism explains how entrepreneurs actively plan ahead in parallel to their improvising and resource creation activities. Since entrepreneurs rarely have enough resources to pursue multiple projects in parallel or to equip themselves with financially sound back-up plans, the most feasible way for entrepreneurs to hedge risks is to generate options that can be exercised quickly when needed. Prior research has highlighted the need for firms to maintain strategic flexibility. Terms such as adaptability, resilience, versatility and agility have been used to describe the flexibility required of companies (Evans, 1991). As noted by Brown and Eisenhardt (1995), companies need to use various tactics to probe into and create the future. This also aligns with the real-options reasoning on entrepreneurial activities proposed by McGrath (1999, p. 16), who argued that the key point of real-options reasoning is “not avoiding failure but managing the cost of failure by limiting exposure to the downside while preserving access to attractive opportunities and maximizing gains.” While the entrepreneurial process may be emergent and seemingly *ad hoc*, there is significant scope for planning, as entrepreneurs seek to generate options and keep them open in the future. Prior literature focusing on the creation perspective emphasizes only action orientation without prediction and analysis. But this strategic mechanism clearly highlights the complementary role between opportunity creation and opportunity discovery. Entrepreneurs need to actively analyse and predict possible routes that may be available to them and take the necessary action to create these options, in order to “probe into the future”.

Contingency exploitation. The strategic mechanism of contingency exploitation aligns with prior research that has highlighted the need for entrepreneurs to exploit contingencies that arise unexpectedly over time (Garud et al., 2010; Sarasvathy, 2001). A contingency is described as a chance event, or an event that is emergent, unpredictable, and non-purposive (Garud et al., 2010; Vergne & Durand, 2010). Prior studies tend to examine contingencies as constraints, focusing on organizational adaptation to negative external conditions, such as economic shocks (Chakrabarti, 2014) or regulatory change (Fox-Wolfgramm, Boal, & Hunt, 1998). Under these conditions, organizations have been advised to respond to these sudden environmental changes with flexibility and resilience

(Evans, 1991). However, other studies have observed that constraints can be reframed positively as opportunities that organizations can take advantage of (Garud et al., 2010), and some have examined cognitive strategies that organizations can adopt (Baron, 2006; Baron & Ensley, 2006; Dyer et al., 2008). These prior studies emphasize the importance of resolving or leveraging contingencies without identifying what contributes to entrepreneurs' abilities to exploit contingencies. I contribute to this stream of research by showing what enables contingencies to be exploited in a timely manner. The findings show that to be able to exploit contingencies, other strategic mechanisms need to be activated concurrently: (1) existing resources are recombined or new resources are accessed to exploit a newly identified opportunity, (2) options are exercised when the existing path meets with significant constraints or when an environmental contingency opens up a link between the contingency and one of the options, or (3) the current goal would be radically transformed to leverage the link between contingencies, resources and options.

Goal transformation. I find that the goal transformation mechanism demonstrates how entrepreneurs make a decision to change their short-term goals according to their resources, options and contingencies. Prior studies have studied organizational goal changes from various angles, such as strategic flexibility (e.g., Sanchez, 1995), adjustment and adaptation (e.g., Levinthal, 1991), or non-predictive transformation (Wiltbank et al., 2006). Flexibility and adaptation perspectives consider goal changes as *ex post*; in other words, organizations respond to their environment by changing goals. On the other hand, the non-predictive transformation perspective considers goal changes as *ex ante*, in other words, organizations continuously remould their goals while factoring in any environmental changes realized. This study highlights that effective start-ups need to transform their goals *ex-ante* but also should be prepared to make *ex-post* goal changes. Technology start-ups in this sample deal with the double conundrum of creating a new market and developing a new product. In this setting, start-ups inevitably find themselves continuously "chasing a moving target" throughout the dynamic processes of market identification and solution generation (Posen & Levinthal, 2012). Resource-tight start-ups therefore constantly transform their goals according to what they have at the moment, what they can get access to, what they can create from the current stock of resources, and what they realize as opportunities from their environments, but they also constantly transform their goals based on

newly identified opportunities and constraints. This strategic mechanism also illustrates the complex integration of the opportunity discovery and opportunity creation perspectives. This findings show clearly the role that goals play in guiding analysis, and planning, but determining a clear, achievable goal requires an iterative series of goal transformations, which are informed by resources, constraints and options uncovered by the start-up.

Overall, I reconcile what have been contrasting perspectives about whether entrepreneurs predominantly use the opportunity creation perspective or the opportunity discovery perspective. The analysis shows that the most successful start-ups are adept at using both. These entrepreneurs engage in opportunity and resource creation by taking actions and transforming goals, yet they simultaneously plan ahead by carefully generating options. The findings of this study thus have significant implications for both the entrepreneurship and the strategic management literature. For the entrepreneurship literature, the findings of this study imply that future research should build on rather than disregard the strategic management literature in considering and examining entrepreneurial processes and strategies, even as I recognize that entrepreneurial processes tend to be more emergent and fluid. For the strategic management literature, I contribute by highlighting how strategy making can be emergent in nature (Mintzberg, 1973). By illustrating how successful entrepreneurs take a proactive perspective of controlling their environment, rather than passively responding to it, I show how integrating a control-dominant logic with strategic thinking appropriately explains the entrepreneurial behavior of technology start-ups.

More specifically, the findings of this study contribute to the field of academic entrepreneurship, both academically and practically, by showing how laboratory technologies are successfully commercialized into innovative products or services by defining problems and creating solutions in a concurrent and iterative way. University spin-offs have been considered a specific type of start-up because of their strong ties to laboratory-developed technologies. Colombo and Piva (2012) describe this specific lineage of university spin-off start-ups as having genetic characteristics. As these genetic characteristics have been realized by taxpayers' contribution in a form of research grants, the general public has been interested in possibly tangible results of university research. The findings of this study cater to these interests by showing a series of snapshots on how novel technologies are

successfully commercialized into new products or services to benefit the general public.

The findings of this study also have significant implications for practice. First, the proposed model provides significant guidance to technical entrepreneurs as to what strategic mechanisms and entrepreneurial actions will lead to progress in the inception, seed and start-up phases of a technology start-up. In particular, I highlight the importance of transforming goals periodically, based on resources accumulated, options generated, and innovative exploitation of constraints and opportunities that emerge. The proposed theoretical model also shows how technology entrepreneurs may think about navigating the problem and solution spaces in an iterative manner, such that they can ensure the alignment between problems and solutions that are critical for a technology start-up.

This study suffers from several limitations. First, the start-up entrepreneurs interviewed in this study are strictly technology entrepreneurs who try to commercialize patented, breakthrough technologies. These entrepreneurs comprise a limited segment of the population of start-up entrepreneurs, as they have to create solutions to non-existent problems. As a result, generalizability of findings is limited to technology entrepreneurs. Second, the survival bias is in play because majority of interview participants have already started the commercialization process and were actively pursuing it. In order to minimize the survival bias, the holistic processes of coming up with new ideas, teaming up with cofounders, deciding to incorporate a start-up, developing solutions, seeking investments, and launching new products or services should be studied, yet the availability of data limits the capacity to observe these commercialization processes as a whole.

Essay 2. Entrepreneurial Strategies: Impact on Innovation Performance for Resource-Constrained Firms

1. Introduction

Entrepreneurs face challenges both internally and externally. Internally only limited level of resources are available, while externally, high level of uncertainty poses difficulties for entrepreneurs to rely on conventional decision making logics. In this setting, why some entrepreneurs, and not others, effectively create successful businesses against all odds remains a perennial question. The existence of high-profile serial entrepreneurs justifies a widely shared belief that these successful entrepreneurs are capable of making more desirable decisions. In this vein, entrepreneurs have been characterized as drivers of innovation who take smart risks with "controlled boldness" (Mintzberg and Waters, 1982, p. 495). An implicit assumption that underlies this description of *smart* risks and *controlled* boldness is that entrepreneurs are successful not only because of pure luck but mostly due to certain competencies they possess. For instance, the existence of serial entrepreneurs such as Elon Musk who have created and led successful start-ups more than once cannot be explained by random chances or serendipity. These repeated successes suggest the possible existence of strategic mechanisms that they have successfully adopted to guide their decision making. Therefore, this seemingly *ad-hoc* process of entrepreneurial actions raises a question of whether there are strategic entrepreneurial mechanisms that might drive the success of innovative entrepreneurs. In other words, are there strategic mechanisms that resource-constrained entrepreneurs rely on to make superior decisions in dynamically changing environments?

Prior studies on decision making under uncertainty share a commonality in that they emphasize the importance of remaining flexible and the need of changing continuously (Levinthal & March, 1993; Mosakowski, 1997; Rindova & Kotha, 2001; Sarasvathy, 2001; Wiltbank et al., 2006). While these studies have used different perspectives to derive such principles, they unanimously defy the conventional idea of elaborate planning and precise execution. Rather, an iterative, short-term approach is favored to preserve room for changes. These theoretical arguments have also been

advocated by practitioners, in one form or other, such as the widely popularized concept of pivoting advocated by the Lean Start-up methodology (Ries, 2011). The pivoting principle suggests that start-ups need to correct their course of actions continuously by testing new ideas quickly.

These theoretical arguments as well as practitioners' applications that emphasize the importance of continuous changes have started a big pendulum swing from traditional characterization of alert entrepreneurs being perseverant through challenges, towards creative thinkers who change short-term goals flexibly. What remains unanswered is whether there are systematic strategic mechanisms that guide entrepreneurs as they continuously change their short-term goals. A recent article on start-up strategy also criticizes the prevalence of too much pivoting without well-thought through strategic intentions (McGinn, 2012). How successful entrepreneurs flexibly changing what they currently do should be distinguished from a mindless pivoting or mere adaptation to environmental constraints. I seek to identify strategic mechanisms underlying entrepreneurs' decision-makings that differentiate between the entrepreneurs who engage in purposeful redesigning versus those who are perpetually making. Therefore, the first research question of this study is: what type of strategies do entrepreneurs adopt as they continuously change their short-term goals?

The short-term goals of entrepreneurs, particularly those who try to commercialize new, innovative ideas, are about introducing innovative products and services, which are either incrementally or radically different from what current markets offer. These entrepreneurs in the process of launching their innovative ideas have been investigated to shed light on what factors lead to more successful innovations. Recent entrepreneurship and innovation studies have started to focus on a set of entrepreneurs' behavior and cognition that are likely to be associated with successful innovations has been gaining research interests (Bird, Schjoedt, & Baum, 2012; Dyer et al., 2008; Dyer et al., 2011; Mueller, Volery, & von Siemens, 2012; Pryor, Webb, Ireland, & Ketchen, 2016). This stream of research views certain set of entrepreneurs' behavioral and cognitive skills as antecedents that are positively related to successful innovations. This perspective not only sheds an interesting light on what separates innovators from the rest in terms of what they do, rather than who they are or what they possess, but also suggests an opportunity for further research on how these sets

of behavioral and cognitive skills affect the innovation performance. This link between these skills and innovativeness has not been investigated thoroughly, mostly due to the differences in level of analysis, and consequently, difficulties in collecting data from different levels. A set of behavioral and cognitive skills are learned and executed in the individual level, whereas innovation is the firm-level performance. In order to understand how certain sets of individual innovative skills are translated into more innovativeness of a company, start-up entrepreneurs become the most viable candidates to be studied, because cofounders of start-ups are individuals who, collectively, produce a firm-level output in terms of how innovative their products or services are. The other problem of the proposition on the linkage between the innovative skills and innovation performance is a lack of strategic mechanism that translates the skills into strategies. In this study, a strategy is defined as, in its broadest term, a pattern or consistency in a stream of decisions (Mintzberg, 1978; Mintzberg & McHugh, 1985; Mintzberg & Waters, 1982). When the innovative skills are repeatedly practiced to develop a pattern or consistency in an entrepreneur's decisions, these skills become antecedents to individual entrepreneurs' strategies. Therefore, the second research question is: how do the innovative skills of individual entrepreneurs impact the innovativeness of a start-ups products or services through individual entrepreneurs' strategies.

In sum, I investigate two research questions in this study: (1) what type of strategies are adopted by entrepreneurs and how these strategies are used dynamically to launch innovative products or services while continuously changing short-term goals, and (2) how individual entrepreneurs' specific behavioural and cognitive skills impact the innovativeness through entrepreneurial strategies. I adopted a multi-method approach and surveyed and interviewed a group of start-up cofounders to study their behavior, decision making patterns, and innovativeness of their products or services. The next section elaborates on two proposed models: (1) the strategy-innovativeness model that hypothesizes the relationships between a set of strategies and innovativeness, and (2) the skill-strategy-innovativeness model that hypothesizes the influences of the innovative skills on entrepreneurs' strategies, and consequently, products' and services' innovativeness.

2. Theory

The most distinguishing characteristic of entrepreneurial decisions is their prevalent need to cope with high level of uncertainty, both internally and externally. Internally entrepreneurs struggle with mobilizing and coordinating limited resources (e.g., Alvarez & Busenitz, 2001), whereas external environment poses threats with high levels of uncertainty (e.g., Alvarez & Barney, 2005; McMullen & Shepherd, 2006). These challenges not only restrict entrepreneurs' capability to plan and work towards an elaborate, long-term goal, but also tend to penalize those who commit to the originally planned courses of actions without the required flexibility (Bhide, 1994; McGrath, Ferrier, & Mendelow, 2004). Moreover, it is simply impossible to foresee every possible contingent event that is likely to happen in future (Morris & Hough, 1987; Weick & Sutcliffe, 2001). Therefore, entrepreneurs are often forced to handle unexpected events, and face the perpetual need to modify and adapt their plans over time (McGrath & MacMillan, 2000). How entrepreneurs make decision in a strategically flexible way has recently become the center of discussions in entrepreneurship research (e.g., Collis, 2016; Ebben & Johnson, 2005; McMullen & Kier, 2016). Majority of prior studies have focused on incorporating flexibility into the existing decision making processes, such as making a decision to disengage from the failing courses of actions in a flexible way (McMullen & Kier, 2016). However, how to make flexible decisions within a pre-designed domain of opportunities has been under-investigated. .

The level of uncertainty is typically highest when an entrepreneur starts to act upon his or her idea to create a new business. Following Knight's (1921) definition of uncertainty including Knightian uncertainty, uncertainty in this study excludes risks that involve known distributions of probabilities and only refer to those whose probabilistic distributions either exist and unknown or non-existent. In other words, I follow the definition of uncertainty in prior studies that focuses on the deficits in the relevant information to reach optimal decisions (Carpenter & Fredrickson, 2001; Keats & Hitt, 1988). Uncertainty has been associated with, or sometimes used interchangeably as, risk, ambiguity, turbulence, or equivocality, to name a few. These related concepts focus on different aspects of unforeseeability, such as unknown distribution of probabilities or unknown frequency,

duration, and intensity of unexpected changes. However, these concepts share one common aspect, which is unavailability of necessary information to make optimal decisions. To be able to make an optimal decision, one needs at least estimated information which results from the known distributions of probabilities. However, for most start-ups, which either launch new products to existing markets or create new markets, distribution of probabilities in either suppliers or demands side, or even none of them, is available for estimation. Therefore, start-up entrepreneurs are forced to make satisficing decisions simply because making optimal ones is not possible (Simon, 1959).

While necessary information to understand the target environment is either unavailable or even non-existent (Dew, Read, Sarasvathy, & Wiltbank, 2008; Read, Dew, Sarasvathy, Song, & Wiltbank, 2009), slack resources are usually minimal for nascent organizations (Bhide, 1992; Khair, 2010). These challenges make nascent organizations particularly vulnerable to unexpected changes in the environment. Slack resources allow organizations to have more freedom with their responses to environmental changes, and consequently, facilitate them to better adapt to competitive landscapes (Levinthal, 1997). Compared to established firms with larger slack resource endowment, start-ups without slack resources are highly likely to face difficulties in handling sudden, unforeseen environmental shocks. For example, Bartz and Winkler (2016) empirically show that start-ups, compared to small- to medium-enterprises, show slower growth during a market crisis. Therefore, entrepreneurs who are cofounders of start-ups provide an optimal context to understand how entrepreneurs make strategically flexible decisions when faced with high level of uncertainty. As start-ups usually operate in the boundaries of markets where customer needs do not exist, or have yet to be articulated, they target niche markets that have unmet needs with incrementally innovative ideas, or create new markets with radically innovative ideas (Freeman & Engel, 2007; Gartner, 1985). In either case, their business ideas contain varying degrees of newness, compared to currently available products and services. How entrepreneurs identify or create this newness, and successfully transforming the new ideas into profitable products or services has attracted interests in innovation research (e.g., Adner, 2006; Freeman & Engel, 2007). Prior research studying the role of uncertainty on firm performance has found that an entrepreneur's ability to recognize environmental uncertainty

and respond by adopting different strategic positions is positively associated with innovation performance (Li & Atuahene-Gima, 2001). This shows that certain specific approaches towards entrepreneurial decision-making under high levels of uncertainty can be expected to be conducive to innovation success.

In order to understand the drivers of successful innovations, various sources has been identified as potential antecedents of innovation successes, e.g., resource endowment such as market knowledge (Luca & Atuahene-Gima, 2007), technological capability (Zhou & Wu, 2010), acquisition (Ahuja & Katila, 2001), or certain capabilities such as absorptive capacity (Cohen & Levinthal, 1990; Tsai, 2001) or dynamic capabilities (Rothaermel & Hess, 2007). Among potential drivers of innovation, entrepreneurs' behavioral or cognitive skills have been investigated recently to understand their impact on innovation performance (Bird et al., 2012; Dyer et al., 2008; Dyer et al., 2011; Mueller et al., 2012; Pryor et al., 2016; Saxton, Wesley, & Saxton, 2016). Researchers adopting this behavioral or cognitive skills approach have studied what entrepreneurs do, that ranges from everyday behavior (Mueller et al., 2012) to strategic decisions (Saxton et al., 2016), or how entrepreneurs process information, respectively. They investigate successful entrepreneurs' behavior or information processing mechanisms to identify any consistent patterns that may lead to more innovativeness.

Among these prior studies that adopt either behavioral or cognitive approach, Dyer, Gregersen, and Christensen (2008) have identified both behavioral and cognitive skills that are associated with successful innovations. They investigate the attributes of successful serial entrepreneurs, and identified the five common skills that these entrepreneurs habitually adopt, i.e., four behavioral skills of questioning, observing, experimenting, and networking, and a cognitive skill of associating, that are later named as the five discovery skills (Dyer, Gregersen, & Christensen, 2009). These five discovery skills are argued to be the trigger to kick-start the cognitive processes that generate innovative ideas. However, how these innovative ideas are implemented to create profitable new products and services has been under-studied. Uncertainty in the context of entrepreneurial decision-making has been argued to be a sense of doubt that blocks individuals' actions (Lipshitz & Strauss, 1997), and consequently, produces hesitancy, promotes indecision, and encourages

procrastination (McMullen & Shepherd, 2006). To be able to act under high levels of uncertainty, an entrepreneur should decrease the sense of doubt that he or she happens to have, not necessarily the uncertainty itself.

One way to decrease the doubt is to create more coherence in available information using two types of skills: (1) gathering more pieces of new information, or (2) reinterpreting existing, yet seemingly unrelated, information by “connecting the dots.” The five discover skills explain how successful entrepreneurs use both behavioral and cognitive skills to collect new information and reinterpret available information by making associations. Therefore, this five discovery skills can be the counter-measures to this *inaction* induced by high levels of uncertainty, and promote entrepreneurs’ actions towards making decisions. In other words, the new ideas triggered by the five discovery skills would be translated into profitable products and services by entrepreneurial decision makings. Therefore, the five skills can be antecedents for entrepreneurial strategies, where each skill may influences different strategies.

Drawing upon both entrepreneurship and innovation literature, I investigate three groups of constructs – skills, strategies, and innovation performance - in two stages. In the first stage, the strategy-innovativeness model is proposed to test the impact of entrepreneurial strategies on start-ups’ innovation performance. In the second stage, the strategy-innovativeness model in the first stage is embedded into the bigger model of the skill-strategy-innovativeness model to test the skills as antecedents to entrepreneurial strategies. Overall, the proposed model is hypothesized and tested to show how individual skills of entrepreneurs influence entrepreneurs’ strategies, and subsequently how entrepreneurial strategies impact the start-ups’ innovation performance in terms of innovativeness of new products and services.

2.1. The Strategy-Innovativeness Model

Following the broad definition of strategy (Mintzberg, 1978), entrepreneurial strategy in this study is defined as any pattern or consistency in a stream of decisions made by an entrepreneur. Decisions as a form of human behavior have been argued to be easily isolated and analyzed to identify

a consistent pattern (Mintzberg & Waters, 1982). Among entrepreneurial decisions, those that involve major strategic changes become even more discernible than ordinary, operational decisions. These major strategic decisions create an important context to study entrepreneurial strategies, because they offer an opportunity to understand what trigger entrepreneurs to change their course of actions from the original plans, and how entrepreneurs reach decisions to change.

Different streams of research have approached the phenomenon of decision to change from different angles. In entrepreneurship research, changes in entrepreneurial actions are largely explained by entrepreneurs' effectual reasoning. According to the effectual logic, entrepreneurs start with readily available resources and try to figure out the goals they can achieve with the resources at hands (Sarasvathy, 2001; Wiltbank et al., 2006). Entrepreneurs transform their goals iteratively according to the resource base they accumulate with the help of committed stakeholders. Part of this resource base is formed by transforming contingent events into favourable resources for the entrepreneur (Sarasvathy, 2001).

How entrepreneurs decide to exploit certain contingencies, but not the others, however, has not been elaborated or empirically explained in the literature. A decision to pivot or make goal changes as a result of unforeseen environmental contingencies may be a signal of the entrepreneur's strategic flexibility and agility. Yet the same decision to change may also be interpreted to be a sign of incompetency because major changes are commonly attributed to poor planning, bad judgment or overselling by an entrepreneur (Bhide, 1992). Therefore, more clarifications are needed to distinguish strategic goal transformations from mere goal adjustments.

Authors of prior studies in innovation research, especially those focusing on new product development, have also emphasized the importance of incorporating flexibility into the innovation process with minimal costs (Sanchez, 1995; Sanchez & Mahoney, 1996; Thomke, 1997; Worren, Moore, & Cardona, 2002; Zhou & Wu, 2010). Innovation, defined broadly as "the development and implementation of new ideas" (Van de Ven, 1986, p. 591), inherently presumes a break from the current path to bring new ideas into existence, requiring an entrepreneur to change the current course

of actions. Increased novelty requires a more significant change from the current path, increasing the level of uncertainty that an entrepreneur faces at the same time. It is empirically shown that, when environmental uncertainty is high, an entrepreneur adopting more flexible strategies shows better innovation performance (Li & Atuahene-Gima, 2001). Likewise, multiple empirical studies have shown that strategic flexibility is positively associated with innovation performance (e.g., Abbey & Dickson, 1983; MacCormack, Verganti, & Iansiti, 2001; Zhou & Wu, 2010). Strategic flexibility in these studies commonly involves some form of iterations to resolve paradoxical conflicts between strategic divergence – casting a wide net to catch more lucrative opportunities – and convergence – operating efficiently with a laser-sharp focus on the current goal. For instance, Andriopoulos & Lewis (2009) find that innovative organizations adopt the iterative process of integrating existing organizational routines and differentiating by diversifying the routines, and name this iterative process as the virtuous cycles of ambidexterity. Especially in the context of start-ups' innovations, these iterative cycles of pursuing conflicting goals have been viewed from the learning perspective, such as trial-and-error learning (Sommer, Loch, & Dong, 2009) or validated learning (Ries, 2011). Due to the resource challenges and unforeseeable nature of uncertainty that most start-ups face, strategizing in a myopic way becomes more suitable for start-ups. In this setting, the learning perspective provide a much-needed room for start-ups to make a series of short-term plans that will be updated and reinforced with new information learned. One of the most popularized learning perspectives for start-ups is the pivoting, defined as "structured course correction designed to test a new fundamental hypothesis about the product, strategy, and engine of growth" (Ries, 2011, p. 149). The idea of pivoting has become the most widely adopted concept of learning by continuous changes (Blank, 2013). It advocates a quick new product development cycle that is enabled by iterative cycles of validated learning and scientific experimentations (Blank & Dorf, 2012; Ries, 2011). However, the pivoting principle functions more as a red flag or safety alarm that gives warning signals to entrepreneurs to show that what they are currently pursuing is highly likely to fail. The pivoting principle encourages entrepreneurs to disengage themselves from a failing course of actions and switch to adjacent new goals, without providing much guidance on when to grab new opportunities

and exploit them by switching to different goals. Further elaboration on when and under what mechanism to shift gears to pivot is needed with empirical evidence.

In contrast to the effectual reasoning or the iterative cycles of innovation, the strategic management literature typically views contingent events in the environment as a constraint to be overcome, as such events pose a great level of uncertainty. Since environmental uncertainty is viewed as posing a threat for the firms (e.g., Zahra, 1993), their principal strategizing focus is on reducing the degree of uncertainty to a manageable level so that analytic methods could be used to make predictions. Reduced degree of uncertainty allows firms to analyse in a systematic way, and consequently, make changes in strategic direction. These changes in strategic direction are largely viewed as adaptation to environmental stimuli (Andrews, 1971; Porter, 1980). Adaptation can occur in two mainly different ways: (1) continuous and incremental adaptation, and (2) discontinuous and transformative adaptation. Major changes from the current course of action have been analyzed based on the latter, which is the perspective of disequilibrium, such as strategic renewal involving discontinuous strategic transformations. This stream of literature stresses the importance of flexibility, but does not view contingency exploitation as a key approach to achieve flexibility. Rather, firms break from the strategic status quo and invest in a transformative change of strategic direction with the long-term prospects. One way of investing in these transformative changes is investing in real options: firms try to preserve flexibility by investing in real options, defined as rights, but not obligations, to take certain courses of actions (Bowman & Hurry, 1993; Myers, 1977). Future choices are preserved in a form of real options, in such a way that relevant one would be exercised when more information becomes available (McGrath et al., 2004). Real options reasoning, defined as "a process heuristic for understanding the economics of sequential resource investment choices" (McGrath, Ferrier, & Mendelow, 2004, p. 88), has become an important tool for firms to make judgments on uncertain opportunities, since conventional analysis can be used to evaluate options (Dixit & Pindyck, 1994). In other words, by adopting real options reasoning, the level of uncertainty would be contained within a manageable level so that analytic methods can be used to estimate probabilities. Although real options reasoning will enable flexible decisions in a pre-planned way, a number of issues occur

when the future goals need to change in a dynamic way. An underlying assumption for real options reasoning is that options are evaluated independently and reallocated in a linear way from other options. This assumption oversimplifies the complex reality of entrepreneurs where multiple options are interrelated (McGrath & Boisot, 2005). Independent evaluation and linear reallocation of interrelated options are simply not possible. Moreover, options provide flexibility only when a goal of a current project remains unchanged. Options reasoning implicitly assumes that the options are created, maintained, exercised, and terminated to achieve a pre-set goal (Klingebiel, 2012). In a situation where the goal keeps transforming itself, real options reasoning loses its power to process uncertainty into a risk.

Integrating the perspectives of contingency exploitation, iterative processes of innovation, and real options reasoning, I examine a set of entrepreneurial strategies to understand their impacts on start-ups’ innovation performance. In this sense, an entrepreneurial strategy becomes a distilled form of an ongoing effort to reconcile opposing practices: cultivating real options in a pre-planned way, yet flexibly changing their goals according to contingent events. I hypothesize the dynamic interaction between options generation and contingency exploitation, which will influence start-ups’ ability to generate innovative new products and/or services. Figure 1 presents the proposed model, showing the relationships among the entrepreneurial strategies and how they influence start-up innovation. Next section elaborates on each relationship and respective hypotheses.

< Figure 1. Proposed Strategy-Innovativeness Model >

2.1.1. Contingency Exploitation: Exploiting Contingencies by Associating Contingent Events with Existing Options

Contingencies are, by definition, chance events, where entrepreneurs rarely have control over their frequency, intensity, or duration of occurring. In the context of entrepreneurship, contingencies have been explained as “emergent contexts for action” (Garud et al., 2010, p. 760) that are “unpredictable, non-purposive, and somewhat random” (Vergne & Durand, 2010, p. 741). Contingencies, therefore, offer a fleeting opportunity or a sudden challenge for entrepreneurs. As highlighted by Gartner (1985, p. 700), “entrepreneurs do not operate in vacuums—they respond to their environments.” Effectual entrepreneurs interpret and make use of contingencies, regardless of whether they are constraints or opportunities, in a favorable way by creatively imagining possibilities (Sarasvathy, 2001). Labelled as the lemonade principle by Sarasvathy (2008), entrepreneurs are particularly proficient at finding ingenious ways to transform negative contingencies into potential opportunities. From this perspective, contingencies become opportunities to create something novel for the entrepreneur, and thus should be captured and exploited in a timely manner (Dew, Read, Sarasvathy, & Wiltbank, 2009).

As highlighted earlier, however, the question on which contingency, but not others, should be exploited still remains unanswered. Exploiting all the contingencies recognized will make an entrepreneur mindlessly meander through random changes. On the other hand, exploiting only the optimal contingencies, without any pre-designed guidelines, is essentially unfeasible, because analyzing and evaluating the recognized contingencies in systematic and comprehensive ways is usually prohibitively costly. Moreover, it is highly likely that the contingencies would expire before the analysis results become available.

In a situation where systematic analysis is impracticable, heuristic search, defined as “selective search using rule of thumb,” becomes more desirable (Simon, 1996, p.27). Simon (1996) calls this heuristically identified choice as good enough, satisficing decisions. Since evaluating each contingency in a systematic, comprehensive way is simply unachievable, an entrepreneur should

make satisficing decision on which contingency to exploit using heuristics. To be able to choose heuristically, the criteria to be used as rules of thumb should be clarified *ex ante*. However, creating a rule of thumb by identifying all the possible contingencies and winnowing out minor ones is impossible (Morris & Hough, 1987). In this context, options generated and preserved aptly fill in as the decision criteria. In other words, when certain contingencies are recognized, an entrepreneur can decide which contingency to pursue by evaluating how these contingencies relate to the options being currently cultivated.

When a set of options have been cultivated physically, via experimentation or fast-and-frugal prototyping, mapping contingencies into existing options becomes a simple associating task. When an entrepreneur preserves options cognitively, schema theory can explain how entrepreneurs can map the recognized contingencies with existing options cognitively. Schemas are mental frameworks that organizes information in one's retained memory (Wyer & Srull, 1984). According to schema theory, people maintain multiple schemas, and when there is environmental stimuli, they engage in pattern matching between the stimuli and the information stored in one of activated schema (Fiske & Taylor, 1991; Mitchell & Beach, 1990). When the pattern is matched, action is taken according to the activated schema to respond to the stimuli. When pressured for time or the stakes are low, an entrepreneur automatically favors coherency over completeness, and processes new information quickly in such a way that processed information would fit into the existing schemas. On the other hand, when accuracy is more important or the stakes are high, the entrepreneur will favor completeness over coherency, and create a new subcategory to store newly acquired information, increasing the complexity of the schema as a result (Fiske, 1993).

Options preserved cognitively can be understood as strategic schemas that an entrepreneur stores in the retained memory. As entrepreneurs create options, these options become available in their strategic schema, which are refined continuously as more information becomes available. Researchers who study decision-makings under causal ambiguity describe this progressive process of generating, cultivating, and refining a set of options a "fermentation" process (Langley et al., 1995, p. 266) or "successive approximation" (Barnard, 1938, p. 206), where decision makers successively

refine their schema as more information is revealed. When strategic schemas are continuously updated with new information, and consequently, remain activated, contingencies that are relevant to existing options are more likely to be recognized by associative thinking (Baron, 2004). I thus hypothesize that entrepreneurs who generate more options have rich schema, and are thus more likely to compare new opportunities presented in terms of environmental contingencies with options in their schema, allowing them to effectively recognize the right contingencies that create the most effective innovation. Hence, I hypothesize:

Hypothesis 1. Entrepreneurs who generate options are more likely to exploit environmental contingencies.

Since options generated allow entrepreneurs to recognize the right contingencies, exploiting these recognized contingencies, not the random ones, is expected to be the most effective approach towards creating innovative products and services. Having these options available is equivalent for entrepreneurs to equip themselves with a “strategic antenna,” which is tuned to detect pre-set ranges of signals, i.e., contingencies, which are relevant to existing options. Without these options generated, entrepreneurs lack this handy strategic antenna to filter through fleeting contingencies. As a result, they put themselves in a danger of committing either an error of commission, i.e., exploiting unfavourable contingencies, or error of omission, i.e., failing to exploit favourable contingencies. In other words, mindlessly engaging in contingency exploitation activities are likely to drive entrepreneurs to respond to contingent event in an *ad hoc* manner. The extreme case of this *ad hoc* responding to contingencies would be randomly selecting contingencies to exploit. Less extreme one would be selecting contingencies that are considered “in fashion.” Or an alert entrepreneur would screen contingencies using his or her prior knowledge and develop recognized opportunities using available information (e.g., Park, 2005; Shane, 2000). In these three cases, entrepreneurs’ existing resources are leveraged in different degrees and magnitudes. However, the most leveraged case of an alert entrepreneur using prior knowledge and available information only draws upon the available resources, without much consideration on how to expand the current resource bases. Options generated and cultivated in addition to the current resource bases will expand an entrepreneur’s

strategic schema in such a way that the entrepreneur can use the schema to sensitize his or her strategic antenna. Simply put, entrepreneurs need good heuristics, i.e., options generated and cultivated, to guide them about which contingencies to exploit.

I do not expect options generation activities to directly result in entrepreneurs' ability to generate innovative products and services, as options generation activities simply create a richer cognitive schema and more physical real options. Options generation alone creates more ideas, lacking a trigger to decide which idea to pursue and act upon the decision to pursue. By nature, options generation activities are endogenous actions of entrepreneurs to diverge on possible goals to pursue. By generating options, entrepreneurs enjoy the value of waiting, because they secure temporal resources to obtain new information in order to make more informed decisions in future. On the other hand, contingency exploitation activities inadvertently involve exogenous actions of entrepreneurs to converge upon which opportunity and possible goal to pursue in a short-term. Contingency exploitation gives entrepreneurs the value of action, as they need to make speedy decisions on which contingency to exploit. Van de Ven (1986) define the process of innovation as the "development and implementation of new ideas by people" (p.590), which assumes that the innovation process consists of two steps: (1) generating an idea or invention, and (2) exploiting the idea, such that an idea is converted into an innovation that is useful for others (Roberts, 2007). Successful innovations are achieved when entrepreneurs have novel ideas, and the ideas are successfully exploited. Opportunity recognition and exploitation has been identified as a major source of innovation success (Marvel & Lumpkin, 2007; O'Connor & Rice, 2001; Park, 2005). Entrepreneurs are found to recognize and exploit opportunities by leveraging their knowledge or experiences, and consequently, deliver successful innovations. Hence, I argue that contingency exploitation activities helps to identify and exploit the right options that have been generated and cultivated by entrepreneurs, thus resulting in more effective innovations.

Entrepreneurs who are good at exploiting appropriate contingencies are expected to introduce more innovative products or services, making the contingency exploitation strategy a mediator between options generation and product and service innovation.

Hypothesis 2a. Entrepreneurs who exploit contingencies are more likely to introduce more innovative products or services.

Hypothesis 2b. Contingency exploitation mediates the relationship between options generation and product and service innovation.

In order to exploit the relevant environmental contingency, simply mapping contingencies into existing options may not be sufficient for an entrepreneur to decide to act upon the contingency. Especially when the decision involves developing and launching new products or services, an entrepreneur needs to take into account the current investment portfolio, and evaluate how the decision to change the current course of actions will affect their existing investments. When a firm chooses a specific path to develop and launch a product, its resources bases are usually wedded into that product portfolio, limiting the firm's range of exploration as a result (Danneels, 2002). If the firm wants to pursue new paths that cannot be explored immediately by using existing resources, it needs to make a decision between two conflicting choices of either pursuing a new path at the sacrifice of current commitments or forgoing opportunities to commit to the current path. Prior studies in innovation research have observed that some innovators are more willing to sacrifice existing investments in order to pursue new opportunities, whereas other innovators lack the propensity. Indeed, studies have empirically shown that an innovator with greater willingness to sacrifice existing investments is more likely to show better innovation performance, as such existing investments are sunk costs, and should not deter entrepreneurs from making strategic changes that will benefit the firm (Chandy & Tellis, 1998; Nijssen, Hillebrand, & Vermeulen, 2005). Chandy and Tellis (1998) named this propensity as "willingness to cannibalize," and defined it as "the extent to which a firm is prepared to reduce the actual or potential value of its investments" (p. 475).

Willingness to cannibalize has been found to facilitate innovation performance in general. Chandy and Tellis (1998) empirically show that there is a positive relationship between willingness to cannibalize and radical product innovation. Govindarajan, Kopalle, and Danneels (2011) further investigate the relationship by differentiating the radical product innovation from disruptive product

innovation, and find that willingness to cannibalize facilitates only disruptive innovation, not radical innovation. This finding further confirms the definition of willingness to cannibalize which emphasizes the potential reduction in the value of investments, as radical innovation does not necessarily involve obsolescence of current investments. Danneels and Sethi (2011) further investigate the environmental factors to show that the positive relationship between willingness to cannibalize and new innovative products becomes strengthened under customer turbulence. In sum, the current consensus on the potential influence of willingness to cannibalize is its positive relationship with innovation performance which requires drastic changes from the current path, especially when the environment changes dynamically in terms of new customer profile and preference. Start-up entrepreneurs' particular challenge to handle uncertainty is to articulate, or partially articulate, unmet customer demands for potential customers, and progressively coalescing this inchoate demand into products by continuously transforming product offerings according to changing demands (Geroski, 2003). Therefore, willingness to cannibalize is expected to be a critical factor to facilitate start-up's innovation outcomes. What lacks in this formula, however, is particular actions of entrepreneurs to produce innovation outcomes, which would be triggered by willingness to cannibalize.

Willingness to cannibalize has been explained in both individual and organizational levels. According to the original definition of Chandy and Tellis (1998), willingness to cannibalize is an individual attitudinal trait of a decision-maker. Following studies expanded the concept and started to view willingness to cannibalize as an organizational culture that promotes pursuing new opportunities at the expense of current investments (Danneels, 2008; Danneels & Sethi, 2011). Willingness to cannibalize alone, either as an attitudinal trait or a cultural aspect, is not sufficient to explain the actions that lead to successful innovations. For an attitude or culture to be materialized into innovation outcomes, entrepreneurs are required to make decisions and act upon those decisions. Since willingness to cannibalize reflects an entrepreneur's determination to act upon new opportunities, entrepreneurs who are more willing to cannibalize existing businesses are expected to be able to more effectively exploit new contingencies.

Hypothesis 3. Entrepreneurs who are more willing to cannibalize existing businesses are more likely to exploit environmental contingencies.

2.1.2. Options generation Strategy: Generating Options by Bricolaging Existing Resources

While examining the inter-relationships between contingency exploitation and options generation and their positive influences on innovation performance, an important challenge for majority of entrepreneurs should be considered – resource constraints that can negatively affect entrepreneurs' ability to innovate. Following the mainstream definition of resources in the resource-based theory, resources in this study are defined as both tangible and intangible assets that are attached to an organization in a semi-permanent way (e.g., Helfat & Peteraf, 2003), which include physical, financial, human, technological or organizational resources (Barney, 1991; Grant, 1991). Slack resources, defined as additional resources an organization possesses in addition to the minimum resource requirements to operate the firm (Damanpour, 1991), are limited or even non-existent for most entrepreneurs. Prior empirical studies about the potential impact of limited slack resources have found that resource constraints alter the behavior of entrepreneurs to become more creative, and as a result, improve their resource allocative efficiency (Baker & Nelson, 2005; Starr & MacMillan, 1990).

Resource constraints pose a significant challenge to start-up entrepreneurs, thus motivating them to think creatively about how they can recombine and use existing resources in novel ways. Baker and Nelson (2005) investigate resource-constrained firms to find that some firms are able to transform their resource-poor environment into unique sets of resources by recombining resources at hand. By borrowing the structural anthropological concept of bricolage (Lévi-Strauss, 1966), defined as making do with “whatever is at hand” (p.17), Baker and Nelson (2005) view entrepreneurs as bricoleurs who skilfully recombine existing resources to either solve new problems or capture new opportunities. Prior studies have reported this practice of creative resource recombination in diverse contexts (e.g., Bechky & Okhuysen, 2011; Galunic & Rodan, 1998; Miller & Shamsie, 1996).

Resource recombination can be done in different levels. At a superficial level, neighboring resources are quickly grouped together to create a new reconfiguration, whereas, at a structural level,

relatively isolate resources are processed and synthesized to be developed into a new resource (Galunic & Rodan, 1998). Prior studies have empirically proven that the reconfiguration-based resource recombination becomes particularly useful when temporal or material resources are limited, such as time-pressured tasks bounded by tight budget (Bechky & Okhuysen, 2011). Resources among whose interactions are already developed and tested, and are quickly pulled together to solve imminent problems. In contrast, synthesis-based resource recombination becomes useful when interactions among resources have not been tested yet, and the current task requires novel ideas (Miller & Shamsie, 1996). Synthesis-based resource recombination takes more time and efforts than reconfiguration-based recombination, yet possesses more potential to deliver creative outputs (Wiklund & Shepherd, 2009).

Bricolage encompasses both reconfiguration-based and synthesis-based resource recombination activities with a specific focus on using resources at hand (rather than additional resources to be acquired), addressing new purposes, and most importantly, emphasizing actions, rather than conducting arm-chair analyses (Senyard et al., 2014). In this sense, bricolage aptly describes how entrepreneurs act to overcome resource constraints. Baker and Nelson (2005), however, observe that excessive use of bricolage does more harm than good for firm growth. Entrepreneurs who engage in parallel bricolage by repeatedly adopting bricolage across multiple domains of activities may fall into a “bricolage trap” by institutionalizing the *ad hoc* practice of using stopgap measures as a dominant strategic mechanism (Senyard et al., 2014). Without control, bricolage can quickly become the source of inefficiencies, incompleteness, or maladaptations (Lanzara, 1999), which result in incapability to develop resources in a structured, cumulative way (Senyard et al., 2014). In contrast, Baker and Nelson (2005) find that entrepreneurs who adopt bricolage narrowly and temporarily show better performance in terms of firm growth. This confined nature of bricolage capacity has been the principal reason behind the negative view of bricolage being a mere coping or survival mechanism (Baker, 2007), or “an inconspicuous but viable style of design” (Lanzara, 1999, p. 333). The bricolage trap implicitly assumes reconfiguration-based, rather than synthesis-based resource recombination. Available resources are quickly reconfigured to create a make-shift solution

to imminent problems. This bricolage activities based on reconfiguration-based recombination will enjoy rapid executions, but suffer from lack of accumulated learning. On the other hand, bricolage activities based on synthesis-based recombinations will facilitate cumulative development at the expense of speedy execution.

The bricolage trap, however, has not been incorporated in empirical studies on the outcomes of bricolage. Prior studies have considered bricolage as an antecedent to various outcomes, such as firm survival (Stenholm & Renko, 2016), financial performance (Stinchfield, Nelson, & Wood, 2013), technology development (Garud & Karnoe, 2003), or innovation outcomes (Ernst, Kahle, Dubiel, Prabhu, & Subramaniam, 2015; Salunke, Weerawardena, & McColl-Kennedy, 2013; Senyard et al., 2014), without factoring in the confined nature of bricolage capacity, i.e., that narrowly and temporarily applied bricolage activities are more likely to result in positive outcomes. However, the empirical finding of Salunke *et al* (2013) offers an interesting opportunity to take a glimpse at the dark side of resource bricolage. Salunke *et al* (2013) investigate potential drivers of service innovation to find that bricolage activities indirectly affect the interactive service innovation performance through supportive innovation, which refers to the back-end efforts to assist actual innovative changes at the front-end. The direct relationship between bricolage activities and service innovation performance was not supported in their study. They elaborate on this finding that firms may become hesitant to use bricolage as a primary strategic mechanism, especially when the goal would have critical impact on the firms' performance: in this case, delivering new services to customers and interacting with them. This finding confirms Baker and Nelson's (2005) argument that bricolage will positively affect the performance only when used in carefully selected a few domains. It also tells the cautionary tale of bricolage trap by showing that bricolage should not be used as a primary strategic mechanism, but is more fitting as a supporting strategic mechanism to expand the resource pool by recombining resources at hands.

Synthesis-based resource recombination occurs when knowledge flows are created between seemingly unrelated and isolated competencies, whereas reconfiguration-based resource recombination quickly leverages well-known interrelations among competencies (Galunic & Rodan,

1998). As a result, the resource pool expanded by synthesis-based resource recombination may take more time, but is more sustainable because it reflects cumulative development and enables subsequent accumulated learning. Empirical examples of bricolage as a synthesis-based resource recombination are frequently found in the research and development context, such as inventors synthesizing their expertise and competencies to create new artifacts (Banerjee & Campbell, 2009). The accumulated practices of recombining resources to create new resources have been argued to be one form of organizational competency (Brush, Greene, & Hart, 2001). By learning through the repeated practices of synthesis-based resource recombination, entrepreneurs not only accumulate a diverse range of new resources, but also develop and hone recombination capability. Therefore, an entrepreneur who has built the recombination capability through repeatedly bricolaging existing resources, especially in the context of research and development, would be more likely to have new ideas that are not feasible enough to be pursued right away, yet, at the same time, not weak enough to be discarded completely.

These ideas can be preserved in a form of options, and cultivated either cognitively or physically in a form of experimentation until they become sufficiently feasible. Lack of slack resources discourages entrepreneurs to actively harvest the options by making sequential investments. Instead, entrepreneurs can make a number of options available in their strategic schema, and refine their values continuously. This cognitive practice relates to the fermentation process of decision making, where decision makers successively approximate their purposes as more information is revealed (Langley et al., 1995). Options generation strategy enabled by resource bricolage provides entrepreneurs with much-needed flexibility, as the mechanism functions to preserve alternative choices while containing costs, which is the core principle to create strategic flexibility (McGrath et al., 2004). Hence, I hypothesize that resource bricolage positively influences options generation strategy, but would not directly impacts innovation performance because of its negative potential to create a bricolage trap.

Hypothesis 4. Entrepreneurs who engage in resource bricolage are more likely to generate and preserve new ideas in a form of options.

2.2. The Skill-Strategy-Innovativeness Model

Research with a specific focus on entrepreneurs' behavioral and cognitive skills has gained traction recently and called for further elucidation (Bird et al., 2012; Mitchell et al., 2004). Responding to the call for further research, and contributing to further clarification of the five discovery skills of expert innovators (Dyer et al., 2008; Dyer et al., 2009; Dyer et al., 2011), I test the influences of an entrepreneur's behavioral and cognitive skills - questioning, observing, experimenting, networking, and associating - on entrepreneurial strategies. Figure 2 presents the proposed theoretical model of the behavioral and cognitive skills, entrepreneurial strategy, and product and service innovativeness.

Dyer *et al* (2008) defined the questioning skill as the "propensity to frequently ask questions, particularly those that challenge the status quo and ask what if about the future" (p. 322). "What if" questions encourage entrepreneurs to brainstorm the possible courses of actions using existing resources. Cognitive mechanism underlying the questioning skill is counterfactual thinking, defined as "thinking in a way that is contrary to existing facts," (Gaglio, 2004, p. 539) Counterfactual thinking consists of two types, i.e., automatic and elaborative, to distinguish between spontaneous reactions and intentional and deliberate thinking process, respectively. To be precise, entrepreneurs exercising the questioning skill engage themselves in elaborative counterfactual thinking by consciously mulling over how things would be if the current interrelations among resources are removed, reshuffled, and recreated. This elaborative counterfactual thinking is argued to serve the preparative function of mental simulation, i.e., anticipating physical and social environments and imagining strategies to achieve goals in anticipated environments (Gaglio, 2004). For entrepreneurs, these imagined strategies in future environments are strategic options. Therefore, entrepreneurs who routinely ask "what if" questions are expected to be more productive at generating options.

Hypothesis 5a. Entrepreneurs who routinely use the questioning skill are more likely to generate options.

Also, questions that challenge the status quo force entrepreneurs to simulate how they would react when the current status changes. Routinely asking these questions implants the idea of flexible status into entrepreneurs' cognition, and nudges them to run a mental simulation. Running a mental simulation, and thereby, creating alternatives, is one of several cognitive heuristics used to break free from the existing framework (Gaglio & Katz, 2001). By having readily available alternatives, entrepreneurs cognitively prepare themselves for future disequilibrium. One of the antecedent to the willingness to cannibalize has been found to be future-market focus, by which entrepreneurs keep imagining future possibilities and equipping themselves to manage imagined possibilities (Chandy & Tellis, 1998). Therefore, those who ask questions that challenge the status quo are expected to show more willingness to cannibalize the existing assets.

Hypothesis 5b. Entrepreneurs who routinely use the questioning skill are more likely to be willing to cannibalize their current assets.

The observing skill is defined as "the extent to which they spend time intensely observing the world around them, paying attention to everyday experiences to find new ideas" (Dyer et al., 2008, p. 322). Paying attention to one's surroundings brings out an entrepreneur's situated alertness to make him or her becoming more alert with environmental contingencies (Valliere, 2013). Prior studies investigating how entrepreneurs identify new opportunities explained the phenomena as entrepreneurs detecting meaningful patterns (Baron & Ensley, 2006), identifying structural alignment between two ideations (Grégoire, Barr, & Shepherd, 2010), or simply "connecting the dots" (Baron, 2006). Schematic theory attributes the proficiency of this pattern recognition to how rich, associated, and primed an entrepreneur's schema is (Valliere, 2013). By intensely observing the surroundings, entrepreneurs nurture their schema by not only expanding but also reorganizing existing schema to incorporate newly observed information. Therefore, the observing skill enables entrepreneurs to arm themselves with richer and more complex schema. As highlighted above, schematic theory explains that entrepreneurs maintaining more complex schema by having multiple options available and continuously priming the schemas by cognitively cultivating these options become more proficient at detecting meaningful patterns. Following the same reasoning of schematic theory, managing richer

and more complex schema will enable entrepreneurs to recognize relevant contingent events by detecting meaningful patterns and decide to take advantage of those events. Therefore, entrepreneurs with the observing skills are expected to show better performance with exploiting contingencies.

Hypothesis 6. Entrepreneurs who routinely use the observing skill are more likely to exploit contingencies.

The experimenting skill is defined as "experiment in and explore the world with a hypothesis-testing mind-set: visiting new places, trying new things, seeking new information, and experimenting to learn new things, as experimenters constantly explore the world intellectually and experientially, holding convictions at bay, testing hypotheses along the way" (Dyer et al., 2008, p. 322). Experimentation has been argued to be better suited form of decision process when the level of environmental uncertainty is high (Lavie, 2006), paths to achieve a goal are causally ambiguous (Mosakowski, 1997), trial-and-error approach is required to solve new problems (Thomke, von Hippel, & Franke, 1998), or limited resources would not allow distant search to increase variety in the resource pool (Andries, Debackere, & Looy, 2013). Thus experimentation, which has been progressively cheaper and easier to execute due to new technological developments (Thomke, 2001), certainly benefits entrepreneurs who face multiple challenges of resource constraints, high level of uncertainty, and the needs to launch innovative products or services. By engaging in experimentation, entrepreneurs perceive new information, test the information against the existing schema, learn from the result, and update the schema according to learning. These updated schema help entrepreneurs to concretize short-term goals, yet majority of entrepreneurial goals are either moving targets or protean developments. In this uncertain environment, prior studies have found that simultaneous, parallel experimentation is the superior approach to increase resource variations without distant or comprehensive search (Andries et al., 2013; Thomke et al., 1998). As highlighted previously, the principal goal of resource bricolage in this study is to expand the current resource pool by recombining and synthesizing existing resources. Hence, I hypothesize that the experimenting skill will have a positive influence on resource bricolage.

Hypothesis 7. Entrepreneurs who routinely use the experimenting skill are more likely to engage in resource bricolage.

The networking skill is defined as "actively find and test ideas with a network of individuals who are diverse in both background and perspective" (Dyer et al., 2008, p. 322). Networking in general, such as interacting with like-minded entrepreneurs or relevant stakeholders to gain resources and legitimacy, has been found to be beneficial to entrepreneurs (Davidsson & Honig, 2003; Walter, Auer, & Ritter, 2006; Zhao & Aram, 1995). The networking skill, however, distinguishes itself from networking in general, and specifically focus on entrepreneurs' interactions with diverse expertise in order to spark breakthrough insights in a collective manner. Johansson (2004) coined the term "the Medici Effect" to describe how the ground-breaking ideas occur by creating an intersection of ideas where individuals with diverse expertise share their minds. Networking with experts who have different backgrounds prompts the divergent thinking, i.e., making unconventional associations by searching in unusual directions (Guilford, 1959). Start-ups that build wide networks spatially by searching unusual directions have been found to produce more novel innovations, whereas locally embedded start-ups are more likely to produce incremental innovations (Freel, 2003). Making unconventional associations, and consequently, creating breakthrough ideas, is the core capability of an entrepreneur to come up with innovative ideas. These novel ideas generated by engaging in expert networking tend to be highly innovative, which may need a period of probing and validation before making a decision of full commitment. Empirical evidence supports the relationship between networking activities and idea generation by showing that networking activities are concentrated in the early stage of start-ups, and gradually decrease as relationships with customers intensify in the later stages (Perez & Sánchez, 2003). Therefore, these innovative ideas are more likely to be options, rather than feasible ideas that can be pursued right away, to be cultivated until more information becomes available or a relevant contingency occurs to be exploited conjointly with the option.

Hypothesis 8. Entrepreneurs who routinely use the networking skill are more likely to generate options.

The associating skill is defined as "the ability to successfully connect seemingly unrelated questions, problems, or ideas from different fields" (Dyer et al., 2009, p. 63). Mapping separate sets of information to identify an implicit association between them is the first step to "connect the dots" and find the meaningful relationships (Baron, 2006). Schema theory explains an interesting duality of associating process. When an individual puts more priority on the accuracy of presumed associations, the individual will engage in systematic information processing and categorize the new information as either a subcategory to the existing schemas or create a totally new schema to organize and store the newly acquired information (Fiske & Taylor, 1991; Sherman, Judd, & Park, 1989). On the other hand, when the individual is under time pressure or accuracy of associations is not critical, he or she will rely on heuristics. The distinctiveness of the new information, which cannot be explained by existing schemas, would be quickly discounted and reinterpreted to fit into the existing schemas (Fiske, 1993). Associating in the context of an entrepreneur trying to launch innovative products or services is more likely to follow the latter process of heuristics, as empirically shown by prior studies (Busenitz & Barney, 1997; Vaghely & Julien, 2010). Entrepreneurs scan the surroundings to understand the contingent events, and recognize relevant contingencies by engaging in pattern recognition heuristically (Baron, 2007). Therefore, associating using a heuristic approach would positively influence the contingency exploitation strategy, because associating between contingent events and existing options is equivalent to pattern recognition. However, heuristic associating would negatively influence the options generation strategy, because more systematic recombination of existing resources and relatively more comprehensive evaluation are required to generate options. In other words, contingency exploitation strategy benefits from heuristic, speedy information processing by engaging in pattern recognition and detecting potentially positive relationships between options and contingencies. No new schema is created by associating activities for contingency exploitation strategy. In contrast, options generation strategy leverages systematic information processing by engaging in exhaustive recombination of existing resources as well as comprehensive evaluation of recombined sets. New schemas are created in a form of strategic options by options generation strategy. Hence, I hypothesize the positive relationship between the associating skill and contingency

exploitation strategy. On the other hand, the negative relationship is hypothesized between the associating skill and options generation strategy.

Hypothesis 9a. Entrepreneur who routinely use the associating skill are less likely to generate options.

Hypothesis 9b. Entrepreneurs who routinely use the associating skills are more likely to exploit contingencies.

< Figure 2. Proposed Skill-Strategy-Innovativeness Model >

3. Method

3.1. Data Sample

Start-ups are chosen as a sampling frame, because majority of start-ups are resource-constrained internally, while, at the same time, facing a high level of uncertainty externally. Comparing to more established firms, such as large corporations or small-to-medium enterprises, start-ups lack slack resources which is likely to force them to strategize in a myopic way. Also, start-ups mostly enter the boundaries of existing markets where they either create a new market or identify a niche market with unmet customer needs. The level of uncertainty in these boundaries is inherently

high, which further aggravates start-ups' strategic near-sightedness. These conditions of start-ups provide an ideal context to test my hypotheses.

The definition of a start-up has not reached consensus, and the only universally agreed-upon idea is that defining a start-up in terms of definite number of tenure, employees, revenue, or growth rate is impossible (Graham, 2012; Robehmed, 2013). One thing in common among various definitions of a start-up is its emphasis on growth and uncertainty. Paul Graham of Y Combinator defines a start-up as "a company designed to grow fast" (Graham, 2012), whereas Eric Ries defines it as "is a human institution designed to create a new product or service under conditions of extreme uncertainty" (Ries, 2011, p. 27). The closest concrete definition is generally adopted by government offices for the purpose of clarifying assessment criteria. Firm tenure less than five years old is the common criteria shared by many government offices, such as Singapore and India. Following this practice, a start-up in this study is defined as an early-stage enterprise with growth potential whose tenure is less than 5 years.

The data in this study is collected from a cross-sectional sample of 153 start-ups in Singapore. I recruited participants by working with government agencies, industry associations, start-up incubators, and co-working spaces for local entrepreneurs. I also attended local business networking events or international entrepreneurship conventions held in Singapore to recruit subjects for this study. The sample consists of founders or cofounders of start-ups in Singapore. The start-up scene in Singapore has become crowded and vibrant recently due to various government initiatives to promote local entrepreneurship. Thanks to this current atmosphere, interviewers were able to snowball from the initial batch of start-up founders to include a wide range of industry sectors. Table 1 shows the breakdown of industry sectors that start-up participants belong to.

< Table 1. Industry Sectors of Start-up Participants >

Industry Sector	Number of Start-up Participants
Manufacturing	8
Construction	6
Wholesale & retail trade	11
Accommodation & food service	3
Transportation & storage	1
Information & communications	47
Business Services	23
Engineering & engineering services	5
Finance & insurance	4
Electronics	2
Biomedical, healthcare, & medical technologies	4
Others	39
Total	153

3.2. Data Collection

As this study investigates entrepreneurial strategies and their impacts on start-ups' innovation performances, a survey questionnaire that only captures a snap shot of the current status would hardly provide the complete picture of what type of uncertainties start-up face, how they make decisions, and subsequent outcomes. Therefore, a face-to-face administration of survey questionnaire combined with a follow-up interview to discuss survey answers in detail has been conducted to further understand the contexts of their decisions and outcomes.

Three researchers including myself concurrently visited individual start-ups to conduct a survey and interview. For each start-up, one founder or multiple cofounders, if available, participated in the study. 167 cofounders from 153 start-ups were administered with survey questionnaire and interviewed face-to-face. When more than one founder participated, two or three researchers visited the site together. Participants were asked to fill out the survey questionnaire first, followed by the interview, which took 30 minutes on average. Interviews were conducted in a semi-structured way, focusing on a start-up's most recent innovative activities. Researchers asked participants to walk through their journeys of developing the innovative product or service since incorporation, and probed on their decisions that involved changes from the status quo, such as the rationale behind the decision, contents of perceived uncertainty, and their understanding of how their decisions impact the start-up performance. Researchers referred to participants' answers to the survey questionnaire, and further

investigated if there were any outstanding tendencies or inconsistencies between survey answers and their interview accounts.

For those start-ups that more than one cofounder participating, the survey questionnaire completed by the key decision maker (mostly a cofounder with a CEO title) was included. I used the interview transcripts of other cofounders, whose survey questionnaires were not included in the analysis, to triangulate the information that was provided by the key decision maker.

3.3. Measures

In this study, I have adopted multi-level variables including firm-level and individual-level variables. As a dependent variable, product and service innovativeness is measured in a firm level. Independent, mediator, and control variables are measured in an individual level.

3.3.1. Dependent variable: product and service innovativeness

The extent of product and service innovation is measured with two separate approaches: a self-reported survey measure, and qualitative codes based on interview transcripts. The survey measure consists of four items: incremental product innovativeness, radical product innovativeness, incremental service innovativeness, and radical service innovativeness. Prior studies measuring innovation performance adopt various proxies, such as the number of new products or services launched (e.g., Damanpour, 1991) or the portion of sales revenue derived from new products or services (e.g., Leiponen & Helfat, 2010)). However, start-ups in early stages lack variety in their product and service portfolios, not to mention the lack of steady revenue streams. Recent studies have shown that newness is another proxy to measure innovativeness, which can be measured by tapping on different categories, e.g., product, service, sources of suppliers, etc. (Johannessen, Olsen, & Lumpkin, 2001), or by assessing the level of newness across these categories in different settings, i.e., within the firm, industry or nation, and worldwide (Amara & Landry, 2005; Dahlqvist & Wiklund, 2012; Zhou & Li, 2012). This conceptualization of innovativeness as newness becomes particularly apt for early-stage start-ups in this sample, as majority of them are in the process of launching the first product or service, and have not had a chance to secure a steady flow of revenue stream. Therefore,

two categories of product and service are chosen, which comprise the basic foundation of start-ups. I measure the extent of incremental innovation by asking participants to report, using a 7-point Likert scale (1: Not at all; 7: To a very great extent) the extent of changes their company have made during the last three years that were perceived to be new for the company, but which have previously been used by other firms, for product and service innovation. Similarly, I measure the extent of radical innovation by asking participants to report, using a similar 7-point Likert scale, the extent of changes their company have made during the last three years that were perceived to be new for the industry, in which their company operate, for product and service innovation. I adopt these measurement items from Johannessen, Olsen, and Lumpkin (2001).

Although prior studies have shown that subjective, self-report measures of performance are indeed consistent with objective measures (Dess, Lumpkin, & Covin, 1997; Venkatraman & Ramanujam, 1986), the evaluation of newness used in this study may be more vulnerable to subjectivity, than others based on quantitative data, such as perceived revenue growth. In order to verify whether such self-reports may be biased, interview transcripts are analyzed to cross-validate the self-reported scores. Interview transcripts are qualitatively coded by two separate researchers: one who interviewed the participant assessed the four categories - incremental product innovativeness, radical product innovativeness, incremental service innovativeness, and radical service innovativeness - right after the interview. At the same time, a second coder, another researcher who was not involved in the interview, reviewed the interview transcript and assessed the same categories independently. Correlations between both sets of codes are evaluated to assess the effects of common method bias.

3.3.2. Mediator variables: entrepreneurial strategies

The mediator variables described below are all evaluated using a 7-point Likert scale (1: Not at all; 7: To a very great extent).

Contingency exploitation. Following the theoretical conceptualization of contingency exploitation originally introduced by Sarasvathy (2001), contingency exploitation strategy is defined as an established pattern of entrepreneurial decision makings in which an entrepreneur flexibly

responds to environmental contingencies through innovative reconceptualization of possibilities. Chandler, DeTienne, McKelvie, and Mumford (2011) created an effectuation measure, which contains the contingency exploitation concept, which has a four-item measure of flexibility. However, the flexibility measure alone lacks a probe to tap on situations where negative contingencies happen, e.g., when facing technical or market challenges. Hence, a four-item strategic reactivity measure developed by Green, Covin, and Slevin (2008) was adapted to supplement the measure. By drawing on these two scales, I adapted the items measuring flexibility and strategic reactivity to create a four-item measure of contingency exploitation. I request respondents to indicate the extent to which they are willing to make changes to their goals and plans, rather than stick to the original goals and plans, when (1) New, attractive opportunities arise that require a change in business goals; (2) New products/services require a change in the way tasks are carried out; (3) Needs of products/services change; and (4) Entrepreneurs see what business practices and competitive tactics work or do not work.

Options generation. The options generation strategy refers to a pattern of entrepreneurial decision making, in which entrepreneurs tend to keep doors open for the ideas that are not ready to be pursued right away, while adopting real-option reasoning to make a low initial commitment and invest sequentially. Klingebiel and Adner (2015) empirically delineate three elements of real-option reasoning - low initial commitment, sequential investment, and resource reallocation - and created one item to measure each element. I adapted the measures to generate five items to measure options generation. I asked respondents the extent to which they create multiple plans and options, rather than focus their resources on the most attractive option, in the following situations, (1) To prepare for the situation when the current business plan is likely to fail; (2) When deciding which markets to pursue; (3) When deciding on which business opportunity or idea to pursue; (4) When designing and developing products and services, and (5) When deciding whether to increase their investment.

Willingness to cannibalize. Nijssen, Hillebrand, Vermeulen, and Kemp's (2006) willingness to cannibalize measure was adapted to generate a four-item measure. I asked respondents to indicate the extent to which they are willing to invest in, rather than avoid, new projects and opportunities if (1)

The new projects and opportunities could potentially take away sales of existing products and services; (2) The new projects and opportunities may cause existing business to become obsolete; (3) Entrepreneurs have to replace or write off existing assets in investments quickly; and (4) Entrepreneurs have to abandon current projects.

Resource bricolage. Senyard, Baker, Steffens, and Davidsson's (2014) resource bricolage measure is adapted to create five items. I asked respondents to indicate the extent they use and combine existing resources, rather than acquire new resources, to (1) Find workable solutions to new challenges; (2) Take on a variety of new challenges; (3) Accomplish new challenges; (4) Respond to new opportunities; and (5) Respond to new problems.

3.3.3. Independent variables: entrepreneurial innovative skills

Dyer, Gregersen, and Christensen's (2008) innovative behavior measure for questioning, observing, experimenting, and networking skills is used. The independent variables described below are all evaluated using a 7-point Likert scale (1: Not at all; 7: To a very great extent).

Questioning. Six items to measure the questioning skill are: (1) I am always asking question; (2) I am constantly asking questions to get at the root of the problem; (3) Others are frustrated by the frequency of my questions; (4) I often ask questions that challenge the status quo; (5) I regularly ask questions that challenge others' fundamental assumptions; and (6) I am constantly asking questions to understand why products and projects underperform.

Observing. Four items to measure the observing skill are: (1) New business ideas often come to me when directly observing how people interact with products and services; (2) I have a continuous flow of new business ideas that comes through observing the world; (3) I regularly observe customers' use of our company's products and services to get new ideas; and (4) By paying attention to everyday experiences, I often get new business ideas.

Experimenting. Five items to measure the experimenting skill are: (1) I love to experiment to understand how things work and to create new ways of doing things; (2) I frequently experiment to

create new ways of doing things; (3) I am adventurous, always looking for new experiences; (4) I actively search for new ideas through experimenting; and (5) I have a history of taking things apart.

Networking. Four items to measure the networking skill are: (1) I have a network of individuals whom I trust to bring a new perspective and refine new ideas; (2) I attend many diverse professional and/or academic conferences outside of my industry/profession; (3) I initiate meetings with people outside of my industry to spark ideas for a new product, service, or customer base; and (4) I have a large network of contacts with whom I frequently interact to get ideas for new products, services, and customers.

Associating. For the associating skill, four-item association and connection measure developed by Tang, Kacmar, and Busenitz (2012) is used: (1) I often make novel connections and perceive new or emergent relationships between various pieces of information; (2) I see links between seemingly unrelated pieces of information; (3) I am good at "connecting dots"; and (4) I often see connections between previously unconnected domains of information.

3.3.4. Control variables

The survey also collected a number of important variables that I included in the analysis as controls. I included information of entrepreneurs' level of education, as well as the entrepreneur's experience in the same industry of his or her current business. As I collected data from start-ups in various industries, I included several measure that also characterize various important attributes of their industry that might affect innovation: slack resources and environmental dynamism. A start-up's slack resources are assessed by Lubatkin, Simsek, Yan, and Veiga's (2006) four-item discretionary slack measure: (1) My firm has plentiful resources to produce its products and/or services; (2) My firm has a great deal of resources available for experimental projects; (3) My firm has more resources than promising ideas to utilize all of its resources; and (4) My firm has abundant resources for training and rewarding employees to actively think about changes or new business problems. Environmental dynamism is measured by Miller and Friesen's (1983) six-item measure. I asked respondents to assess the extent to which they agreed with the following statements, comparing to other industries: (1)

There are major changes in the modes of production and/or service provision in this industry in recent years; (2) There is a high rate of innovation in this industry; (3) There are major changes in consumer demographics in this industry; (4) There are frequent and major changes in government regulations in this industry; (5) There is an increasing amount of spending on research and development in this industry; and (6) There are frequent and major changes in the number of competitors in this industry.

Initial analyses reveal that the relationships between three control variables - an entrepreneur's same industry experience, slack resources, and environmental dynamism - and the dependent variable are statistically insignificant. Therefore, for the sake of presenting the most parsimonious model, these three statistically insignificant control variables are excluded in the final models to be analyzed. The presented analysis includes only the entrepreneur's education as a control variable.

3.4. Analyses

Structural equation modeling (SEM) is used to test the proposed model and research hypotheses. SEM allows researchers to link the latent variables to multiple indicators and estimates multiple associations, while accounting for the random measurement errors in the latent variables (Shook, Ketchen Jr, Hult, & Kacmar, 2004). Anderson and Gerbing's (1988) two-step approach is adopted. Firstly, the measurement model is validated using factor analyses, and secondly, a series of nested structural models is compared to identify the structural model that best captures the covariance between constructs. The models are analyzed using LISREL 8.80 (Jöreskog & Sörbom, 1993). Multiple fit indices are evaluated: the comparative fit index (CFI) (Bentler, 1990), the non-normed fit index (NNFI), also known as the Tucker-Lewis index (TLI) (Tucker & Lewis, 1973), the root mean square error of approximation index (RMSEA) (Steiger & Lind, 1980), and the standardized root-mean-square residual (SRMR) (Bentler, 1995), as suggested by Gerbing and Anderson (1992) and Hu and Bentler (1998). The following section reports the results from these two steps.

4. Results

Results are reported in two phases. The first phase tests and reports the result of the proposed strategy-innovativeness model in Figure 1, which hypothesizes the impact of entrepreneurial strategies on product and service innovativeness. The second phase tests and reports the result of the proposed skill-strategy-innovativeness model in Figure 2, which hypothesizes the influences of innovative behavioral skills on entrepreneurial strategies, and subsequently, the impact of entrepreneurial strategies on product and service innovativeness.

4.1. Strategy-Innovativeness (SI) Model

4.1.1. SI model: factor analyses and reliability analyses results

Since I either modified the existing measures, i.e., resource bricolage, effectuation, willingness to cannibalize, and strategic reactivity, or created new items based on existing theories, i.e., options generation, both exploratory and confirmatory factor analyses are conducted. First of all, face validity was evaluated by requesting eleven fellow doctoral students in management science to categorize randomly mixed questionnaire items into unknown number of categories. Each participant was provided with carbon copies of each item, which were sorted in random sequences. Six participants successfully identified four factors, whereas rest of the participants concluded two factors. Upon finishing the categorization, I had asked each participant about their understanding and assumptions behind the categorization. Majority of them correctly identified each factor, yet some constructs were explained in different labels. Some of them understood options generation items as a form of planning, while others figured the willingness to cannibalize items as strategic renewal. Interestingly, those participants who identified two factors were found to collapse resource bricolage and options generation items into one category that describes “resources,” and willingness to cannibalize and contingency exploitation items into another category that describes “changes.” Although it was not explicitly mentioned by these participants, their further elaboration on their reasoning revealed that resource bricolage and options generation items were understood as a form of strategic divergence, whereas willingness to cannibalize and contingency exploitation items were

considered as a form of strategic convergence. This dichotomous understanding is well aligned with theoretical definition of four constructs of entrepreneurial strategy. Both resource bricolage and options generation focus on expanding the resource pool, whereas willingness to cannibalize and contingency exploitation focus on recognizing a lucrative opportunity and deciding to change. Further discussion with these participants who identified two factors concluded that the entrepreneurial strategy items have four factors.

Exploratory factor analysis. Two items - the second item of resource bricolage measure and the second item of options generation measure - are dropped after initial tests, because of poor correlations with other items. I also identified interpretational reason to drop these items. The second item of resource bricolage measure, “2. *Take on a variety of new challenges,*” is suspected to emphasize “a variety” of challenges, rather than challenges, opportunities, or problems, as in other items. The second item of the options generation measure, “2. *When deciding which markets to pursue,*” may have a different level of abstraction compared to other items that ask business opportunity, idea, business plan, product and service, or investments. Exploratory factor analysis with 16 items using Varimax rotation produced a four-factor solution, as shown in Table 2. There were no problems with the cross-loadings, as the largest cross-loading across factors is .248.

Confirmatory factor analysis. Confirmatory factor analysis (CFA) result shows that the measurement model has a good fit: $\chi^2 = 205.41$ ($df = 138$, $p < .001$); CFI = .95; NNFI = .94; RMSEA = .055; SRMR = .056. Although establishing universal cutoff levels is difficult, Hu and Bentler (1999) suggest a cutoff value close to .90 for CFI and NNFI, .06 for RMSEA, and .08 for SRMR. Statistical significance of each indicator's factor loading, and, subsequently, each construct's reliability and average variance extracted are evaluated, as suggested by Hair, Anderson, Tatham, and Black (1998).

< Table 2. Results of Exploratory Factor Analysis of Entrepreneurial Strategy Items >

Item	1	2	3	4
Resource bricolage				
RSC3	.857	.007	.045	.138
RSC5	.854	-.067	.100	.086
RSC1	.838	.081	.037	.009
RSC4	.788	-.163	.095	.208
Willingness to cannibalize				
WTC2	-.013	.844	.225	-.029
WTC4	.047	.796	-.042	.069
WTC3	-.101	.782	.196	.176
WTC1	-.072	.771	.248	.126
Contingency exploitation				
CTG3	.175	.164	.809	.035
CTG2	.101	.164	.794	.103
CTG1	-.151	.048	.706	.241
CTG4	.137	.158	.640	.067
Options generation				
OPT3	-.002	-.009	.143	.785
OPT5	.096	.153	.050	.765
OPT4	.203	.087	.170	.701
OPT1	.107	.073	.049	.666

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

Table 3 shows the final items, their factor loadings, Cronbach's coefficient alpha, and variance extracted. CFA results indicate that all the relationships between an indicator and its respective variable are statistically significant ($p < .001$), which verifies the convergent validity of each construct and its indicators. To check the discriminant validity, bivariate inter-factor correlations are examined (Table 4). The highest inter-factor correlations is .367, verifying the discriminant validity as suggested by Tabachnick and Fidell (1996). Following Ling, Simsek, Lubatkin, and Veiga (2008), I further verified the discriminant validity by confirming that the variance explained by each variable is larger than its shared variance explained in conjunction with any other variable. Cronbach's coefficient alpha values for all constructs are larger than .70, which indicates a high level of internal consistency (Nunnally, 1967). Resource bricolage and willingness to cannibalize strategies, whose items are adapted from existing measures, have alpha values of .87 and .84, respectively. Contingency exploitation and options generation strategies have alpha values of .76 and .74, respectively, which

fall within the acceptable range considering them being newly developed measures and having a small number of items (four items each) (Cortina, 1993).

< Table 3. Factor Results for Entrepreneurial Strategies >

Entrepreneurial Strategy Measures	Items	Factor Loadings	Corrected Item-Total Correlation
Resource Bricolage	Please indicate to what extent you use and combine existing resources, rather than acquire new resources to:		
	1. Find workable solutions to new challenges.	.74	.69
	3. Accomplish new challenges.	.81	.75
	4. Respond to new opportunities.	.79	.72
	5. Respond to new problems.	.82	.75
	Eigenvalue	4.15	
	Cronbach's alpha	.87	
	% variance explained	25.93	
Contingency Exploitation	Please indicate to what extent you are willing to make changes to your goals and plans, rather than stick to the original goal and plans, when:		
	1. New, attractive opportunities arise that require a change in business goals.	.57	.48
	2. New products/services require a change in the way tasks are carried out.	.75	.64
	3. Needs of products/services change.	.79	.66
	4. You see what business practices and competitive tactics work or do not work.	.59	.46
	Eigenvalue	1.72	
	Cronbach's alpha	.76	
	% variance explained	10.75	
Willingness To Cannibalize	Please indicate to what extent you are willing to invest in, rather than avoid, new projects and opportunities if:		
	1. They could potentially take away sales of existing products/services.	.79	.68
	2. They may cause existing business to become obsolete.	.85	.74
	3. You may have to replace or write off existing assets and investment quickly.	.75	.69
	4. You have to abandon current projects.	.62	.59
	Eigenvalue	3.03	
	Cronbach's alpha	.84	
	% variance explained	18.95	
Options generation	Please indicate to what extent you create multiple plans and options, rather than focus your resources on the most attractive option, in the following situations:		
	1. To prepare for the situation when the current business plan is likely to fail.	.56	.47
	3. When deciding or which business opportunity or idea to pursue.	.66	.55
	4. When designing and developing products and services.	.70	.56
	5. When deciding whether to increase our investment.	.68	.57
	Eigenvalue	1.51	
	Cronbach's alpha	.74	
	% variance explained	9.45	

< Table 4. Means, Standard Deviations, and Correlations among Variables >

Variables	Mean	S.D.	1	2	3	4	5	6	7	8	9	10
1. Product and service innovativeness	4.812	1.391										
2. Resource bricolage	5.288	1.204	.207*									
3. Contingency exploitation	5.712	.903	.301***	.173*								
4. Willingness to cannibalize	4.456	1.374	.126	-.037	.366***							
5. Options generation	4.941	1.045	.073	.257**	.305***	.212**						
6. Questioning	5.141	1.009	.147	.140	.304***	.233**	.333***					
7. Observing	5.439	.924	.150	.120	.241**	-.025	.189*	.358***				
8. Experimenting	5.415	1.062	.157	.333***	.194*	.022	.277**	.384***	.449***			
9. Networking	4.962	1.175	-.068	.068	.034	-.108	.203*	.097	.420***	.293***		
10. Associating	5.679	.949	.282***	.262**	.199*	-.030	.129	.357***	.487***	.444***	.241**	
11. Entrepreneur's education	2.248	.700	.210**	.030	-.027	.039	-.108	.025	-.086	.048	-.175*	.209**

n = 153

* p< .05

** p< .01

*** p< .001

4.1.2. SI Model: Nested Structural Models Results

The second step of Anderson and Gerbing's (1988) two-step approach is to compare and contrast the model fit results of a series of nested models, in order to identify the model that has the closest fit and accounts for the highest observed covariances among latent variables. Following Bollen (1989), multiple fit indices - CFI, NNFI, RMSEA, SRMR, χ^2 and df - are evaluated to identify the closest fit, and at the same time, assess the statistical significance of the completely standardized path estimates to test the hypotheses. Table 5 lists the sequence of nested models and their fit indices to be contrasted.

Model 0 (M0) is the measurement model that is the baseline model. Model 1 (M1) is a covariate only model to specify the influence of entrepreneurs' education on other variables. Entrepreneurs' education accounts for only 5 percent of the variance in product and service innovativeness. Entrepreneurs' education has no significant influence on the four entrepreneurial strategy constructs. Model 2 (M2) is a non-mediated model that specifies the direct influences of entrepreneurial strategies, except contingency exploitation, on product and service innovation. The R^2 explained in product and service innovation is .16 that is the variance explained by three

entrepreneurial strategies - resource bricolage, willingness to cannibalize, and options generation - only, excluding the influence of contingency exploitation strategy.

Model 3 (M3) adds the direct influence of contingency exploitation strategy on product and service innovation. With M3, R^2 explained in product and service innovation increases to .26, which shows the additional variance ($\Delta R^2 = .10$) explained by contingency exploitation strategy. However, all three added paths in M3, i.e., paths from resource bricolage, willingness to cannibalize, and options generation towards product and service innovativeness, remain statistically insignificant. I then evaluated three other cases, where the paths from resource bricolage, willingness to cannibalize, and options generation towards product and service innovation are added, in addition to contingency exploitation. None of these models show superior fit indices.

I then specified the proposed mediation model. Model 4 (M4) is a fully mediated model that specifies the mediated influences of three entrepreneurial strategies - resource bricolage, willingness to cannibalize, and contingency exploitation - through contingency exploitation strategy. All paths in M4 are statistically significant. Differences between the fit indices of M4 ($\chi^2[df=145, n=153] = 222.84, p < .001$; CFI = .94; NNFI = .94; RMSEA = .057; SRMR = .079) and those of M3 ($\chi^2[df=142, n=153] = 219.84, p < .001$; CFI = .94; NNFI = .93; RMSEA = .057; SRMR = .075) are insignificant: M4 indicates slightly higher NNFI ($\Delta NNFI = .01$) and SRMR ($\Delta SRMR = .004$). Variance in product and service innovativeness is slightly more captured in M3 ($\Delta R^2 = .03$). Although M3 explains more variance in product and service innovativeness, M4 should be considered as the better-fitting model because of all paths being statistically significant. Two-tailed chi-square test also reveals that the difference in χ^2 of 3.00 ($\Delta df = 3$) between M3 and M4 is not statistically significant. Therefore, it is concluded that the hypothesized model of M4 is the best-fitting model.

Both options generation (.32, $p < .01$) and willingness to cannibalize (.40, $p < .001$) strategies positively influences the contingency exploitation strategy, supporting Hypotheses 1 and 3, respectively. Contingency exploitation strategy is positively associated with product and service innovativeness (.41, $p < .001$), supporting Hypothesis H2a. The fact that options generation does not

have a direct influence on innovation (see M3 results), and that contingency exploitation significantly mediates the relationship between options generation and innovation provides support for Hypothesis 2b. Finally, resource bricolage strategy (.34, $p < .01$) is positively associated with options generation strategy, supporting Hypothesis 4. Figure 3 presents the path coefficients of the hypothesized model.

< Table 5. Summary of Fit Indices for Nested Strategy-Innovativeness Models >

Model	df	χ^2	CFI	NNFI	RMSEA	SRMR	R ² in DV
M0: measurement model	138	205.41***	.95	.94	.055	.056	
M1: covariate only	148	281.49***	.91	.89	.074	.130	.05
M2: non-mediated model	143	229.63***	.94	.93	.060	.081	.16
M3: partially mediated model	142	219.84***	.94	.93	.057	.075	.26
M4: fully mediated model (hypothesized model)	145	222.84***	.94	.94	.057	.079	.23

n = 153

*** $p < .001$

< Figure 3. Strategy-Innovativeness Model >

4.1.3. SI Model: *Post Hoc* Analysis

To ensure that the rating of innovation is not completely subjective and is backed by qualitative evidence, interview transcripts of all 153 cases were qualitatively coded by the interviewer immediately after he or she had conducted the interview, and an independent coder, who is a researcher involved in this study yet has not participated in any of the interviews. The dependent variable is triangulated by evaluating the correlations among three sets of data: (1) self-reported product and service innovativeness scores, (2) qualitative scores from the interviewer conducting the interview, and (3) qualitative scores by the independent coder, derived from a review of the interview transcripts. Both sets of qualitative codes are strongly correlated with self-report scores (correlation

coefficients: .82 ($p < .01$) between codes by the interviewer and the self-reported scores; .71 ($p < .01$) between codes by the independent coder and the self-reported scores). This shows the reliability of the dependent variables, and that the scores are backed by concrete evidence that the entrepreneurs are able to assess their innovation performance with minimal subjectivity.

4.2. Skill-Strategy-Innovativeness (SSI) Model

Once the best-fitting model for the strategy-innovativeness model is identified, entrepreneurial skills constructs are brought in as antecedents to entrepreneurial strategy to test the rest of hypotheses (Figure 2). After initial tests, three items - one item from experimenting, and two items from questioning - that show either poor loadings or inconsistent correlations with other items within a variable were dropped. The final set of five-factor, 20-item measure for entrepreneurs' innovative skills is analyzed. Same procedure of contrasting model fits of a sequence of nested models was adopted (Anderson & Gerbing, 1988). Table 6 presents the fit indices of nested structural models.

Model 0 (M0) is the baseline model of measurement model. Model 1 (M1) is a non-mediated model that specifies the direct influences of entrepreneurs' five innovative skills - questioning, observing, experimenting, networking, and associating - on product and service innovativeness. None of the direct paths between skills and product and service innovativeness is found to be statistically significant. Model 2 (M2) and Model 3 (M3) are partially mediated models in which direct paths from entrepreneurs' innovative skills to product and service innovativeness (M2) and contingency exploitation (M3), respectively, as well as the mediated paths, are freed. None of the direct paths in M2 and M3 is statistically significant. Model 4 (M4) is a fully mediated model that specifies the mediated influence of entrepreneurs' innovative skills through entrepreneurial strategy. All paths in M4 are statistically significant, finalizing M4 as the best-fitting model. Fit indices of M4 ($\chi^2[df=676, n=153] = 1016.65, p < .001$; CFI = .93; NNFI = .92; RMSEA = .051; SRMR = .075) indicate a moderate fit of the hypothesized model. Variance in product and service innovativeness that is

explained by entrepreneurs' innovative skills and entrepreneurial strategy is .25. Additional variance captured by the innovative skills is .02.

< Table 6. Summary of Fit Indices for Nested Skill-Strategy-Innovativeness Models >

Model	df	χ^2	CFI	NNFI	RMSEA	SRMR	R ² in DV
M0: measurement model	648	987.65***	.93	.92	.054	.067	
M1: non-mediated model	672	1013.19***	.93	.92	.052	.075	.19
M2: partially mediated model (to product and service innovativeness)	671	1008.33***	.93	.92	.051	.074	.33
M3: partially mediated model (to contingency exploitation)	673	1014.52***	.93	.92	.051	.074	.25
M4: fully mediated model (hypothesized model)	676	1016.65***	.93	.92	.051	.075	.25

n = 153

***p < .001

< Figure 4. Final Skill-Strategy-Innovativeness Model >

Questioning skill is strongly associated with the options generation strategy (.51, $p < .001$), supporting Hypothesis 5a. It also positively influences the willingness to cannibalize strategy (.24, $p < .05$), as hypothesized by Hypothesis 5b. Hypothesis 6, which posits the positive influence of observing skills on the contingency exploitation strategy, is not supported. Experimenting skill is strongly associated with the resource bricolage strategy (.38, $p < .001$), supporting Hypothesis 7. Networking skill positively influences the options generation strategy (.26, $p < .05$), as hypothesized

by Hypothesis 8. Hypothesis 9 shows mixed results: associating skill is negatively associated with the options generation strategy ($-.22, p < .05$), supporting Hypothesis 9a, whereas the contingency exploitation strategy is not influenced by associating skills (Hypothesis 9b not supported). Figure 4 presents the path coefficients for the final skill-strategy-innovativeness model. The hypotheses in this study and their statistical significance are summarized in Table 7.

< Table 7. Summary of Fit Indices for Nested Skill-Strategy-Innovativeness Models >

Hypotheses	Results
H1. Entrepreneurs who generate options are more likely to exploit environmental contingencies.	Supported
H2a. Entrepreneurs who exploit contingencies are more likely to introduce more innovative products or services.	Supported
H2b. Contingency exploitation mediates the relationship between options generation and product/service innovation.	Supported
H3. Entrepreneurs who are more willing to cannibalize existing businesses are more likely to exploit environmental contingencies.	Supported
H4. Entrepreneurs who engage in resource bricolage are more likely to generate and preserve new ideas in the form of options.	Supported
H5a. Entrepreneurs who routinely use the questioning skill are more likely to generate options.	Supported
H5b. Entrepreneurs who routinely use the questioning skill are more likely to be willing to cannibalize their current assets.	Supported
H6. Entrepreneurs who routinely use the observing skill are more likely to exploit contingencies.	Not supported
H7. Entrepreneurs who routinely use the experimenting skill are more likely to engage in resource bricolage.	Supported
H8. Entrepreneurs who routinely use the networking skill are more likely to generate options.	Supported
H9a. Entrepreneur who routinely use the associating skill are less likely to generate options.	Supported
H9b. Entrepreneurs who routinely use the associating skills are more likely to exploit contingencies.	Not supported

5. Discussion

Entrepreneurs are argued to “operate at the edge of what they do not know (Hill & Levenhagen, 1995, p. 1057), without objective guidelines to assess emerging opportunities or slack resources to engage in systematic search for opportunities. To make this matter of uncertainty worse, competitive landscape for entrepreneurs is argued to be rugged (Levinthal, 1997) and “dimly visible” (Bettis & Hitt, 1995, p. 7). Even with these significant challenges, some entrepreneurs successfully

introduce innovative products or services. In this study, I investigated how entrepreneurs flexibly changes the current course of actions to introduce more innovative new products or services, when the environmental uncertainty is high, and how innovative behavioral and cognitive skills of entrepreneurs impact the product and service innovativeness through entrepreneurial strategies. Two entrepreneurial strategies, options generation strategy and contingency exploitation strategy, and their relationships are tested to empirically show that entrepreneurs who use both strategies concurrently as two gears of the innovation process introduce more innovative products or services.

Recent studies in entrepreneurship have focused on the flexibility of entrepreneurial decisions, such as iterative goal transformations (Sarasvathy, 2001; Wiltbank et al., 2006; Wiltbank et al., 2009) or continuous strategic changes (Blank, 2013; Ries, 2011). These studies advocate the importance of changes by breaking free from historic paths and not being strategically confined by the current course of actions. On the other hand, the other streams of research call for a resumed interests on the importance of planning in entrepreneurial decision makings (Delmar & Shane, 2003), empirically showing the beneficial side of planning (Brinckmann, Grichnik, & Kapsa, 2010). These studies view planning as an important stepping stone to action because entrepreneurs convert abstract goals into concrete milestones by engaging in formal planning.

I respond to these calls by empirically showing how entrepreneurs both pre-plan and cater for the future, and, at the same time, flexibly respond to contingencies. Entrepreneurs are found to pre-plan, not in a conventional way of setting up a long-term goal and creating plans, but by generating options. Overall this result highlights the following approach entrepreneurs use to adapt to resource constraints and environmental uncertainties: Entrepreneurs either habitually recombine existing resources to put them into new uses, or have no choice but to bricolage existing resources to solve new problems due to resource constraints. Entrepreneurs that introduce more innovative products or services are found to not only bricolage existing resources to address imminent problems, but also recombine available resources to internally search for new ideas. Those ideas that are not feasible enough, yet assessed to have commercial potential, are kept in a form of options, so that entrepreneur will pursue any option when more information becomes available or favorable contingent events

happen. Options generated provide an entrepreneur with a pre-planned guideline to decide which contingent events to exploit. Options as a rule of thumb to quickly decide which contingency to exploit allow entrepreneurs to make fast decisions. Therefore, cultivating options and, as a result, maintaining a richer strategic schema, enables entrepreneurs to become more flexible when an opportunity opens up in a form of contingent event.

Adopting both options generation strategy and contingency exploitation strategy enables entrepreneurs to balance complexity and simplicity simultaneously. By having options available in one's schema, the entrepreneur promotes complexity by having a richer strategic schema. At the same time, entrepreneurs are ready to exploit contingencies, which are quickly evaluated to find whether they are relevant to existing options. The contingency exploitation strategy boosts simplicity in an entrepreneur's strategic schema by deciding to pursue only relevant contingencies, not the others. The two strategies as opposing gears to counter-balance complexity and simplicity address the chronic problem of entrepreneurship on how to handle uncertainty. McMullen and Shepherd (2008) explain the uncertainty dilemma that an entrepreneur faces as balancing error of commission, defined as "taking action only to find their belief was unfounded (p. 139)," and error of omission, defined as "not taking action only to regret it when time proves that their passed-over hunch was correct (p. 139)." The two opposing errors are balanced by adopting entrepreneurial strategies of options generation and contingency exploitation, as an entrepreneur decides to commit only when the contingency is evaluated to be relevant to existing options. Prior studies in real options reasoning have cautioned that, without a decision maker's sustained attention on options, the value of options are unlikely to be realized (Barnett, 2008; Klingebiel, 2012). The options generation strategy of entrepreneurs further elaborate on this argument by showing that the entrepreneurs who keep an eye on the options by continuously generating and preserving options are more likely to exploit favorable contingencies. Levitas and Chi (2010) equates the value of options to the value of waiting, because through options, entrepreneurs reserve the right to fully commit, until more information becomes available. On the contrary, the value of contingencies exploited becomes equivalent to the value of acting, because contingencies to be exploited signals an entrepreneur to stop waiting and start acting on the

contingency in conjunction of the relevant option. The findings of this study also support the argument that the belief in having a Eureka moment to start an innovation is a big myth (Birkinshaw, Bouquet, & Barsoux, 2011). Rather than conceptualizing the flashes of insights happening serendipitously, entrepreneurial strategies assume the deliberate efforts of entrepreneurs to create the insights.

Using options generation and contingency exploitation strategies as two gears to drive an innovation engine offer a possible theoretical lens to understand the perspective that views an organization as a sponge to absorb different levels of knowledge depending on its capacity. Endorsing the positive influence of absorptive capacity on innovation performance (Cohen & Levinthal, 1990), Fiol (1996) argues that simply focusing on “squeezing the sponge harder,” i.e., leveraging an organization’s absorptive capacity to create innovation, hardly guarantee a good performance. In contrast, not only “filling the sponge” should precede the squeezing, but also various ways of squeezing should be applied to create successful innovations. The findings of this study aptly describe the process to fill the sponge by showing entrepreneurs adopt resource bricolage to expand the current resource pool and generate strategic options. The process of squeezing the sponge is kick-started when an entrepreneur recognizes a contingent event, which is highly relevant to preserved options, and decides to exploit that contingency.

This study also empirically shows the association between the entrepreneurial strategies and innovative behavior. The five behavioral and cognitive skills of an innovator, i.e., questioning, observing, experimenting, networking, and associating skills (Dyer et al., 2008; Dyer et al., 2009; Dyer et al., 2011), are found to be antecedents to the entrepreneurial strategies, with each skill influencing different strategies. Although questioning, experimenting, and networking skills are found to be positively associated with the options generation strategy as hypothesized, either directly or through mediator, hypotheses on associating and observing skills positively influencing the contingency exploitation strategy are not supported. Possible explanation would be that the associating measure particularly highlights associating the “seemingly unrelated information,” resulting in activating systematic thinking, rather than heuristic thinking of an entrepreneur.

Associating has systematic-heuristic duality according to the schema theory (Fiske, 1993; Fiske & Taylor, 1991), and was hypothesized to happen in a heuristic way because entrepreneurs are largely pressured for time and in need of quick decision making. However, the survey items specifically ask about associating unrelated information, which may have captured the systematic thinking portion of an entrepreneur's associating process. Hypothesis 6, which tests the positive influence of observing on the contingency exploitation strategy, lacks statistical power to be supported. It is possible that the observing skill may have captured the portion of observing ordinary encounters, rather than detecting meaningful contingencies. It is possible that intense observation on surrounding signals will deplete an entrepreneur's cognitive resources, which may desensitize the entrepreneur's radar to detect the valid signal.

The findings of this study further clarify what has been empirically found in prior innovation studies. Prior studies have empirically observed and described an innovation journey as a nonlinear dynamic system which is neither orderly nor predictable, but, at the same time, neither totally random nor stochastic (Cheng & van de Ven, 1996). More specifically, Cheng and van de Ven (1996) made a sequential demonstration that, during the initial period of innovation development, both decision-makers' actions and their outcomes show chaotic pattern, whereas orderly and periodic patterns emerge during the ending period of innovation development. The findings of this study explain the initial chaotic pattern in terms of resource bricolage and options generation strategies, which are positively influenced by experimenting, questioning, and networking skills. Contingency exploitation and willingness to cannibalize strategies offer a possible mechanism to migrate from the initial chaotic patterns to more orderly patterns in later stages by explaining how a decision-maker concretize innovation goals by leveraging contingent events and relevant options.

By showing the process of an innovation journey, the findings of this study address two central problems of in innovation management: the human problem of managing attention and the process problem of translating new ideas into innovative products or services (Van de Ven, 1986). The perennial question in innovation research is how to manage an innovator's attention on both managing current practices and exploring innovation opportunities. The options generation strategy

demonstrates how entrepreneurs manage their attention in a form of strategic options by identifying and cultivating them over time. Maintaining options in their activated cognitive schema shows how human attention is managed to produce innovative products and services. Moreover, the findings of this study describe the holistic process from generating new ideas to exploiting them.

This study makes a number of contributions to entrepreneurship and innovation literature. First, the proposed entrepreneurial strategies of options generation and contingency exploitation elaborate on how these strategies dynamically interact with each other to produce more innovative products or services. This responds to the calls from prior studies to further concretize a strategy, mechanism, or technique that underlies entrepreneurial processes (Sarasvathy et al., 2003). Second, the proposed entrepreneurial strategies and their dynamic relationships offer a possible explanation on how algorithmic-heuristic duality of information processing coexists (Vaghely & Julien, 2010). Algorithmic information processing underlies the options generation strategy when an entrepreneur recombines existing resources in a comprehensive manner to search for meaningful recombination. On the other hand, heuristic information processing underlies the contingency exploitation strategy when the entrepreneur maps the existing options with environmental contingencies to quickly decide which contingency to exploit. Third, this study links entrepreneurial behavior to entrepreneurial strategies, and subsequently, strategies to innovation performance. Prior studies in innovation research have advocated the need for future research to investigate the whole process of behavior-strategy-performance. However, empirical evidence has not been available yet due to the differences in level of analysis, i.e., behavior at an individual level, whereas strategy and performance at a firm level. Studying a sample of start-up cofounders overcomes this problem of differences in levels of analysis, because start-ups cofounders are individuals, and, at the same time, are the same people who decide on the strategies of the firm and directly affect firm performance. With the findings of this study, I also respond to the call for the need to investigate the whole process starting from idea to feasible opportunity to successful opportunity (Gaglio & Katz, 2001). Fourth, the findings of this study contribute to the stream of research that investigates how entrepreneurs in penurious environment mobilize resources. More specifically, the strategy-innovativeness model in this study theorizes and

empirically tests the dark side of resource bricolage. By showing that resource bricolage influences only options generation in a positive way, not the innovation performance in general, this study further strengthens the argument of bricolage trap that warns the negative effect of overused bricolage activities. Fifth, this study explains how entrepreneurial cognition and behavior are related to be conducive to better innovation performance. Prior studies in entrepreneurship not only call for more investigation in entrepreneurial cognition (Mitchell et al., 2002, 2004), but also emphasize the importance of investigating both entrepreneurial cognition and behavior as an integrated system (Baron, 2007). Addressing these calls, this study shows how entrepreneurial cognition and behavior collectively impact the innovation performance.

The findings of this study also address practitioners' interests. Venture capitalists and investors are keen on identifying unicorns in their early stages. The conventional wisdom shared in entrepreneurial communities is well captured in George Doriot's remark in 1940s: Always consider investing in a grade A man with a grade B idea. Never invest in a grade B man with a grade A idea (quoted in Bygrave & Timmons, 1992, p. 104). An implicit assumption in this remark is the belief in entrepreneurial competency, which enables an entrepreneur to transform even mediocre ideas into successful products. The findings of this study offer a glimpse of possible entrepreneurial competency in terms of entrepreneurial strategies. Specific mechanism that innovative entrepreneurs use to counter-balance complexity and simplicity in their strategic portfolios is empirically tested in this study to show that entrepreneurs who generate options using existing resources, and subsequently, exploits contingencies that are relevant to preserved options are likely to introduce more innovative products or services. Entrepreneurs may also benefit from the findings of this study. Once entrepreneurs understand the mechanisms underlying the successful innovations and the relevant skills that are likely lead to these mechanisms, they will be able to consciously develop the skills and adopting or experimenting with proposed mechanisms to facilitate their own innovation processes. Another practical issue that has been at the center of discussions recently is whether entrepreneurship is teachable or not (Haase & Lautenschlager, 2011). The findings of this study elaborate on how entrepreneurs behave and think, leading them to adopt certain strategies in order to create innovations.

By showing how to think and how to act upon what has been thought through for entrepreneurs, this study advocates the teachability of entrepreneurship and contributes to the current discussions of educators of entrepreneurship.

This study suffers from several limitations. First, the survey and interview is conducted at a single point of time, while the skills, individual strategies, and innovation performance are measured by self-report scores. In order to confirm whether common method bias is significant or not, I have triangulated the innovation performance scores with two other scores assessed by the interviewer and an independent researcher. All three scores are found to be highly correlated ($>.70$), which indicates common method bias is insignificant with the current sample of start-up entrepreneurs. Future research will be able to further strengthen the findings by designing a longitudinal study. Second, participants in this study are start-up entrepreneurs who are in the process of launching and selling their first batches of new products or services. Although these entrepreneurs indeed have current assets that have been invested and irreversible, the scale of the current investment tends to be smaller than entrepreneurs with several product portfolios. Therefore, start-up entrepreneurs' status quo bias is expected to be less substantial than entrepreneurs in general. Since the status quo bias, or sunk cost fallacy, has been found to be one of the most significant motives of entrepreneurs to resist to changes (Samuelson & Zeckhauser, 1988), further investigation is needed to test the model with the sample of entrepreneurs whose status quo bias would be more significant than start-up entrepreneurs. Lastly, this study suffers from the tight boundary conditions of start-up entrepreneurs in early stages of the start-up process and the innovativeness of their newly launched products or services. Future research may further investigate whether the skill-strategy-innovative model is generalizable by studying broader sets of participants, e.g., small-and-medium enterprises or corporate ventures, or investigating the innovativeness in other dimensions such as new business model or new partnerships. It would be interesting to investigate the entrepreneurs in different contexts, such as corporate entrepreneurs, to show how their strategies are related and leveraged in a different way.

APPENDIX A. INTERVIEW PROTOCOL

Interview Questionnaire for the First Round of Interview

1. Generating the idea
 - a. What was your initial idea? How did you come up with that idea?
 - b. What were some of the key challenges you faced in this idea generation phase?
 - c. Who are the individuals who played a significant role in this process? How did you get connected to them?
2. Decision to commercialize
 - a. What made you decide to commercialize this technology (for ideas from academics)?
 - b. Who are the individuals who played a significant role in this process? How did you get connected to them?
3. Determine strategy and process of commercialization; Forming of founding team
 - a. What is your strategy for commercializing the technology? How was this formed? How did the strategy change over time?
 - b. Who are the individuals who played a significant role in this process? How did you get connected to them?
 - c. What were some of the key challenges you faced at this stage?
4. Pre-seed funding: Seek funding to sustain activities aimed at proving to investors that a new technology has a certain level of commercial and technical viability.
 - a. When did you decide that it was time to seek funding? What was the funding for, and how much?
 - b. What were some of the key challenges you faced?
 - c. Who are the individuals who played a significant role in this process? How did you get connected to them?
5. Generation of prototype and establish commercial and technical viability
 - a. What were some of the key challenges you faced?
 - b. Who are the individuals who played a significant role in this process? How did you get connected to them?
6. Getting a CEO/other third parties into the company
 - a. What were some of the key challenges you faced?
 - b. Who are the individuals who played a significant role in this process? How did you get connected to them?
7. Other than the individuals mentioned, what other resources did you draw upon from the university to help you in your process?
8. What types of barriers did you face from the university in your process of starting up the business?

Interview Questionnaire for the Second Round of Interview

1. Developments of the firm:
 - a. Update about how the company has developed since the last time we spoke (give brief overview of what we know from the last interview). How has the strategy adopted by the company changed over time
 - i. Changes in leadership team
 - ii. Target market
 - iii. New developments in technology. Changes in technological direction of product – changes in application, or direction of technology development

- iv. Funding mechanisms (e.g. from VCs, government funding,
 - v. Cultivating partnerships
 - vi. Leadership team of the firm
 - b. What is your current approach?
 - i. Funding: Grow organically and slowly vs Grow quickly and seek funding aggressively
 - ii. Testing the market: Test with a couple customers, tweaking products as you go along, or launch on a big scale.
- 2. Changes to plans
 - a. Did you have an initial roadmap for the growth of the firm? To what extent has the company developed according to this roadmap? How significant is this change?
 - b. Why did you deviate from your plans? Or why has their plans changed?
 - i. Changes in the market, new developments in technology/competitors
 - ii. Based on what they learn from their network/partners/major players in the industry
 - iii. Due to changes in leadership team, or board changes, or investor changes
- 3. Generating options:
 - a. In the process of growing your company, in what ways have you tried to expand the options available to your company to cope with uncertainty? E.g. sort of keeping the foot in the door even if you may not go down that route in the near future (keeping options possible even if they have not materialized)
- 4. Challenges and problems:
 - a. What were the key challenges you encountered in trying to grow your firm in the past year? How were these challenges different from when you were starting out in the initial years?
 - b. What type of resources was most difficult for you to obtain for your firm in this past year? (e.g., funding, reputation in the industry, or expertise networks, etc)
 - c. Any decisions that you may have regretted?
- 5. What have the firm done well in the past year?
- 6. Internal workings of the team
 - a. How has the team worked in the past year – any internal conflicts or disagreements?

APPENDIX B. MICROSCOPECO CASE

MicroscopeCo is a biomedical spin-out company, co-founded by two faculty members and a post-doctoral student. MicroscopeCo develops an automated microscope to understand and diagnose the conditions of patients. The company has developed several versions of automated microscope based on the principles of the magnetic field to image the motion of magnetic beads that are inserted into the specimen.

MicroscopeCo's technology was generated from extensive research collaborations between Ryan, a professor at Department of Physics and Astronomy, and Ron, a research professor with a joint appointment in the Departments of Computer Science and of Physics and Astronomy. Their research project, which was funded by National Institute of Health, aimed for developing magnetic systems using force technologies. The project was interdisciplinary by nature, which needed diverse expertise such as physicists, chemists, biologists, hardware and software engineers. Idea generation greatly benefited from this interdisciplinary team: through intensive discussions with the team, Ryan figured out that current technologies of mechanical biology would provide a number of opportunities develop an automated microscopic system. Ryan thought that the current microscope market was unnecessarily dominated by high-end yet bulky products. These products were not user-friendly, either: users needed to go through multiple complex steps to study specimen. Ryan realized that a reasonably priced, compact, and easy-to-use automated microscope that comes with various add-on software packages for analysis would appeal to researchers and clinicians.

The first technological challenge that Ryan needed to resolve was how to miniaturize twelve sets of combined microscopes into a compact integrated system. A quick hallway conversation among Ryan and his graduate students gave him an idea of a flattened magnetic system, that was essential for a compact, yet high-performing automated microscope. Next step was to automate the data analysis procedure: a user puts specimen, selects an analysis function, and the microscope would automatically analyze the specimen and shows results. Ryan and Ron built the prototype for the lab uses, yet the automated microscope began to attract attentions from colleagues. Everyone who used Ryan's microscope wanted one for his or her laboratory. Ryan and Ron became certain of commercial potential of his microscope technology.

The thought of commercializing technologies developed at his lab was something Ryan has had for a while. Royce, a recently graduated doctoral student at Ryan's lab who had been interested in starting a company due to the influence of his entrepreneur father, was a perfect candidate to be a co-founder of MicroscopeCo. He was a technology expert who is also highly motivated to be an entrepreneur. Without having any training in business, the first step Ryan took to commercialize his technology was to enroll himself and Royce to the one-year entrepreneurship course at the Business School, which was tailored for faculty members and students who wanted to commercialize their technologies. Ryan and Royce were teamed up with two fellow MBA students who helped them with market research and business planning.

During the entrepreneurship course Ryan was introduced to the head of university venture accelerator that provides support for faculty members who want to commercialize biomedical technologies. The venture accelerator liaised Ryan to the entrepreneurial community in biomedical industry, and provided him with seed funding to purchase market reports and hire a consultant. Brian, an experienced entrepreneur in the medical diagnostics market with a doctoral degree in mechanical engineering, was hired as a consultant for MicroscopeCo. The venture accelerator also introduced Royce to Kauffman Foundation where Royce obtained funding for his post-doctoral researcher position. Since MicroscopeCo's technology was still in an early stage, the team decided to pursue research grants such as Small Business Innovation Research (SBIR) rather than private funding sources. Three SBIR applications have been filed so far, with one re-filed after rejection. Depending on the availability of such government funding sources, the team would also consider contacting private equity firms and angel investors in following years.

Collaborating with Brian and other mentors met through the venture accelerator, the MicroscopeCo team developed the product roadmap first: having concerns over the need to build relationships and partnerships with various companies that produce complementary products and components, as well as to manage technical compatibility among the components, the team decided to develop the whole microscopic system, rather than a module. In order to position MicroscopeCo's product in a reasonable price range and enable customized microscope catering to the needs in different analysis functions, MicroscopeCo decided to productize in two tiers: (1) to launch an automated microscope, and (2) to introduce various analysis packages as add-ons, which can be plugged in to the microscope to execute automated analysis.

Regarding target markets, the team initially judged that MicroscopeCo's technology would be able to create a new market or launch a new product. After quick preliminary market research, the team decided on two target markets: (1) biofluid, especially mucus, diagnostics market with an automated microscope to analyze viscoelastic and mechanical properties of biofluid such as mucus, and (2) cancer diagnostics market with an automated microscope to analyze mechanical stiffness of cancer cells. Biofluid diagnostics market had not been formed yet: MicroscopeCo would need to create an interdisciplinary partnership to collaborate on technology development for measuring characteristics of biofluid to diagnose related diseases. Cancer diagnostics market already existed, yet MicroscopeCo would introduce new instrument that enables easy detection of cancer cells. For cancer diagnostics market, MicroscopeCo would need to convince potential users, such as researchers and clinicians, of the ease of using automated microscope.

In addition to these two target markets, the team identified the blood clotting market as a potential target as well, especially because Brian had an extensive knowledge and network from his previous start-up experience in the blood clotting market. However, the blood clotting market had been established quite long, and the competition among incumbents was fairly high. MicroscopeCo's strategy would be to launch less expensive and more efficient automated microscopes, which required MicroscopeCo to compete with the incumbents under existing value chains. As the team judged that MicroscopeCo's technology would have advantage in new markets or products, the team decided to keep the blood clotting market as an option. The team decided to target cancer diagnostics and biofluid diagnostics first.

While studying cancer diagnostics and biofluid diagnostics markets, the team learned of two important issues. Firstly, creating new market or launching a new product would require much more resources than initially estimated. The team also realized that the advantages of leading the market without any competitor do not necessarily outweigh the disadvantages of educating the market. For example, MicroscopeCo's cancer metastasis instrument that can inform patients before the cancer metastasizes is a pioneer product in the cancer diagnostics market. While the technology is ground breaking, the novelty of the product becomes a liability: MicroscopeCo must educate the market on the functionality and potential of the product. Consequently the team judged that leveraging existing resources would be better than trying to seek new resources. Since Brian's hands-on experience in the blood clotting market was a valuable resource that could be used immediately, the team decided to target the blood clotting market first. In order to compete in relatively niche market, the team planned to develop a mobile hand-held device to measure blood clotting levels.

Secondly, handling distribution and sales relationships such as reimbursement issues were more complex than expected. As MicroscopeCo's strength solely resides in research and development, professional companies would be needed to manage these issues. The team also judged that future investors would consider more risks involved with MicroscopeCo if the team executes everything in house without any strategic partnership. As a result, the team decided to find strategic partners to launch a product.

In addition to securing funding, MicroscopeCo's biggest challenge at the time of writing is to find a candidate for CEO with experience in the diagnostics market. Ryan has been temporarily designated as MicroscopeCo's CEO, but he had no intention of leaving his academic position. Royce, meanwhile, has been appointed the Vice President of Product Development.

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