TOWARD A PROCESS THEORY OF ENTREPRENEURSHIP: REVISITING OPPORTUNITY IDENTIFICATION AND ENTREPRENEURIAL ACTIONS

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DECLARATION OF ORIGINALITY

I hereby confirm that:

I. The thesis is the result of my original work during the period of registration at Imperial College Business School;

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ABSTRACT

This dissertation studies the early development of new ventures and small business and the entrepreneurship process from initial ideas to viable ventures. I unpack the micro-foundations of entrepreneurial actions and new ventures' investor communications through quality signals to finance their growth path. This dissertation includes two qualitative papers and one quantitative study. The qualitative papers employ an inductive multiple-case approach and include seven medical equipment manufacturers (new ventures) in a nascent market context (the mobile health industry) across six U.S. states and a secondary data analysis to understand the emergence of opportunities and the early development of new ventures. The quantitative research chapter includes 770 IPOs in the manufacturing industries in the U.S. and investigates the legitimation strategies of young ventures to gain resources from targeted resource-holders.

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CHAPTER 1 - INTRODUCTION

The study of entrepreneurship and small business is one of the fastest growing areas within economics, management, finance, and even law (Klein, 2008). Entrepreneurship has been considered as the core of the dynamics of capitalism (Baumol, 1993) and the entrepreneur is "the driving force of the whole market system" (Mises, 1949: 149). Extant research in entrepreneurship theory focuses on the emergence of an opportunity idea and the pursuit of an entrepreneurial opportunity (Alvarez & Barney, 2007, 2010; Dimov, 2011; Read, Song, & Smit, 2009). As such, entrepreneurship has long been conceptualized as a process (Bhave, 1994; Davidsson, 2003; Gartner, 1985, 1990), including one's cognitive process of opportunity identification, judgment decisions about opportunities (Choi & Shepherd, 2004; Gruber, MacMillan, & Thompson, 2008, 2013; McMullen & Shepherd, 2006), and entrepreneurial actions to exploit opportunities (Autio, Dahlander, & Frederiksen, 2013; Minniti & Bygrave, 2001).

Entrepreneurial action concerns the introduction of new goods, services, raw materials, or organizing methods that departs substantially from existing practices (Gruber et al., 2008; Santos & Eisenhardt, 2009). The origin of entrepreneurial actions therefore exists at the nexus of individuals and opportunities (Shane, 2003; Venkataraman, 1997). To date, research on entrepreneurship has focused on the nature and source(s) of opportunities (Alvarez & Barney, 2010; Jackson & Dutton, 1988; McMullen, Plummer, & Acs, 2007), factors explaining which individuals or organizations are better able to identify and exploit opportunities (Gruber, MacMillan, & Thompson, 2012; Short, Ketchen, Shook, & Ireland, 2009), and entrepreneurial cognitions (R. A. Baron, 2004; R. K. Mitchell et al., 2002). However, the current literature seems to have different definitions of entrepreneurship so that different measures are applied (Westhead, Wright, & Mcelwee, 2011) and has an ambivalent

understanding of the contestable boundaries of claims in entrepreneurship theory, the micro-foundations of entrepreneurial phenomena (Zahra & Wright, 2011), and its incorporation into strategy (Foss, Klein, Kor, & Mahoney, 2008; Klein, 2008). For example, the measures used by economists differ significantly from those used by researchers in psychology (Westhead et al., 2011). The economic approach emphasizes occupational choices of different individuals, cost and production functions, and risk-bearing abilities of entrepreneurs; while the psychological approach focuses more on individual differences such as the need for achievement, self-efficacy, and tolerance for ambiguity (Drnovšek, Wincent, & Cardon, 2010; McMullen & Shepherd, 2006; Rindova, Barry, & Ketchen, 2009). Although many empirical studies have been conducted, the dialogue between psychology-based and economics-based entrepreneurship research is rather limited (Zahra & Wright, 2011).

In addition, although contextual influences on entrepreneurial actions have long been acknowledged (Aldrich, 1999; Aldrich & Fiol, 1994; Welter, 2011), research on entrepreneurial behaviour has shown great interest in finding "general laws" of entrepreneurship (Autio, Kenney, Mustar, Siegel, & Wright, 2014; Hjorth, Jones, & Gartner, 2008; Zahra & Wright, 2011). Rather than looking into the sources of environmental dynamics and relating them to entrepreneurial actions, some researchers tend to introduce statistical controls for context (Zahra & Wright, 2011). However, salience of research questions, theoretical merits of an argument, and causal relationships are usually context-specific (Van de Ven, 2007). Even though controlling for the effects of industrial dynamism is one thing, looking into the various dimensions of contextual impacts can bring greater clarity about the relationships between contextual impacts and entrepreneurial actions. Contextualization involves the "linking of observations to a set of relevant facts, events, or points of view that make possible research and theory that form part of a larger whole" (Rousseau & Fried, 2001:1). Incorporating the different dimensions of entrepreneurial

contexts into theory building and testing may further enrich the understanding of the nature of entrepreneurship and its consequences (Welter, 2011).

Environmental contingencies not only influence entrepreneurial actions but also determine the way that ventures accumulate resources and their growth path (Clarysse, Bruneel, & Wright, 2011). Extant entrepreneurship research has paid substantial attention to privilege growth of ventures (Davidsson, 2006; Davidsson, Steffens, & Fitzsimmons, 2009; Gilbert, McDougall, & Audretsch, 2006) and highly emphasises how resources (e.g., human, financial, technological, social capitals) are related to venture growth (Clarysse, Wright, & Van de Velde, 2011; Ensley, Pearson, & Amason, 2002; Heirman & Clarysse, 2004; Hindle & Yencken, 2004; Khaire, 2010). However, extant research mostly focuses on evaluating how much companies grow but has little consideration for how they grow (McKelvie & Wiklund, 2010). Growth results from both internal and external mechanisms (Gilbert et al., 2006). Contextual impacts play a determinative role in explaining different growth patterns of ventures (Clarysse, Bruneel, et al., 2011; Dess & Beard, 1984). However, extant research pays less attention to resource configuration in different environmental contexts.

1.1 Motivations and Focus

This dissertation aims to contextualise the entrepreneurship process, thereby unpacking the micro-foundations of entrepreneurial actions and bridging psychology-based and economics-based entrepreneurship research. By doing so, this research contributes to defining the boundaries of theories and propositions to establish strong explanatory powers in relation to the claims in the entrepreneurship theory.

Contextual influences on entrepreneurship can be distinguished between effects on entry behaviours and effects on post-entry behaviours (Autio et al., 2013). Influences on entry behaviours exhibit themselves as selection effects and are associated with who engages in

entrepreneurial behaviours. In the post-entry stage, selection effects continue to influence entrepreneurial behaviours and another set of contextual influences associated with strategic choices entrepreneurs engage in. These work through the perceived desirability or feasibility to influence the way that ventures exploit opportunities and this perceived desirability or feasibility would ultimately reflect contextual facts such as formal institutions (e.g., intellectual property perfection) (Autio et al., 2014). In the dissertation, I aim to investigate the contextual influences on entry and post-entry entrepreneurial behaviours.

1.1.1 Focus on the impacts of entrepreneurial determinants on the decision making associated with entrepreneurial tasks (entry behaviours)

Entrepreneurship research has long centred on the question "why, when and how some people and not others discover and exploit opportunities" (Shane & Venkataraman, 2000, p.219). Most research emphasizes how the individual characteristics of entrepreneurs make them more likely to be alert to certain opportunities such as their prior knowledge and experience (Choi & Shepherd, 2004; Grégoire, Corbett, & McMullen, 2011; McMullen & Shepherd, 2006) their self-image (J. R. Mitchell & Shepherd, 2010), genetic profile (Nicolaou, Shane, Cherkas, Hunkin, & Spector, 2008), and their personality traits (Zhao & Seibert, 2006) and how entrepreneurs connect their prior knowledge with the changes they alert in the environment to identify opportunities (Gaglio, 2004; Gaglio & Katz, 2001). Extant research seems to suggest that entrepreneurs are more likely to recognise opportunities within a certain distance from their current knowledge (Grégoire, Barr, & Shepherd, 2010; Grégoire & Shepherd, 2012). However, in the real business world we can also find several cases in which entrepreneurs pursue opportunities without obvious connections with their current knowledge. Entrepreneurial action is not just a reaction to objective conditions but may initiate from the interpretation of external stimulations by entrepreneurs (Wood &

McKinley, 2010) and the interpretation may include other cognitive factors involved such as emotion (Goss, 2007; Hjorth, 2007). If entrepreneurs are the central actor in new firm creation, the current literature lacks a consideration of a full range of entrepreneurial determinants underlying entrepreneurial decisions. Therefore, extant research can explain why some entrepreneurs choose to exploit opportunities found in the neighbourhood of their current activities but fails to explain why some entrepreneurs do not follow the same pattern.

In this research, we aim to address the research question: What entrepreneurial determinants are influential in spurring a particular type of opportunity ideas in the first place and in directing the formation of opportunity beliefs. Specifically, I integrate research about the nature of entrepreneurial opportunities with cognitive research to focus on two opportunity characteristics which are likely to influence the formation of opportunity intention – the superficial and structural similarities between new ventures' current technology and market knowledge and the knowledge required in a target market where they will operate (Gentner & Markman, 2006; Grégoire et al., 2010; Grégoire & Shepherd, 2012; Markman & Gentner, 1993). I aim to investigate the factors determining the way that new ventures use to identify opportunities and their decision making on the types of entrepreneurial tasks.

Research Focus 1: How the variance in entrepreneurial determinants influences entrepreneurs' cognitive-processes to approach different entrepreneurial opportunities.

1.1.2 Focus on the micron-foundations of entrepreneurial phenomena (entry and post-entry behaviours)

Researchers have long conceptualized entrepreneurship as a process (Bhave, 1994; Davidsson, 2003; Gartner, 1985, 1990). Seen from a process perspective, scholars consider how entrepreneurs identify and exploit opportunities and usually distinguish entrepreneurial actions into the phases of opportunity search, evaluation, and exploitation (Choi & Shepherd, 2004; Gruber et al., 2008, 2013; McMullen & Shepherd, 2006) and study entrepreneurial behaviours in each discrete phase.

Past studies have substantially advanced the understanding of discrete phases of entrepreneurial actions. In the literature on opportunity recognition, scholars have studied several characteristics of an entrepreneur (Choi & Shepherd, 2004; Grégoire et al., 2010; McMullen & Shepherd, 2006; J. R. Mitchell & Shepherd, 2010; Zhao & Seibert, 2006) which make him/her more alert to opportunities (Kirzner, 1973) and how entrepreneurs use prior knowledge as a basis to interpret what can be done (Gaglio, 2004; Gaglio & Katz, 2001; Grégoire et al., 2010). In the literature on opportunity evaluation, current research focuses on how entrepreneurs develop a coherent judgment between what one perceives from the environment and one's desire and beliefs about the value and feasibility of these potential opportunities to transmit third-person opportunities into the first-person opportunities (Shepherd, McMullen, & Jennings, 2007). In the literature on opportunity exploitation, researchers focus on the growth of ventures, including marketing testing (Danneels, 2002, 2007), resources integration and accumulation (Bruneel, Yli-Renko, & Clarysse, 2010; Chung, Singh, & Lee, 2000; Hitt, Ireland, & Lee, 2000), organizational learning (Teece, Pisano, & Shuen, 1997; Zahra, Ireland, & Hitt, 2000), business model design (Andries & Debackere, 2007; Nicholls-Nixon, Cooper, & Woo, 2000), etc. However, the current

literature lack an integrative view which shows how entrepreneurs come up with entrepreneurial ideas and how entrepreneurial behaviours conducted in one phase impact on entrepreneurial behaviours in the next phase, which eventually turns an idea to a real business.

This research aims to fill these gaps by considering the following research questions.

Resource Focus 2-1: How entrepreneurs come up with entrepreneurial ideas

Resource Focus 2-2: How entrepreneurial behaviours conducted in one phase impact on entrepreneurial behaviours in the next phase, which eventually turns an idea to a real business.

1.1.3 Focus on new venture legitimation strategies to gain resources

Young ventures are usually characterized by a high amount of intangible assets and negative cash flow and face substantial technological and/or market uncertainty during their first few years of operation. In the start-up process, they tend to rely on external sources of finance such as venture capital to commercialize their innovation (Baeyens & Manigart, 2003). However, once they have grown out of the venture capital phase, they need to raise money on the stock market to finance their growth path. But substantial evidence shows that entrepreneurs tend to sell their shares at a price lower than the actual market value of their initial public offerings (IPOs) in order to attract investors (Loughran & Ritter, 2002). In the IPO market, information asymmetry between corporate insiders and outsiders is the widely accepted explanation for IPO underpricing (Rock, 1986). Young ventures which are based on novel technologies generate many information asymmetries because it is difficult to assess their real potential (Aboody & Lev, 2000; Heeley, Matusik, & Jain, 2007). However, although information asymmetry theory explains why underpricing happens in these cases, the theory has little to say on how to mitigate this underpricing.

This study attempts to address this gap by including an analysis of the signalling effect of patent stocks and introducing an institutional perspective to the debate. Conceptually speaking, patents not only reveal information regarding the technological and managerial capabilities of ventures but also provide legal rights against infringement (Cohen, Nelson, & Walsh, 2000; Hall & Ziedonis, 2001; Levin, Klevoric, Nelson, & Winter, 1987; Teece, 1986). However the disclosure is only sufficient to someone who is "skilled in the art" to practice the innovation and provides limited information regarding the way in which the innovating firms will use the patent to capture profits (Heeley et al., 2007). Moreover, patents rarely confer perfect appropriability as they are supposed to do in theory. Their function, as well as the level of value appropriability, varies across industries (Hall & Ziedonis, 2001; Heeley et al., 2007; Hsu & Ziedonis, 2013; Kash & Kingston, 2001). Since in some cases a venture's innovation activities, including innovation input (R&D expenditures) and output (e.g., patent stocks), may not clearly convey its value, in light of this challenge prior studies have suggested that a venture can lease the reputation of third party affiliations (e.g., venture capitalist, alliances partners) to increase its own legitimacy to justify its actions as meaningful and trustworthy (Hsu, 2004; Jepperson, 1991; Podolny, 1994; Stuart, Hoang, & Hybels, 1999). However, the signalling effect of venture capital backing is too noisy. Some researchers argue that VCs provide access to resource bundles (Hsu, 2004) but others argue that once the industry effects and underwriter quality are controlled, there is no difference in underpricing between VC backed IPOs and non-VC backed IPOs (Bradley & Jordan, 2002). Besides, some research argues that VC backed IPOs experience larger underpricing backed IPOs because higher underpricing leads to more future flows of capital into venture capital funds (Lee & Wahal, 2004) and some found VC backed IPOs are less underpriced than non-VC backed IPOs during normal periods of activity but are more underpriced than non-VC backed ones during "hot issue" periods (Franzke, 2004; Rossetto, 2008).

Apart from VCs, among varying quality signals, researchers have identified that the most central of these combines signalling theory with institutional theory (Certo, 2003). A venture's legitimacy enhances its persistence and credibility (Parsons, 1960; Suchman, 1995) and helps to access resources (DiMaggio & Powell, 1983). When a venture's quality is uncertain, its legitimacy serves as an extremely important factor to justify its actions as meaningful and trustworthy (Jepperson, 1991; Podolny, 1994; Stuart et al., 1999). However, current research has focussed more on how new ventures transfer their prestigious partners' status to improve their performance (Stuart et al., 1999) but devotes less attention to how the impact of endorsing legitimacy changes in different contexts, especially in a R&D intensive market, and how public investors consider the information delivered by a venture's endorsing legitimacy.

Research Focus 3.1: How the signalling of patent stocks and endorsing legitimacy affects a venture's IPO price when taking into account the level of information asymmetry.

Research Focus 3.2: How the appropriability regime of the industry in which the venture operates moderates the importance of patent stocks and endorsing legitimacy.

1.2 Outline of Dissertation

I aim to investigate the above research focuses in the following ways and across the following chapters. During the past four years, I started from the third research focus with a quantitative study including 770 IPOs and then conducted a multiple-case research including seven new medical device manufacturers in the mobile health market to address the first and

the second research focuses. (The third paper in this dissertation is the first paper I did in my PhD study and then the second and the first papers in the dissertation respectively.)

CHAPTER 2 addresses Research Focus 1 of this dissertation, that is, how the variance in entrepreneurial determinants influences entrepreneurs' cognitive-processes to approach different entrepreneurial opportunities. I conducted an inductive case study to identify entrepreneurial determinants and integrate them with the research on opportunity characteristics, the superficial and the structural similarities between new ventures' current knowledge and the knowledge required in the market where they choose to operate. The results show that the formation of opportunity beliefs is motivated by technology-driven, operation-driven, or user-driven-driving determinants. Entrepreneurial determinants determine the way that entrepreneurs identify and evaluate opportunities. Different determinants and approaches in opportunity identification influence entrepreneurs' decision making on entrepreneurial tasks. These factors eventually lead new ventures to pursue opportunities with different levels of similarities with their current knowledge.

CHAPTER 3 addresses Research Focus 2-1 and 2-2 of this dissertation, how entrepreneurs come up with entrepreneurial ideas and how entrepreneurial behaviours conducted in one phase impact on entrepreneurial behaviours in the next phase. In this paper, we focus on the "entrepreneurial process" and aim to empirically understand how entrepreneurial determinants influence the formation of their opportunity beliefs and how the entrepreneurial determinants and opportunity beliefs jointly influence new ventures' entrepreneurial actions. The results show that in an almost homogenous environment, namely the nascent market of mobile health medical equipment, entrepreneurs motivated by different entrepreneurial determinants take different paths to identify opportunities. We indicate three entrepreneurial determinants for new firm creation: Technology-driven, operation-driven, and

user-driven determinants. Different determinants lead entrepreneurs to initiate diverse cognitive processes to interpret which resources are going to be transformed to which applications and how to complete the transformation. Different determinants also lead new ventures to conduct different opportunity exploitation strategies (pivoting strategies, diversification strategies, and business model refinement).

CHAPTER 4 address the third Research Focus 3-1 and 3-2, that is how the signalling of patent stocks and endorsing legitimacy affects a venture's IPO price when taking into account the level of information asymmetry and how the appropriability regime of the industry in which the venture operates moderates the importance of patent stocks and endorsing legitimacy. This study is the first research I did in my PhD study. I conducted a quantitative study including 770 IPOs issued by manufacturing firms during 1995-2006. The results show that in the industries with a tight appropriability regime, the level of innovation-based information asymmetry does not even have a positive impact on IPO underpricing. Conversely, when the transparency of innovations to future returns is unclear, affiliations are more prevalent in serving as a credible and observable signal for the investment community to make an accurate assessment of firm value. Endorsing legitimacy mitigates the level of IPO underpricing and the innovation-based information asymmetry in those industries where the appropriability regime tends to be weak.

CHAPTER 5 concludes this dissertation by reviewing the main findings and by discussing the theoretical contributions.

CHAPTER 2 – DIFFERENCES IN ENTREPRENEURIAL OPPORTUNITIES: HOW ENTREPRENEURIAL DETERMINANTS IMPACT OPPORTUNITY RECOGNITION

(The third paper of my PhD study)

ABSTRACT

Although scholars in the field of entrepreneurship continually increase the general understanding of why, when and how some people and not others discover and exploit opportunities, questions about its nature nevertheless persist. In this study, we seek to complement recent research on the process of opportunity recognition by revisiting the role of entrepreneurial determinants of new venture creation in directing entrepreneurs' attentions to recognise particular types of opportunities. We aim to explain why some entrepreneurs spot and act on distant opportunities but some do not. We do this by integrating the research about the nature of entrepreneurial opportunities with cognitive research. In an inductive multiple-case study, we illustrate three types of determinants of new venture creation (technology-driven, operation-driven, and user-driven determinants) and how these determinants influence the process of opportunity recognition, evaluation, and entrepreneurial decision making. Our findings show that entrepreneurial motivations affect decision making on the means of opportunity recognition and the types of opportunities that entrepreneurs spot and eventually exploit. Those opportunities may or may not have clear connections with their prior knowledge and experience.

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2.1 Introduction

Entrepreneurship research has long centred on the question "why, when and how some people and not others discover and exploit opportunities" (Shane & Venkataraman, 2000, p.219). Most of current research focuses on how entrepreneurs connect their prior knowledge and experience with the changes they alert in the environment to define what can be done (R. A. Baron, 2006; Gaglio, 2004; Gaglio & Katz, 2001; Grégoire et al., 2010; McMullen & Shepherd, 2006). Following these logics, entrepreneurs are more likely to recognise opportunities within a certain distance from their current knowledge. For example, the founders of Google, two computer scientists, alerted to the fact that people were overwhelmed by the information they found through search engines and then developed an internet site-ranking system (Vise & Malseed, 2008). However, in the real business world we can also find several cases in which entrepreneurs pursue opportunities without obvious connections with their current knowledge. The founders of Nike, for instance, were two sports lovers. One's eureka moment happened when he was making waffles and thought that a waffle-patterned outer sole would improve traction and produce faster running times. The other one spotted the opportunity while writing a course assignment (Bragg & Bragg, 2005). They both lacked knowledge and experience related to the athletic footwear market but they established NIKE and it turned out to be a well-known global brand. Following the argument in the current literature, NIKE should not exist. Therefore the questions remain: Where do the entrepreneurial ideas come from? Why do some entrepreneurs spot distant opportunities and decide to act on them rather than working on those close to their current knowledge?

Extant research in the opportunity identification literature concentrates on why, how, and with what consequence entrepreneurial beliefs are formed (Grégoire et al., 2010; Haynie, Shepherd, & McMullen, 2009; Read et al., 2009; Sarasvathy, 2001; Shepherd et al., 2007). Most research focuses on how individual characteristics of an entrepreneur – such as

knowledge and experience stock (Choi & Shepherd, 2004; Grégoire et al., 2011; McMullen & Shepherd, 2006), images of themselves (J. R. Mitchell & Shepherd, 2010), genetic profile (Nicolaou et al., 2008) or personality traits (Zhao & Seibert, 2006) - impact their alertness to opportunities. In order for opportunity identification to happen, entrepreneurs connect the changes they are alert to with what they might be able to do to interpret these changes (R. A. Baron, 2006). This cognitive process includes the association between external information and individual knowledge (e.g., using prior knowledge as a basis to understand unusual changes (Gaglio, 2004; Gaglio & Katz, 2001)) and the association between components of entrepreneurial opportunities (e.g., aligning the structural capabilities of new technologies with structural causes underlying latent demands (Grégoire et al., 2010)). In addition, some research focuses on the role of entrepreneurs' imagination and effectuation in transforming existing artefacts at hand into new ones to define opportunities (Dew, Read, Sarasvathy, & Wiltbank, 2008; Sarasvathy, 2001, 2003). Current research mostly focuses on the role of entrepreneurs in new firm creation and suggests that entrepreneurs are more likely to act on opportunities with similarities with their current knowledge or experience. This logic can explain why some entrepreneurs choose to exploit opportunities found in the neighbourhood of their current knowledge. However, it fails to explain why some entrepreneurs do not follow the same pattern (e.g., NIKE), which implies that some cognitive mechanisms which may direct entrepreneurs' attention in recognising opportunities are underestimated.

The mechanism for actualizing an opportunity often initially exists in entrepreneurs' mind, which is usually referred to one's entrepreneurial determinants (Shane, Locke, & Collins, 2003). Previous research has explored several determinants (e.g., needs for achievement, locus of control, tolerance for ambiguity, risk taking, self-efficacy, and self-image) and their impacts on entrepreneurship, including such areas as entrepreneurial career intentions (Barbosa, Gerhardt, & Kickul, 2007; Hansemark, 2003; McMullen & Shepherd,

2006; Zhao, Seibert, & Hills, 2005), entrepreneurial cognition (Ardichvili, Cardozo, & Ray, 2003; J. R. Mitchell & Shepherd, 2010), new venture survival (Ciavarella, Buchholtz, Riordan, Gatewood, & Stokes, 2004). However, although there is a substantial amount of research considering the role of entrepreneurial determinants, most of them focus on the characteristics of entrepreneurs and how these characteristics increase/ decrease the likelihood of them to become entrepreneurs and the propensity of entrepreneurs to form first-person opportunity beliefs toward particular opportunities in terms of the high/ low level of uncertainty, ambiguity, or risk. Few studies address the impact of entrepreneurial determinants on the types of opportunities that entrepreneurs may spot in the first place which may influence the following entrepreneurial process.

Entrepreneurship theorists posit that entrepreneurs and opportunity characteristics jointly shape new firm creation (Shane & Venkataraman, 2000). Recently some researchers have begun to examine the interrelationships between individual characteristics of entrepreneurs and the types of opportunities that they exploit. Grégoire and Shepherd (2012), for instance, theorize the effect of similarity differences between an opportunity idea's means of supply and market context on the formation of opportunity beliefs and the moderating effects of individual entrepreneurial intent to engage in start-up activities and prior knowledge on the processing of cognitively demanding structural similarity. Dencker and Gruber (2014) consider how the type of opportunities that an entrepreneur exploits is contingent on the relevance of his/her knowledge and show that high-risk opportunities favour entrepreneurs with managerial experience; while low-risk opportunities favour entrepreneurs with industry experience. Both studies emphasizes the role of entrepreneurs' prior knowledge and experience in opportunity recognition, decision making, as well as new firm performance but ignore other entrepreneurial determinants (e.g., emotion, personal frustration) which may also influence the opportunity-recognition process. Entrepreneurial

action is not just a reaction to objective conditions but may initiate from the interpretation of external stimulations by entrepreneurs (Wood & McKinley, 2010). If entrepreneurs are the central actor in new firm creation, the current literature mainly highlights the role of prior knowledge and experience in opportunity recognitions but lacks a consideration of a full range of entrepreneurial determinants underlying entrepreneurial decisions.

In this research, we aim to address the research questions: what entrepreneurial determinants are influential in spurring a particular type of opportunity ideas in the first place and in directing the formation of opportunity beliefs. To ascertain this research question, we integrate the research about the nature of entrepreneurial opportunities with cognitive research and conducted an inductive multiple-case study (Eisenhardt, 1989), including seven new ventures working in the medical equipment market section in an nascent market, the mobile health (mHealth) market, in North America. We target a nascent market because it lacks a dominant business model (Aldrich & Fiol, 1994). We chose new ventures because their strategic actions reflect their entrepreneurial determinants in relation to particular opportunities.

Our findings illustrate three types of entrepreneurial determinants – technology-driven, operation-driven, and user-driven determinants – which direct the process of opportunity recognition. Ventures driven by technology aimed to look for a new market to exploit current technologies (we labelled them as technology-driven ventures); ventures driven either by the founders' past operational experiences or personal frustration in using current products were looking for a technical solution to satisfy unmet needs in a particular market (in this case, the mHealth market) (we labelled them as operation-driven ventures and user-driven ventures respectively). Technology-driven ventures used their current technologies as a basis to search opportunities. As such, the opportunities they pursued usually had high technology similarities with their current knowledge. In addition, to avoid operating their new business

from scratch, they preferred opportunities with at least a medium level of structural similarities in terms of market knowledge. Operation-driven ventures were established to solve the problems found in their founders' past careers. Therefore, the opportunities they pursued tended to have high technology and market similarities with their prior knowledge and their prior knowledge helped them to evaluate the feasibility of the opportunities. User-driven ventures were established because of their founders' dissatisfaction with current products. This entrepreneurial determinant directed their attention to solve the problems they faced even if these tasks had no obvious connection with their prior knowledge. In addition, they tended to generalized market demands from their own needs and relied on their knowledgeable peers to evaluate technological feasibility of the opportunities they targeted.

In this research, we contribute to the opportunity recognition literature by revisiting the role of entrepreneurial determinants and indicating three entrepreneurial determinants for new firm creation and how different determinants lead to different processes of opportunity recognition and evaluation. We especially indicate the impact of emotional issues (e.g., personally frustration) on opportunity recognition to explain why some entrepreneurs generate opportunity beliefs at a distance. In addition, we integrate cognitive research with the nature of entrepreneurial opportunities to show how different entrepreneurial determinants eventually lead new ventures to pursue opportunities with different levels of similarities with their current knowledge. Besides, we conducted a multiple-case study to show empirically how different entrepreneurial determinants lead to the construction of multiple types of opportunity ideas, which has greater ecological validity than the previous tests which used experimental design methodology (Grégoire et al., 2010; Grégoire & Shepherd, 2012).

2.2 Theoretical Background: The Formation of Entrepreneurial Beliefs

The opportunity-recognition process refers to "how entrepreneurs use simplifying mental models to piece together previously unconnected information that helps them to identify and invent new products or services and to assemble the necessary resources to start and grow businesses" (Mitchell et al., 2002, p.97). To date, the primary focus in the entrepreneurship research regarding opportunity recognition is on factors explaining which individuals or organisations are better able to identify opportunities (Gruber et al., 2008; Plambeck & Weber, 2009; Short et al., 2009). A significant portion of research, therefore, emphasises the differences in "alertness" to profit opportunities between entrepreneurs and non-entrepreneurs (Kirzner, 1973), which is related to their knowledge and experience stocks (Gaglio & Katz, 2001; Shane, 2003). The literature shows that prior experience may not directly influence opportunity recognition, but that it is transformed into knowledge structures which can be observed in speech and action (Argote & Miron-Spektor, 2011; Walsh & Ungson, 1991). Different researchers consider these knowledge structures as "beliefs" (Walsh, 1988). Beliefs guide and determine an entrepreneur's actions (Haynie et al., 2009; McMullen & Shepherd, 2006; Shane & Venkataraman, 2000; Wood & Pearson, 2009)

In order for opportunity identification to ensue, entrepreneurs "connect the dots" (R. A. Baron, 2006) between the changes they notice and what could be done to interpret the changes. Extant research indicates that the processes of opportunity recognition include associations between external information and individual knowledge and between components of entrepreneurial opportunities. The first cognitive association emphasizes how entrepreneurs' knowledge interacts with external stimuli and how the association leads to the formation of insightful new business ideas. For example, entrepreneurs may be alert to new opportunities by using prior knowledge of how things are as a basis to understand unusual changes in the environment (Gaglio, 2004; Gaglio & Katz, 2001). This counterfactual

thinking helps entrepreneurs consider association between what is and what might be and leads to the identification of alternate courses of actions. Baron (2004, 2006) advances the concept that entrepreneurs identify opportunity by recognising patterns in their environment and then connect the dots "between changes in technology, demographics, markets, government policies and other factors" (Baron, 2006, p.104). The second cognitive association emphasises entrepreneurs' mental connections between the information components of opportunities in and of themselves. For example, Smith and Di Gregorio (2002) propose that opportunity recognition involves the combination of information from different domains such as manufacturers, customers and markets. More recently, Grégoire and his colleagues (2010) argue that entrepreneurs identify potential opportunities by aligning the structural capabilities of new technologies with structural causes underlying latent demands in a particular market. In this regard, Grégoire and Shepherd (2012) distinguish opportunities by emphasising the superficial and structural similarities between new technologies and a target market in which these new technologies can be introduced. They indicate that the more similar a new technology is to a market, the more positive beliefs that bringing in this technology in the market to constitute an opportunity will be. Also, they found that entrepreneurs with higher entrepreneurial intent tend to form more positive beliefs about less obvious opportunities although superficial similarities between technology and the market is absent. Dencker and Gruber (2014) take into account how the types of opportunities that entrepreneurs exploit conditions on the relevance of their knowledge endowment and consider how opportunity and founder characteristics interact to shape new firm performance. Their results show that high-risk opportunities favour entrepreneurs with managerial experience; while low-risk opportunities favour entrepreneurs with industry experience.

The current research on the opportunity-recognition process mostly emphasizes the role of prior knowledge and experience in being alert to promising opportunities and in

helping entrepreneurs to make sense of disconnected facts. It suggests that entrepreneurs are more likely to recognise and select opportunities that they believe they have the means and ability to do and perceive to be positive and valuable to themselves (Ajzen, 1985, 1991; Fishbein & Ajzen, 2005). However, the mental models to piece together unconnected information to invent new products/ services include not only how entrepreneurs connect information but also why they connect particular information, which is related to their entrepreneurial determinants to start a new business (Shane et al., 2003).

Entrepreneurial determinants includes internal factors that impel action and external factors that work as inducements to action (Locke & Latham, 2004), which determines entrepreneurs' ideas for interpreting and exploiting an opportunity (Shane et al., 2003). Previous research has explored several determinants (e.g., needs for achievement, locus of control, tolerance for ambiguity, risk taking, self-efficacy, and self-image) to develop theories of the entrepreneurial process including entrepreneurial career intention (Begley, 1995; Collins, Hanges, & Locke, 2004; Mueller & Thomas, 2001; Zhao et al., 2005), entrepreneurial cognition (Ardichvili et al., 2003; McMullen & Shepherd, 2006; J. R. Mitchell & Shepherd, 2010), and new venture survival (Ciavarella et al., 2004). For example, Ardichvili and his colleagues (2003) propose a theoretical model to indicate how entrepreneurs' personality traits, social networks, and prior knowledge increase/ decrease the likelihood of an opportunity being recognised. Mitchell and Shepherd (2010) indicate that entrepreneurs' images of vulnerability and images of capability influence the process of first person opportunity recognition. However, these studies focus on the impact of entrepreneurial determinants on one's propensity to become entrepreneurs or act on particular opportunities with high or low risk, uncertainly, or ambiguity but have little to say where these opportunities come from. Therefore, the explanations of the fact that some

entrepreneurs target distant opportunities even if necessary resources are currently not under their control remain missing.

2.3 Method

Given the lack of comprehensible theory on the understanding of the cognitive process underlying particular decision making which determines the types of opportunities that entrepreneurs eventually select, we conducted an inductive, multiple-case study (Eisenhardt, 1989). Inductive studies are particularly appropriate for developing theoretical insights for a phenomenon that extant research is under-addressed (Ozcan & Eisenhardt, 2009). A multiple-case study includes comparative data which are likely to yield more accurate and generalizable theory than what a single-case study can provide (Eisenhardt, 1991; Yin, 1994).

To understand how the variance in entrepreneurial determinants influences the types of opportunities that entrepreneurs recognise and eventually exploit, we specifically focus on two opportunity characteristics which are likely to influence the formation of opportunity intention to exploit particular opportunities – the superficial and the structural similarities between entrepreneurs' current technology and market knowledge and the knowledge required in a target market. Superficial similarity increases as two objects, concepts, or situations have common basic information elements that resemble each other; whereas structural similarity increases when two objects, concepts, or situations have common logical relationships between their respective components and other superficial factors (Gentner & Markman, 2006; Markman & Gentner, 1993). For technology knowledge, a superficial similarity arises as the basic elements of a technology (e.g., its parts and components, the inputs it requires) are similar to a venture's current technology knowledge; whereas structural similarity arises as the intrinsic capabilities of a new technology (what it can do, the logical

or scientific mechanisms underlying it) are similar to a venture's current technology knowledge. For market knowledge, superficial similarity arises as the basic characteristics of a particular market (e.g., market participants, customers, customer demands) are similar to a venture's current market knowledge; whereas structural similarity arises as the higher-order market condition (e.g., operational rules, regulations, problems of market activities) is similar to a venture's current market knowledge.

2.3.1 Research setting

We targeted new ventures in the medical device manufacturing market in the mobile health (mHealth) industry in North America (mainly in the U.S.) (see Table 1). 'Mobile health' is referred to as a new way to provide healthcare by using mobile devices to collect and deliver clinical health data between practitioners, researchers, and patients to provide real-time monitoring and direct care (Germanakos, Mourlas, & Samaras, 2005). We chose the medical equipment market because it emerged as a new field including distinctive categories (e.g., healthcare services, insurance, government, connectivity technology), which causes a high level of market complexity. Companies in a complex market may have various strategic actions. Also it is a nascent market without a dominant business model (Aldrich & Fiol, 1994) to influence or guide each company's decision. In addition, we targeted new ventures because their strategic actions may strongly reflect their judgment of the path to recognise opportunities.

Table 1 Data representation

Active new ventures in the medical device segment in the mHealth market[1]		No.	Status	No.
Area	North America [2]	17	Being acquired before 2013[3]	5
			Bankruptcy before 2013	3
			No-response	2
			In Sample	**7**
			Alive new ventures in the North America	**9**
	Europe	6	-	-
Total		23	Sample coverage probability	78%

We undertook the following steps to identify targeted companies: (1) Reviewing all strategic alliances listed in the three MobiHealthNews Year End Reports (2009, 2010, 2011); (2) identifying each company's North American Industry Classification System (NAICS) code on Hoover's online database[4]; (3) selecting firms in the electro-medical and electro-therapeutic apparatus manufacturing (NAICS code: 334510), surgical and medical instrument manufacturing (NAICS: 339112), and medical, dental, and hospital equipment and supplies merchant wholesalers (NAICS code: 423450); and (4) ruling out firms founded before 2000[5].

[1] In this research we focused on active players in the medical device department in the mHealth market by choosing new ventures featuring alliance relationships in 2009, 2010, or 2011 as reported in the MobiHealthNews Year End Reports.

[2] To avoid bias resulting from healthcare systems and policies in different countries or areas, we focused on the market with the largest number of players. In this case, we targeted the market in North America (all focal firms work in the U.S. market).

[3] This research begins from 2013. Thus, we selected new ventures that were alive in the medical device department in the mHealth market in 2013.

[4] Hoover's online databasE (http://www.hoovers.com/)

[5] In 1997, Ericsson launched its GS 88 "Penelope" and described concept of Penelope as a "Smart Phone" (Sager, 2012). In 2000, NTT launched the first 3G network. The combination of the smartphone and 3G network offers the possibility of the development of mHealth (De Vriendt, Laine, Lerouge, & Xu, 2002).

2.3.2 Data sources

We include seven new ventures in North America[6]. Data sources include exploratory interviews, archival data, and formal semi-structured interviews. (1) The seven exploratory interviews were conducted to understand the dynamics of the mobile health market in Boston in 2012. The informants include policy makers in the US government, clinicians, healthcare providers, and researchers in the medical and engineering schools. (2) The archive data included 933 news items about focal firms collected from the Factivia database, three years of MobiHealthNews Year End Reports (2009, 2010, 2011), each company's product portfolio on the US Food and Drug Administration (FDA) website, and the founding team's portfolio on company websites. (3) We undertook three rounds of interviews, including 24 semi-structured interviews (see Table 2) and we taped and transcribed the interviews turning into 409 pages of double spaced interview transcripts. The first round was conducted from late March until May 2013 and includes seven phone interviews and one face-to-face interview and was. We applied event tracking interview technique to guide informants to find an overview of events that happened in the previous years (Eisenhardt, 1989). The second round was conducted six months later (October 2013) and included nine face-to-face interviews. We extended our understanding to why the founders of focal firms initiated their business and what resources they had. The last round was also conducted six months after (late April to early June 2014) and included seven phone interviews to confirmed our findings with focal firms to ensure no misunderstanding would make the results bias.

[6] All of the seven ventures focus on the U.S. market.

Table 2 Data inventory

New Venture	Location	Year Founded	Age	No. of founders	No. of interviews	Interview details			
						Date	Time Mins	Type	Informant
A	Greater Boston area, MA	2005	9	1	3	18/04/2013	66	Phone	Founder
						24/10/2013	73	Face-to-face	
						13/05/2014	47	Phone	
B	Boca Raton, FL	2008	6	3	3	25/04/2013	63	Phone	Co-founder
						10/10/2013	65	Face-to-face	
						28/04/2014	54	Phone	
C	Annapolis MD	2003	11	1	5	29/05/2013	81	Phone	Founder
						22/10/2013	56	Face-to-face	Lead hardware Engineer
						22/10/2013	27	Face-to-face	CTO
						24/10/2013	61	Face-to-face	Founder
						04/06/2014	65	Phone	Founder
D	San Diego CA	2007	7	3	3	17/04/2013	64	Phone	Founder
						16/10/2013	57	Face-to-face	
						28/04/2014	46	Phone	
E	King of Prussia, PA	2008	6	4	4	18/03/2013	70	Phone	Founder (VP of sales and marketing)
						23/04/2013	82	Face-to-face	
						09/10/2013	113	Face-to-face	
						29/04/2014	69	Phone	
F	San Diego CA	2004	10	2	3	20/03/2013	52	Phone	VP of market development
						15/10/2013	91	Face-to-face	
						02/05/2014	49	Phone	
G	Toronto, Canada	2002	12	2	3	23/04/2013	81	Phone	General manager
						14/10/2013	90	Face-to-	
						28/04/2014	51	Phone	

2.3.3 Data analysis

We started from developing the time line of each focal firm by reviewing news items, industry reports, and interviews transcripts and then began open coding of interview transcripts by using Nvivo after most data had been collected (Eisenhardt, 1989). By doing so, we preserve the integrity of replication thinking logics in cases (Eisenhardt, 1989; Yin, 1994). Data analysis followed a cross case analysis to identify similar constructs (Eisenhardt & Graebner, 2007). We followed the Gioia template (Gioia, Corley, & Hamilton, 2013) to order open coding and then gradually combined the vivo codes into first order codes.

Following the standards of content analysis (Krippendorff, 2012; Neuendorf, 2002), two coders independently code the raw data: One author and a junior researcher who was blind to the theoretical rationales. We calculated interrater reliability including percentage of agreement and Cohen's κ for all coding dimensions made by two coders. We reached 93.8% agreement (κ=0.930) which reaches the acceptable level of interrater reliability. The two coders discussed discrepancies and gradually had agreements on all statements. To ensure reliability and common understanding with the second author, first order codes were marked in line with the different components of opportunity recognition and the nature of entrepreneurial opportunities. In the next round of coding, we tentatively combined first order codes into fewer and theoretically grounded second-order codes through axial coding (Strauss & Corbin, 1997). We also cross-checked the second order codes with literature on opportunity recognition and the characteristics of entrepreneurial opportunities to avoid ignoring theoretically relevant knowledge (Suddaby, 2006). This interaction between theory and data helped us to sharp construct definitions and the theoretical relationship between constructs (Eisenhardt, 1989).

2.4 Findings

This research aims to investigate how entrepreneurs come up with their opportunity ideas and how variations in entrepreneurial determinants influence the entrepreneurs' attention to recognise and exploit different types of opportunity ideas. We clarify the entrepreneurial determinants which influence entrepreneurs' cognitive processes to recognise different types of opportunities and how these determinants influence the formation of entrepreneurial intention to exploit particular opportunities.

2.4.1 Entrepreneurial Determinants and the Processes of Opportunity Recognition and Evaluation

Our data indicates that opportunity recognition is motivated by three entrepreneurial determinants: Technology-driven, operation-driven, or user-driven determinants. Three of the seven ventures (Companies A, B, and C) in the sample were established with a technology prototype and the goal was to leverage current technology to other profitable market segments (Quotations 1-3 in Table 3). For example, Company A had a platform to deliver a service through a TV set which can be used in the energy management, security, and medical markets. Company B had a product prototype with tracking technology which is helpful for pet tracking, Alzheimer patients, and elderly people. Company C had remote physiological monitoring technology and a product which worked in the researchers, sport, military, and first-responder markets. The main goal of these ventures was to maximize the value of their current technology, so they conducted a study to evaluate the potential of each opportunity. The medical device market was chosen because the market was growing and provided foreseeable ROI (Quotations 7-9 in Table 3).

Two ventures (Companies D, and E) were motived by their founders' past operational experiences (Quotations 10-12 in Table 3). The founders of Company D noticed the demands of chronic disease patients because they had a long history in the healthcare solution market. The founders of Company E worked in the life safety security market and found there was no sophisticated product which can match with customers' needs. While evaluating potential value of the opportunities they targeted, these two ventures did not conduct a complete study but relied on their founders' prior knowledge (Quotations 13-14, and 16 in Table 3). In addition, they particularly conducted empirical tests (e.g., establishing a product prototype (Quotation 15 in Table 3) or acquired key technology (Quotation 17 in Table 3)) before starting new business to ensure that they have the abilities to realise their product concept.

Three ventures (Companies D, F, and G) were motivated by their founders' personal frustration in searching for a product to solve the problems they faced in their everyday lives (Quotations 18-20 in Table 3). For example, the founders of Companies D and G were searching for a product to take care of their family members suffering from chronic diseases or age-related conditions. One of the founders of Company F, a cardiologist, was looking for a solution to continually monitor the heart pressure of heart disease patients[7]. These founders started their new business because they failed to find a suitable product in the current market to satisfy their needs. Their opportunity ideas came from their everyday lives which may not had obvious connections with their current resources. While evaluating technology feasibility, Companies F and G - whose founders did not worked in the medical device markets - relied on the consensus of knowledgeable peers (Quotation 21 and 24 in Table 3). But in most cases, they did not empirically create a product prototype before they started their new business. When evaluating the market feasibility of the targeted opportunities, these two ventures (Companies F and G) usually generalized market demands from their founders' needs. For instance, the founders of Company G believed that other elderly people, like their parents/grandparents, needed a device to deal with their age-related conditions (Quotation 23 in Table 3).

[7] Although he worked in the healthcare market, his role was as a medical device "user" instead of a "producer". Therefore, he did not have knowledge regarding operating a medical device company.

Table 3 Data structure of entrepreneurial motivations

Second-order Codes	First-order Codes		Representative Data
Technology-driven forces	**Technology leveraging**	1	*"Between 2001 to 2005, our solution was very flexible. We thought we can create an application box that is connected to TVs. …we thought we can apply to energy management, security, healthcare, all of those. So we were starting looking around, [assessing] what is a different industry which our system can help."* [Interview with Founder of Company A, 24 Oct. 2013]
		2	*"What we see is the trend that chronic disease patients will be [in their] homes and their conditions will deteriorate and then they get very sick. They end up in hospital and get two or three weeks care and then they go back home. So it is continuously up and down. That's where the costs of health care are dramatically exponential. So providing the connectivity for patients using their TV sets and bringing some medical devices into the home will provide an environment which can continuously monitor their health, provide guidance in order to keep their disease level [steady]*. [Interview with Founder of Company A, 18 April 2013]
		3	*"He [one of the founders] wanted to do something about tracking and mPRES was only one of the ideas. He said pet tracking, Alzheimer tracking, mPERS. He didn't know. His business plan is very unfocused. But I like the tracking idea. And [Another founder] was the one helped the market research"* [Interview with Co-founder of Company B, 10 Oct. 2013]
		4	*"We started with the goal of physiological monitoring and the product required a sensor, a wireless connection, and analytical software. ... The four main reasons to monitor human beings remotely were for human performance or fitness, industrial safety, medical. ... We can measure anybody remotely, which in one of them has always been for medical reasons* [Interview with founder of Company C, 29 May 2013]
		5	*"Since we have had the hardware, the hardware itself is not a product because no one can use just a hardware. ... The software side tends to be more market specific. For example, the sport software has something in common with the medical software but it is directed toward sports and it [a medical device] is directed toward medical. The hardware for both of them is actually the same.* [Interview with Lead Hardware Engineer of Company C, 22 Oct. 2013]
	Feasibility assessment	6	*"What we found was the energy industry was no revenue. There is no clear ROI to build it. In security, again, very low margins. There was no return on investment for a new solution. Healthcare seems like the only one where we seem to fit. We saw there were a lot more needs. ... Healthcare is a very interesting and complex environment where you not only need to work with nurses, you not only work with doctors, [but] you have to work with pharmacists to get the complete cares. So the need for communication and connectivity are much more complex and can save a lot of money. So there was potential for ROI for saving a lot of money and justifying the cost for implementation."* [Interview with Founder of Company A, 24 Oct. 2013]
		7	*"We decided pretty early on. The entire focus [on the healthcare market was] because we were trying to see if there was any other possible markets [or] business models in other segments. [But] no [other business model] is sustaining for us. I think it took us probably two years before we decided that it was our entire focus."* [Interview with Founder of Company A, 13 May, 2014]
		8	*"The other big advantage was this company [a partner and this partnership happened before Company A focused exclusively on the mHealth market] was an expert in delivering one of the solutions [a solution for diabetes patients]. So it was a great learning experience for us to discover how they think about delivering care and delivering medical devices. So how they manufacture, how to get FDA approvals, all those things are our other benefits from this partnership. And they, of course, got a lot of tests regarding how patients think about the solution"* [Interview with Founder of Company A, 13 May, 2014]

Second-order Codes	First-order Codes		Representative Data
		9	*"He [one founder] had a prototype of a tracking device which is similar to our mobile device. The functionality is similar. ...he [another founder] was the one helped the market research and said let's go for mPRES ... And we noticed that industry was really lacking technology innovation. ... So we saw a window of opportunity for us to go and disrupt the market place by bringing in a new idea to do the same business..... In the U.S., the elderly population is growing because of the baby boom and the trend which is to keep costs down. Also the elderly people want to stay at their own homes as long as possible because that makes them feel comfortable."* [Interview with co-founder of Company B, 25 April 2013]
		10	*"We got confirmation from him [an advisor] that the market [PERS market] still has not changed probably in 20 years. ... I think we all knew that they would [like our product]. We didn't need the whole market research to know [that] they would like the mobility piece because we know elderly people like to be active [and] not just staying at home."* [Interview with Founder of Company B, 28 April 2014]
		11	*"We like the elderly market because it is growing because of the baby boomers. So we knew the market will expand and we didn't how many people are willing to pay that much money for pets to tracking pets. It is not big enough to make a company... We thought about Alzheimer but it was not that established. There is no one else doing that which could be used as a benchmark to establish a business model. We had to create the whole business model from scratch. That would be very difficult. Within the PERS industry, it has already been established with how they do and the prices. We thought we would be better to disturb that market and be the first one in that market."* [Interview with co-founder of Company B, 10 Oct. 2013]
		12	*The main reason [to enter the medical market] was the demand was growing so is the profitability of that market. ... Sport market is a quite niche market. There are not many players in that market. They are mainly multinational companies like Nike, Adidas, and large companies. They need a lot of the technology we have."* [Interview with CTO of Company C, 22 Oct. 2013]
		13	*"The biggest issue was the whole medical market for monitoring; no one knew who was going to pay for it. That was the big change. And now Obama and some other changes in performance-based procedures, then there were much more interest because they will get penalized if they don't do it."* [Interview with CTO of Company C, 22 Oct. 2013]
Operation-driven forces	**Perception form related operational experience**	14	*"We are actually starting from chronic disease because my last company that I sold to [a company] was [name of a company]. It was a cure care ... very long after patient was in trouble. I decide to get earlier on disease progression. And so I decide to do chronic diseases. ...it is not till the later on, we realized that diabetes cost a lot. Very expensive side effects. If we were doing it over based on the market size, we probably do congestive heart failure not diabetes because congestive heart failure has bigger population."* [Interview with Co-Founder of Company D, 16 Oct. 2013]
		15	*"They [the founders] knew the industry very well. And it [the personal emergency response market] was a very competitive market because everyone was selling basically the same thing. .. And most of the equipment used at that time was less sophisticated. So the main driving force is to find a better product to penetrate the existing large market.* [Interview with VP of sales and marketing of Company E, 9 Oct. 2013]

Second-order Codes	First-order Codes		Representative Data
		16	*"The founders at the time the company started were in the home security market. …everybody was familiar with the medical home alarm business. … Most of time, you saw somebody fall down. You assume they can talk through the pendant but actually they cannot. ... Most of time people get injured in their homes, like elderly people, because they fall. The other thing is that the way that the traditional system works ... you have to be [using] speaker boxes or all those systems to talk back when you press the buttons. But the fact is that as homes became larger and people fall in showers when the door closed, these are representative of serious shortcomings. So the founders of the company thought they were able to provide a solution. That could really and truly improve the performance and reliability of this type of system. This was basis of the company"* [Interview with VP of sales and marketing of Company E, 29 April 2014]
	Feasibility assessment	17	*"I understand the market and get to put it together "* [Interview with co-founder of Company D, 16 Oct. 201]
		18	*"We just created the product and the whole concept because we knew there were customers for glucose monitors. … It was pretty simple because glucose meters have been around for years. They are very standard in term of using consumable test strips and discipline and results, these kinds of things. So the glucose meter technology is very well developed when we entered the market. What we wanted to do was add the features of wireless connectivity. … We added another concept to that which was online monitoring"* [Interview with co-founder of Company D, 28 April 2014]
		19	*"My partners and I [one of the founders] decided that we wanted to build a blood glucose meter together [which used a] mobile phone and we had a prototype. Actually we have had the prototype before we started the company because we were doing other things, and once we went through the prototype developing process, we knew we could actually make this device. That's why we founded this company."* [Interview with co-founder of Company D, 17 April 2013]
		20	*"There are a lot of users and studies have been done [regarding the personal emergency respondence system]. The founders had a background in the completive products."* [Interview with VP of sales and marketing of Company E, 29 April 2014]
		21	*"What happened was the founders were introduced to an engineer who had a patented approach to talk through the pendent. … So they felt that well "we'll come up with a product that everybody just talks through the pendant. That would allow us to go into the market place and have this patented feature" ... One of founders knew him [the engineer] before the company started. So that was the root of how things happened."* [Interview with VP of sales and marketing of Company E, 29 April 2014]
User-driven forces	**Perception form personal life experience**	22	*"All three of the founders including myself have diabetes in family. So we saw the relative suffering of this disease. So we thought there must be a better way to manage this glucose data."* [Interview with Co-Founder of Company D, 16 Oct. 2013]
		23	*"[The founder, a cardiologist] said 'it would be very cool if you [co-founder] are able to produce [a product] to give me blood pressure continually.' [The founder, a cardiologist] deals with a lot of high potential patients. And in the U.S., we know 70 million [people] in the U.S. have potential. So this could be a big deal and it had have not been down very successfully before.* [Interview with VP of market development of Company F 15 Oct. 2013]
		24	*"[The founder] was working for his father [the co-founder] at that time and looking for a way to stay in touch with his grandparents. They are remote. And he wanted to help to manage their aging conditions."* [Interview with General Manager of Company G, 14 Oct. 2013]

Second-order Codes	First-order Codes		Representative Data
	Feasibility assessment	25	*"The family friend [one of the founders, a cardiologist] identified a clinical problem and said if you [another founder] could [develop] continuous blood pressure that would be very helpful for the clinical communities and patients. So that's why [the second founder mentioned in the paragraph] said "I am going to do that exactly." And then [the second founder mentioned in the paragraph] developed the continuous blood pressure monitor. So he was respondent to a clinical need and solved that problem."* [Interview with VP of Market Development of Company F, 2 May 2014]
		26	*"[One founder, a cardiologist] said "it would be very cool if you are able to produce a device to give me blood pressure continually" ... [the founder] is a cardiologist. So he deals with a lot of high potential patients. And in the U.S., we know 70 million [people] in the U.S. have potential. So this could be a big deal and it had not been done very successfully before."* [Interview with VP of Market Development of Company F, 15 Oct. 2014]
		27	*"They saw their own needs and figured out this was the need that others had, so they thought it could be a business they can develop and then [one of the founders] wanted to start the business."* [Interview with General Manager of Company G , 28 April 2014]
		28	*"...the founder, the father had products made in the Orient for 25 to 30 years. When they [two founders] researched the market, they found one of the big complaints was the wiring and hook-up to the devices and they knew that would never work in the direct to the consumer market model. That was too complicated. So the manufacturers [who produced products for one of the founders before] told them they had experience in Bluetooth. So early on, they know they can take advantage of these relationships in the Orient to develop products with Bluetooth before anybody else understood the value of Bluetooth."* [Interview with General Manager of Company G, 14 Oct. 2014]

2.4.2 The nature of entrepreneurial opportunities

Firstly, we identified the level of superficial and structural similarities between focal firms' *'technology'* knowledge and what was required in the target market. We found that five ventures (Companies A, B, C, D, and E) focused on the opportunities with high superficial and structural similarities in terms of technology knowledge (Quotations 25-29 and 32-37 in Table 4). In the interviews, we found Companies A, B, and C usually added new functions to their current products or product prototypes which resulted in high superficial (Quotations 25-27 in Table 4) and high structural similarities with their current technologies (Quotations 32-34 in Table 4). For example, Company C leveraged the sensor, wireless connection, and data transformation technologies – used in other market segments – in the new business in the mobile health market and leveraged the remote physiological monitoring technology in relation to a vital signs monitor.

The founders of Companies D and E had a long history working in related market segments. They usually had some technology which they developed in their past career can be leveraged to the new business (Quotations 28-29 and 35-37 in Table 4). For example, Company D leveraged telecommunications, tracking technology, and the knowledge of healthcare records and self-service software solutions in aid of the creation of a new device. Company E had life safety security technology and accessed the patents of remote communication and alarm system through the founders' personal connection (Quotations 37 in Table 4). However, the opportunities Companies F and G targeted tended to lacked obvious similarities with their founders' prior technology knowledge (Quotations 30-31 and 38-39 in Table 4). For example, the founders of Company F were a doctor and an expert in GPS technology; while the founders of Company G came from the toy industry. They all lacked technology knowledge or experiences related to the medical device market.

Secondly, we reviewed the similarities in the *'market'* knowledge of focal firms. Companies A and B targeted opportunities with a medium level of structural similarities (e.g., medical regulation and operational rules) with their existing market knowledge (Quotations 47-48 and 53 in Table 4) although the superficial similarities (e.g., target customers) may not be significant (Quotations 44-45 in Table 4). For example, in the former business, Company A had a partnership with a big medical device company and learned how to operate in the medical device market (structural similarities in operational rules) (Quotations 53 in Table 4). In addition, in the former business, Company A worked with medical service providers and medical device manufacturers to deliver medial education through a service platform. Although in the new business the main customer turned out to be insurance companies, Company A still needed to work with medical device providers and healthcare service providers (medium superficial similarities) (Quotation 40 in Table 4). For Companies B and C, while working in other market segments, they accumulated experience regarding regulation issues such as FDA regulations because of their former customers' requests (Quotations 47-48 in Table 4).

The founders of Companies D and E both had related market knowledge in terms of market participants, customer, customer demands, regulation, and operational knowledge which can guide their business development (Quotations 41-42, 49, and 54-56 in Table 4). However Companies F and G targeted the opportunities without significant superficial and structural similarities with the market knowledge their founders had (Quotations 46, 51-52, and 59-60 in Table 4). Only one founder of Company F, a cardiologist, had some market knowledge regarding the customer in the medical device market but his role was as a medical device user instead of a provider.

Table 4 Data structure of opportunity selection

Second-order Codes	First-order Codes	Representative Data	
Technology similarities	**Superficial similarities (Basic elements of technology)**		**High similarities**
		29	**[Old technology/product]** A service platform to collect and transmission clinical data [Information from the interview with the founder of Company A, 18 April 2013] **[New technology/product]** *"What we see is the trend that chronic disease patients will be [in their] homes and their conditions will deteriorate and then they get very sick. They end up in hospital and get two or three weeks care and then they go back home. So it is continuously up and down. ... So providing the connectivity for patients using their TV sets and bringing some medical devices into the home will provide an environment which can continuously monitor their health, provide guidance in order to keep their disease level [steady].* [Interview with Founder of Company A, 18 April 2013]
		30	**[Old technology/product]** A product prototype with the tracking technology [Information from the interview with the founder of Company B, 25 April 2013] **[Old technology/product]** *"One of the other gentlemen who is our CEO is a double E engineer and so he has already understood the product and the process in creating new products."* [Interview with co-founder of Company B, 25 April, 2013] **[New technology/product]** *"...he [the cofounder] looked at all the opportunities that were available for what the prototype could do. And he searched the mobility piece for the PERS industry, and we determined the existing leaders in the market place had not really focused any attention on the mobility piece."* [Interview with Co-founder of Company B, 28 April 2014]
		31	**[Old technology/product]** A physiological monitoring device with sensor, wireless connection, and data transformation technology [Information from the interview with the founder of Company C, 29 May 2013] **[New technology/product]** *"From entering in the medical market to six months later, we shipped our first product. That's because we have had FDA and we already had 80% of the product.…. The only need for R&D is the gap we faced."* [Interview with Founder of Company C, 4 June 2014] **[New technology/product]** *"We started with the goal of physiological monitoring and the product required a sensor, a wireless connection, and analytical software. ... The four main reasons to monitor human beings remotely were for human performance or fitness, industrial safety, medical. ... We can measure anybody remotely"* [Interview with founder of Company C, 29 May 2013]
		32	**[Old technology/product]** Healthcare information, software, and teleconferencing [Information from the interview with a co-founder of Company D, 17 May 2013] **[New technology/product]** *"My technology which I have worked in my whole career has been communication talk, communication technology. So I feel comfortable in the technology [sector] and I worked in telecom outside of healthcare, in [another market]. And then I got involved in healthcare. That's sort of the coming through for the technology standpoint, through the all companies I have done. So we looked at how could we apply telecommunication technology to diabetes to make the data collection more efficient"* [Interview with co-founder of Company D, 28 April 2014]

Second-order Codes	First-order Codes		Representative Data
Technology similarities (Cont.)	**Superficial similarities (Basic elements of technology) (Cont.)**	*33*	**[Old technology/product]** Life safety security technology [Information from the interview with VP of sales and marketing of Company E, 23 April 2013] **[New technology/product]** *"[One founder] was doing something in security systems and he got interested in the post alarm systems. And he and a marketing guy... the guy worked in manufacturing those devices and they know a lot about what the industry is doing and [were able to] envision a new product."* [Interview with VP of sales and marketing of Company E, 9 Oct. 2013]
			Low similarities
		34	**[Old technology/product]** *"He [one founder] came from the automotive industry. ... [He] was something like GPS tracking."* [Interview with VP of market development of Company F 15 Oct. 2013] **[New technology/product]** *A vital sign monitor* [Information from the interview with VP of market development of Company F , 23 April 2013 and FDA website]
		35	**[Old technology/product]** *"Actually [one founder] was in a toy business and so there was nothing to do with health care, nothing to do with anything that we are doing now, except for selling products to persons. So [the founder] sold the company and decided to fund his son's idea."* [Interview with General Manager of Company G, 14 Oct. 2013] **[New technology/product]** Medical devices for chronic disease / a connection gateway a web platform for clinical data collection and transmission [Information from the interview with General Manager of Company G, 23 April 2013 and FDA website]
	Structural similarities (Intrinsic capabilities of new technology)		**High Similarities**
		36	**[Old technology/product]** *"In process automation, my focus was networking communications like the company that I worked with before; they built solutions for automation industries, factories, park stations. So if you look at the concepts, they have remote control and provide different services in process automation so that the concepts are very similar. But this was appealing to consumers. This is appealing to the mainstream markets.* [Interview with Founder of Company A, 24 Oct. 2013] **[New technology/product]** A service platform to automatically collect and transmission clinical data [Information from the interview with the founder of Company A, 18 April 2013 and FDA website]
		37	**[Old technology/product]** *"Part of that [product] is the hardware and software system because we control signalling and data. We also have lots of expertise in the distributed software systems to be able to keep all these things up and running. That's our key experience from the web-hosting industry that is where we came from when we were a hosting company 10 years ago."* [Interview with co-founder of Company B, 25 April 2013] **[New technology/product]** A mobile personal emergency respond system [Information from the interview with the founder of Company B, 25 April 2013]

Second-order Codes	First-order Codes		Representative Data
Technology similarities (Cont.)	**Structural similarities (Intrinsic capabilities of new technology) (Cont.)**	*38*	**[Old technology/product]** *"The first product we created was for researchers. So it was [a product name] and the main reason we developed that was we developed some technology for smart fabric for sensing activities. So we wanted to find a use in a product ... And initially it was for researchers to be able to monitor patients or subjects on a lap-top environment. ... With that development and with scholarly researching for that, we did a bit with the U.S. Army ... we supply physiological monitoring systems for soldiers. ...once we developed the military products, we had some good success in that market. Within it, we had some investment from [an investor] who allowed us to transit to take the product to recharge to the firefighter market."* [Interview with CTO of Company C, 22 Oct. 2013] **[New technology/product]** A vital signs monitor [Information from the interview with the founder of Company C, 29 May 2013 and FDA website]
		39	**[Old technology/product]** *"... I worked with [a given company] ... on the electronic healthcare record system. We developed the communication network which can transmit these healthcare records around the world because [the employees of the company] are constantly moving from one place to the next. And the record had to follow them. ... Then I left that company and did another company that we sold to [another company name]. That was applying telecommunication technology to operating rooms. ...we developed a way to transmit the audio and video in the ER operating rooms to different places, to doctors' offices or to other operating rooms. So that was telecommunication applied to the surgery. Then the next company was a tracking company that we tracked people and patients and equipment around the hospitals. And that was ZigBee technology which was a form of low data rate networking. ... And then after I left there and started [Company D], that was an application of telecommunication technology to glucose monitoring. "* [Interview with co-founder of Company D, 28 April 2014] **[New technology/product]** A glucose meter and a web platform for clinical data collection and transmission [Information from the interview with a co-founder of Company D, 17May 2013 and FDA website]
		40	**[Old technology/product]** *[The CTO, one of the founders] has over 25 years of corporate and entrepreneurial experience in a wide range of software and technology enterprises. Prior to joining [Company D], [the CTO] served as the president and founder of a company] where he was the chief architect of the [the company's] self-service healthcare solutions. He served as the chief technology officer and founder of another company]'s subsidiary, He was responsible for the continued development of existing and new healthcare and education self-service software solutions. [The CTO] developed the technology used in automated self-service patient services using touch screen kiosks and wireless PC tablets and the Internet."* [Company website of Company D] **[New technology/product]** A glucose meter and a web platform for clinical data collection and transmission [Information from the interview with a co-founder of Company D, 17May 2013 and FDA website]

Second-order Codes	First-order Codes		Representative Data
Technology similarities (Cont.)	**Structural similarities (Intrinsic capabilities of new technology) (Cont.)**	*41*	**[Old technology/product]** *"Prior to joining [Company E], he [one co-founder] was a senior security consultant for [a company], a structured wiring company. He is also a co-founder of [another company], one of the nation's top 30 home integration companies."* [Company website of Company E] **[Old technology/product]** "*[One consultant, one founder's friend, who joined the company since it was founded]* is the original inventor of the PERS technology*.... he won Best Invention of the Year at the Consumer Electronics show in [a named place] with his revolutionary new medical alert system"* [Company website of Company E] **[New technology/product]** A mobile personal emergency respond system [Information from the interview with VP of sales and marketing of Company E, 23 April 2013]
			Low Similarities
		42	*"Everything is completely new. ... They [the two founders] had nothing at hand"* [Interview with VP of market development of Company F, 2 May 2014]
		43	*"In my knowledge, the founders of our company had no experience of FDA clearance devices but did jump right into developing ... I think they just learned what they needed as the business evolved".* [Interview with General Manager of Company G, 28 April 2013]
Market similarities	**Superficial similarities (Basic capabilities of the mHealth market)**		**High Similarities**
		44	**[Old market/ market knowledge]** *"We decided pretty early on [before Company A entered into the medical device market]. The entire focus [was on the healthcare market was] because we were trying to see if there was any other possible markets [or] business models in other segments. [But] no [other business model] is sustaining for us. I think it took us probably two years before we decided that it was our entire focus."* [Interview with Founder of Company A, 13 May, 2014] *"In [a certain year before Company A entered into the mHealth market], the concept which we were looking at was to build a service platform where you can deliver services though TV in the home. So it was a period of time [two years before Company A entered into the mHealth market]. We started talking to a company called [a company name, a large medical equipment company]. ...they asked us to build a prototype and build a solution ...so they can get education about diabetes by using the TV. So it was one of the vertical services that we can satisfy using our flexible systems."* [Interview with Founder of Company A, 24 Oct. 2013] **[New market/ market knowledge]** Insurance companies/ Hospitals/ Medical devices providers [Information from the interview with the founder of Company A, 18 April 2013]
		45	**[Old market/ market knowledge]** *[The CEO's] career includes ten years at [a named company], the FORTUNE 500 engineering, and technology applications company ... Following [the company mentioned before], [the CEO] founded [another company], a systems integration company. ... In [a year], [the CEO] co-founded [a company, a telecommunication company]. In 2004, [the CEO] founded [a company, a healthcare technology company]."* [Company website of Company D] **[New market/ market knowledge]** Hospitals/ Insurance companies/ Mobile health solutions integrator/ Medical devices providers [Information from the interview with a co-founder of Company D, 17May 2013]

Second-order Codes	First-order Codes		Representative Data
	Superficial similarities (Basic capabilities of the mHealth market) (Cont.)	*46*	**[Old market/ market knowledge]** *"The founders, by the time the company started, were in the home security market."* [Interview with VP of sales and marketing of Company E, 29 April 2014] **[New market/ market knowledge]** End users (elderly people and their families) [Information from the interview with VP of sales and marketing of Company E, 23 April 2013]
		47	*"[One founder] is a cardiologist ... he deals with a lot of high potential patients."* [Interview with VP of market development of Company F, 15 Oct. 2013]
			Low Similarities
		48	*"...this is a whole new industry for all of us. I think as a successful entrepreneur, we have to react very quickly, making very small changes and learning: learning by doing."* [Interview with Co-founder of Company B, 28 April 2014]
		49	*"The first product we created was for researchers. So it was [a product name] and the main reason we developed that was we developed some technology for smart fabric for sensing activities. ... With that development and with scholarly researching for that, we did a bit with the U.S. Army ... we supply physiological monitoring systems for soldiers. ...once we developed the military products, we had some good success in that market. Within it, we had some investment from [an investor] who allowed us to transit to take the product to recharge to the firefighter market."* [Interview with CTO of Company C, 22 Oct. 2013]
		50	*"The two funders' background was primary consumer products."* [Interview with General Manager of Company G, 23 April 2013]
	Structural similarities –Regulation		**High Similarities**
		51	*"[One of the co-founders] knew a lot [about the regulation issue] from his experience and then ... because in the previous company that I mentioned that we had sold, [that it] was for medical software. So he was very familiar with the FDA process, so we actually have hired an FDA resource, a quality resource."* [Interview with Co-founder of Company B, 28 April 2014]
		52	*"A lot of FDA approvals in those early days were for military products. .... It was part of the military contract."* [Interview with CTO of Company C, 22 Oct. 2013]
		53	*"[In] the company that I had and sold to [a company name], we didn't really know much about the regulatory, quality systems, and developing products under a quality system. So at [a company name], I learned a lot about that."* [Interview with co-founder of Company D, 28 April 2014]
			Low Similarities
		54	*"Medical devices, I think there is always complexity, like FDA certification. It is a big challenge. So to conquer that, I think the clear thing was to find an expert who knows that. And we were able to successfully to find somebody who is exceptional and has very deep knowledge of medical devices. So we have to comprise our existing innovative thinking with somebody who knew how to bring a medical device to market."* [Interview with founder of Company A, 24 Oct. 2013]
		55	*"[One founder] is a cardiologist.... He [another founder] came out from the automotive industry. ... [He] was [doing] something like GPS tracking."* [Interview with VP of market development of Company F, 15 Oct. 2013]
			"He [one founder, a cardiologist] didn't really work here ....he [one founder, a cardiologist] doesn't get directly involved in day-to-day operations" [Interview with VP of Market Development of Company F, 30 April. 2014]

Second-order Codes	First-order Codes		Representative Data
		56	*"Actually [one founder] was in a toy business and so there was nothing to do with health care, nothing to do with anything that we are doing now, except for selling products to persons."* [Interview with General Manager of Company G , 14 Oct. 2013]
	Structural similarities– Operational rules		**High Similarities**
		57	*"The other big advantage was this company [a partner and this partnership happened before Company A focused exclusively on the mHealth market] was an expert in delivering one of the solutions [a solution for diabetes patients]. So it was a great learning experience for us to discover how they think about delivering care and delivering medical devices. "* [Interview with Founder of Company A, 13 May, 2014]
		58	*"I [The co-founder] understand the market and get to put it together "* [Interview with co-founder of Company D, 16 Oct. 201]
		59	*"Throughout his [the CEO's, one of the founders'] career he has specialized in healthcare delivery and organizational process improvement through the use of telecommunications and information technology… [The CEO's] career includes ten years at [a named company], the FORTUNE 500 engineering, and technology applications company ... Following [the company mentioned before], [the CEO] founded [another company], a systems integration company. ... In [a year], [the CEO] co-founded [a named telecommunications company]. In 2004, [the CEO] founded [a company, a healthcare technology company]."* [Company website of Company D]
		60	*"The current CEO for example, was in the home security business. And the first marketing sales person actually worked for other company who made one of these monitoring devices. ... What happened was everybody was familiar with the medical home alarm business."* [Interview with VP of sales and marketing of Company E, 29 April 2014]
			Low Similarities
		61	*"...this is a whole new industry for all of us. I think as a successful entrepreneur, we have to react very quickly, making very small changes and learning: learning by doing."* [Interview with Co-founder of Company B, 28 April 2014]
		62	*"We hire people to pull the DNA in. I need to change the DNA of the company. ... I had a very experienced team including myself that knew the question to ask to modify our platform to go to a particular market and solve the problem for that market. So we are extremely experienced. So we start to design a medical product in March and start to work on patients in December. ... So we are really good at that. But the sales and understanding the regulations, I knew I needed to change the DNA of the company to be a medical company. And so we hired people who already have that experience*." [Interview with founder of Company C, 22 Oct. 2013]
		63	*"We hired sales because we didn't know how to sell. ... And we hired clinicians because we needed people in the company who have been doctors and nurses so they could tell us how our products are needed to work."* [Interview with Founder of Company C, 4 June 2014]
		67	*"He [one founder] came out from the automotive industry. ... [He] was [doing] something like GPS tracking."* [Interview with VP of market development of Company F, 15 Oct. 2013]
		65	*"Actually [one founder] was in a toy business and so there was nothing to do with health care, nothing to do with anything that we are doing now except for selling products to persons."* [Interview with General Manager of Company G , 14 Oct. 2013]

2.4.3 The interrelationships between entrepreneurial determinants, types of opportunities identified, and entrepreneurial decision making

This research aims to understand empirically what entrepreneurial determinants are influential in spurring a particular type of opportunity ideas in the first place and in directing the way to form opportunity beliefs. In the interviews, we found three types of entrepreneurial determinants – technology-driven determinant, operation-driven determinant, and user-driven determinant – that direct entrepreneurs' attention in opportunity search. In our sample, we found three of the seven ventures (Companies A, B, and C) aimed to discover a new market domain to maximise the value for their current technologies. We labelled them as "technology-driven ventures". Companies D and E aimed to find a technical solution for particular unmet demands observed in their founders' past careers. We labelled them as "operation-driven ventures". Companies F and G were looking for a solution to solve problems found in their founders' daily lives. We labelled them as "user-driven ventures".

Before investigating the impacts of entrepreneurial determinants on the process of opportunity recognition and decision making, we reviewed the founders' backgrounds and focal firms' resources at "the founded year" to understand whether the entrepreneurial determinants resulted from the different resource endowment levels. The results (See Table 5) do not reveal systematic differences in founders' entrepreneurial experiences and sources of funding, but show differences in market knowledge and technology resources. We found technology-driven and operation-driven ventures all had some technology resources related to medical devices when they were established; whereas user-driven ventures did not. For the market knowledge, companies D and E had substantial market knowledge related to the medical device market, Companies A, B, and C have some related knowledge, but Companies F and G had very limited market knowledge. The result indicates that the

endowment of resources do not have a significant impact on the types of opportunities that the ventures pursued.

Table 5 Value chains comparison at "the founded year"

Ventures	**Technology-driven ventures**			**Operation-driven ventures**		**User-driven ventures**	
	A	**B**	**C**	**D**	**E**	**F**	**G**
Age	9	6	11	7	6	10	12
Entrepreneurial experiences	No	Some (not in the medical market)	No	Some (in the medical market)	No	One (not in the medical market)	One (not in the medical market)
Market knowledge	Some related to the medical market	Some related to the medical market	Some related to the medical market	All founders knowledge related to the medical market	All founders knowledge related to the medical market	Limited related to the medical market	No
Human resources	Some personal connections	Some personal connections	Limited personal connections	Some personal connections	Some personal connections	Some personal connections	Some personal connections
Technology resources	Some	Some	Some	Some	Some	No	No
Sources of funding	Private funding	Private funding/ Venture capitals	Private funding/ Venture capitals	Private funding	Private funding	Private funding/ venture capitals/ institutional investors	Private funding

In the next stage, we compared the impacts of entrepreneurial determinants on the cognitive process of opportunity recognition, evaluation, entrepreneurial decision making in three types of ventures.

Technology-driven ventures

Technology-driven ventures aimed to search for a new market space to exploit their technology for more profits. This determinant directs technology-driven entrepreneurs to be alert to opportunities with high superficial and structural similarities with their current technology knowledge. Within a certain distance, they believed their technology had a higher utility to generate profits.

In the phase of opportunity evaluation, they did not have special preferences for particular opportunities as long as they can bring in a similar amount of profits. Their opportunity evaluation process, thus, was relatively rational. In order to realise the potential profits, the level of uncertainty certainly played an important role in their cognitive process. Before selecting an opportunity, they conduct market research to consider rationally whether the potential reward for this particular opportunity was worth the potential cost and whether they had necessary resources and ability to exploit the opportunity. As cognitive research has suggested, when interpreting ambiguous stimuli in the face of uncertainty, people tend to have a distinct preference for reasoning that involves a high order of structural relationships (Gentner, 1989; Holland, Holyoak, Nisbett, & Thagard, 1986). We found technology-driven ventures tended to avoid operating in a market from scratch. Therefore they favoured opportunities with at least a medium level of structural similarities to their prior market knowledge.

Operation-driven ventures

The founders of operation-driven ventures were motivated by the problem they found in their past operational experiences. Their long history in the related market segments helped them be alert to the lack of a sophisticated product which can better satisfy customer demands. Instead of searching for possible opportunities in terms of what technology-driven ventures did, their entire focus was on looking for a technical solution to solve particular demands they observed. Therefore, the opportunities that operation-driven entrepreneurs pursued usually had high market similarity with their prior knowledge. In addition, the targeted opportunities were not far away from their founders' past work experiences. Although exploiting prior technology resources was not their key determinant to start the new business, the technology resources that they developed in their past career usually can aid

their new product development. Thus, the opportunities they eventually pursued naturally had higher technology similarities with their prior technology resources.

In the opportunity evaluation phase, different from technology-driven ventures conducting market research to compare the viability of potential opportunities, operation-driven ventures relied on their founders' knowledge and their cognitive process tended to be implicit. Their founders' market knowledge - in terms of how the market worked, how to interact with other players in the market, the regulation policies, customer acceptance, and other associated issues - naturally led them to only focus on opportunities with high market feasibility. In addition, while evaluating the technology feasibility, they not only relied on their own technology abilities but empirically developed a product prototype or acquired key technologies before their market entries.

User-driven ventures

The founders of user-driven ventures were motivated by personal frustration in searching for a suitable product to solve their own problems in their everyday lives. This determinant directed their attention to developing a technical solution to satisfy their own needs. Different from technology-driven ventures and operation-driven ventures which relied on prior technology or operational experience to recognize opportunities, user-driven ventures recognised opportunities based on their founders' life experiences. The cognitive process of opportunity recognition tended to be dominant by their emotional concerns. In most cases, their decision making tended to be irrational to such an extent that they started the new business without sufficient resources at hand. Therefore, we found that user-driven ventures were more likely to act on opportunities with low superficial and structural seminaries with their founder's prior knowledge.

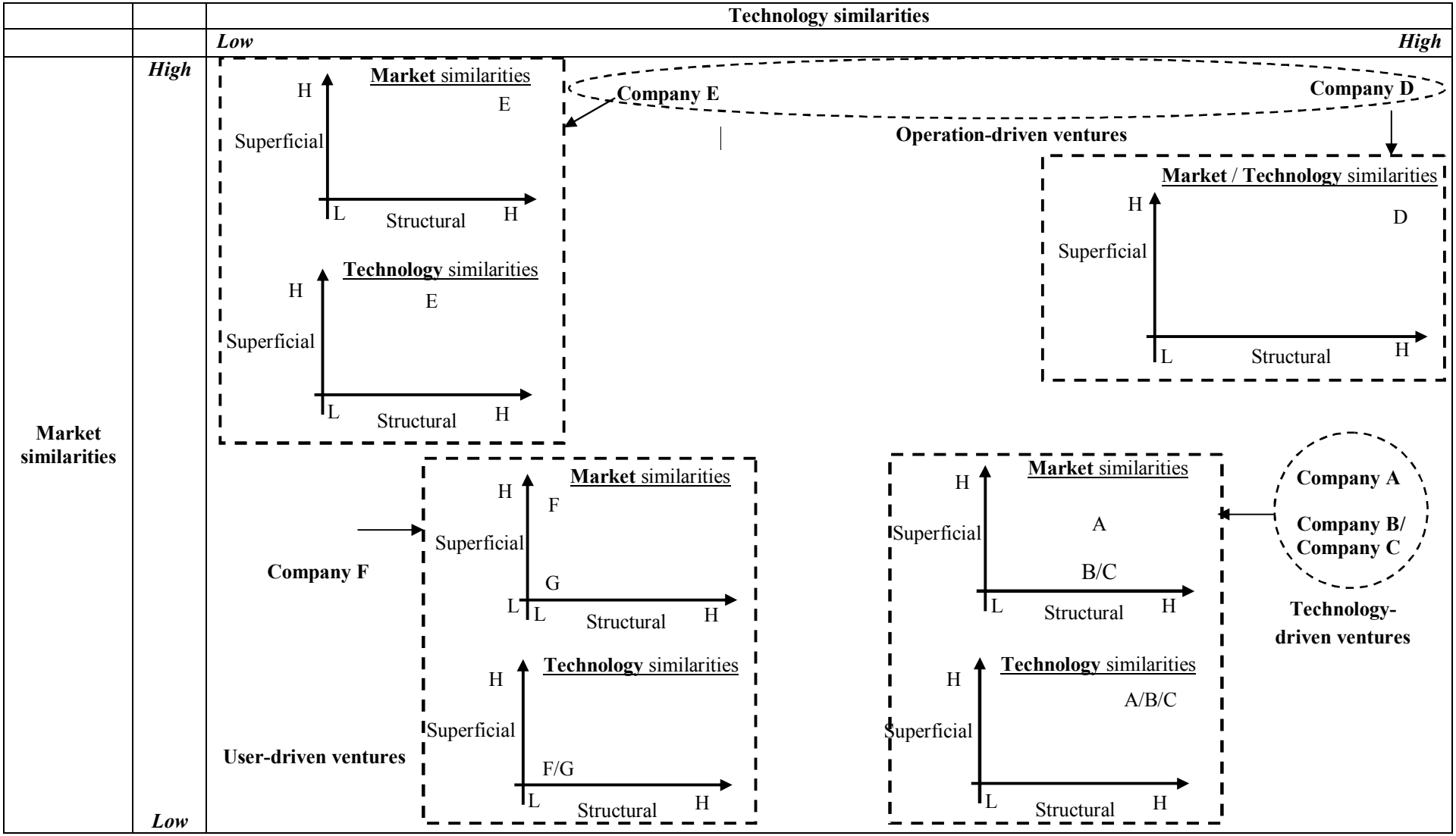
User-driven ventures spotted opportunities because of their founders' personal frustration. Those opportunities usually had no clear connection with their prior knowledge

and experience. Therefore, in the phase of opportunity evaluation, they relied on their peers' affirmation to ensure the feasibility of their ideas. However, the peers' affirmation was mainly about the technological feasibility rather than the market feasibility. They tended to generalized market demands from their own needs. In the interviews, we founded their entrepreneurial determinant triggered their perceptions of a possible envisioned future that was desirable and feasible. Therefore, once their knowledgeable peers had an agreement regarding technological feasibility, they established a new business.

2.5 Discussion and Conclusions

This study illustrates the relationship between entrepreneurial determinants and the types of opportunities that new ventures recognise and exploit (see Figure 1). Technology-driven ventures aim to maximise the value of their current technology such that they are alert to opportunities within a certain technological distance to their current technology and under a certain level of market uncertainty. Therefore, they are located at the bottom right corner in Figure 1. Operation-driven ventures are motivated by a perception of unmet needs from their founders' past operational experiences. They usually have some technology to support their opportunity ideas or personal connections developed in past career to access key technologies. In addition, they have substantial market knowledge to guide their business development. Thus, they are located in the upper middle to right corner in Figure 1. Meanwhile user-driven ventures are motivated by founders' dissatisfaction with current products to solve problems happen in their daily lives. Although they have rather limited technology resources and market knowledge, they decide to start the new business. Thus, they are located at the bottom left corner in Figure 1. These findings demonstrate that entrepreneurial decisions on acting different entrepreneurial opportunities in terms of different levels of similarity with their knowledge are determined by entrepreneurial determinants. Entrepreneurial determinants also determine the way entrepreneurs evaluate opportunities, which make entrepreneurs decided to pursue different types of opportunities. In the next section, we discuss the theoretical and practical implications of our observations.

Figure 1 The relationships between entrepreneurial motivation and attention to different types of opportunity ideas



2.5.1 Implications for theory

One way in which our findings contribute to theory is that they present antecedent factors which direct the development of the entire entrepreneurial process of a venture and contribute direct evidences about the mental connection to recognise opportunities, thereby contributing to previous research investigating the process of opportunity recognition. We illustrate three entrepreneurial determinants - technology-driven determinant, operation-driven determinant, and user-driven determinant - which direct entrepreneurs' cognitive process. Consistent with research in cognitive psychology (Gentner, 1989), some of our results confirm that prior knowledge provides relevant bases for assessing the meaning of the external spur (R. A. Baron, 2006; Gaglio, 2004; Gaglio & Katz, 2001; Grégoire et al., 2010; McMullen & Shepherd, 2006). This research further enrich previous research investigating pattern recognition among entrepreneurs (R. A. Baron, 2006; R. A. Baron & Ensley, 2006). Differences in cognitive processes are not necessarily caused by differences in the perceived quality of the information received but related to the different meanings that a given piece of information may induce (Crossan, Lane, & White, 1999). Our results show that not every firm which perceives opportunities based on prior knowledge has been through the same cognitive processes. For example, both technology-driven ventures and operation-driven ventures recognise opportunities based on their prior knowledge but the former one aims to maximize the value of their current knowledge and the later one aims to solve particular problems they perceived through the proxy of their prior knowledge, which lead to different entrepreneurial processes. Besides, the former one selects opportunities after conducting a complete market research but the later one has a clear goal in mind before the establishment of new ventures. In this research, we revisit the role of entrepreneurial determinants which includes internal factors that impel action and external factors that work as inducements to action (Locke & Latham, 2004). Entrepreneurial determinants are related to one’s mental

model reflecting why one intends to undertake some entrepreneurial actions (and, by extension, what he/she does not intend) (Krueger, 2000). Our findings show how different entrepreneurial determinants direct entrepreneurs to diverse cognitive processes to recognise and exploit opportunities.

In addition, we indicate a special scenario – user-driven ventures. Entrepreneurs operate in a social world (McMullen & Shepherd, 2006; R. K. Mitchell et al., 2002; Shepherd et al., 2007) and the ways they recognise opportunity ideas and form opportunity beliefs are not simply a response to objective conditions but may have subjective concerns involved. In some cases, the weight of subjective concerns in influencing entrepreneurial decision is higher than that of objective conditions. For example, for user-driven ventures, their founders' personal frustration strongly forces them to look for a technical solution to satisfy their demands. This determinant triggers their perceptions of a possible envisioned future that was desirable and feasible (Stevenson, Roberts, Grousbeck, & Bhide, 1994) and makes them underestimate the potential operational risks resulted from the lack of necessary knowledge and resources.

Our results show empirically that in an almost identical market, different paths of opportunity recognition can co-exist. The approach to recognise opportunities is an option for entrepreneurs and determined by their entrepreneurial determinants. The entrepreneurs of technology-driven ventures followed an opportunity search-evaluation-exploitation process, while the entrepreneurial beliefs of the operation-driven ventures and user-driven ventures emerged from entrepreneurs' imagination.

Moreover, we associate entrepreneurial determinants with the nature of entrepreneurial opportunities. Entrepreneurship theorists have posited that entrepreneurs and opportunity characteristics jointly shape new firm creation (Shane & Venkataraman, 2000).

Our findings contribute to previous research investigating the interrelationships between individual characteristics of entrepreneurs and the types of opportunities that they exploit (Dencker & Gruber, 2014; Grégoire & Shepherd, 2012) by bringing in multiple cognitive mechanisms underlying entrepreneurial decision making into the dialogue. Entrepreneurial actions may arise from the interpretation of external stimuli by actors and different individuals may interpret the same stimulus differently (Walsh, 1988), which is related to one's mental model reflecting why one is motivated to undertake some entrepreneurial actions (and, by extension, what he/she is not motivated) (Krueger, 2000). We investigate the role of entrepreneurial determinants in entrepreneurial decisions making and how entrepreneurial determinants directs entrepreneurs' attention to recognise opportunities in the first place and the following evaluation process. Our findings present a next step understanding of why some entrepreneurs spot and work on distant opportunities but some do not, thereby enriching the opportunity recognition literature.

In addition, since entrepreneurs play central roles in new firm creation, we conducted a multiple-case study to show empirically how different entrepreneurial determinants lead to the construction of multiple types of opportunity ideas, which has greater ecological validity than the previous tests which used experimental design methodology (Grégoire et al., 2010; Grégoire & Shepherd, 2012).

2.5.2 Implications for Practice

The results of this study provide some guidance to practitioners. Although there is extensive information on the types of opportunities as they relate to performance and on the role of determinants (e.g., needs for achievement, locus of control, tolerance for ambiguity, and risk taking, self-efficacy, self-image) on the likelihood to engage in entrepreneurial

careers or to invest in particular opportunities with high/low uncertainty, risk, or ambiguity, less is known about where opportunities come from in the first place and why some people form opportunity belief at distance. Our results specifically suggest entrepreneurial decision makers should recognised that their own entrepreneurial determinants can direct their attentions to be alert to particular types of opportunities and influence their decision making process. In this way, our findings guide practitioners that while making entrepreneurial decisions, they should revaluate the impact of their entrepreneurial determinants on the process of opportunity recognition and evaluation to avoid possible bias and an increasing operational risk because their determinant makes them underestimate the potential challenges.

By introducing the impact of entrepreneurial determinants into opportunity-recognition process, practitioners can be more aware of the relevant mechanisms which might restrict the scope of their opportunity recognition and make them perceive some information differently. In addition, practitioners may be able to anticipate the specific kinds of skills they may need to effectively exploit opportunities if they take into account the imp act of their entrepreneurial determinants in their entrepreneurial decision making.

CHAPTER 3 - Revisiting Opportunity Identification, Entrepreneurial Actions and Resource Application: An Inductive Study of Entrepreneurial Processes in a Nascent Market

(The second paper of my PhD study)

Abstract

Researchers have long conceptualized entrepreneurship as a process. Nevertheless, the extant literature lacks an integral understanding of micro-foundations of entrepreneurial phenomena to identify opportunity ideas and turn them to real business. In this paper, we focus on the "entrepreneurial process" and aim to empirically understand how entrepreneurial determinants direct new ventures' entrepreneurial actions to exploit opportunities. The results show that in an almost homogenous environment, namely the nascent market of mobile health medical equipment, entrepreneurs with different entrepreneurial determinants take different paths to identify opportunities. We indicate three entrepreneurial determinants for new firm creation: Technology-driven, operation-driven, and user-driven determinants. Different determinants lead entrepreneurs to initiate diverse cognitive processes to interpret which resources are going to be transformed to which applications and how to complete the transformation. Different determinants also lead new ventures to conduct different opportunity exploitation strategies (pivoting strategies, diversification strategies, and business model refinement).

Declaration

I would like to thank for the help and support of my co-author, Prof. Bart Clarysse (also my supervisor) with this paper. The first version of this paper was accepted by BCERC (Babson College Entrepreneurship Research Conference) in 2014. The second version of this paper has been accepted by the 2014 Strategic Management Society (SMS) Annual International Conference.

3.1 Introduction

Entrepreneurial success stories such as Google (Girard, 2009), Amazon.com (T. Davila, Epstein, & Shelton, 2012; Feeny & Oztel, 2001) and Netflix (Byrne, 2011) have attracted the attention of both practitioners and academic scholars. One source of discussion is why the entrepreneurs behind these companies came up with these venture ideas or how they made them real and successful. For instance, two computer scientists, Larry Page and Sergey Brin, observed that search sites such as Yahoo produced so much information that the user no longer knew what to look at (Vise & Malseed, 2008), so they developed an internet site-ranking system and founded Google. The eureka moment of Jeff Bezos, Amazon's founder, came in while he was sitting at his desk at his Wall Street office and found a site stating that the number of users of the newly commercialized internet was growing at the rate of 2,300% a year (Quittner, 1999). Reed Hastings, the founder of Netflix, got his business idea from his large late fee for "Apollo 13". After that, he introduced the "online pay-per-rental model" to interrupt the traditional video rental industry (Byrne, 2011). The above entrepreneurs formed entrepreneurial beliefs through different paths, but eventually all of them created successful companies. However, questions remains: How do they come to these ideas and how do they successfully exploit them especially if they do not have related prior knowledge?

Researchers have long conceptualized entrepreneurship as a process (Bhave, 1994; Davidsson, 2003; Gartner, 1985, 1990). Seen from a process perspective, scholars consider how entrepreneurs identify and exploit opportunities and usually distinguish entrepreneurial actions into the phases of opportunity search, evaluation, and exploitation (Choi & Shepherd, 2004; Gruber et al., 2008, 2013; McMullen & Shepherd, 2006) and study entrepreneurial behaviours in each discrete phase. In the literature on opportunity recognition, scholars have studied several characteristics of an entrepreneur - such as one's prior knowledge and

experiences (Choi & Shepherd, 2004; Grégoire et al., 2010; McMullen & Shepherd, 2006), self-images of him/herself (J. R. Mitchell & Shepherd, 2010), and personality traits (Zhao & Seibert, 2006) - make him/her more alert to opportunities (Kirzner, 1973). In order to identify opportunities, entrepreneurs use prior knowledge as a basis to interpret what can be done (Gaglio, 2004; Gaglio & Katz, 2001; Grégoire et al., 2010). In the literature on opportunity evaluation, current research focuses on how entrepreneurs develop a coherent judgment between what one perceives from the environment and one's desire and beliefs about the value and feasibility of these potential opportunities to transmit third-person opportunities into the first-person opportunities. The judgment comes from the rules that entrepreneurs have learned from their past experience and knowledge structures (Shepherd et al., 2007). In the literature on opportunity exploitation, researchers focus on the growth of ventures, including marketing testing (Danneels, 2002, 2007), resources integration and accumulation (Bruneel et al., 2010; Chung et al., 2000; Hitt et al., 2000), organizational learning (Teece et al., 1997; Zahra et al., 2000), business model design (Andries & Debackere, 2007; Nicholls-Nixon et al., 2000), etc. These studies mainly centre on the question about how to develop and reconfigure resources for new venture survival. Recently, some research (Danneels, 2011) further associates the direction of resource application with managerial cognition and indicates the mental model held by managers involving resources identification and the understanding of their fungibility influences a firm's resource application strategy.

In addition, some scholars consider the entrepreneurial process as one complex loop. They suggests that entrepreneurs start by recombining resources at hand for different applications (Baker & Nelson, 2005; Lévi-Strauss, 1966; Rao, 1998; Sarasvathy, 2001) and then wait for a response from the market to adjust their initial beliefs (Sarasvathy, 2008).

However, the current literature – no matter whether it considers the entrepreneurial process in discrete phases or as one complex loop – lacks an integrative view which shows

how entrepreneurs come up with entrepreneurial ideas and how entrepreneurial behaviours conducted in one phase impact entrepreneurial behaviours in the next phase.

To address these questions, we conducted a multiple-case study (Eisenhardt, 1989), including seven new ventures in the medical device manufacturing market in the mobile health (mHealth) industry in North America (mainly in the US). We chose a nascent market as our research context because it lacks a dominant business model (Aldrich & Fiol, 1994) to direct new ventures' strategic actions. In addition, we focus on new ventures because their business models in terms of opportunity identification and exploitation are relatively simple, which is an ideal situation to analyse the formation of entrepreneurs' opportunity beliefs and their impacts.

Our findings unpack empirically the influences of entrepreneurial determinants for new firm creation to opportunity identification and opportunity exploitation. In an almost homogeneous environment, entrepreneurs with different entrepreneurial determinants take different paths to identify opportunities. Three of the seven ventures in our sample can be labelled as "technology-driven ventures". They start with a particular technical prototype and only exploit opportunities after rigorous opportunity search and evaluation. Therefore, their entrepreneurship process is more like a planned behaviour (search-evaluation-exploitation). In contrast, four of the seven ventures in our study begin with a perception of unmet needs in a particular market. Two of them are motivated by founders' operational experience and two are motivated by founders' personal frustration in searching for a satisfactory product. We label them as "operation-driven ventures" and "user-driven ventures" respectively. Both of them focus on the search for a technical solution to solve a particular problem their founders observed, e.g. by using mobile technology. The entrepreneurs of these four ventures had a very clear goal in mind before they started their companies such that they do little market research and have few interactions with customers in their "first" product development. In

this case, related market experiences and knowledge become critical. In addition, our results indicate the impacts of entrepreneurial determinants on new ventures' resource application strategies. Entrepreneurs starting with different entrepreneurial determinants have different mindset to exploit opportunities, which direct their attention to apply particular resources and eventually leads to different exploitation modes (e.g., pivoting, diversification, business model refining).

In this research, we contribute theoretically to the entrepreneurship literature by highlighting the sources of opportunities and the micro-foundations of entrepreneurial phenomena to turn opportunity ideas to real business. First, we extend theories of opportunity identification by illustrating three types of entrepreneurial determinants which influence opportunity search and evaluation. Second, we give insights to research on the evolving entrepreneurial micro-foundations process by investigating empirically the interrelationships between entrepreneurs' decisions made in each phase of the entrepreneurial process and the entrepreneurial actions conducted in the next phases, which eventually leads new ventures exploit opportunities in diverse ways. Third, our research bridges entrepreneurial theories with strategy and organizational theories. Our results show that founding decisions have lasting effects on shaping the ventures' evolution to generate innovative possibilities, which explains the inter-firm differences in the strategies of their business development.

In addition, our research enriches the knowledge on the factors determining one's subjective perception of selecting particular resources to develop a new product. We associate the literature of competence-based new product innovation and the literature of opportunity identification and further consider the role of entrepreneurial determinants in the interrelationships between opportunity identification, resource application, and new product innovation.

3.2 Theoretical Background

Extant research in entrepreneurship theory has focused on the emergence of an opportunity idea and the pursuit of an entrepreneurial opportunity (Alvarez & Barney, 2007, 2010; Dimov, 2011; Read et al., 2009). The current research usually consider entrepreneurial actions in discrete phases (opportunity search/recognition, evaluation, and exploitation) (Haynie et al., 2009; McMullen & Shepherd, 2006; Shepherd et al., 2007; Wood & McKinley, 2010; Wood & Pearson, 2009). In the literature on opportunity recognition, researchers focus on the factors influencing one's abilities to be alert to profit opportunities (Kirzner, 1973), which is related to their knowledge and experience stock which eventually constructs their opportunity nexus (Gaglio & Katz, 2001; Grégoire et al., 2010; Shane, 2003). Prior experience is processed and transformed into knowledge structures which can be observed in speech and action (Argote & Miron-Spektor, 2011; Walsh & Ungson, 1991). Different scholars refer to these knowledge structures as 'beliefs' (Walsh, 1988) which guide and determine an entrepreneur's actions (Haynie et al., 2009; McMullen & Shepherd, 2006; Shane & Venkataraman, 2000; Wood & Pearson, 2009). Recent studies have further indicated that entrepreneurs connect their prior knowledge with the changes they are alert in the environment to define what can be done (R. A. Baron, 2006; Gaglio, 2004; Gaglio & Katz, 2001), e.g., by aligning the structural capability of new technology with the structural causes of potential demands in a particular market to recognize opportunities (Grégoire et al., 2010; Grégoire & Shepherd, 2012). Some researchers focus on the founding-team level and consider how the variation in the similarity of the founding teams' background influences opportunity search and recognition after new ventures are established (Gruber et al., 2008, 2013). The results indicate that founding teams with more diverse industry experiences and external knowledge can recognise more and varied market opportunities before their first market entry. Besides this, serial entrepreneurs are more likely to recognise opportunities

compared to novice entrepreneurs and founding teams with a mix of prior entrepreneurial experience and experience in technology (or marketing) recognize more opportunities than those with technology (or marketing) experience only.

After the opportunity search phase, entrepreneurs' next decision is whether 'this is an opportunity for me'. The extant research shows that entrepreneurs rely on a number of characteristics related to opportunities to judge the feasibility and desirability of the opportunities (Shepherd et al., 2007). For example, Choi and Shepherd (2004) reveal that "entrepreneurs are more likely to exploit opportunities when they perceive more knowledge of customer demand for the new product, more fully developed necessary technologies, greater managerial capability, and greater stakeholder support." In related work, Mitchell and his colleagues (2000) identify three types of cognitive scripts used to make sense of new information, including arrangement, ability, and willingness scripts. Arrangement scripts refer to those considerations associated with access to resources and market demands. Ability scripts include the entrepreneur's skill to execute entrepreneurial actions. Willingness scripts have to do with the entrepreneur's motivation to act.

After substantial opportunity search and evaluation, in the phase of opportunity exploitation, entrepreneurs may anticipate the specific kinds of skills they may need to effectively exploit opportunities. In the literature on opportunity exploitation, resources focus on new ventures' strategic actions for their growth paths. Some researchers focus on the impact of resource integration and reconfiguration on venture growth. The resources include financial, human, social, and technological resources such as the know-how and entrepreneurial experiences of the founding teams (Baum & Silverman, 2004; Eisenhardt & Schoonhoven, 1990), investments from venture capitalists (Hellmann & Puri, 2002; Hsu, 2004), external networks to acquire or learn knowledge and resources (Bruneel et al., 2010; Hitt et al., 2000), and technology leveraging (Hicks & Hegde, 2005). Others emphasize the

interactions between market understanding and product innovation (Danneels, 2002, 2007) to consider how the interrelationships between resources allocation, resources transformation, and market competences impact venture growth. Resources lie upstream from the end product. They may be utilised in a range of applications for different market domains (Danneels, 2003, 2007; Prahalad & Hamel, 1990). Innovative activities are contingent on the agent's subjective perception of which products or services that the firm can or cannot do for which markets (Penrose, 1959). Recently, some research (Danneels, 2011) associates the direction of resource application with managerial cognition and indicates that the way managers identify resources and their the understanding of their fungibility impacts a firm's resource application.

In addition to resource reconfiguration and application, some researchers focus on the business model design and evolution (Andries & Debackere, 2007; Andries, Debackere, & Looy, 2013; Bucherer, Eisert, & Gassmann, 2012; Morris, Schindehutte, & Allen, 2005). They investigate the characteristics of new ventures' business models and consider how new ventures evolve their initial value propositions into a viable business model.

However, although extant research provides substantial understanding of entrepreneurial actions in each entrepreneurship phase, entrepreneurship is a process (Bhave, 1994; Davidsson, 2003; Gartner, 1985, 1990) such that the entrepreneurial behaviours in each phase is supposed to be strongly associated instead of being independent. Current research lacks integral consideration of the transition of entrepreneurial actions between phases to consider the evolution of opportunity ideas and its interactions with entrepreneurs' cognitive processes. In addition, resource application for new product creation includes not only managers' resources identification and understanding of the nature of resources but a series of entrepreneurial decisions of which resources are going to be transformed to which applications and how. Extant literature lacks an in-depth understanding of how the factors

which determine entrepreneurs' venture ideation interact with a venture's resource application strategies to generate new innovative possibilities.

3.3 Methods

This research selected the emerging mobile health market as a research context. Given the lack of research empirically considering individual difference in opportunity identification and its impact on the following entrepreneurship process, we conducted multiple-case research (Eisenhardt, 1989), including seven new ventures, in order to analyse the decision models that entrepreneurs used to identify and evaluate opportunities and new ventures' opportunities exploitation strategies. Multiple cases are effective because comparative data are likely to yield more accurate and generalizable theory than a single-case study (Eisenhardt, 1991; Yin, 1994).

3.3.1 Research setting

We used medical device manufacturers in the mobile health (mHealth) industry in the North America (mainly in the U.S.) as our target (see Table 6). 'Mobile health' is a new way to provide real time healthcare service by integrating the use of mobile devices for clinical health data collection and delivery between practitioners, researchers and patients (Germanakos et al., 2005). The mHealth industry is an excellent research context for two reasons. Firstly, the medical equipment market in the mHealth industry emerged as a new field that includes distinctive categories such as healthcare services, insurance, governmental regulation, and communication and connectivity technology. It has a high level of market complexity. Secondly, the mHealth industry is a nascent market which is ill-structured and lacks a dominant business model (Aldrich & Fiol, 1994). New ventures' strategic actions may strongly reflect their judgments of the path needed to identify and exploit opportunities.

To construct our sample, we firstly reviewed the lists of strategic alliances in three MobiHealthNews Year End Reports (2009, 2010, 2011) and then identified the North American Industry Classification System (NAICS) code of each player on the list on Hoover's online database[8]. The medical device market includes the following segments: electro-medical and electro-therapeutic apparatus manufacturing (NAICS code: 334510), medical, dental, and hospital equipment and supplies merchant wholesalers (NAICS code: 423450), and surgical and medical instrument manufacturing (NAICS: 339112). After selecting medical devices manufactures, we ruled out companies founded before 2000[9] to only focus on new ventures.

Table 6 Data representation

Active new ventures in the medical device segment in the mHealth market[10]		No.	Status	No.
Area	North America [11]	17	Being acquired before 2013[12]	5
			Bankruptcy before 2013	3
			No-response	2
			In Sample	**7**
			Alive new ventures in the North America	**9**
	Europe	6	-	-
Total		23	Sample coverage probability	78%

3.3.2 Data sources

This research includes seven new ventures in North America (all of them focus on the US market). Data sources include exploratory interviews, archival data (news and industrial

[8] Hoover's online databasE (http://www.hoovers.com/)

[9] In 1997, Ericsson launched its GS 88 "Penelope" and described concept of Penelope as a "Smart Phone" (Sager, 2012). In 2000, NTT launched the first 3G network. The combination of the smartphone and 3G network offers the possibility of the development of mHealth (De Vriendt et al., 2002).

[10] In this research we focused on active players in the medical device department in the mHealth market by choosing new ventures featuring alliance relationships in 2009, 2010, or 2011 as reported in the MobiHealthNews Year End Reports.

[11] To avoid bias resulting from healthcare systems and policies in different countries or areas, we focused on the market with the largest number of players. In this case, we targeted the market in North America (all focal firms work in the U.S. market).

[12] This research begins from 2013. Thus, we selected new ventures that were alive in the medical device department in the mHealth market in 2013.

reports), and formal semi-structured interviews with focal firms. (1) The seven exploratory interviews were conducted to understand the dynamics of mobile health in Boston in 2012 with experts, including policy makers in the US government, doctors, healthcare service providers, and researchers in the medical and engineering schools at Harvard University and Massachusetts Institute of Technology. (2) The extensive archive included 933 news items about focal firms collected from the Factivia database, three years of MobiHealthNews Year End Reports (2009, 2010, 2011), and the product portfolio of each company on the US Food and Drug Administration (FDA) and company website. We reviewed three annual market reports to map out the relative positions of market players, the status of technology development, the bargaining power between different players, and an overview of market conditions. We used those news items, reports, and FDA and company website information to reconstruct the history of each focal firm. We highlighted each company's key partners, investors, new product launches, participation in eco systems, pilot projects, and main customers. By doing so, we portrayed the business models and network relationships of focal firms to understand the process of their new product development and commercialization. (3) We conducted three rounds of interviews, including 24 semi-structured interviews (see Table 7) and we taped and transcribed the interviews resulting in 409 pages of double spaced interview transcripts. The first round included seven phone interviews and one face-to-face interview and was conducted from late March until May 2013. The interviews ranged from 52 to 81 minutes. On average each interview took 70 minutes. We confirmed each partnership with informants and the strategic concerns behind each partnership's formation, activity and strategic change. The second round was conducted six months later in October 2013 and included nine face-to-face interviews. The interviews ranged from 27 to 113 minutes. Each interview took an average of 70 minutes. We extended our understanding of why the founders of focal firms initiated their business and their entrepreneurship process.

The last round was also conducted six months after (late April to early June 2014) and includes seven phone interviews. The interviews ranged from 49 to 69 minutes. On average each interview took 54 minutes. In this round, we confirmed our findings and quotations with focal firms to ensure no misunderstanding would bias the results.

Table 7 Data inventory

New Venture	Location	Year Founded	Age	No. of founders	Background of Founders	No. of interviews	Interview details			
							Date	Time (Mins)	Type	Informant
A	Greater Boston area, MA	2005	9	1	• CEO: Process control systems industry	3	18/04/2013	66	Phone	Founder
							24/10/2013	73	Face-to-face	
							13/05/2014	47	Phone	
B	Boca Raton, FL	2008	6	3	• Previous CEO: Sales (left the company) • Current CEO: Wireless messaging, medical notification and alert management solutions • Chairman: Web hosting	3	25/04/2013	63	Phone	Co-founder
							10/10/2013	65	Face-to-face	
							28/04/2014	54	Phone	
C	Annapolis, MD	2003	11	1	• CEO: Electronic engineer, head of a consulting company	5	29/05/2013	81	Phone	Founder
							22/10/2013	56	Face-to-face	Lead Hardware Engineer
							22/10/2013	27	Face-to-face	CTO
							24/10/2013	61	Face-to-face	Founder
							04/06/2014	65	Phone	Founder
D	San Diego, CA	2007	7	3	• CEO: Healthcare information technology, medical imaging systems, and medical technology integration • Chairman: Telephone communications services • CTO: Healthcare solutions, Software technology	3	17/04/2013	64	Phone	Founder
							16/10/2013	57	Face-to-face	
							28/04/2014	46	Phone	
E	King of Prussia, PA	2008	6	4	• Prior CEO: Sales (left the company) • Current CEO: Life safety security • VP of Strategic Alliance: Life safety security • VP of Corporate Development: Brand development	4	18/03/2013	70	Phone	Founder (VP of sales and marketing)
							23/04/2013	82	Face-to-face *(The interview was conducted in London, UK)*	
							09/10/2013	113	Face-to-face *(The interview was conducted in Atlanta, GA)*	
							29/04/2014	69	Phone	

New Venture	Location	Year Founded	Age	No. of founders	Background of Founders	No. of interviews	Interview details			
							Date	Time (Mins)	Type	Informant
F	San Diego, CA	2004	10	2	• CEO: GPS engineering (left the company) • Advisor: Cardiologist (board member)	3	20/03/2013	52	Phone	VP of market development
							15/10/2013	91	Face-to-face	
							02/05/2014	49	Phone	
G	Toronto, Canada	2002	12	2	• CEO: Toy industry • President: Consumer electronic products	3	23/04/2013	81	Phone	General manager
							14/10/2013	90	Face-to-face *(The interview was conducted in San Diego, CA)*	
							28/04/2014	51	Phone	

3.3.3 Data analysis

We started reviewing news items, industry reports, and interviews to reconstruct the history of each case and then began open coding of interview data by using Nvivo to support our axial coding process. After most data had been collected in order to preserve the integrity of replication thinking logics in cases (Eisenhardt, 1989; Yin, 1994), we began the cross-case analysis to identify similar constructs across the cases (Eisenhardt & Graebner, 2007). We compared several constructs at once in tables to highlight the similarities and differences (Miles & Huberman, 1994). Starting from the emerging constructs and themes, we gradually combined the vivo codes into first order codes. Following the standards of content analysis (Krippendorff, 2012; Neuendorf, 2002), two coders independently code the raw data: One author and a junior researcher who was blind to the theoretical rationales. We calculated interrater reliability including percentage of agreement and Cohen's κ for all coding dimensions made by two coders. We reached 95.56% agreement (κ=0.953) which reaches the acceptable level of interrater reliability. The two coders discussed discrepancies and gradually had agreements on all statements. To ensure reliability and common understanding with the second author, first order codes were labelled in line with the different components of the genesis and the formation of entrepreneurial beliefs and the strategic actions in the opportunity exploitation. In a further round of coding, we tentatively combined first order codes into fewer and theoretically grounded second-order codes through axial coding (Strauss & Corbin, 1997). We also cross-checked the second order codes with the theoretical findings in the literature on opportunity identification and exploitation to avoid ignoring theoretically relevant knowledge (Suddaby, 2006). This interaction between theory and data helped us to sharp construct definitions and the theoretical relationship between constructs (Eisenhardt, 1989). Given our focus on the entrepreneurial process, we also tracked event sequences in each case (Ozcan & Eisenhardt, 2009).

3.4 Findings

We found that entrepreneurial determinants impact the formation of first-person opportunity beliefs. Also, the focal firms with different entrepreneurial determinants manifested different entrepreneurial processes.

3.4.1 Pre-Market entry: Entrepreneurial determinants and the formation of the first-person opportunity beliefs

Our data indicates that entrepreneurial determinants of new firm creation emerged from technology-driven, operation-driven, or user-driven determinants. Three of the seven ventures (Companies A, B, and C) started with a technology prototype which acted as guidance to help them be alert to profitable market spaces where they can exploit current technologies. The medical device market was usually one of their options (see Quotations 1-11, Table 8). For example, the founder of Company A described the evolution of opportunity recognition as that:

> *"Between 2001 to 2005, our solution was very flexible. We thought we can create an application box that is connected to TVs... ...we thought we can apply to energy management, security, healthcare, all of those. So we were starting looking around, [assessing] what is a different industry which our system can help.*[13]*"*

A similar story happened on Companies B and C. One recognised the tracking-technology can be applied to pet tracking, Alzheimer patients, or the elderly populations and one alerted remote physiological monitoring technology can be applied to the academic, sports, military, first responder, and medical markets. The medical device market was chosen by these companies because it could provide foreseeable ROI. For example, the founder of Company B described his decision making process as that:

[13] Quotation from the interview with the founder of Company A on 24 Oct., 2013

"We like the elderly market because it is growing because of the baby boomers. ...we didn't know how many people are willing to pay that much money for pets to track pets. ... We thought about Alzheimer but it was not that established. There is no one else doing that which could be used as a benchmark to establish a business model. We had to create the whole business model from scratch[14]."

However, demand can only turn to profit if market conditions can support market development. Hence, the policy of reimbursement and regulation became the second key concern of entrepreneurs. For example, the founder of company C mentioned that:

"We have been doing health control for 5 to 6 years but I kept the company out of healthcare because I felt the regulation and political politics, and industry, and the funding, were not there[15]."

Companies D and E were established because their founders' perceived unmet needs in the healthcare market from their past operational experience (see Quotations 12-14, Table 8). The founders of Company D realized the importance of monitoring the deterioration of patients because of their twenty-year experience of the healthcare solution and device market[16]. Company E was established because the founders had a long history in the life security market and were aware that current products mismatched the needs of elderly people because they did not usually fall down at locations close to the alarm devices[17]. Companies D was also motivated by founders' personal frustration in searching for a product to solve their own problems and the same thing happened on Companies F and G (see Quotations 15-17, Table 8). For example, the founders of Company D and G aimed to take care of their family members with chronic diseases or aging condition but failed to find a suitable product[18].

[14] Quotation from the interview with the founder of Company B on 10 Oct., 2013
[15] Quotation from interview with the founder of Company C, 24 Oct., 2013
[16] Information from the interview with the founder of Company D on 16 Oct., 2013
[17] Information from the interview with the founder of Company E on 9 Oct., 2013
[18] Information from the interviews with the founder of Company D on 16 Oct., 2013 and the general manager of

Company F was started because one founder, a cardiologist, knew continuous monitoring of blood pressure may increase substantially the cure rate of cardiovascular diseases[19]. However, in this case, he is a medical device user not a producer.

The entrepreneurial determinants of these four ventures (Companies D, E, F, and G) were not to maximise the investment returns of their technologies. For example, one founder of Company D mentioned that

> *"...if we were doing it over based on the market size, we would probably do congestive heart failure, not diabetes*[20]*."*

But it does not mean that they choose target markets blindly. For example, the founders of Companies D and G examined the size of the chronic disease market.

Company G on 14 Oct., 2013

[19] Information from the interview with the VP of market development of Company F on 15 Oct., 2013

[20] Quotation from interview with the founder of Company D, 16 Oct., 2013.

Table 8 Overview of data structure (Pre-market entry)

Second-order Codes	First-order Codes		Representative Data
Technology-driven source	**Technology distance evaluation**	1	*"Between 2001 to 2005, our solution was very flexible. We thought we can create an application box that is connected to TVs. …we thought we can apply to energy management, security, healthcare, all of those. So we were starting looking around, [assessing] what is a different industry which our system can help."* [Interview with Founder of Company A, 24 Oct. 2013]
		2	*"He [one of the founders] wanted to do something about tracking and mPRES was only one of the ideas. He said pet tracking, Alzheimer tracking, mPERS. He didn't know. His business plan is very unfocused. But I like the tracking idea. And [Another founder] was the one helped the market research"* [Interview with Co-founder of Company B, 10 Oct. 2013]
		3	*"We started with the goal of physiological monitoring and the product required a sensor, a wireless connection, and analytical software. ... The four main reasons to monitor human beings remotely were for human performance or fitness, industrial safety, medical. ... We can measure anybody remotely, which in one of them has always been for medical reasons* [Interview with founder of Company C, 29 May 2013]
		4	*"Since we have had the hardware, the hardware itself is not a product because no one can use just a hardware. ... The software side tends to be more market specific. For example, the sport software has something in common with the medical software but it is directed toward sports and it [a medical device] is directed toward medical. The hardware for both of them is actually the same.* [Interview with Lead Hardware Engineer of Company C, 22 Oct. 2013]
	Assessing potential profits from exploiting current technology	5	*"What we found was the energy industry was no revenue. There is no clear ROI to build it. In security, again, very low margins. There was no return on investment for a new solution. Healthcare seems like the only one where we seem to fit. We saw there were a lot more needs. ... Healthcare is a very interesting and complex environment where you not only need to work with nurses, you not only work with doctors, [but] you have to work with pharmacists to get the complete cares. So the need for communication and connectivity are much more complex and can save a lot of money. So there was potential for ROI for saving a lot of money and justifying the cost for implementation."* [Interview with Founder of Company A, 24 Oct. 2013]
		6	*"We decided pretty early on. The entire focus [on the healthcare market was] because we were trying to see if there was any other possible markets [or] business models in other segments. [But] no [other business model] is sustaining for us. I think it took us probably two years before we decided that it was our entire focus."* [Interview with Founder of Company A, 13 May, 2014]
		7	*"... he [the cofounder] looked at all the opportunities that were available for what the prototype could do. And he searched the mobility piece for the PERS industry, and we determined the existing leaders in the market place had not really focused any attention on the mobility piece. ... We thought they were lazy and that was a good chance for us to use disruptive technology to break into the industry before they knew it."* [Interview with Co-founder of Company B, 28 April 2014]

Second-order Codes	First-order Codes		Representative Data
		8	*"He [one founder] had a prototype of a tracking device which is similar to our mobile device. The functionality is similar. ...he [another founder] was the one helped the market research and said let's go for mPRES ... And we noticed that industry was really lacking technology innovation. ... So we saw a window of opportunity for us to go and disrupt the market place by bringing in a new idea to do the same business..... In the U.S., the elderly population is growing because of the baby boom and the trend which is to keep costs down. Also the elderly people want to stay at their own homes as long as possible because that makes them feel comfortable."* [Interview with co-founder of Company B, 25 April 2013]
		9	*"We like the elderly market because it is growing because of the baby boomers. So we knew the market will expand and we didn't know how many people are willing to pay that much money for pets to tracking pets. It is not big enough to make a company... We thought about Alzheimer but it was not that established. There is no one else doing that which could be used as a benchmark to establish a business model. We had to create the whole business model from scratch. That would be very difficult. Within the PERS industry, it has already been established with how they do and the prices. We thought we would be better to disturb that market and be the first one in that market."* [Interview with co-founder of Company B, 10 Oct. 2013]
		10	*The main reason [to enter the medical market] was the demand was growing so is the profitability of that market. ... Sport market is a quite niche market. There are not many players in that market. They are mainly multinational companies like Nike, Adidas, and large companies. They need a lot of the technology we have."* [Interview with CTO of Company C, 22 Oct. 2013]
		11	*"The biggest issue was the whole medical market for monitoring; no one knew who was going to pay for it. That was the big change. And now Obama and some other changes in performance-based procedures, then there were much more interest because they will get penalized if they don't do it."* [Interview with CTO of Company C, 22 Oct. 2013]
Operation-experience-driven source	**Demand perceptions form past operational experiences**	12	*"We are actually starting from chronic disease because my last company that I sold to [a company] was [name of a company]. It was a cure care ... very long after patient was in trouble. I decide to get earlier on disease progression. And so I decide to do chronic diseases. ...it is not till the later on, we realized that diabetes cost a lot. Very expensive side effects. If we were doing it over based on the market size, we probably do congestive heart failure not diabetes because congestive heart failure has bigger population."* [Interview with Co-Founder of Company D, 16 Oct. 2013]
		13	*"They [the founders] knew the industry very well. And it [the personal emergency response market] was a very competitive market because everyone was selling basically the same thing. .. And most of the equipment used at that time was less sophisticated. So the main driving force is to find a better product to penetrate the existing large market.* [Interview with VP of sales and marketing of Company E, 9 Oct. 2013]

Second-order Codes	First-order Codes		Representative Data
		14	*"The founders at the time the company started were in the home security market. ...everybody was familiar with the medical home alarm business. ... Most of time, you saw somebody fall down. You assume they can talk through the pendant but actually they cannot. ... Most of time people get injured in their homes, like elderly people, because they fall. The other thing is that the way that the traditional system works ... you have to be [using] speaker boxes or all those systems to talk back when you press the buttons. But the fact is that as homes became larger and people fall in showers when the door closed, these are representative of serious shortcomings. So the founders of the company thought they were able to provide a solution. "* [Interview with VP of sales and marketing of Company E, 29 April 2014]
User-experience-driven source	**Demand perceptions form personal life experience**	15	*"All three of the founders including myself have diabetes in family. So we saw the relative suffering of this disease."* [Interview with Co-Founder of Company D, 16 Oct. 2013]
		16	*"[The founder, a cardiologist] said 'it would be very cool if you [co-founder] are able to produce [a product] to give me blood pressure continually.' [The founder, a cardiologist] deals with a lot of high potential patients. And in the U.S., we know 70 million [people] in the U.S. have potential. So this could be a big deal and it had have not been down very successfully before.* [Interview with VP of market development of Company F 15 Oct. 2013]
		17	*"[The founder] was working for his father [the co-founder] at that time and looking for a way to stay in touch with his grandparents. They are remote. And he wanted to help to manage their aging conditions."* [Interview with General Manager of Company G, 14 Oct. 2013]

3.4.2 Post market entry: Opportunity exploitation

According to the industry reports and the interviews, we found that the healthcare device market can be divided into five segments based on users' health status and the purposes of their use of healthcare products (see Table 9). The mobile health (mHealth) market mainly takes care of pre-sick people (e.g. the elderly population) and patients with chronic diseases, meaning that their products are mostly FDA Class I or Class II devices.

Table 9 Market structure of healthcare device

Health status	**Fitness**	**Wellness**	**Pre-sick**	**Chronic disease**	**Serious disease**
Product type	Entertainment	Health check	Non-regulated or FDA Class I devices[21]	FDA Class II devices[22]	FDA Class III devices[23]
Product Example	Remote performance measurement for athletes	Weight scale	Personal emergency response system, stethoscope	Diagnostic tests, cardiac catheters	Devices that are used in ICUs

In the data (see Table 10), we found that the two ventures (Companies A and C) worked in other market segments (e.g., non-regulated or FDA Class I device markets) and

[21]According to FDA regulation, " Class I means the class of devices that are subject to only the general controls authorized by or under sections 501 (adulteration), 502 (misbranding), 510 (registration), 516 (banned devices), 518 (notification and other remedies), 519 (records and reports), and 520 (general provisions) of the act. " (http://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfcfr/CFRSearch.cfm?fr=860.3)

[22] According to FDA regulation, "Class II means the class of devices that is or eventually will be subject to special controls. A device is in class II if general controls alone are insufficient to provide reasonable assurance of its safety and effectiveness and there is sufficient information to establish special controls, including the promulgation of performance standards, postmarket surveillance, patient registries, development and dissemination of guidance documents (including guidance on the submission of clinical data in premarket notification submissions in accordance with section 510(k) of the act), recommendations, and other appropriate actions as the Commissioner deems necessary to provide such assurance." (http://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfcfr/CFRSearch.cfm?fr=860.3)

[23]According to FDA regulation, "Class II means the class of devices that is or eventually will be subject to special controls. A device is in class II if general controls alone are insufficient to provide reasonable assurance of its safety and effectiveness and there is sufficient information to establish special controls, including the promulgation of performance standards, postmarket surveillance, patient registries, development and dissemination of guidance documents (including guidance on the submission of clinical data in premarket notification submissions in accordance with section 510(k) of the act), recommendations, and other appropriate actions as the Commissioner deems necessary to provide such assurance." (http://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfcfr/CFRSearch.cfm?fr=860.3)

then leveraged their technologies to enter into the FDA Class II device segment. Two ventures (Companies B and E) started from a non-regulated medical segment (life safety security for the elderly population). The other three ventures (Companies D, F, and G) immediately started in the FDA Class II device segment but only Company D had related market experience.

Table 10 The evolution of business development

Company	**Before** entering into the mHealth market	**After** entering into the mHealth market
A	A software system company providing a service platform connected through TV to provide various services	In FDA Class II device market *(The product concept and technology remain the same)*
B	- (One founder worked in the life security market)	In a non-regulated device market
C	A consulting company and a remote physiological monitor serving in the academic, the sports, the military, and first responder markets	In a FDA Class II device market *(The product concept and technology remain the same)*
D	- (Founders worked in the healthcare solutions market)	In a FDA Class II device market
E	- (Founders worked in the life security market)	In a non-regulated device market
F	-	In a FDA Class II device market
G	-	In a FDA Class II device market

To exploit opportunities, ventures need to establish their managerial and organizational process. In the interviews, we found the entrepreneurial actions of focal firms include three phases: “market testing strategies” to integrate and reconfigure their resources and to understand market demands; “building resources” to manufacture medical devices, and “performance review and strategy modification” to redefine the direction of their business development.

Market-testing strategies.

Delineating customer solutions. Two ventures in our sample (Companies A and C) started their opportunity exploitation by delineating customer solutions (see Quotations 18-20, Table 11). They consulted their potential customers and experts while they were developing the 'first' medical devices to further understand the market requirements[24]. Two ventures (Companies B and E) entered the mobile health market by entering an existing market segment (the life safety security market) with better solutions. The market segment has existed for more than 20 years with a well-established product concept and business model. These two ventures did not need to especially delineate customer needs[25] (see Quotations 21 and 23, Table 11). The other three companies (Companies D, F, and G) all introduced new medical devices with brand new product concepts but interestingly instead of being close to their potential buyers to understand the market demands, they created their devices internally to solve the problems their founders observed (see Quotations 22, 24, and 25, Table 11). Company D relied on their founders' prior knowledge to ensure what they did was what customers expected; while Companies F and G simply generalized market demands from their own needs. For example, the general manager of Company G mentioned that:

> *"They saw their own needs and figured out this was the need that others had, so they thought it could be a business they can develop and then [one of the founders] wanted to start the business.*[26]*"*

Leveraging experiences in business operations. All founders in our sample tried to leverage prior experiences to their new business (see Quotations 26-35, Table 11). However Companies F and G lacked complete market understanding and related market experiences as

[24] Information from the interviews with the founder of Company A on 18 April, 2013 and on 13 May, 2014 and with the founder of Company C on 24 Oct., 2013 and 4 June, 2014.
[25] Information from the interviews with the founder of Company B on 18 April. 2013, the founder of Company B on 28 April, 2014, and the founder of Company E on 29 April, 2014.
[26] Quotation from interview with the general manager of Company G, 28 April, 2014.

guidance. They usually misunderstood the fit between the experiences they were leveraging and the market requirements (see Quotations 34-35, Table 11). For example, while the general manager of Company G reviewed the mistakes they made in the early stage, he mentioned:

> *"The two funders' background was primary consumer products. ... Initially, the market was developed directly to consumer products for care givers to manage their parents or family members with chronic diseases. ... They didn't start marketing the product. It was their belief that they didn't want anybody to know what they were doing. They thought it was the right decision to be somewhat secretive about the market. That came from their history of being in the consumer product market where once you announce something, everybody could copy it. ... They didn't understand the difference between the mobile health industry and the consumer product industry. Consumer products change very rapidly and healthcare changes very slowly. So, on my side, I believe they realized they made a mistake*[27]*."*

Leveraging technology resources. Companies A, B, C, and D had technology resources which can aid new product creation[28] (see Quotations 36-43, Table 11). Company E had personal connections to acquire key technology before entering into the market[29]. However, the only technological resource that Company F could apply was their founders' educational backgrounds[30]; while Company G did not have related technology resources to be leveraged.

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[27] Quotation from interview with the general manager of Company G, 23 April, 2013.
[28] Information from the interviews with the founder of Company A on 24 Oct., 2013 and on 28 April, 2014. with the founder of Company B on 25 April, 2013, with the lead hardware engineer of Company C on 22 Oct., 2013, with the founder of Company C on 4 June, 2014, and with the founder of Company D on28 April, 2014.
[29] Information from the interviews with the founder of Company E on 29 April, 2014.
[30] "*One [one reason why the founder felt he can make the product] was his education. That was the driver, to find whether he can achieve the goals that he was trying to achieve. ... He is a PhD in physical chemistry from [a given university]."* [Interview with VP of Market Development of Company F, 2 May, 2014]"

Leveraging human resources. Most of the founders of focal firms leveraged their personal connections to access resources (see Quotations 44-49, Table 11). Only the founder of Company C is from other country and had no strong connection with the U.S. market[31]. The founders of Company F had no relationship which could directly help their business in the mHealth market.

[31] Information from the interviews with the founder of Company C on 4 June, 2014.

Table 11 Overview of data structure (Post-market entry - Market testing strategies)

Second-order Codes	First-order Codes		Representative Data
Market testing strategies	**Delineating customer solutions**		**Delineating customer Solutions**
		18	*"... we had discussions with multiple segments like hospital systems, insurers which are the payers. We also talked to physician groups. In the U.S., some physicians form their own groups. It is like a smaller hospital but they don't do surgery or all those things. They are more doctor groups. So they were in those market segments that we were discussing and understanding, and analysing the environment in 2005 to 2007.* [Interview with founder of Company A, 18 April 2013]
		19	*"I think the advantage of being a medical industry person is you know more people so you can keep all relationships going faster and you understand some of the vagaries so as the release experimentation [thereby] you should be able to succeed faster. However, what you may do is not to ask many questions and respond to market feedbacks dynamically. We have nothing to prove the result. We want to sell you solutions. So we are going to ask what you want to be solved. So we will give you our thesis and then have a conversation to see if the thesis makes sense ... We are not going to simplify the problem. We know it is complicated because we have done it before. We know the radio is complicated. The sensor is complicated. We know it is consumer experience. Most of these medical companies don't consider patients as consumers. They are still considering them in the old paradigm which is the patient is a patient."* [Interview with founder of Company C, 24 Oct. 2013]
		20	*"We hired clinicians ... so they could tell us how our products needed to work. ... We treated every customer as a consumer no matter whether you are a doctor, nurse, or patient….So what we did was we built up expertise on what a certain kind of product needed to do and how to sell it."* [Interview with Founder of Company C, 4 June 2014]
			Not delineating customer Solutions
		21	*"We got confirmation from him [an advisor] that the market [PERS market] still has not changed probably in 20 years. ... We didn't need the whole market research to know [that] they would like the mobility piece because we know elderly people like to be active [and] not just staying at home."* [Interview with Founder of Company B, 28 April 2014]
		22	*"[We didn't get potential buyers involved in our first product development.] We just created the product and the whole concept because we knew there were customers for glucose monitors. ... It was pretty simple because glucose meters have been around for years. They are very standard in term of using consumable test strips and discipline and results, these kinds of things. So the glucose meter technology is very well developed when we entered the market. What we wanted to do was add the features of wireless connectivity. ... We added another concept to that which was online monitoring, so we could gain revenue from the online monitor."* [Interview with co-founder of Company D, 28 April 2014]
		23	*"There are a lot of users and studies have been done [regarding the personal emergency respondence system]. The founders had a background in the completive products."* [Interview with VP of sales and marketing of Company E, 29 April 2014]
		24	*"The family friend [one of the founders, a cardiologist] identified a clinical problem and said if you [another founder] could [develop] continuous blood pressure that would be very helpful for the clinical communities and patients. So that's why [the second founder mentioned in the paragraph] said "I am going to do that exactly." And then [the second founder mentioned in the paragraph] developed the continuous blood pressure monitor. So he was respondent to a clinical need and solved that problem."* [Interview with VP of Market Development of Company F, 2 May 2014]

Second-order Codes	First-order Codes		Representative Data
	Delineating customer solutions (Cont.)	25	*"They saw their own needs and figured out this was the need that others had, so they thought it could be a business they can develop and then [one of the founders] wanted to start the business."* [Interview with General Manager of Company G , 28 April 2014]
	Leveraging experiences in business operations	26	*"The other big advantage was this company [a partner and this partnership happened before Company A focused exclusively on the mHealth market] was an expert in delivering one of the solutions [a solution for diabetes patients]. So it was a great learning experience for us to discover how they think about delivering care and delivering medical devices. So how they manufacture, how to get FDA approvals, all those things are our other benefits from this partnership. And they, of course, got a lot of tests regarding how patients think about the solution"* [Interview with Founder of Company A, 13 May, 2014]
		27	*"[The product concept is] mature. And the business model is mature, too. We don't have to invent a business model. We had to adapt to it and that business model was a very difficult one because the medication means that customers would not buy equipment. They are renting it ...that's very expensive to get to start it because you have to finance the equipment and start-up acquisition costs at the beginning."* [Interview with Co-founder of Company B, 28 April 2014]
		28	*"[One of the co-founders] knew a lot [about the regulation issue] from his experience and then ... because in the previous company that I mentioned that we had sold, [that it] was for medical software. So he was very familiar with the FDA process, so we actually have hired an FDA resource, a quality resource."* [Interview with Co-founder of Company B, 28 April 2014]
		29	*"We have worked in several markets which are highly regulated and require FDA [approval] ...there are a lot of rules and regulations. The rules are different. We have worked with lots of different rules. Some are similar in philosophy... We were set up and experienced with facing similar challenges as in the market places."* [Interview with Founder of Company C, 4 June 2014]
		30	*"I understand the market and get to put it together "* [Interview with co-founder of Company D, 16 Oct. 201]
		31	*"I learned from [a company]. Single use item creates the utility, and so we were quite interested in the fact it could be our meter or any glucose meters there that patients used every day and so they have to keep buying them [test strips] and buying them. So they create the revenue stream. That was our business model and then the idea was to make a connected meter so that is more appealing than unconnected meters. So the revenue stream would come to us from our competitors."* [Interview with co-founder of Company D, 28 April. 2014]
		32	*"[In] the company that I had and sold to [a company name], we didn't really know much about the regulatory, quality systems, and developing products under a quality system. So at [a company name], I learned a lot about that. So when we started the company, we started right from the first step, working the quality system and thinking about the regulatory issues. So [for] the people they are coming from unregulated area into a regulated area, I think there is a steep learning curve ..."* [Interview with co-founder of Company D, 28 April. 2014]
		33	*[One founder], for example, is in the security industry. ... [Another founder] was doing something in security systems and he got interested in the post alarm systems. ... They knew the industry very well. And the company pulls sale and marketing persons to work for it.* [Interview with VP of sales and marketing of Company E, 9 Oct. 2013]

Second-order Codes	First-order Codes		Representative Data
		34	*"The two funders' background was primary consumer products. ... Initially, the market was developed directly to consumer products for care givers to manage their parents or family members with chronic diseases."* [Interview with General Manager of Company G , 23 April 2013]
		35	*"They didn't start marketing the product. It was their belief that they didn't want anybody to know what they were doing. They thought it was the right decision to be somewhat secretive about the market. That came from their history of being in the consumer product market where once you announce something, everybody could copy it. And so they decided to only go to selected companies that we had [already approached] between 2006 and 2009. ... They thought it would be too easy to be copied. They didn't understand the difference between the mobile health industry and the consumer product industry. Consumer products change very rapidly and healthcare changes very slowly. So, on my side, I believe they realized they made a mistake."* [Interview with General Manager of Company G , 23 April 2013]
	Leveraging technology resources	36	*"In process automation, my focus was networking communications like the company that I worked with before, they built solutions for automation industries, factories, park stations. So if you look at the concepts, they have remote control and provide different services in process automation so that the concepts are very similar. But this was appealing to consumers. This is appealing to the mainstream markets.* [Interview with Founder of Company A, 24 Oct. 2013]
		37	*"I think all of these [issues] related to what happens in process automation. If you see process automation, their solutions are much more integrated ... they control the whole automation plan. So they bring in different sensors, different solutions, and different control logics. All those solutions are integrated. ... So that is relevant to how we leverage to build up some of our solutions."* [Interview with Founder of Company A, 28 April. 2014]
		38	*"Part of that [product] is the hardware and software system because we control signalling and data. We also have lots of expertise in the distributed software systems to be able to keep all these things up and running. That's our key experience from the web-hosting industry that is where we came from when we were a hosting company 10 years ago."* [Interview with co-founder of Company B, 25 April 2013]
		39	*"One of the other gentlemen who is our CEO is a double E engineer and so he has already understood the product and the process in creating new products."* [Interview with co-founder of Company B, 25 April, 2013]
		40	*We sell to doctors with a prescription device, a FDA clearance device. It is difficult. It takes time ... So what we have been doing is leveraging one area to go to another."* [Interview with Lead Hardware Engineer of Company C, 22 Oct. 2013]
		41	*"As a consultancy, there are some advantages and some disadvantages. The advantage is you are exposed to a lot of technology and lots of market problems. ... you have been charged by the hour or a fixed price; you become operationally excellent at innovation, and so you get innovation excellent."* [Interview with Founder of Company C, 4 June 2014]
		42	*"From entering in the medical market to six months later, we shipped our first product. That's because we have had FDA and we already had 80% of the product. Three different products for three different markets, and so we were sort of breaking out three different puzzles. The only need for R&D is the gap we faced. So 80% [R&D investment can] reuse."* [Interview with Founder of Company C, 4 June 2014]

Second-order Codes	First-order Codes		Representative Data
		43	*"... I worked with [a given company] ... on the electronic healthcare record system. We developed the communication network which can transmit these healthcare records around the world because [the employees of the company] are constantly moving from one place to the next. And the record had to follow them. ... Then I left that company and did the company [another company name] that we sold to [another company name]. That was applying telecommunication technology to operating rooms. ...we developed a way to transmit the audio and video in the ER operating rooms to different places, to doctors' offices or to other operating rooms. So that was telecommunication applied to the surgery. Then the next company was a tracking company that we tracked people and patients and equipment around the hospitals. And that was ZigBee technology which was a form of low data rate networking. ... And then after I left there and started [Company E], that was an application of telecommunication technology to glucose monitoring. Now we broke into the application of telecommunication technology to collect different kinds of biometrics like blood pressure, ECG, different things. So the issue is the companies were a little bit different. They were all in healthcare but they were all different segments of healthcare."* [Interview with co-founder of Company D, 28 April. 2014]
	Leveraging human resources	44	*"I always play a very front role, as you probably know. Personal connections always help regardless with which companies [one engages with]. ...that is another key thing that you built and your roll from that"* [Interview with Founder of Company A, 13 May, 2014]
		45	*"He [one of the co-founders] has a lot of experience from the past working in an engineering product development role, mainly on hardware. Because his first job was working for a very large company with a lot of structure, he learned how they do things and that was why he could develop his relationship with our manufacturing partner in [a country]."* [Interview with Co-founder of Company B, 28 April 2014]
		46	*"I don't think personal connection per se give you anything more. I think personal connections are commercial relationships. You got your personal relationship because you brought in value. ... I am from [a given country]. I don't have any personal relationship in my market which is in America. It might be the reason."* [Interview with Founder of Company C, 4 June 2014]
		47	*"I understand the market and get to put together and of course my telecommunication background but you end up with the relationships you worked with. That helps you."* [Interview with co-founder of Company D, 16 Oct. 2013]
		48	*"What happened was the founders were introduced to an engineer who had a patented approach to talk through the pendent. ... So they felt that well "we'll come up with a product that everybody just talks through the pendant. That would allow us to go into the market place and have this patented feature" ... One of founders knew him [the engineer] before the company started. So that was the root of how things happened."* [Interview with VP of sales and marketing of Company E, 29 April 2014]
		49	*"[One founder's] experience is in sales and business development and sourcing product in the Orient. So we have all our hardware made in the Orient. He is there now and so he has a deep relationship on the Orient to allow us to have the product we need to make the system work."* [Interview with General Manager of Company G , 14 Oct. 2013]

Building resources

R&D for new technologies and *constructing supply chain systems.* All focal firms invested in R&D for necessary technology (see Quotations 50-66, Table 12). Companies A and C leveraged their supply chain systems used in former business to the new one[32]. For the remaining focal firms, the founders construct their supply chains based on their personal connections[33].

Improving human resources. Interestingly, we found focal firms improved their human resources at different stages of their business development. Except for the founders of Companies B, D and E had related market experiences, the other ventures hired experts to define proper business models. Company A and C realized they need to hire experts while developing their first devices (see Quotations 67-69, Table 12). For example, the founder of Company C mentioned that:

> *"I had a very experienced team including myself that knew the question to ask to modify our platform to go to a particular market and solve the problem for that market. ... But the sales and understanding the regulations, I knew I needed to change the DNA of the company to be a medical company. And so we hired people who already have that experience.*[34]*"*

However, Company F and G hired experts to re-define business models 'after' they realized their original strategies did not work[35] (see Quotations 70-71, Table 12).

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[32] Information from the interviews with the founder of Company A on 24 Oct, 2013 and with the founder of Company C on 4 June, 2014.
[33] Information from the interviews with the founder of Company B on 10 Oct., 2013, with the founder of Company D on 17 April, 2013 and 28 April, 2014, with the founder of Company E on 29 April, 2014, with the founder of Company F on 30 April, 2014, and with the general manager of Company G on 14 Oct., 2013.
[34] Quotation from interview with the founder of Company C, 22 Oct., 2013.
[35] Information from the interviews with the VP of Market Development of Company F on 30 April, 2014 and with the general manager of Company G on 28 April, 2014.

Accessing financial resources. All foal firms had similar financial supports (see Quotations 72-86, Table 12). Most focal firms gradually added institutional investors as their strategic partners.

Table 12 Overview of data structure (Post-market Entry - Building resources)

Second-order Codes	First-order Codes		Representative Data
Building resources	**R&D for new technologies**	50	*"[We have Bluetooth but] we don't limit to Bluetooth. Bluetooth is easier and convenient. We also have wire cable or USB devices, we also have internet devices, and we have Zigbee devices. So our devices are not limited."* [Interview with founder of Company A, 18 April 2013]
		51	*"The prototype was just a box. ... And he [one of the founders] hired contracted engineers to make a prototype. ... And then what we did was that we used that as a basis and then [another founder] did the modified product. And then [Another founder] worked with the company in [A country] to do our final product development round. "* [Interview with Co-founder of Company B, 10 Oct. 2013]
		52	*"We did everything internally. Because by doing so, we can have complete control of all solutions……As a multi-skilled product, we have a fashion designer, mechanical engineers, electrical engineers, four different types of software designers, and the only way to come up with those solutions is to keep all those people in one office working together to solve the multi-skilled operation."* [Interview with founder of Company C, 29 May 2013]
		53	*"All the software is designed by our company and the hardware is designed by a partnership with a company in [A country]."* [Interview with co-founder of Company D, 17 April 2013]
		54	*"We evolved a solution to the problem. You can technologically say we make people become mobile because they can ... have the ability to communicate when they need help. Our device covers a whole house. You can be 200 meters around the house. So people can be not limited mainly in the house."* [Interview with VP of sales and marketing of Company E, 23 April 2013]
		55	*"He [one of the founders] spent the first 4 years developing the science for continuous blood pressure."* [Interview with VP of market development of Company F, 15 Oct. 2013]
		56	*"This company is built on really two things. We have a very smart science group and also a very capable engineering group as well. And for a medical device, you usually get one or the other. We are pretty unique because we have both. And we have a lot of expertise in both"* [Interview with VP of market development of Company F 15 Oct. 2013]
		57	*"Unlike most companies in our market, we develop our own dedicated cellular gateway. As I said it is running on a machine to machine network. Everybody else is pretty much running their programs on smart phones and tablets, which is more costly."* [Interview with General Manager of Company G , 23 April 2013]
		58	*"our core competency was developing wireless Bluetooth technology for devices to [connect to] the Internet and from that, we then had to build the devices which could connect our product technology …… and then no one wanted to take our data and put that in their software, so we had to build software as well. So over the early years, we had to hire engineers and computer programmers. ..... And our uniqueness was they were not required PC but they were working over panel telephone modem and that was how we were successful ..... we had a very low cost and easy to use solution used their telephone lines."* [Interview with General Manager of Company G , 23 April 2013]

Second-order Codes	First-order Codes		Representative Data
	Constructing supply chain systems	59	*"Yes we do [share the supply chain system of the former company founded by the founder of company A]. It was just a lot of market research that we have to do to find the right partners and manufacturers.* [Interview with Founder of Company A, 24 Oct. 2013]
		60	*"We worked with a company in [a given country] whose has engineers there. ... We out-sourced our technology and ideas to them. We paid them to finish manufacturing stuff. ... They worked with [a company] and [one of the founders] worked in [the company]."* [Interview with Co-founder of Company B, 10 Oct. 2013]
		61	*"What we needed to do was to look after the factories. Once you get into a low volume, you have a low volume factory and then you have a medium factory and a high volume factory. ... you just discovered and you did a lot by yourself as you grow the business. I think it is simple growth"* [Interview with Founder of Company C, 4 June 2014]
		62	*"All the software is designed by our company and the hardware is designed by a partnership with a company in [a given country]. We have a long term and close relationship. We are the legal manufacturers of the device software."* [Interview with Co-Founder of Company D, 17 April. 2013]
		63	*"We found the company because one of my partners had a lot of experience in Korea. We had connections with manufacturing companies in Korea."* [Interview with co-founder of Company D, 28 April, 2014]
		64	*"The company that manufactures the devices is able to get the approval process, so we have a contract with them."* [Interview with VP of sales and marketing of Company E, 29 April 2014]
		65	*"The second thing is then we have to decide whether we are going to outsource the supply chain to find somebody else who can make it for us or we […] manufacture ourselves. So we made the decision. So we hired a CTO, [a person's name]. He has done this before. He built up a medical device company and developed a product which is very good. And then the executive team made this decision that we will manufacturer it locally. So we did all the manufacturing quality [by] ourselves."* [Interview with VP of Market Development of Company F, 30 April. 2014]
		66	"The father's experience is in sales and business development and sourcing product in the Orient. So we have all our hardware made in the Orient. He is there now and so he has a deep relationship on the Orient to allow us to have the product we need to make the system work." [Interview with General Manager of Company G , 14 Oct. 2013]
	Improving human resources	67	*"Medical devices, I think there is always complexity, like FDA certification. It is a big challenge. So to conquer that, I think the clear thing was to find an expert who knows that. And we were able to successfully to find somebody who is exceptional and has very deep knowledge of medical devices. So we have to comprise our existing innovative thinking with somebody who knew how to bring a medical device to market."* [Interview with founder of Company A, 24 Oct. 2013]
		68	*"We hire people to pull the DNA in. I need to change the DNA of the company. ... I had a very experienced team including myself that knew the question to ask to modify our platform to go to a particular market and solve the problem for that market. So we are extremely experienced. So we start to design a medical product in March and start to work on patients in December. ... So we are really good at that. But the sales and understanding the regulations, I knew I needed to change the DNA of the company to be a medical company. And so we hired people who already have that experience."* [Interview with founder of Company C, 22 Oct. 2013]

Second-order Codes	First-order Codes		Representative Data
		69	*"We hired sales because we didn't know how to sell. … And we hired clinicians because we needed people in the company who have been doctors and nurses so they could tell us how our products are needed to work."* [Interview with Founder of Company C, 4 June 2014]
		70	*"This company has two chapters. If you look at the first chapter, the founder had zero experience in the medical devices before and the cardiologist had no experience either. But in the second chapter, [a person] and I do have experience in medical devices. … So they didn't sell anything in the first four or five years. It was a scientific project and for science, they didn't really focus on what kind business they wanted, but they were trying to accommodate the clinical need. Once they have done that, they hired a CEO to identify the market place."* [Interview with VP of Market Development of Company F, 30 April, 2014]
		71	*"They were referred to me because they needed someone to sell and I was recommended to them as someone who could do this. They had the basis of the product that could be sold. They hired me because of the sales capacity more than the product develop capacity." (The general manager is the first employee with healthcare background)* [Interview with General Manager of Company G , 28 April, 2014]
	Accessing financial resources	72	*"For us, the founding was just done by myself. … So originally I started it by putting my own money on and then we have angle groups. One of the angle group which is a small club of private investors."* [Interview with founder of Company A, 24 Oct. 2013]
		73	*"It was a period of time in 2003 and 2004. We started talking to a company called [a company name] and [the company] found it tricky that now patients can talk to or communicate with their doctors right from the TV, using the home TV. So they asked us to build a prototype and build a solution [to work on the demonstration project] … it [the demonstration project] was a funded project. … [The company] is the only one who funded the demonstration".* [Interview with founder of Company A, 24 Oct. 2013]
		74	*"At the beginning, there was just the three of us, so we had to be very bounded by who did what. I was more like a strategic investor and the only investor. So they used my money. I invested [an amount of] dollars to do the development."* [Interview with co-founder of Company B, 10 Oct. 2013]
		75	*"We have probably 30 to 40 investors now [2014]. … There is a venture capital partner who just bought some shares a month ago. So it is our first institutional investor. So there is very little institutional money going into the company." [Interview with Founder of Company B, 28 April 2014]*
		76	*Company C has venture capital funds* [Data source: VentureXpert database]
		77	*Company C has institutional investors in the early stage of the Company D evelopment* [Data source: Interviews with founder of Company C, 29 May 2013/24 October 2013 and news from *Associated Press Newswires* APRS on 18 June 2009]
		78	*"A company invested us for medical reasons as well as safety reason and I did the analysis just over two years ago from now. … And the entire focus on the company investment is in the healthcare. "* [Interview with founder of Company C, 22 Oct. 2013]
		79	*"'This new investment adds a significant strategic partner in [company name] and capital to accelerate commercialization of our game-changing mHealth solution,' said Company C Founder & CEO. 'The team [Company C] is unique in that it has deployed monitoring systems to help medical practitioners in the most extreme environment.'"* [News from *Business Wire*, 16 Aug. 2012]
		80	*"I have two other partners and we all sold companies in the past. … So we all have money to fund the company."* [Interview with Co-Founder of Company D, 17 April. 2013]

Second-order Codes	First-order Codes		Representative Data
		81	*"It [funding] was our money plus a large contact we had early on that funded the development. ... After we started it [Company E], we got a contract with a company in [a given place]. They have purchased [products] and [the company] hired us as the management team to go out and merchandise [these products]."* [Interview with co-founder of Company D, 28 April, 2014]
		82	*"The company was initially under private investments."* [Interview with VP of sales and marketing of Company E, 29 April 2014]
		83	*Company F has institutional investors in the early stage of the company's development* [Data source: Interviews with VP of market development of Company F, 20 March 2013/ 24 October 2013; News from PR Newswire (U.S.) on 31 March 2008 and on 13 December 2011]
		84	*"We started with some angles and then we went to round A and then to B to have [a certain amount of dollars]. In the C round, I cannot remember exactly, I think overall, we are in the middle of closing D round."* [Interview with VP of Market Development of Company F, 30 April. 2014]
		85	*Company F has venture capital funds.* [Data source: VentureXpert database]
		86	*"[One founder] sold the company and decided to fund [the other founder]'s idea. ... [It is] self-founded by family and friends.* [Interview with General Manager of Company G , 14 October 2013]

Performance review and strategy modification.

Performance review. All focal firms considered market conditions and customer reactions to their products while reviewing their performance. However, Companies A and C emphasized more the market environment such as policy and potential profits [36] (see Quotations 87, 89-90, Table 13); while Companies B, D, E, F, G paid more attention to the customer reaction to their products and their product portfolios[37] [38] (see Quotations 88, 91-94, Table 13);.

Strategic experiments. Companies B and E didn't change their market focus because their technology (tracking technology) had some limitations to its being leveraged in other market segments[39] [40] (see Quotations 95-96, Table 13). But Company E evolved a new marketing approach[41] (see Quotations 102, Table 13). Companies A and C tried to approach different market segments when the development of initial market segments was not as good as expected [42] (see Quotations 98-99, Table 13). For example, Company A entered into the military healthcare service market because the mobile health market for hospitals, insurance companies, and patients was slow in adapting new technology[43]. Company C did not enter the mobile health market till the political environment was ready for their innovations [44]. Companies A and D changed their focus on their product portfolios from hardware to software to react to changes in market demand[45] [46] (see Quotations 97, 100, Table 13).

[36] Information from the interviews with the founder of Company A on 24 Oct, 2013, with the lead hardware engineer of Company C on 22 Oct., 2013, and with the founder of Company C on 23 Oct., 2013.
[37] The life safety security market where Companies B and E operated was an existing market with a clear market structure such that it was not urgent for market participants to especially concentrate on market conditions.
[38] Information from the interviews with the founder of Company B on 28 April, 2014, with the founder of Company D on 28 April, 2014, with the founder of Company E on 29 April, 2014, with the founder of company F on 15 Oct., 2013, and with the founder of general manager of Company G on 28 April, 2014.
[39] Information from the interview with the founder of Company B on 28 April, 2014
[40] Information from the interview with the founder of Company E on 29 April, 2014
[41] Information from the interview with the founder of Company E on 29 April, 2014
[42] Information from the interview with the founder of Company E on 29 April, 2014
[43] Information from the interview with the founder of Company A on 24 Oct., 2013
[44] Information from the interview with the founder of Company C on 29 May, 2013
[45] Information from the interviews with the founder of Company A on 24 Oct., 2013 and with the founder of

Companies D and G expanded their product portfolios and tried to penetrate into the fitness, wellness, or serious disease markets[47] [48] (see Quotations 101, 103-104, Table 13).

Interacting with customers to upgrade products. All focal firms had strong connections with their customers "after they had the first devices" [49] (see Quotations 105-108, Table 13).

Business Model and product redesign. Company F faced a serious challenge while commercializing their first device [50] (see Quotations 109-114, Table 13). The VP of market development described it as that:

> *"...in the U.S. all those diagnostic clinics have patients to go there four times a week. ... They have their patients to be diagnosed and they get constant blood pressure. So we thought maybe this is a good opportunity where we can sell our continuous blood pressure. ... And then we realized it is a large market but it is not much money in it. [A diagnostic clinic] and [Another diagnostic clinic] run 40% each on the diagnostic clinics in the U.S. And [The second diagnostic clinic mentioned in this paragraph] buys all the equipment from [The first diagnostic clinic mentioned in this paragraph]. So really you only have one customer. If [the first diagnostic clinic mentioned in this paragraph] says 'we don't want to buy your product,' then we are out.[51]"*

Therefore, the board hired experts to redefine the target market and redesign the business model and product. The VP of market development of Company F mentioned that:

Company D on 16 Oct., 2013
[46] Information from the interview with the founder of Company E on 29 April, 2014
[47] Information from the interviews with the founder of Company D on 28 April, 2014 and with the general manager of Company G on 15 Oct., 2014.
[48] Information from the interview with the founder of Company E on 29 April, 2014
[49] Information from the interview with the founder of Company E on 29 April, 2014
[50] Information from the interview with the founder of Company E on 29 April, 2014
[51] Quotation from interview with the VP of market development of Company F on 15 Oct., 2013.

"He [the CEO at that time] hired myself and [another person]. ... I was from [a medical device company] and he was from [another medical device company]. ... [The current CEO] and I probably have interviewed 250 nurses to just go through every single detail we could to say "what do you think of this?", "What do you think of this?", "How's about this?", and "What's your problem here?" That allowed us to be able to produce a product that we think now it is ground breaking and we got a lot of feedback to say it is actually what people want[52]."

[52] Quotation from interview with the VP of market development of Company F on 15 Oct., 2013.

Table 13 Overview of data structure (Post-market entry: Performance review and strategy modification)

Second-order Codes	First-order Codes		Representative Data
Performance review and strategy modification	**Performance review**	95	*"I think in 2010, we realized this industry is going to take time to grow. And we were seeing that other competitors were going out of this business, not doing so well. So in 2010, one of the things we did was we started working with the department of defence veteran administration." [Interview with Founder of Company A, 24 Oct. 2013]*
		96	*"[We are concerned with] market reaction. We start selling and we would like the market to tell us if they liked it. Like I said, we don't have a chance to change to switch strategy. We don't have enough money." [Interview with Co-founder of Company B, 28 April 2014]*
		97	*"One of the things we learned from the Fire Department is they have very limited budgets and they have a very long cycle time for purchasing. If the Fire Department wants to buy something, they usually have to go through the accounting commission, which a long budget process because when they buy a system for a lot of people, it is not cheap. ... As it goes to a capital expenditure through a government entity, it takes a very long cycle time and especially when it does not already have a perceived value to it.* [Interview with Lead Hardware Engineer of Company C, 22 Oct. 2013]
		98	*"I thought that consumer business was good revenue but we would not become a large consumer brand. We don't have the money for marketing. Sport is too small to get the sales. First responders and the Army would take 10 years to adapt ... So I re-structured the company. ...stop doing R&D on those products [sold in sport, first respondence, and defence market] and just sold the products we have. ... The consumer market is just made on Amazon. And the entire focus on the company investment is in the healthcare".*[Interview with Founder of Company C, 22 Oct. 2013]
		99	*"We have to always keep our eyes on the market to make sure the product and our offering are meeting the market needs. ... We review our performance against our competitors and look at what markets are there and what are the specific market niches, then we adjust our strategies accordingly. We early on had very good clinical trial business and so we have continued to focus on the clinical trial business to develop a strong reputation in that business." [Interview with co-founder of Company D, 28 April. 2014]*
		100	*"... increasing cash flow because the accounting system in our industry is very different from ... the tradition in a product sale company. The accounting principle does not allow you to recognize profits. For a certain period of time for rental ... financial performances vs. financial growth are two different things. So our goals are to increase the number of subscribers and to have a positive cash flow meaning that you get beyond the cost of operation, including the equipment and marketing."* [Interview with VP of sales and marketing of Company E, 29 April 2014]
		101	*"...in the U.S. all those diagnostic clinics have patients to go there four times a week. ... They have their patients to be diagnosed and they get constant blood pressure. So we thought maybe this is a good opportunity where we can sell our continuous blood pressure. ... And then we realized it is a large market but it is not much money in it. And equally [A diagnostic clinic] and [Another diagnostic clinic] run 40% each on the diagnostic clinics in the U.S. And [The second diagnostic clinic mentioned in this paragraph] buys all the equipment from [The first diagnostic clinic mentioned in this paragraph]. So really you only have one customer. If [the first diagnostic clinic mentioned in this paragraph] says 'we don't want to buy your product,' then we are out."* [Interview with VP of Market Development of Company F, 15 Oct. 2013]
		102	*"The actual revenue model where we penetrate into [has] an acceptable degree and [a] growing user base. And in the B2B model, we are adding more customers and expanding existing customers with new sales, and we found it is true so we continuously grow the company."* [Interview with General Manager of Company G , 28 April. 2014]

Second-order Codes	First-order Codes		Representative Data
	Strategic experiments		**No Strategic experiments**
		103	*"I think there is some limitation and half-flexibility for our platform to be adapted to different markets. It would be difficult to do that."* [Interview with Founder of Company B, 28 April 2014]
		104	*"We don't have a chance to change to switch strategy. We don't have enough money. We have to be focused. We are still confident that we can at least make a decent business out of it regardless."* [Interview with Founder of Company B, 28 April 2014]
			Strategic experiments
		105	*"Our original model was to sell our hardware and then provide services. But as the model for other industries has changed, the mobile industry doesn't charge too much with hardware but focuses on monthly revenue, the revenue by customer using the solution. So we evolved from a hardware company to a service company. Hardware is important but not the critical thing for the solution." [Interview with Founder of Company A, 24 Oct. 2013]*
		106	*"We thought we are going to focus on that group [the Department of Defence Veteran Administration] because what we found was all the commercial health insurance companies, hospital systems, physicians groups, home healthcare agencies are all in the market segment which is actually waiting for the reform of the healthcare effect. So we anticipated it is going to take more time. And the expectation was correct because even now if you see, these companies are not buying a lot of products yet." [Interview with founder of Company A, 24 Oct. 2013]*
		107	*"For consumer business, we always include consumer market to have a good cash flow but we feel it is not very scalable enough to be a focus for a company. So for the medical business, the environment is ready for adaption. It is 90% of the focus of our company. We feel that we have to focus to grow revenue."* [Interview with Founder of Company C, 29 May. 2013]
		108	*"From the very first day of the company, we had both [hardware and software]. We have the software platform online and we have a mobile application, and we have the meter. Over time, as the market has evolved, the relative value of those different pieces has changed. When we first started to focus on the most valuable ... offering, we felt it would be the meter. For the platform, there was a point in time, we felt we might not even continue with it because we are getting a lot of integration companies that want to integrate our meter into telehealth systems and so we provided that to them. So then there was less interest in the platform. And now today, that has shifted. There are a number of glucose meters out there competing with ours and we have been building on this platform for six years."* [Interview with co-founder of Company D, 16 Oct. 2013]
		109	*"Since we had the last talk, we are now working with a company with a Class 3 implantable device. But the reason why they want to work with us is because we have a Class 2 platform and they want data from their Class 3 devices to be integrated with those Class 2 devices. ... So we have a transition to a greater care and more complex care, and that transition is what we are trying to approach with mobile health, so, like, I have a customer working with a professional soccer team. Obviously, these players are athletes and in good shape but they are looking at activities. They are looking at sleep quality. And then we have people. They are middle age, overweight. We are trying to motivate them to be more active." [Interview with co-founder of Company D, 28 April. 2014]*

Second-order Codes	First-order Codes		Representative Data
		110	*"The business model is not the business model they started out with. Traditionally, it is a consumer device, it was advertised by television, and printed media or it was sold to companies to provide the service themselves ... It was sold through pretty intensive direct marketing. One of the classic problems is very high customer acquisition cost. What we did at beginning was that we were kind of taking advantage [of the fact] that we had a co-marketing deal together with some infomercials and we tried to work with people who were in the direct market tier. And then there were two major problems. One is they had very high customer acquisition costs. If you are making it with somebody else in their marketing systems, they want to take the bigger piece of the pie. If you do this by yourself, you have to have a large investment. Also the fact is the payback is important because 85% of this business is the recovering revenue. We don't actually sell a unit. You place it for somebody for no cost. And you provide the service for using it. ... And then we evolved to the model with [a given company] ... selling through them, [thus] reducing the acquisition cost largely."* *[Interview with VP of sales and marketing of Company E, 29 April 2014]*
		111	*"Their original idea was direct to consumers for family care givers. ..... they met a doctor here in south California socially. He convinced them this is the product he needs for his business. So the doctor convinced [founders] to deliver it as a business to business model not direct to a consumer model. He also convinced them that once they have a platform, the end consumers will also be there. That was a correct decision. The market is just slow to evolve but everyone expects it."* [Interview with General Manager of Company G , 10 Oct. 2013]
		112	*"We announced an arrangement earlier this year with a strategic partner [names a given company]. [The company] is the largest home security company in the America. ... They wanted to get into wellness, so they chose us as a leader in that market and so together they are going to direct market to consumers to use our technology. ... With [the company's] offering to support their technology and with the call centres, they will assist us in direct consumer marketing and that is going to be a new growth area for us."* [Interview with General Manager of Company G , 10 Oct. 2013]
	Interacting with customers to upgrade products	113	*"That was just listening to our customers in the healthcare [context], a lot of solutions actually work for doctors and nurses but our focus is how to provide interfaces for the patients. So all of our thinking points are what is the easiest and simplest way to provide care to them rather than looking from the doctor's prospect in delivering care. So we look at what is simple and we found that even connecting a small box to the TV was not that easy in those days. HDMI was not there and a lot of things were complex. So we decided to build a tablet. So we build a tablet before iPad and all these things came in. But it was mainly because what our customers were looking for was the integrated system which does not require installation, not complicated to use. iPhone was just coming in, so we looked at the ease of use for iPhone and tried to apply it on a tablet. And we released our product before iPad was really there."* [Interview with founder of Company A, 24 Oct. 2013]
		114	*"In the first four year of the company, we were operating both as a consultancy for cash flow as well as doing product design and then took products to the early adopters and then refined the products by the feedback from these early adopters to allow us to know the business problems that our solutions could solve."* [Interview with founder of Company C, 29 May 2013]
		115	*"I think my personal focus is move forward for a complete solution. ..... I am talking to our customers [about] what's I don't have but you need in terms of the overall solution"* [Interview with the co-founder of Company E, on 16 October, 2013]
		116	*"They did that [the first product development] on their own. After we had the first product ...we were very interactive with our customers. Our customers continuously drive our product development."* [Interview with General Manager of Company G , 28 April 2014]

Second-order Codes	First-order Codes		Representative Data
	Business Model redesign	117	*"He [the CEO at that time] hired myself and [another person]. ... I was from [A medical device company] and he was from [Another medical device company]. ...In my background, I spent 3 years in [the first medical information system service company mentioned in this paragraph] managing wireless health division. In that time, I recognized patients deteriorate on the general floor. And so we were trying to figure out a way a way about which market we are targeting and what we are trying to do and value proposition and so on."* [Interview with VP of Market Development of Company F, 15 Oct. 2013]
		118	*"He [one founder, a cardiologist] didn't really work here. He is a founder but never worked here. [Another founder] left but the doctor is still the majority shareholder of the company. But he doesn't get directly involved in day-to-day operations. ... We [the CEO and the VP of market development who both have medical device backgrounds] investigated everything because we have to make sure we are right [including] home, AMS, American medical systems, military, EMS."* [Interview with VP of Market Development of Company F, 30 April. 2014]
		119	*"Most hospital's position was that they knew this patient is so sick and could have a cardiac arrest. They would not promote from the general floor. If you do have a cardiac arrest on the general floor, you have 1/20 chance to survive. If you are in the ICU you have 1/5 chance to survive. Even though you are considered to be sicker, your chance to survive is higher because you get people around you and you get monitoring facilities. So then you need to consider what you are going to do on the general floor. ... Now you noticed that nurses are doing exactly the same thing in the general floor ... So how could we get more monitors to the general floor? What nurses take when they go into the patient's room is ECG, blood pressure, breath rate, SpO2, body temperature. So okay, we need these five vital signs and put them into a small package that we can put on every patient. We should be able to provide a much safer environment for the patient. I should also have a work-flow improvement process for nursing stuff".* [Interview with VP of market development of Company F, 15 Oct. 2013]
		120	*"[The current CEO] and I probably have interviewed 250 nurses, probably about two thousand hours to just go through every single detail we could to say 'what do you think of this?,' 'What do you think of this?', and so on. 'How's about this?' 'What's your problem here?' That allowed us to be able to produce a product that we think now, it is ground breaking and we got a lot of feedback to say it is actually what people want. ... I would say it took [the current CEO] and I six months to do another research, maybe 6 to 9 months to do enough research in 2008. So by 2009, maybe the second quarter of 2009, we were able to go to the board and say, 'Here is what we want to do'.* [Interview with VP of market development of Company F, 15 Oct. 2013]
	Product redesign	121	*"Now we have a continuous blood pressure technique. ... What we are able to find out is the vital signs. ... We should be able to provide much safer environment for the patient. We should also have a work-flow improvement process for nursing stuff, and maybe potentially save the hospital's money."* [Interview with VP of Market Development of Company F, 15 Oct. 2013]
		122	*The first four years was the development of the continuous blood pressure monitor but we didn't sell this product. ... There is no value or only limited value in selling this product into the hospitals. Although they can do continuous blood pressure, they still need to do other things. ... here in 2008 to 2009, what we want to do for this devices is to incorporate this but we have a new trajectory to go to [A Product, the Vital Signs Monitor]."* [Interview with VP of Market Development of Company F, 15 Oct. 2013]

3.4.3 The interrelationship between entrepreneurial determinants, entrepreneurial attention on resources application, and opportunity identification

We indicate three entrepreneurial determinants for new venture creation: Technology-driven, operation-driven, and user-driven determinants. We labelled focal firms based on their founders' initial determinants to start the new business. Companies A, B, and C were labelled as "technology-driven ventures" because they aimed to discover a new market domain to exploit their technology at hand. Company D and E were labelled as "operation-driven ventures" because they aimed to solve the problems observed by their founders in their past career. Companies F and G were labelled as "user-driven ventures" because they were founded to solve the problems that their founders failed to find a suitable product to satisfy their needs.

Before we further consider the impact of entrepreneurial determinants on opportunity identification and exploitation, we compared the backgrounds and resources stocks of focal firms and their founders at "the founded year" to ensure focal firms' entrepreneurial actions were determined by their founders' entrepreneurial determinants rather than by their different resources endowment levels. The results (see Table 14) did not present significant differences in founders' entrepreneurial experiences and financial resources. The main differences lay in new ventures' technology and market knowledge. Although both technology-driven ventures and operation-driven ventures had technology resources which can be leveraged to the new business, not all of them were motivated to maximum their current technologies. In addition, user-driven ventures started new business even if they had no necessary resources at hand.

Table 14 Ventures' background and opportunity selection before market entry at "the founded year"

Venture Types	1 **Technology-driven ventures**	2 **Operation-driven ventures**	3 **User-driven ventures**
Numbers of ventures	3	2	2
Number of founders	1-3	3-4	2
Venture status before entering in the mHealth	Most of them in non-regulated market segments or FDA class I segments	- (established in mHealth)	- (established in mHealth)
Financial resources	Private funding (One with venture capital funding)	Private funding	Private funding (One with venture capital funding and an institutional investor)
Entrepreneurial experience	Company A: No Company B: Yes Company C: No	Company E: Yes Company G: No	Yes
Market experience	Mostly unrelated	Related	Mostly unrelated
Technology experience	Related	Related	Not related

In the next stage, we compared the process of opportunity identification in three types of ventures. Technology-driven ventures were motivated to maximise the value of current technology at hand which is a fungible capability that can generate profits in multiple markets (Danneels, 2011; W. Mitchell, 1992). Their founders may have market-related resources in other market domains but their entrepreneurial determinants led their attentions to leveraging their technology resources and using them as guidance to search opportunities (Gaglio & Katz, 2001; Kirzner, 1997; Shane, 2003), especially those with a short technology distance to their current technology. Since increasing the economic return of their existing technologies was their first priority, they did not have special preference toward particular opportunities (e.g., the mobile health market is one of their options) as long as they all can provide profits. Before selecting opportunities, they conducted in-depth market research to examine market conditions and to evaluate the feasibility of each opportunity in their opportunity sets. In the evaluation process, they gradually understand the market requirements and their advantages/disadvantages in relation to the opportunities.

In contrast, the entrepreneurial determinants of operation-driven ventures and user-driven ventures came from their founders perceptions of particular unmet needs. The founders of both operation-driven ventures and user-driven ventures had a clear goal in mind before they started their business. The transition from entrepreneurial determinants to first-person opportunity beliefs, thus, was implicit. The founders of operation-driven ventures aimed to solve problems they perceived in their previous operational experiences in related market domains. This entrepreneurial determinant directed them to focus on utilizing the bundle of market-related resources they had which is a less fungible experience and only can generate profits in related market segments (Danneels, 2011; W. Mitchell, 1992). The founders of user-driven ventures perceived the needs from their personal frustration, which is not fungible experience and cannot generate profits outside current markets. The founders of use-driven ventures may have technological expertise or market knowledge in other market domains. However, their ideation process usually took place by entrepreneurial theorizing without direct experiences and not by analogy with what they have known and the resources they had. Their new product innovation, thus, was close to a pure exploration process (Danneels, 2002).

The main difference between operation-driven ventures and the user-driven ventures was the possession of related knowledge and experience. Although operation-driven ventures lacked substantial market research, their founders' related market and technology knowledge made them capable of anticipating the challenges they might face. However, in most cases, the founders of user-driven ventures started their business without necessary resources at hand. In addition, instead of conducting proper market research in terms of what technology-driven ventures did, they had their entire focus on creating a technological solution to solve the problems they found. As such, they usually failed to anticipate potential challenges they

may face. It implies that new venture creation is not always based on a rational analysis but has some emotional issues involved.

In addition, our results show empirically that in an almost identical market, different paths of opportunity identification (either through opportunity search-evaluation-exploitation or through entrepreneurs' imagination based on founders' operational experiences or past searching experience for a satisfactory product) can co-exist. The approach to identify opportunities is an option for entrepreneurs and determined by their entrepreneurial determinants. The entrepreneurs of technology-driven ventures followed an opportunity search-evaluation-exploitation process, while the entrepreneurial beliefs of the operation-driven ventures and user-driven ventures emerged from entrepreneurs' imagination.

3.4.4 Entrepreneurial determinants, opportunity exploitation strategies, and resource application

The product development phase (before the first product launch)

New ventures starting with different entrepreneurial determinants usually have been through different processes of opportunity identification, which results to different level of understanding of the challenges they may face in their opportunity exploitation phase. Also, different entrepreneurial determinants tend to induce new ventures to use particular types of resources to exploit opportunities, which may influence the path of their future development.

We compared the initial opportunity exploitation strategies of focal firm (e.g., delineating customer demands, leveraging resources, and building resources) to investigate the impact of entrepreneurial determinants on the opportunity exploitation strategies (see Table 15). Technology-driven ventures aimed to maximum economic returns of their technologies. In order to ensure the possibility to earn the expected profits, they conducted

rigorous market research which made them capable of anticipating the challenges they might face and the specific skills they might need. The understanding guided their following strategic actions to effectively exploit opportunity. Therefore, after entering into the mHealth market, they leveraged technology resources and naturally hired or consulted experts to help product development and had close connection with potential buyers to ensure their product matched customer demands. By doing so, they started developing their market resources.

Table 15 Market testing strategies after market entry

Venture Types	1	2	3
	Technology-driven ventures	**Operation-driven ventures**	**User-driven ventures**
Understanding customers and the market			
Delineating customer solutions	1. Listened to early adaptors' feedback 2. Consulted or hired experts	Relied on founders' market experience and knowledge	Relied on founders' perception of unmet needs in the current market while they were searching for products for their own demands.
Resource leverage			
Experience of business operation	Leveraged some experiences and learned from market research	Leverage operational experiences in the medical device/ solution market	Leverage operational experiences but some of them are not unsuitable to the mHealth market
Technology resource	Leverage technology built while operating in other market segments	Leverage technology built in founders' past career in related market segments.	(No direct technology resources to be leveraged)
Human resources	Leverage personal connections	Leverage personal connections	Leverage personal connections

However, we found operation-driven ventures and user-driven ventures did not conduct complete market research before entering into the mHealth market and had fewer interactions with customers while developing their 'first' devices. Their entrepreneurial determinants lead them to quickly focus on developing a technical solution to satisfy the unmet needs they perceived rather than doing market research. In this case, related knowledge played a determined role to exploit opportunities and create business models. Because the entrepreneurial ideas of operation-driven ventures originated from their founders' well-

known domains, they can draw on their founders' market knowledge to guide their business development and technological resources to develop new products.

But for user-driven ventures, the formation of their entrepreneurial ideas was not from aligning capabilities of their existing resources with potential demands in a particular market but from their founders' personal frustration in finding a product to successfully satisfy their needs. This opportunity identification process exposed them to higher operational risks. In most cases, they lacked required knowledge and resources to exploit their chosen opportunities. Ideally, they should conduct rigorous market research as what technology-driven ventures did to understand the market conditions and the resource gaps between their current resource endowments and the opportunity required. However, they usually quickly focused on developing a technical solution to solve the problems they faced. The lack of related resources and complete market research, thus, made them unable to be alert to the fit between the resources and experiences that they were leveraging and the market requirements. Thus, they usually misidentified target customers and their demands. For example, after product development, Company F found that no hospital would buy their product if they only can monitor one vital sign. Company G initially kept everything secret and directly faced the end-user market but the mHealth market lacked a clear product concept and the adaption of new solutions in the healthcare market took longer than that in the consumer product market. Ideally user-experience driven ventures should hire experts to help them define the direction of their strategic moves since the ventures were founded. However the lack of market research and market knowledge made them underestimate the difficulty of operating in the mHealth market. Therefore, they hired experts to help them bring their devices to the market after they faced vital challenges (see Table 16).

Table 16 Building resources after market entry

Venture Types	1	2	3
	Technology-driven ventures	**Operation-driven ventures**	**User-driven ventures**
R&D	R&D for necessary technology	R&D for necessary technology	R&D for necessary technology
Constructing supply chains	Mostly leveraged the supply chain systems they built in other markets.	Relied on founders' personal connections	Relied on founders' personal connections or manufactured internally
Improving human resources	Hired experts since the ventures were founded	Relied on founders' related market experience and knowledge	Hired experts after the ventures made mistakes
Accessing financial resources	Gradually acquired institutional investors as their strategic partners	Gradually acquired institutional investors as their strategic partners	Gradually acquired institutional investors as their strategic partners

The performance review and strategy modification phase (after the first product launch)

Although all focal firms considered the impact of product-related factors and market condition-related factors on their firm performance, different entrepreneurial determinants influenced the weights of these factors which work in focal firms' performance review (see Table 17). Technology-driven ventures tended to pay substantial attention to overall market conditions (e.g., the speed of innovation adoption, policy, market size); while operation-driven ventures and user-driven ventures emphasized more the performance of their products (e.g., the profit structure of their product portfolios). The focus of performance reviews led focal firms to approach different growth paths.

In addition, their entrepreneurial determinants influenced their initial attention on resource application to exploit opportunities. The impact of their entrepreneurial determinants continually existed on focal firms' growth strategies. The main purpose for technology-driven ventures was to exploit the economic value of their existing technologies which have higher fungibility. The high fungibility allowed these ventures to create a wider range of strategic choices when the environment changed. In our study, we found once the market conditions of

the initial target markets were not as good as expected, technology-driven ventures initiated a new round of opportunity search and pivoted their technologies to other market domains.

Operation-driven ventures aimed to solve the problems that their founders found in their past work experiences in related market domains. This determinant led these ventures to focus on utilizing their market resources. Compared with technology resources, operational experiences are less fungible and cannot be applied to a wide range of market domains. Therefore, we found after the ventures achieved early growth in their initial target market domains, operation-driven ventures were more likely to penetrate into related market segments based on their market knowledge.

User-driven ventures were established because their founders failed to find a product to satisfy their own demands in their personal lives. The product searching experiences for a particular demand is not fungible and only exhibits value in one particular market. In addition, the lack of related resources and knowledge made them struggle in defining their customers and an appropriate business model. In order to successfully commercialize their entrepreneurial ideas, they usually had to fine tune their initial business models. After user-driven ventures had a viable business model, their entrepreneurial strategies turned to be the same as that of operation-driven ventures to diversify their product portfolios.

Table 17 Performance review and strategy modification

Venture Types	1	2	3
	Technology-driven ventures	**Operation-driven ventures**	**User-driven ventures**
Performance review	Reviewed market conditions and customer reactions to their products but **emphasised more on "market conditions"**	Reviewed market conditions and customer reactions to their products but **emphasised more on "customer reactions"**	Reviewed market conditions and customer reactions to their products but **emphasised more on "customer reactions**"
Strategic experiments	Approached other related market segments when the initial market conditions became worse	(1) Changed the focus of product portfolios to react to changes in market demands. (2) Expanded product portfolios and tried to penetrate into the fitness, wellness, or serious disease markets.	
Interacting with customers to upgrade products	All ventures intensively interact with customers after they launched the first products in order to upgrade their products or develop second devices.		
Business model redesign	(no radical change)	(no radical change)	Company F: Hired experts to make a radical change in the business model.
Product redesign	(no radical change)	(no radical change)	Company F: Hired experts to make a radical change in product design.

3.5. Discussion and Conclusion

Our study unpacks the entrepreneurial process in a nascent market from the formation of entrepreneurial ideas to the pursuit of opportunities. We empirically show the role of entrepreneurial determinants in leading the formation of first-person opportunity beliefs, and how entrepreneurial determinants and the process of opportunity identification jointly influence new ventures' opportunity exploitation modes.

Firstly, we identify three entrepreneurial determinants (technology-driven, operation-driven, user-driven determinants) to start a new business and how these forces lead entrepreneurs to take different paths to search opportunities and form first-person opportunity beliefs (see Figure 2, Figure 3, Figure 4, and Table 18). Technology-driven ventures aim to profit from exploiting current technologies such that they search and evaluate opportunities

rationally. Operation-driven ventures and user-driven ventures aim to satisfy particular needs observed in their founders' past operational experiences or their dissatisfaction of current products. They do not go through a clear opportunity-search process and their transition from the third-person opportunity recognition to the first-person opportunity beliefs is implicit. In addition, the ideation process of user-driven ventures usually takes place without considering whether they have required resources at hand.

In addition, we empirically show that the rational process of opportunity identification through rigor opportunity search and evaluation makes new ventures capable of anticipating the special skills and resources they may need to effectively exploit opportunities. However, opportunity identification through imaging particular customers will benefit from using particular products may increase operational risks. In this case, related market knowledge is a very important element of entrepreneurial success.

Secondly, our results present that entrepreneurial determinants influence entrepreneurs' decision of initial resources application, which in turn leads to different opportunity exploitation modes (pivoting strategy, diversification strategy, and business model refinement) (see Table 18). The entrepreneurial process of technology-driven ventures starts from exploiting existing technology to make profits. Technology is a fungible resource and can generate profits for end users in multiple market domains. The high fungibility allows technology-driven ventures to conduct pivoting strategies to apply technologies to other market domains when the expected economic returns may not be realised. Operation-driven ventures are driven by their founders' past operational experiences and aim to find a technological solution to solve the problems they observed. Operational experience is less fungible and only can generate profits in the related market segments. It makes operation-driven ventures more likely to penetrate into related market segments where they can leverage their operational experiences after they well establish in the initial markets. User-

driven ventures are established because their founders fail to find a suitable product to satisfy their personal demands. This searching experience is not fungible and cannot generate profits outside current market domains. In addition, user-driven ventures usually lack sufficient market understanding such that their opportunity exploitation usually includes business model refinement. Once they successfully establish in their initial target markets, they gradually penetrate into related market segments.

Figure 2 The entrepreneurship process of **technology-driven ventures**

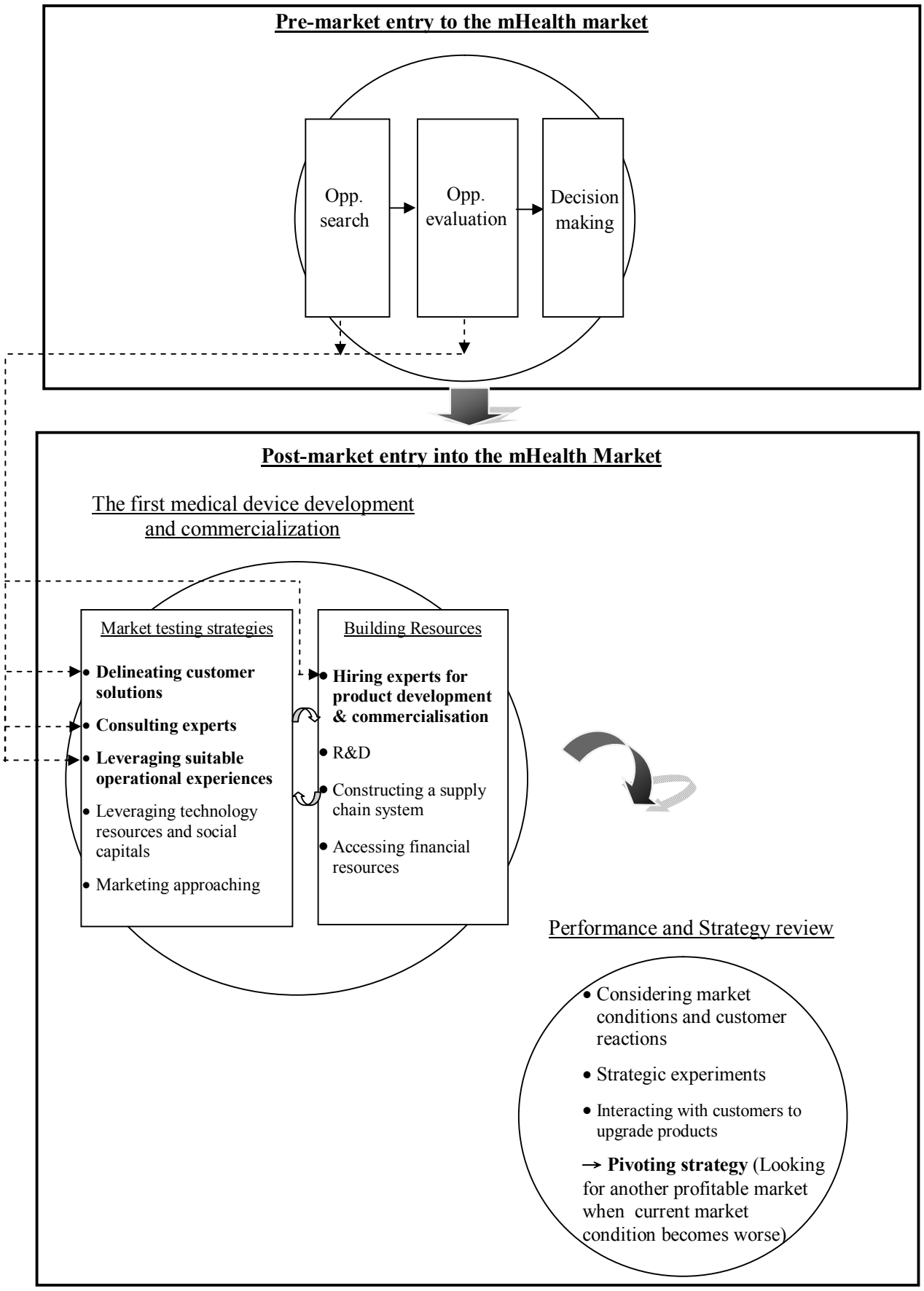


Figure 3 The entrepreneurship process of **operation-driven ventures**

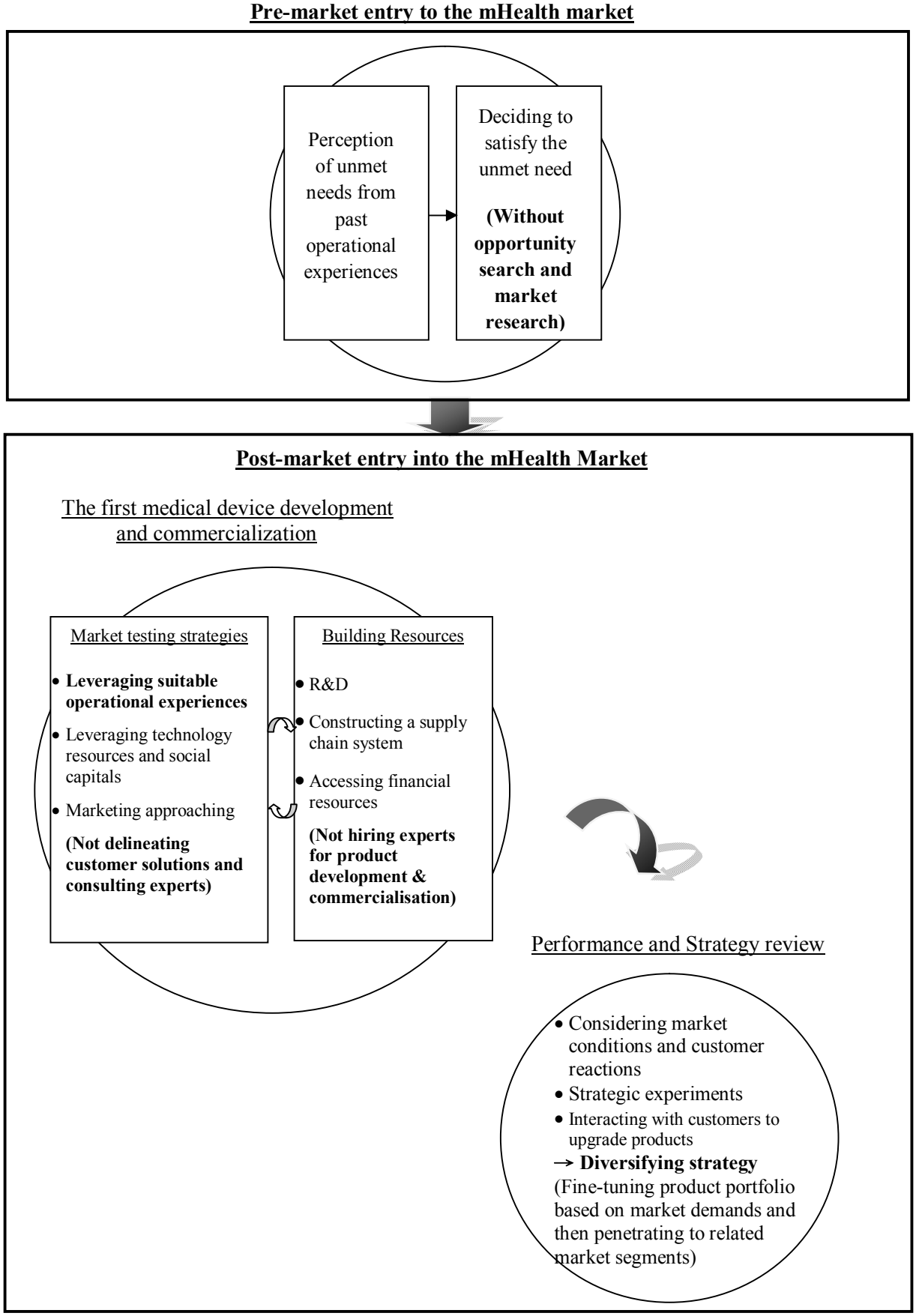


Figure 4 The entrepreneurship process of **user-driven ventures**

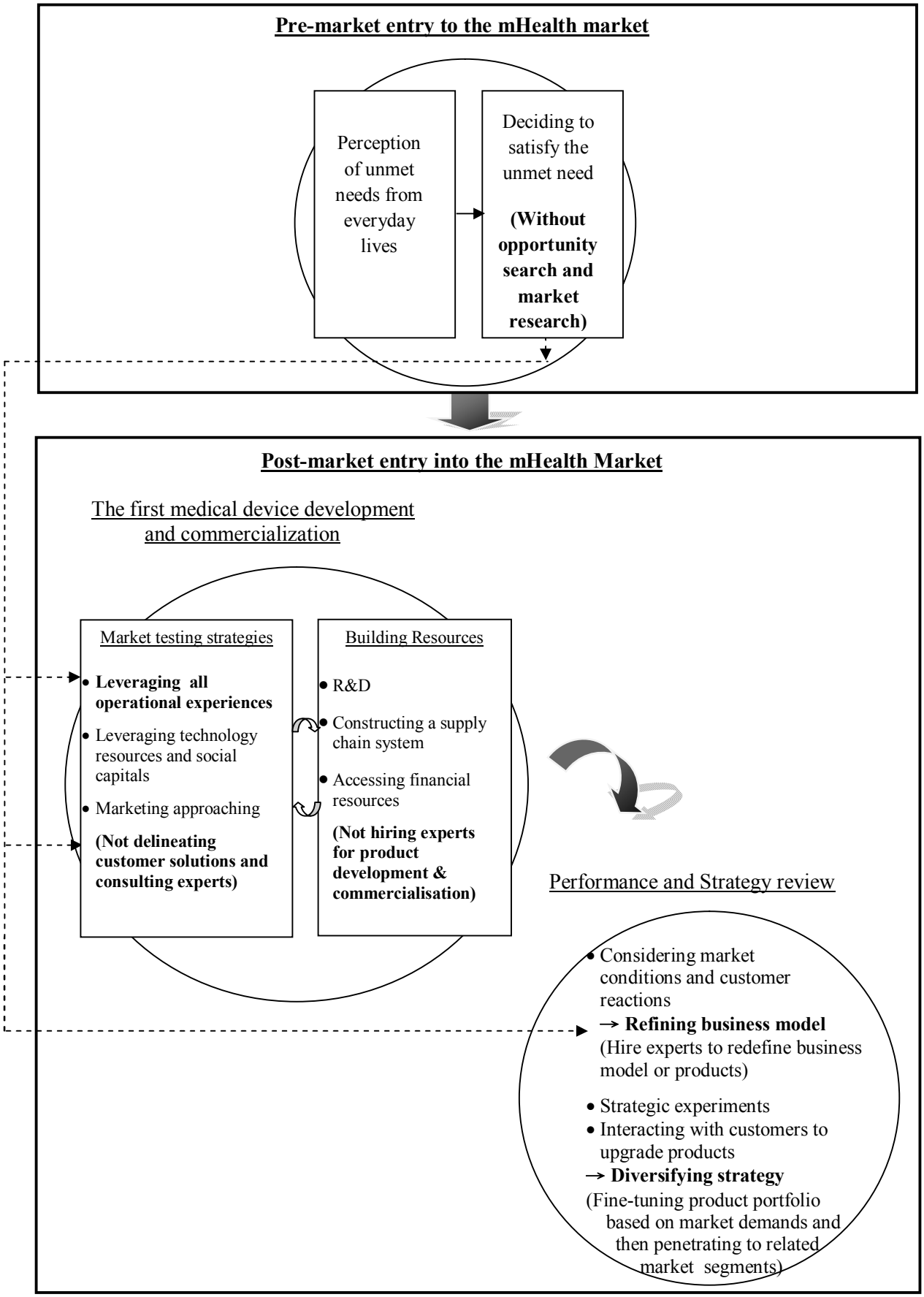


Table 18 The interrelationships between entrepreneurial determinants, opportunity beliefs and opportunity exploitation strategies

	Technology-driven ventures	Operation-driven ventures	User-driven venture
Entrepreneurial determinants	Find a new market domain to exploit current technology	Perceive particular unmet needs found in past operational experiences	Perceive particular unmet needs found in personal frustration
The formation of opportunity beliefs	**Opportunity Search -** Searching opportunities within a certain technological distances to current technology **Opportunity Evaluation -** **1. Desirability-** No special preference for particular opportunities as long as they can maximise the value of current technology **2. Feasibility-** Evaluating every opportunity recognised including economic returns, market condition, policy, etc.	**Desirability-** Satisfy unmet needs found in past career **Feasibility -** Considering the market size of the targeted opportunities and technology abilities Lacking substantial market research	**Desirability-** Satisfy unmet needs found in past career **Feasibility -** Considering the market size of the targeted opportunities. Lacking substantial market research
Fungibility of founders' prior knowledge applied in the new business	**Fungible** (The technology applied in the medical market is fungible and can create benefits for end users in multiple market domains)	**Less fungible** (The operational experience applied in the medical market is less fungible and only can create benefits for end users in related market domains)	**Not fungible** (The perception of an unmet need found in founders' searching experience for a suitable product is not fungible and cannot create benefits in other market domains)
Strategies of opportunity exploitation	**1. Product development:** Leveraging technology resources R&D for necessary technology Building market resource (e.g., hiring experts) since the early stage of product development. **2. Performance reviews** More focus on examining market reactions and conditions **3. Business development strategy** Pivoting Strategies (Initiate a new round of opportunity search when market conditions are not good)	**1. Product development:** Leveraging technology and market resources (exploiting technology resources is not the main purpose to start a new business) R&D for necessary technology **2. Performance reviews** More focus on examining customer reactions **3. Business development strategy** Diversification strategies (Penetrate into other related segments after well establish in the initial target markets)	**1. Product development:** Leveraging experiences which may or may not suit target opportunities R&D for necessary technology **2. Performance reviews** More focus on examining customer reactions **3. Business development strategy** Refining Business Model (Lacking related knowledge usually leads to inappropriate strategies and business models) → Diversification strategies (Penetrate into other related segments after well establish in the initial target markets)

3.5.1 Implications for Theory

Contributing to theories of the evolving entrepreneurial process and micro-foundations

Our research unpacks empirically how entrepreneurial decisions made in one phase impact entrepreneurial decisions and behaviours in the next phase, thereby contributing to entrepreneurial and strategy theories on decision making in three ways. Firstly, we reposition entrepreneurs at the centre of the process of new firm creation to show how the entrepreneurs' situated cognitions – such as their expression of their beliefs – determine their entrepreneurial actions. Different knowledge structures, cognitive frameworks, or aspirations may lead to different entrepreneurial decisions (Krueger, 2000). We indicate three types of entrepreneurial determinants for new venture creation. Different determinants lead to different cognitive processes on opportunity search and evaluation which in turn lead to diverse entrepreneurial decisions of opportunity selection.

Some of our results confirm previous findings about how entrepreneurs based on prior knowledge to be alert to promising opportunities (R. A. Baron, 2006; Gaglio, 2004; Gaglio & Katz, 2001; Grégoire et al., 2010; Grégoire & Shepherd, 2012). In addition, apart from prior knowledge, our findings illustrate multiple entrepreneurial determinants which also influence the formation of first-person opportunity beliefs. For example, extant entrepreneurship literature mainly assumes that entrepreneurs without sufficient resources would not start their business but the fact is they do. In this research, we indicate the impact of subjective concerns (e.g., personal frustration) on entrepreneurial decision making to explain the existence of those companies whose business developing processes differ from the patterns that current literature suggest (e.g., user-driven ventures).

In addition, our findings show that the way to identify opportunities can be an act of entrepreneurial agency rather than being determined by the environment. In an almost identical environment, different opportunity identification paths can co-exist.

Secondly, our research gives insights to the literatures on micro-foundation of the entrepreneurial actions by showing the transitions between entrepreneurial phases (opportunity search, evaluation, and exploitation). Although entrepreneurship have long been considered as a process (Bhave, 1994; Davidsson, 2003; Gartner, 1985, 1990), current research usually distinguish entrepreneurial actions into the phases and study entrepreneurial behaviours in each discrete phase (Choi & Shepherd, 2004; Gruber et al., 2008, 2013; McMullen & Shepherd, 2006). Our integral approach shows how the strategic decisions made in one phase influence the following entrepreneurial process. Different entrepreneurial determinants lead to multiple paths of opportunity identification and evaluation, which influence the extent of market understanding that new ventures have before their market entry. Different extents of understanding lead to different levels of operational risks and challenges that new venture may face in their opportunity exploitation. Thus, by considering the entrepreneurial process from an integrated view, our research presents a next step in the understanding of cognitive dynamics that support and foster entrepreneurship.

Thirdly, our research bridges entrepreneurial theories with strategy and organizational theories. Extant research in organization theories (Stinchcombe, 1965) and corporate strategy and governance (Boeker, 1989; Nelson, 2003) argues that firms become different not only because of adaption but because policies, procedures, and culture at the time of founding determine the evolution of firms (Stinchcombe, 1965). The founder imprinting literature has suggested that the early choices that entrepreneurs make can affect the policies, procedures, and culture of the organization (J. N. Baron, Burton, & Hannan, 1996; Boeker, 1989; Stinchcombe, 1965). Therefore, the way entrepreneurs ideate and conceptualize their ventures may imprint on the ventures' development strategies (Hsu & Lim, 2014). Our findings show that new ventures founded because of different entrepreneurial determinants manifest different strategies to exploit opportunity and enhance

their growth. We suggest that founders' imprinting effects may start in an earlier phases of company development, that is, venture ideation and opportunity recognition and then determine the direction of the venture's business development. Our results show that founding decisions have long-lived effects on shaping the ventures' evolution to generate innovative possibilities, which explains the inter-firm differences in the strategies of their business development.

Bridging the gap between resource application and entrepreneurial intention in the current literature

Our research enriches the knowledge on the factors determining the agent's subjective perception of selecting particular resources to develop a new product. Resources lie upstream from the end product. They may be utilised in a range of applications for different market domains (Danneels, 2003, 2007; Prahalad & Hamel, 1990). Innovative activities and opportunity identification are contingent on the agent's subjective perception of which products or services that the firm can or cannot do for which markets (Penrose, 1959). In this research, we indicate three entrepreneurial determinants for new venture creation which determine entrepreneurs' venture ideation and the way they reconfigure resources to generate new innovative possibilities. We associate the literature of competence-based new product innovation (Danneels, 2002) and the literature of opportunity identification and further consider the role of entrepreneurial determinants in the interrelationships between opportunity identification, resource application, and new product innovation.

3.5.2 Implications for Practice

The results of this study can guide practitioners in several ways. Although there is a substantial amount of studies investigating entrepreneurial actions in different phases of the entrepreneurial process, less considers the process from an integral point of view. The

entrepreneurial decisions made at different stages of new venture development are not supposed to be independent but strongly associated with each other. Our results reveal the interrelationships between decisions on opportunity search, evaluation, and exploitation. In this way, our research guides practitioners in their own decisions about opportunities by reaffirming the importance of their initial entrepreneurial determinants and its lasting impact on opening or restricting the scope of their cognitive processes in decision making.

By emphasizing the lasting impact of founding decisions on the entire entrepreneurial process, our research guides practitioners to not only focus on how to realize their chosen entrepreneurial ideas but also consider the aid that their other resources which are neglected in current entrepreneurial actions may provide to their survival and growth. Entrepreneurial determinants may lead practitioners to focus on particular types of resources and the fungibility of the resource may restrict the scope of identifying alternative strategies for firm growth.

CHAPTER 4 – ENDORSING LEGITIMACY TO AVOID IPO UNDERPRICING WHEN THE MARKET FOR TECHNOLOGY FAILS

(The first paper of my PhD study)

ABSTRACT

Bringing institutional theory and the signalling effect of patents into the debate, we investigate how to mitigate IPO underpricing caused by R&D investment in different appropriability regimes. Empirical evidence shows that in the industry with a transparent link between R&D expenditures and value appropriation, the level of R&D expenditures does not even have a positive impact on IPO underpricing, and a venture's patent stock effectively mitigates investors' concerns regarding its future prospect. Conversely, when the link between innovations and future returns is unclear, the endorsing legitimacy is extremely prevalent, especially for high-tech IPOs. Post hoc analysis shows that it does decrease the level of IPO underpricing caused by innovation-based information asymmetry, proxied by the R&D expenditures. The result extends information asymmetry theory by considering institutional prospective and by contextualizing firm information. It also contributes to institutional theory by showing how this theory contributes to our understanding of firm behaviour in the absence of well-functioning markets (e.g., market for technology).

Declaration

I would like to thank for the help and support of my co-author, Prof. Bart Clarysse (also my supervisor) with this paper and Prof. Erkko Autio for very useful comments. The first version of this paper was accepted by BCERC (Babson College entrepreneurship research conference) in 2012 and has been selected to be published in its entirety in the 2012 edition of Frontiers of Entrepreneurship Research (FER). The second version of this paper has been accepted and presented in the Academy of Management 2012 Annual Meeting.

4.1 Introduction

Young ventures usually have balance sheets that are characterized by a high amount of intangible assets; they have a P&L which shows only negative cash flow and face substantial technological and/or market uncertainty during their first few years of operation. In the start-up process, they tend to rely on external sources of finance such as venture capital to commercialize their innovation (Baeyens & Manigart, 2003; Chemmanur, Krishnan, & Nandy, 2011). However, once they have grown out of the venture capital phase, they need to raise money on the stock market to finance their growth path. Despite the fact that the extant venture capital literature considers IPOs to be success stories (Barry, Muscarella, Peavy Iii, & Vetsuypens, 1990; A. Davila, Foster, & Gupta, 2003; Lerner, 1994), substantial evidence shows that entrepreneurs tend to sell their shares at a price lower than the actual market value of their initial public offerings (IPOs) in order to attract investors (Chambers & Dimson, 2009; Loughran & Ritter, 2002; Zheng & Stangeland, 2007). In the IPO market, information asymmetry between corporate insiders and outsiders is the widely accepted explanation for IPO underpricing (Rock, 1986). Young ventures which are based on novel technologies generate many information asymmetries because it is difficult to assess their real potential (Aboody & Lev, 2000; Heeley et al., 2007). This explains why young technology based ventures are usually more seriously underpriced than companies with a track record in an easy-to-understand industry. However, information asymmetry theory explains why the innovation-based information asymmetry occurs but has little to say regarding how to mitigate this underpricing.

Early research on IPOs concentrated mostly on financial issues such as offer pricing and share allocation (Beatty & Ritter, 1986; Ibbotson, 1975; Welch, 1989). In the past two

decades, pricing in the IPO market has received increasing attention from management and entrepreneurship scholars. Some research focuses on who is involved with IPOs (e.g., venture capitalists, top managements teams, underwriters). The research in this theme suggests that to prevent increases in the level of information asymmetry from agency issues (e.g., firms and underwriters' adverse selection (Stiglitz, 1985), managers' moral hazard (Bergemann & Hege, 1998; Yung & Zender, 2010), firms are required to disclose information on top management team (TMT) members, board members, primary underwriters, compensation contracts, and institutional investors (Aggarwal, Prabhala, & Puri, 2002; Bell, Filatotchev, & Aguilera, 2014; Certo, Daily, Cannella, & Dalton, 2003). In addition, better and more reputable top managers may communicate the value of their firms' credibly to the equity market prior to IPOs (Beckman, Burton, & O'Reilly, 2007; Certo et al., 2003; Kroll, Walters, & Le, 2007). Some research focuses on social influence and emphasizes the impact of venture capitalists (VCs), institutional investors, and alliances partners in terms of fundraising in the equity market (Chemmanur et al., 2011; Echols & Tsai, 2005; Gulati & Higgins, 2003; Hsu, 2006; Stuart et al., 1999). Some research focuses on innovation issues and has a particular interest in the role of R&D expenditures on the performance of IPOs (Aboody & Lev, 2000; Heeley et al., 2007). Although R&D activities affect a firms' inventive success and may significantly impact on firm performance (Helfat, 1994), invention causes knowledge asymmetries between corporate insider and external parties (Anton & Yao, 1994) and increases the difficulty in assessing a firm's real potential, which results in the fact that younger ventures with more novel technologies are underpriced more. However, in contrast to the research on corporate governance providing some solutions to reduce information asymmetries caused by agency issues, underpricing scholars have little to say regarding how to mitigate the underpricing caused by innovation-based information asymmetries. Also, current research has highlighted

the importance of other mechanisms (e.g., VC backing, the reputation of prestigious underwriters and alliance partners) in reducing information asymmetries in the IPO market but pays less attention to the roles that those mechanisms play when innovation-based information asymmetries happen and how public investors actually render the information delivered by those mechanisms.

Some researchers argue that the outcomes of innovation (e.g., patent stocks) can be a quality signal to convey a firm's value to investors (Haeussler, Harhoff, & Müller, 2009; Teece, 1986). Conceptually speaking, patents not only reveal information regarding the technological and managerial capabilities of ventures but also provide legal rights against infringement (Cohen et al., 2000; Hall & Ziedonis, 2001; Levin et al., 1987; Teece, 1986). Thus, some research argues that patents not only serve an isolating role against imitation, but also serve a signalling function (Haeussler et al., 2009; Hsu & Ziedonis, 2013; Long, 2002). However, the disclosure is only sufficient to someone who is "skilled in the art" to practice the innovation and provides limited information regarding the way in which the innovating firms will use the patent to capture profits (Heeley et al., 2007). Public investors usually lack related technology knowledge and are different from VCs who are involved in operational management and can sit in board meetings to understand the value of each innovation. It is difficult for them to predict the potential of each innovation. Therefore, although patent stocks can be a quality signal, Hsu and Ziedonis (2013) found that patenting matters more as a signalling device in early financing stages. Moreover, patents rarely confer perfect appropriability as they are supposed to do in theory. Their function – as well as the level of value appropriability – change across industries (Cohen, 2010; Hall & Ziedonis, 2001; Heeley et al., 2007; Kash & Kingston, 2001). In some industries, patents safeguard monopoly control but in other industries patents are bargaining chips, so that the returns generated from

patents are determined by the strength of the appropriability regime (Kash & Kingston, 2001). In some, industries such as the software industry, patents are less useful because the market changes rapidly and it is difficult to patent an entire product in the software industry (Graham, Merges, Samuelson, & Sichelman, 2009; Mann, 2004). Managers struggle to decide whether to use limited funds for patent-related activities or for hiring programmers (Mann, 2004). Thus, it is worth unravelling the fundamental insights of patent stocks and their efficacy as a quality signal in order to reduce the information asymmetry in the IPO market in different industrial contexts.

Since in some cases a venture's innovation activities, including innovation input (R&D expenditures) and output (e.g., patent stocks), may not clearly convey its value, in light of this challenge prior studies have suggested that a venture can lease the reputation of third party affiliations (e.g., venture capitalist, alliances partners) to increase its own legitimacy to justify its actions as meaningful and trustworthy (Hsu, 2004; Jepperson, 1991; Podolny, 1994; Stuart et al., 1999). Some researchers argue that VCs provide access to resource bundles and prestigious VCs provide a powerful signal of a venture's quality to outside investors (Hsu, 2004). However, the relationship between VCs and IPO underpricing is complex. Some researchers argue that once the industry effects and underwriter quality are controlled, there is no difference in underpricing between VC backed IPOs and non-VC backed IPOs (Bradley & Jordan, 2002). Some research argues that VC backed IPOs experience larger underpricing than comparable non-venture backed IPOs because higher underpricing leads to more future flows of capital into venture capital funds and the effect of underpricing is attenuated for younger VCs (Lee & Wahal, 2004). Another explanation is the timing when IPOs are issued. VC backed IPOs are less underpriced than non-VC backed IPOs during normal periods of

activity but are more underpriced than non-VC backed ones during "hot issue" periods (Franzke, 2004; Rossetto, 2008).

Apart from VCs, among varying quality signals, researchers have identified that the most central of these combines signalling theory with institutional theory (Certo, 2003). Organizational behaviour is embedded in an institutional environment which imposes significant pressure on ventures to legitimate their actions (Dacin, Ventresca, & Beal, 1999; Scott, 1995). A venture's legitimacy enhances its persistence and credibility (Iakovleva & Kickul, 2011; Parsons, 1960; Suchman, 1995) and helps to access resources (DiMaggio & Powell, 1983; Hitt, Ireland, Sirmon, & Trahms, 2011). Thus, young ventures which endorse their legitimacy might be able to decrease the information asymmetry that is generated through the uncertain technological and/or market environment in which they operate. The importance of endorsing legitimacy might be even more prevalent in those industries where the appropriability regime is rather weak. In a complex product technology industry where value appropriability is unclear, legitimacy may be a good signal for ventures to convince potential investors about their earning potential and mitigate information asymmetries, so that the market for technology (Arora & Fosfuri, 2003) is not a potential exit option for investors. However, current research has focussed more on how new ventures transfer their prestigious partners' status to improve their performance (Stuart et al., 1999) but devotes less attention to how the impact of endorsing legitimacy changes in different contexts, especially in a R&D intensive market, and how public investors consider the information delivered by a venture's endorsing legitimacy.

This study attempts to understand how new ventures, especially technology-intensive ones, mitigate the information asymmetry caused by R&D expenditures. In order to fill in this

gap, this research includes an analysis of the signalling effect of patent stocks and introduces an institutional perspective to the debate. Research questions include: (1) how the signalling of patent stocks and endorsing legitimacy affect a venture's IPO price when taking into account the level of information asymmetry, and (2) how the appropriability regime of the industry in which the venture operates moderates the importance of patent stocks and endorsing legitimacy.

Empirical results from a sample of 770 IPOs issued by manufacturing firms during 1995-2006 support our hypothesis that the link between R&D expenditures and value appropriation plays a more important role than initially thought. In the industries with a tight appropriability regime, the level of innovation-based information asymmetry does not even have a positive impact on IPO underpricing, and a venture's patent stock can effectively mitigate potential investors' concerns regarding its future prospects. Conversely, when the transparency of innovations in relation to future returns is unclear, affiliations are more prevalent in serving as a credible and observable signal for the investment community to make an accurate assessment of firm value. Post hoc analysis shows that endorsing legitimacy mitigates the level of IPO underpricing and the innovation-based information asymmetry in those industries where the appropriability regime tends to be weak. This research extends information asymmetry theory by introducing institutional theory into the debate. The endowment of legitimacy is a critical quality signal for younger ventures, especially for high-tech IPOs to influence investors' assessments of their value. This research also contributes to institutional theory by showing how this theory contributes most to our understanding of firm behaviour in the absence of well-functioning markets (such as the market for technology).

4.2 The Underpricing of Initial Public Offerings and Information Asymmetries

Underpricing of initial public offerings occurs when the initial offered price is significantly lower than the closing price at the end of the first day of trading. Substantial evidence shows that when young ventures have grown out of the venture capital phase, they tend to discount their offering prices on their initial public offerings (IPOs) to attract investors (Ibbotson, Sindelar, & Ritter, 1988; Loughran & Ritter, 2002; Rock, 1986). In the 1980s, the average underpricing discount was around 7.4%; it then rose to 14.8% from 1990 to 1998; and from 1999 to 2000, it increased sharply to 65%. In dollar terms, from 1990 to 1998, IPO firms left 29.62 billion on the table and from 1999 to 2000 they left 66.63 billion in the U.S. IPO market alone. Compared to the average profits that these same companies earn in the year before they go public (approximately $8 billion), the amount of money they left on the table is even higher than their three-year aggregate profits (Loughran & Ritter, 2004; Loughran & Ritter, 2002)[53].

Researchers have examined a variety of explanations for the underpricing phenomenon in the IPO market, such as underwriter reputation (Carter, Dark, & Singh, 1998; Corwin & Schultz, 2005), venture capital backing (Barry et al., 1990; Chemmanur et al., 2011; Echols & Tsai, 2005; Hochberg, Ljungqvist, & Lu, 2007), firm size (Ibbotson et al., 1988), and firm age (Megginson & Weiss, 1991). The leading theory is Rock's (1986) argument, the 'winner's curse' model, which expounds Akerlof's (1970) lemons problem and argues that information asymmetry between corporate insiders and outsiders causes the investor community's hesitation regarding the potential of the issuing firms (Christensen,

[53] Underpricing averages are based on data available on Jay Ritter's website (http://bear.warrington.ufl.edu/ritter/ipodata.htm)

2002). The information gaps force investors to reduce investments in order to avoid their anticipated agency costs (Chahine & Filatotchev, 2008). An increase (or decrease) in the level of information asymmetry related to assessing the true value is positively associated with a corresponding increase (decrease) in the amount of underpricing (Heeley et al., 2007).

Underpricing is very costly for younger ventures. It not only dilutes the value of the shares that they retained after the IPO, but also makes securing financial resources challenging (Daily, Certo, Dalton, & Roengpitya, 2003; Loughran & Ritter, 2002). Bridging information gaps, therefore, is particularly important, yet a difficult activity due to the absence of an observable history of performance of new ventures and uncertainty about their technology. Although information asymmetry theory explains why underpricing happens in these cases, the theory has little to say regarding how to mitigate it. In entrepreneurship literature, previous research has investigated a range of mechanisms such as founders' backgrounds (Certo, Daily, & Dalton, 2001; Eisenhardt & Schoonhoven, 1990), TMT structure and reputation (Beckman et al., 2007; Certo et al., 2003; Kroll et al., 2007), and endorsements from third parties (Chemmanur et al., 2011; Gulati & Higgins, 2003; Hsu, 2004; Stuart et al., 1999), which are used to reduce information asymmetries. However, there are relatively few studies considering how the signalling effects of those mechanisms change in different contexts and how investors actually render those signals.

4.3 Hypotheses Development

4.3.1 Innovation and information asymmetry

Although it is widely accepted that R&D activities affect a firm's inventive success and may significantly contribute to organizational performance (Helfat, 1994), a considerable amount of research has noted the problems associated with financing research and R&D (see

Hall, 2008 for a review). In the IPO market, previous studies have found that information asymmetries correlate substantially with a firm's R&D expenditure due to the nature of uncertainty (Guo, Lev, & Shi, 2006; Heeley et al., 2007). As the level of R&D expenditures increases, so does the amount of information necessary to judge the value of innovations. Before innovation can be successfully commercialized in a product, it is just a R&D expenditure on financial statements rather than direct information on the value of the innovation itself. Thus, high-tech ventures generate more information asymmetries because it is difficult to assess their real potential. For investors, the higher the R&D expenditures, the more uncertainty regarding the future performance of the ventures (Anton & Yao, 2004; Eisenhardt & Martin, 2000; Knight, 1921), notwithstanding the fact that that future performance might be significantly higher. Thus, a higher level of R&D expenditures increases the need for more firm specifics and project information (Heeley et al., 2007). Also, because of the information gap, corporate insider gains are relatively larger for R&D intensive ventures than ventures without R&D (Aboody & Lev, 2000). When investors find it difficult to evaluate the quality of the R&D investment, ventures might find it hard to secure financial backing (Hall, 2008; Leland & Pyle, 1977).

However, the level of uncertainty or information asymmetries is not uniform in different contexts (Cohen, 2010; Levin et al., 1987; Warshofsky, 1994). For instance, young ventures have a choice between competition strategy (e.g. entering the product market) and cooperation strategy (e.g. entering the technology market) (Arora & Ceccagnoli, 2006; Gans, Hsu, & Stern, 2002; Gans & Stern, 2003). The success of the strategy chosen depends on the venture's unique capabilities and resource configurations (Gans & Stern, 2003; Teece, 1986). Ventures which choose to license their technologies focus on developing their technology basis and building up a strong IP portfolio (Arora, Fosfuri, & Gambardella, 2001; Gans, Hsu,

& Stern, 2008; Ziedonis, 2004) and compete on the upper stream of the value chain (Arora & Ceccagnoli, 2006). In contrast, ventures participating in the market for products generate value from production-related activities which might require significant investments in co-specialized assets (Arora et al., 2001; Teece, 1986). They need capabilities to manage multiple uncertainties which are related to transforming the technology into new products and convincing customers of a new value proposition (Gans & Stern, 2003). Thus, these different strategies (entering the market for products or the market for technology) influence the amount and complexity of information necessary for investors to evaluate a venture's potential (Gans et al., 2002; Graham et al., 2009; Teece, 1986).

Value appropriability of a venture's commercialization strategy

A venture's commercialization strategy is determined by the relative returns from a competition (entering the market for products) versus cooperation strategy (entering the market for technology). The profits from different strategies are contingent on the strength of the appropriability regime within the industry and the extent to which incumbent firms control complementary assets (Arora & Ceccagnoli, 2006; Gans & Stern, 2003).

A regime of appropriability refers to the environmental factors (excluding firm and market structure) that influence an innovator's ability to capture the profits created by innovations. The key determinants of the appropriability regime are the efficiency of legal mechanisms of protection and uncertainty about the value of the technology (Arora & Ceccagnoli, 2006; Arora & Gambardella, 2010; Gans et al., 2002; Teece, 1986). The strength of intellectual property rights (IPR) substantially affects the expropriation threat (Anton & Yao, 1994; Arrow, 1962; Ziedonis, 2004) and influences the relative returns to cooperation. While bargaining with incumbents, ventures in environments with tight IPR can avoid the

threat of expropriation and increase the venture's outside option (e.g., terminating the negotiation and entering the product market). Moreover, certain types of IPR such as patents reduce the transaction costs (Gans et al., 2002). However, even with tight appropriability regimes, the appropriability of innovation also skewed. Many innovations, in the end, generate no or very little value. The difference between high and not low innovation values can be 10 million Euros (Gambardella & Giarratana, 2007). Nevertheless, it is difficult to distinguish between valuable innovations and poor ones. The uncertainty about true technology value may hinder bargaining between focal firms and other contingent contracting provisions (Arora et al., 2001; Gans et al., 2008). The increase in the transaction cost might dilute the potential earnings from each innovation.

In addition, cooperation strategy (entering market for technology) allows innovators to exploit complementary assets owned by incumbents (Teece, 1986). When specialized complementary assets are required, firms tend to avoid duplication and the sunk costs related to competition in product markets by collaborating with incumbents for the transactions of technologies (Arora et al., 2001; Gans & Stern, 2003). Therefore, firms are more likely to participate in the market for technology when IPR is tight, transaction costs are low, and sunk costs to enter product markets are high. In weak IPR regimes, the market for product seems to be the only option (Gans et al., 2002).

Moreover, the environment in which a venture operates is another potential factor which might affect the returns from cooperation strategy (entering market for technology) and competition strategy (entering market for products). Empirical evidence suggests that the economic value of innovation is not uniform across sectors (Cohen et al., 2000; Graham et al., 2009; Levin et al., 1987). Cohen et al. (2000) attribute this sector-level variation to the

technology complexity (complex technologies and discrete technologies) in each market. They categorize complexity of product technologies by ISIC (International Standard of Industrial Classification of All Economic Activities)[54] classification which groups together firms producing the same type of goods or service or who use similar processes. The key difference is whether it is a process consisting of numerous separate elements versus relatively few elements (Kash & Kingston, 2001; Kusunoki, Nonaka, & Nagata, 1998; Levin et al., 1987). For example, on average new drugs make up a relatively small number of patentable elements. Electronic products, however, are comprised typically of a larger number of elements and, thus are characterized as complex technology (Cohen et al., 2000; Heeley et al., 2007). Kusunoki et al.'s (1998) research also proposes a similar concept. In their study, they categorize "material" and "system" industries. However, they exclude food, steel, and metal products because they are difficult to classify based on their category definition. Under different industrial situations, the appropriability regime as well as the possibility to control complementary assets changes (Cohen, 2010; Graham et al., 2009).

In the discrete product technology industry, the value of one commercializable product is characterised by a relatively low innovation number. The potential outcomes generated by each dollar of R&D investments are relatively high and easy to predict (Levin et al., 1987). The value of each innovation usually can be understood by an individual and precisely transmitted across firms (Rycroft & Kash, 1999). For example, pharmaceutical formulae are comprehensible to all trained chemists. The consensus on components of the technology shared by experts helps firms to demonstrate monopoly rights and make technology licensing possible. Therefore, given that the value of each innovation is clear and

[54] ESDS International (http://www.esds.ac.uk/international/support/user_guides/unido/isic_guide.asp)

the bargaining with incumbents is comparatively easy, the transaction cost in the market for technology is relatively low, so that the returns from innovations in a discrete product technology industry are more predictable.

However, in the complex product technology industry, the quantity of knowledge that each innovation relies on is too large and diverse to be understood by an individual (Rycroft & Kash, 1999). It is difficult to conceive of each innovation's usefulness in the future; hence, many technologies lack a predictable market (Kash & Kingston, 2001). As the value appropriability is not transparent, evaluators need more firm-specific information, which further increases information asymmetries (Heeley et al., 2007). For example, complex technologies are synthetic systems which consist of diverse knowledge (Kash & Kingston, 2001; Rycroft & Kash, 1999). Technology transfer is a complicated process. Also, the complex systems need a large number of separate elements and the same performance can normally be achieved by different designs or combinations. Incumbents find it difficult to determine which innovation is more valuable than others to improve the efficiency or performance of the systems. Competitors can also destroy the value of one innovation simply by filing 'engineer around' patents (Kash & Kingston, 2001). In addition, ventures in a complex product technology industry normally lack proprietary controls over all the essential complementary components underlying their products. The mutual dependence between firms may constrain a firm's earning (Cohen et al., 2000). Consequently, the large quantity of knowledge that complex technology combines makes technology transactions difficult and increases mutual dependence between firms. New ventures need extra efforts to communicate specific information about their innovation with incumbents in order to eventually turn their R&D expenditures into profits. Investors necessitate more information to assess a venture's

value and possible returns from its R&D expenditures. Therefore, this research hypothesizes that:

Hypothesis 1: In a complex product technology industry, the impact of information asymmetries caused by R&D expenditures on IPO underpricing is higher than that in a discrete product technology industry, holding other venture characteristics constant.

4.3.2 Quality signals of ventures

Bridging information gaps between corporate insiders and outsiders is the first priority for young ventures to secure their financial capital from the public investment community. Previous research has investigated a range of proxies to reduce information asymmetries, such as patent stocks (Conti, Thursby, & Rothaermel, 2011; Hsu & Ziedonis, 2013), venture capital backing (Bradley & Jordan, 2002; Hsu, 2004; Megginson & Weiss, 1991), and third-party affiliations (Gulati & Higgins, 2003; Levitas & McFadyen, 2009; Stuart et al., 1999). However, most of them assume signal receivers only play passive roles and are placed on the receiving end of discourse. Few studies consider evaluators' active cognitive processing and how they actually render quality signals in different industrial contexts.

The signalling effect of patents

Patents, the outputs of innovation (albeit an intermediate one), are a potential proxy for ventures to shows their innovation achievements (Conti et al., 2011; Haeussler et al., 2009; Heeley et al., 2007; Hsu & Ziedonis, 2013). Theoretically patents not only reveal information regarding the technological and managerial capabilities of ventures but also provide legal rights for ventures, which influence profit expectations. The exclusionary rights are supposed

to assist ventures to appropriate returns from investments in R&D and to commercialize their technologies (Cohen et al., 2000; Hall & Ziedonis, 2001; Levin et al., 1987; Teece, 1986). However, the signalling effect of patents is too noisy. Firstly, according to Patent Law 35 U.S.C. 112, the disclosure is technical information and only sufficient to someone who is "skilled in the art" to practice the innovation. Thus, the patent disclosure only provides limited information to a majority of investors and does not convey the way in which the innovating firms will use the patent to capture profits (Heeley et al., 2007). Secondly, the function of patents as well as the level of value appropriability changes across industries (Cohen, 2010; Graham et al., 2009; Heeley et al., 2007; Kash & Kingston, 2001). Rarely do patents confer perfect appropriability as they are supposed to do in theory. Surveys of large manufacturing firms (Cohen et al., 2000; Levin et al., 1987) and small ventures (Ceccagnoli, Graham, Higgins, & Lee, 2010) show that in chemical industries, there is a comparatively clear standard to evaluate a chemical patent's validity and to defend against infringement. The protection of patents is stronger for firms in life science and chemical industries than for companies in hardware sectors (Graham et al., 2009). Surveys of firm-level patenting behaviours during 1979-1995 in the U.S. market also support this point. Even though there is a remarkable increase in patenting in the semiconductor industry (Hall & Ziedonis, 2001), the main purpose for semiconductor firms to file patents is to use these as a trading currency to access other technologies (Kash & Kingston, 2001). The effectiveness of patents as bargaining chips correlates strongly with the strength of intellectual property rights (IPR) (Gans et al., 2002; Levin et al., 1987; Teece, 1986). If the market for technology works, firms may capture profits generated by their innovation by licensing their technologies and using their innovations to exchange complementary technologies by cross-licensing. In addition, in some industries – such as the software industry – patenting has limited function to protect a

company's intellectual property or increase organizational performance because the market changes rapidly and it is hard to patent an entire product (Graham et al., 2009; Mann, 2004).

In the complex product technology industry, a large number of the interacting components which a product needs not only makes it difficult for investors without diverse knowledge to discern the usefulness of each innovation in the future, but also causes the relatively weak utility of each patent (Cohen et al., 2000; Rycroft & Kash, 1999). Moreover, if any of the components is patented, without being licensed the profit which a venture can capture from its innovation is limited, even though the venture can integrate the remaining components (Kash & Kingston, 2001). Therefore, patenting as many components of the technology as possible is an inevitable investment to avoid possible lock-out and to establish the strongest position for cross-licensing. However, compared with incumbents' boundaries of specialized and co-specialized assets, the innovation stocks of younger ventures are comparatively small, so that it is difficult for ventures to turn their efforts regarding developing technologies into profits. The stock of innovations eventually only increases R&D expenditures and provides a limited guarantee for future returns. Furthermore, uncertainty about the value of each technology in an industry with complex product technology further increases the transaction costs connected with technology licensing. Thus, the market for technology might be not a profitable option for ventures in this industrial situation. Combining the above reasons, this research hypothesizes that:

Hypothesis 2: In a discrete product technology industry, the impact of patent stock on reducing IPO underpricing is higher than that in a complex product technology industry, holding other venture characteristics constant.

The signalling effect of third-party affiliations

A good signal of quality should be easily detected (Connelly, Certo, Ireland, & Reutzel, 2011) and correspond honestly to the sought-after quality of the signaller (Gulati & Higgins, 2003). When a venture's innovation outcomes (e.g., patent stock) fail to convey the potential of its value to public investors, some research suggests that ventures can try to lease the reputation of third-party affiliations, including venture capitalists and alliance partners (Gulati & Higgins, 2003; Hsu, 2004; Hsu & Ziedonis, 2013; Stuart et al., 1999). Some researchers suggest that venture capitalists (VCs) help ventures attain business and financial resources (e.g., alliance partners, management teams, and reputable investment bankers) to increase a venture's dynamic capabilities related to product and management development (Hsu, 2004). Therefore, VC backing may be a good signal to convey a venture's quality in the IPO market. However, the relationship between VCs and IPO underpricing is complex. Financial research has indicated various positive and negative impacts of VCs on IPO pricing. Some found no difference in underpricing between IPOs with and without VC backing after controlling industry effects and underwriter quality (Bradley & Jordan, 2002). Some found the impact of VC changes depending on the timing when an IPO is issued (Franzke, 2004; Rossetto, 2008). Some found that VC backed IPOs are more underpriced because higher underpricing leads to greater future flows of capital into venture capital funds (Lee & Wahal, 2004). Apart from the signalling from the affiliation with VCs, among varied quality signals researchers have identified that the most central of these combines signalling theory with institutional theory which considers firms' endeavouring for legitimacy in order to survive (Certo, 2003). Legitimacy, on the one hand, is embedded in a system of institutionalized beliefs. Audiences are more likely to supply resources to organizations that seem desirable, proper, or appropriate (Parsons, 1960); therefore, legitimacy serves as a critical signal which

contributes to a firm's persistence. On the other hand, the cultural congruence captured by legitimacy increases firms' credibility and provides rational explanations for firms to justify what they are doing and the reasons for doing this (Jepperson, 1991).

While legitimacy is important to all firms, it is more critical for young ventures that need to establish themselves in business environments (Carroll, 1983; Hannan, Pólos, & Carroll, 2007; Stuart et al., 1999). With little or no observable history and given the high uncertainty of technologies, the investor community normally doubts an issuing firm's qualities which determine its success in the long run (Certo et al., 2001; Daily et al., 2003) and the firm's true intention in seeking external financing (Mouri, Sarkar, & Frye, 2011). As Stuart et al. (1999:317) states, "because the quality of young companies often cannot be observed directly, evaluators must evaluate the company based on other observable attributes that are thought to co-vary with its underlying but unknown quality. Resource holders, therefore, assess value by estimating the conditional probability that a firm will succeed, given by a set of observable characteristics of the organization". Previous research has found endorsements from ventures' inter-organizational exchange relations serve as a certification of their intrinsic value and enhance their perceived quality (Baum & Oliver, 1991; Podolny, 1994; Stuart et al., 1999). Their affiliations can alleviate misgivings that external investors may have by showing that they are able to access abundant resources which can increase their survival prospects (Reuer & Tong, 2010; Singh & Mitchell, 2005).

In a complex product technology industry where the link between innovation and value appropriation is not transparent (Gans & Stern, 2003; Teece, 1986) and the market for technology is imperfect, investors lack certain standards to assess the value of a venture. Moreover, even though the market for products is another option, it is very challenging for a

venture to develop its technology and establish production and distribution activities simultaneously (Pries & Guild, 2007). The profit which a venture may gain from product markets is, hence, extremely doubtful, whereas their operating risk normally increases. The uncertainty of a venture's earning potential in either market might hinder investors from correctly evaluating a venture's quality, so that the importance of endorsing legitimacy might be more prevalent for ventures in a complex product technology industry. Affiliations are presumed to be correlated with quality and yet are more observable than quality itself (Podolny, 1994). Moreover, affiliation generates positive information by showing that ventures are able to access more resources which increases their survival prospects and growth opportunities (Reuer & Tong, 2010; Singh & Mitchell, 2005). Thus, signalling legitimacy might be a good way for young ventures to convince potential investors about their earning potential in an industrial context.

Hypothesis 3a: In a complex product technology industry, the impact of signalling legitimacy on reducing IPO underpricing is higher than that in a discrete product technology industry, holding other venture characteristics constant.

For ventures with more investments in R&D, endorsing legitimacy plays a more critical role in helping them establish confidence about their quality. Compared with large firms which have experiences of innovation projects (Nohria & Gulati, 1996) and the resource slack to absorb failure (Danneels, 2002; Galunic & Rodan, 1998; Majchrzak, Cooper, & Neece, 2004), young ventures face high existential risks if the innovation fails and they normally lack experience in running innovation projects. Moreover, given the low transparency of value appropriation and the absence of well-functioning markets in a complex product technology industry, only young ventures which endorse their legitimacy

are potentially able to decrease the information asymmetry that is generated through the uncertain technological and/or market environment in which they operate. Different from ventures in a discrete product technology industry with clear commercial promise, the endorsing legitimacy may be the only way for ventures with high R&D expenditures in a complex product technology industry to signal their unobservable value and make their behaviours more predictable and trustworthy (Jepperson, 1991). Thus, this research hypothesizes that:

Hypothesis 3b: In a complex product technology industry, the impact of signalling legitimacy can reduce IPO underpricing which is caused by high R&D expenditures, holding other characteristics of ventures constant.

The influence of endorsing legitimacy from affiliations is not equal across different types of alliance partners. Stuart et al. (1999:321) show that there is an "implicit transfer of status across inter-organizational exchange relations (such as inter-corporate equity and alliance ties), which builds confidence about the quality of a new venture among potential customers, suppliers, employees, collaborators, and investors " According to Washington and Zajac's (2005:284) definition, status refers to "a socially constructed, inter subjectively agreed upon and accepted ordering or ranking of individuals, groups, organizations, or activities in a social system". It emphasises social justification and captures differences in the actors' social ranks that generate privilege or discrimination (Benjamin & Podolny, 1999; Washington & Zajac, 2005).

Status includes a dual character. On the one hand it is an attribution which firms depend on to infer their quality when that cannot be directly or easily observed (Shapiro, 1983). On the other hand, a firm's status develops not only from past performance but also

from the status of their exchange partners. Ventures with high-quality partners are more likely to gain access to valued expertise in other firms and thereby reduce the transaction costs of dealing with less trustworthy partners. These ventures are also more likely to form advantageous alliances in the future, hence, enhancing their future competitive potential (Dacin, Oliver, & Roy, 2007; Dyer & Singh, 1998). Previous research also shows that alliances with prominent partners can improve a firm's visibility among numerous unaffiliated organizations and enlarge its set of prospective investors (Reuer & Tong, 2010). Therefore, the ties to higher-status partners increase the esteem of a firm and the evaluation of its quality.

For young ventures, the relationship with prominent organizations might be a convincing quality signal to investors, given their relatively low status. Prominent firms need to risk their reputation when they build relationships with young ventures; thus, prominent firms have a correspondingly strong incentive to avoid low-quality exchange partners (Podolny, 1994; Stuart et al., 1999). Exclusiveness turns to be an endorsement for a venture attempting to distinguish itself from low quality ventures and a form of certification by virtue of the fact that it has withstood the due diligence process of a selective and highly capable evaluator (Baum & Oliver, 1991; Stuart et al., 1999). This endorsement is more prevalent for R&D intensive ventures. Partners with technological prominence – referring to firms with many influential innovations – are competent and selective judges of the technological potential of ventures in their areas of expertise; hence, the affiliation with technological prominent partners is like a certification of a venture's technological ability (Stuart et al., 1999). For high-tech young ventures, this signal is particularly important to reduce the level of information asymmetry regarding the novelty and uncertainty of their technologies. In addition, in complex technology industries, investors require information not only regarding

the technology itself but also relating to the portion of the rent from the innovation that will accrue to a venture. It is incredibly hard for investors without professional and diverse knowledge to judge the value of each technology and the possible profit generated by each innovation. Thus, affiliations with partners with technological prominence might serve as a critical signal for ventures to demonstrate their technological achievements (Baum & Oliver, 1991).

Hypothesis 3c: In a complex product industry, the signalling impact of alliances partners' technological status can reduce IPO underpricing caused by high R&D expenditures, holding other characteristics of ventures constant.

4.4 Data sources and variable definitions

This research collected a sample of IPOs issued by manufacturing industries (SIC 20-39) in the U.S. from 1995 to 2006. The research used the Securities Data Corporation database to identify IPO firms and collect information regarding their alliance relationships in the five years prior to their IPOs. First-day trading information was obtained from the Centre for Research in Security Prices tapes. Patent data in the five years prior to focal firms' IPOs was obtained from the U.S. Patent and Trademark Office database. The sectoral patenting trend was gained from the U.S. Patent and Trademark Office website. Firms' ISIC code, assets, sales, ages, and R&D expenditures in the year prior to their IPOs were obtained from Standard and Poor's COMPUSTAT data tapes. Underwriter quality was measured with Loughran and Ritter's (2004) update of the underwriter reputation ranking developed by Carter and Manaster (1990). This research deleted firms with (1) an offer price below $5 dollars or (2) incomplete data (Heeley et al., 2007).

Dependent and independent variables

IPO underpricing is measured by the percentage change in the stock price of a firm during its first day of trading ([closing price – offering price]/offering price). *R&D intensity* was measured as the ratio of R&D expenditure divided by sales in the year prior to a firm's IPO and was taken log transformation to account for skewness in the data and controlled by assets in the year prior to the initial public offering (Guo et al., 2006). *Patent stock* is measured by the number of patents a firm had in the five years prior to its IPO. This research concentrated on patents in the five years prior to the IPO for two reasons. Firstly, recent patents show a firm's inventive abilities at the time of IPO. Secondly, previous research shows that patent protection rarely lasts for 20 years from the date of filing, but instead lasts for a relatively short period (Mansfield, Schwartz and Wagner, 1981). The *alliance dummy* is measured by whether a firm has an alliance relationship in the five years prior to its IPO. (A five year window is widely accepted in the literature as an adequate period to measure a firm's alliances (Gulati, 1995; Gulati & Gargiulo, 1999), because normally the duration of alliances is no more than five years (Kogut, 1988, 1989)). *The technological prominence of the alliance partners*[55] was measured by the number of patent citations in the five years prior to a focal firm's IPO. To measure the *appropriability regime*, this research used ISIC code to separate IPOs into discrete or complex product technology industries. ISIC code classifies enterprises according to their economic activities. Firms which produce the same type of goods or services or use similar processes (e.g., the same skills or technology) will be grouped together. It is different from NAICS, which is based on a production-oriented concept and groups industries by the similarity of the processes used to produce goods or

[55] In unreported models, we measured a partner's technological prominence scores by using total patent citations. This is generated by averaging patent citations to account for the possible bias if the addition of low-prestige partners might lower perceptions of a focal firm's quality, and by selecting the maximum prominence score of any of a focal firm's partners. The results of these measurements were the same.

services[56]. Industries with ISIC codes lower than 2900 were defined as discrete product technology industries (e.g., pharmaceuticals), whereas those with an ISIC code of 2900 or higher were identified as complex product technology industries (e.g., computers and electrical equipment) (Cohen et al., 2000; Heeley et al., 2007). This coding scheme is similar to Kusunoki's (1998) study.

Control variables

This research controlled firm ages, measured as years since founding and took log-transformation into account in order to adjust for skewness in the data. On average, older firms have more public information and records about their value, which can reduce information asymmetries. To control for the effect of firm size, this research took log-transformation of firm assets in the year prior to the IPO. On average, larger firms have more patents and low information asymmetry about their earning potential. This study used a dummy variable to indicate whether a firm was founded by venture capital or not. To account for the effect of underwriter reputation, this research followed Loughran and Ritter's (2004) prestigious underwriter backing. This research also counted the number of IPOs in the same industry in one prior year to a focal firm's IPO to control the effect of hot markets characterized by rotating periods of significant activity (Heeley et al., 2007). Prior research has found that hot markets are related to higher underpricing than cold markets (Ritter, 1984). This research used lagged market return measured by weighted return for the 30-day pre-IPO period to control the impact of recent market conditions which are excluded in the final offering price. To account for firm-level effects, this research included industrial technology dummies to control the level of technology (high, low and stable), following by Chandler's (1994) industry classifications. Finally, to account for macroeconomic factors which are not

[56] United States Census Bureau (http://www.census.gov/)

controlled by the above measures, this research used annual dummy variables in all regression analyses. Since the influences of annual dynamics have been controlled, this research did not include another set of dummy variables to control the impact of the internet bubble. The sectoral patenting trend was measured by the number of patents granted per year in each sector.

4.5 Results

4.5.1 Descriptive statistics

Table 19 shows the descriptive statistics for the sample of IPO firms. The mean of IPO underpricing is 25.16 percent. 87.4 percent of our sample conducted R&D and 50 percent filed patents prior to the IPO, which shows the importance of innovation for manufacturing firms. The means of R&D intensity and patent stocks were 5.07 percent and 18.38 respectively. In full sample, 25.5 percent of focal firms had effective alliance partners and the mean of partners' patent citations was 341.11 times. The average age of focal firms was 18-year old, average asset was 440.53 million dollars at the time of IPO. In addition, 55.7 percent of focal firms were backed by venture capitalists and their underwriters' average reputation score was 5.95. To further examine how the effects of R&D intensity and quality signals on IPO underpricing change in different contexts, we separated our sample into two groups based on the transparency of value appropriation: the complex product technology industries, where value transparency was low, and the discrete product technology industries, where value transparency was high.

Comparing the prominence of innovation in two groups, we found that the proportions of focal firms conducting R&D and filing patents prior to their IPOs were similar in both groups, but the mean of R&D intensity was greater in the group characterized by high

value transparency (8.1%) compared to the other group (4.12%). This pattern means that the level of innovation-based information asymmetry was higher in the discrete product technology industries. However, the average number of patents was higher in the complex product technology industries. This result is consistent with the real situation because complex product technology is comprised of many patentable elements. The proportion of ventures with alliance partners was not different between the two groups but the mean of partners' technological status was relatively higher in the discrete product technology industries (the average number of patent citations was 552.6) than that in the complex product technology industries (average number of patent citations, 275.65). In addition, comparing firm assets, firm size in the discrete product technology industries (914.8 million dollars) was larger than that of the other group (292.72 million dollars), but the average age of firms in the discrete product technology industries (12.97 years) was younger than the other (19.62 years).

Table 19 Descriptive statistics

Variables	Full samples		Discrete Product Industry		Complex Product Industry	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Underpricing [a]	25.16	0.54	12.53	0.31	29.07	0.59
R&D intensity	5.07	32.43	8.1	23.87	4.12	34.64
Patent Stock	18.38	213.16	11.98	38.44	20.36	243.01
Sectoral Patenting Trend [b]	12028.11	7812.34	9308.39	5778.3	12871.37	8164.9
Alliance partners' technological status [c]	341.11	2748	552.6	4989.23	275.65	1482.95
Assets [d]	440.53	2560.57	914.8	4488.16	292.72	1502.45
Age	18	106.43	12.97	21.97	19.62	121.71
Underwriter reputation	5.95	3.85	5.87	3.84	5.97	3.85
Hot markets	8.71	8.13	9.82	8.42	8.36	8
Lagged market returns [a]	0.07	0.01	0.05	0.01	0.07	0.01
Firms with R&D expenditures	87.4		87.9		87.2	
Firms with patent stocks	50		51.1		49.7	
Firms with effective alliance relationship(s) [a]	25.5		29.7		24.1	
Firms with announced alliance relationship(s	28.4		33.5		26.9	
Venture capital backing [a]	55.7		57.1		55.3	
Low-technology firms [a]	5.2		9.3		3.9	
Stable-technology firms [a]	11.6		12.1		11.4	
High-technology firms [a]	83.2		78.6		84.7	
Number of observations	770		182		588	

[a] Expressed as a percentage
[b] In the number of patents granted in each year
[c] The total number of patent citations
[d] In millions of dollars

In Table 20, we conducted bivariate correlations to further explore the relationships between variables. We found that the sectoral patenting trend was positively correlated with IPO underpricing, which means that IPO firms in the industry with a stronger patenting trend experienced more underpricing. Firm age was negatively correlated with IPO underpricing, suggesting that older firms were less underpriced. There was a positive correlation between underpricing and the measure of lagged market returns, which supports previous research which argues that offering prices did not fully reflect recent market situations (Logue, 1973; Loughran & Ritter, 2002). We also found a negative correlation between stable-technology and underpricing and a positive correlation between high-technology and underpricing. This result means that higher R&D expenditures correlate with a higher level of information asymmetries and uncertainty. In addition, the result also shows that venture capital backing and underwriter reputation were positively correlated with underpricing. This pattern means

that the role of venture capital is consistent with Lee and Wahal's finding (2004) and that agency problems of underwriters which Loughran and Ritter (2004) argued do exist.

The result also shows a negative correlation between R&D intensity and our measures of patent stocks and firm assets. However, the correlations between R&D expenses and these two measures ($r=0.299$, $p<0.001$ and $r=0.557$, $p<0.001$ respectively) and between sales and these two measures ($r=0.864$, $p<0.001$ and $r=0.244$, $p<0.001$ respectively) were positive. The correlation between R&D expenditure and firm sales was positive as well ($r=0.350$ $p<0.001$). In addition, even though the correlation between R&D expenditures and firm age was not significant, the coefficient was positive and the correlation between sales and firm age was positive ($r=0.327$, $p<0.001$). These patterns mean that firms with higher R&D expenditures or higher sales have more patents and larger or elderly firms have more R&D expenditures and sales. However, the increase in sales was higher than the increase in R&D expenditure. There was no significant correlation between R&D intensity and underpricing, patent stock and underpricing, and endorsing legitimacy and underpricing. In the next section, we further divided the sample into two groups to explore how the relationships change in different contexts. We expected that the roles of R&D intensity, patent stocks, and endorsing legitimacy would vary across industries.

Table 20 Bivariate correlations

	Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Underpricing														
2	R&D intensity	0.05													
3	Patent stock	-0.03	-0.06												
4	Number of alliance partners	-0.02	0.12 ***	0.19 ****											
5	Alliance partners' technological statu	0.02	0.09 ***	0.17 ****	0.61 ****										
6	Sectoral Patenting Trend	0.14 ****	-0.06	-0.01	-0.02	-0.03									
7	Assets	-0.04	-0.46 ****	0.30 ****	0.03	0.07 *	0.05								
8	Age	-0.11 ***	-0.28 ****	0.19 ****	0.00	-0.04	0.01	0.26 ****							
9	Hot markets	0.06	0.38 ****	-0.04	0.07	0.11 ***	-0.09 ***	-0.26 ****	-0.19 ****						
10	Low-technology firms	-0.04	-0.24 ****	0.02	-0.06	-0.05	-0.01	0.21 ****	0.15 ****	-0.21 ****					
11	Stable-technology firms	-0.09 *	-0.29 ****	0.10 ***	0.02	-0.06	0.02	0.22 ****	0.15 ****	-0.30 ****	-0.08 *				
12	High-technology firms	0.10 ***	0.40 ****	-0.10 ***	0.02	0.08 *	-0.01	-0.31 ****	-0.22 ****	0.38 ****	-0.52 ****	-0.81 ****			
13	Venture capital backing	0.13 ****	0.46 ****	0.03	0.09 ***	0.08 *	-0.02	-0.32 ****	-0.18 ****	0.29 ****	-0.16 ****	-0.28 ****	0.34 ****		
14	Underwriter reputation	0.01	-0.03	0.12 ***	0.10 ***	0.09 ***	-0.02	0.17 ****	0.06	0.04	-0.01	0.03	-0.02	0.02	
15	Lagged market returns	0.08 *	0.04	-0.07	0.02	0.00	0.02	0.01	-0.04	0.00	0.10 *	-0.03	-0.03	0.02	0.000

4.5.2 Empirical analysis

Table 21 shows the results of the OLS regression analysis in two groups. We started by estimating a model that shows the effect of control variables (Model 1). The result shows that in the discrete product technology industries, the asymmetry in the information about a firm's value or viability is relatively low; thus, most of the effects of control variables regarding IPO underpricing were not significant. In the complex product technology industries, we found that effect of venture capital backing was positive and significant, providing support for Lee and Wahal's findings (2004) which argue that VC-backed offerings were more underpriced. As with previous research, the result also shows that the effect of lagged market returns was positive and significant. Even though the effect of a hot market was not significant, the effect of hot markets could be encapsulated in the annual dummies. The result also showed no differences in the level of underpricing between low-technology, stable-technology, and high-technology groups. However, the absence of an effect of firm age and assets was surprising. The pattern suggests that relationships between information asymmetries, firm age, and assets have become more complicated in recent years; thus the result is different from previous research (Ibbotson et al., 1988; Megginson & Weiss, 1991). The absence of a negative underwriter reputation effect was unexpected. Nevertheless, to some extent, the positive effect is in line with Loughran and Ritter's (2004) agency hypothesis regarding the role of underwriters.

Table 21 Results of regression analysis of the IPO underpricing [a]

	Model 1		Model 2		Model 3	Model 4	Model 5
	Discrete Product	Complex product	Discrete Product	Complex product	Complex product	Complex product	Complex product
Intercept	-0.245	-0.618	-0.415	-0.779 **	-0.777 **	-0.764 **	-0.762 **
	(0.355)	(0.278)	(0.366)	(0.286)	(0.287)	(0.287)	(0.287)
Hot market	0.000	-0.003	-0.001	-0.004	-0.004	-0.004	-0.004
	(0.004)	(0.003)	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)
Technology dummy (Low technology)	-0.009	-0.019	0.026	-0.015	-0.015	-0.019	-0.018
	(0.101)	(0.122)	(0.104)	(0.122)	(0.122)	(0.122)	(0.123)
Technology dummy (High technology)	0.051	0.086	0.022	0.038	0.035	0.036	0.033
	(0.088)	(0.071)	(0.097)	(0.072)	(0.073)	(0.072)	(0.073)
Venture capital backing	-0.041	0.172 ***	-0.046	0.170 **	0.168 **	0.169 **	0.167 **
	(0.056)	(0.048)	(0.061)	(0.049)	(0.049)	(0.049)	(0.049)
Underwriter reputation	-0.012	0.001	-0.016 *	0.000	0.000	0.000	0.000
	(0.007)	(0.006)	(0.007)	(0.006)	(0.006)	(0.006)	(0.006)
Assets[b]	0.037 *	0.008	0.055 **	0.027	0.027	0.029	0.028
	(0.015)	(0.015)	(0.018)	(0.017)	(0.017)	(0.017)	(0.017)
Age[b]	-0.029	-0.019	-0.014	-0.013	-0.013	-0.013	-0.014
	(0.027)	(0.025)	(0.028)	(0.025)	(0.025)	(0.025)	(0.025)
Lagged market returns	-0.076	6.881 **	-0.758	7.902 **	7.830 **	7.910 **	7.832 **
	(2.914)	(2.570)	(3.038)	(2.575)	(2.588)	(2.581)	(2.594)
Sectoral patenting trend[b]	0.028	0.060 *	0.033	0.056 *	0.057 *	0.055 *	0.055 *
	(0.034)	-0.027	(0.034)	(0.027)	(0.027)	(0.027)	(0.027)
(R&D intensity+1)[b]			0.050	0.127 **	0.130 **	0.127 **	0.129 **
			(0.044)	(0.042)	(0.042)	(0.042)	(0.042)
(R&D intensity+1)[b] squared			-0.005	-0.013 **	-0.014 **	-0.013 **	-0.014 **
			(0.004)	(0.005)	(0.005)	(0.005)	(0.005)
(Patent stock+1)[b]			-0.044 *	-0.013	-0.030	-0.015	-0.028
			(0.020)	(0.017)	(0.033)	(0.017)	(0.033)
Effective alliance relationship dummy			0.062	-0.159 **	-0.165 **		
			(0.070)	(0.061)	(0.061)		
Announced alliance relationship dummy						-0.128 *	-0.130 *
						(0.060)	(0.060)
Alliances partners' technological status [b]			0.002	0.017	0.039	0.014	0.033
			(0.014)	(0.012)	(0.027)	(0.013)	(0.027)
(R&D intensity+1)[b] × (Patent stock+1)[b]					0.005		0.003
					(0.009)		(0.009)
(R&D intensity+1)[b] ×(Alliances partners' technological status+1)[b]					-0.006		-0.005
					(0.006)		(0.006)
Adjusted R2	0.131	0.274	0.145	0.288	0.287	0.285	0.284
F	2.362 **	12.075 ***	2.232 **	10.501 ***	9.740 ***	10.374 ***	9.607 ***
n	182	588	182	588	588	588	588

a Values are regression coefficients with standard errors in parentheses; all regressions include annual dummies.

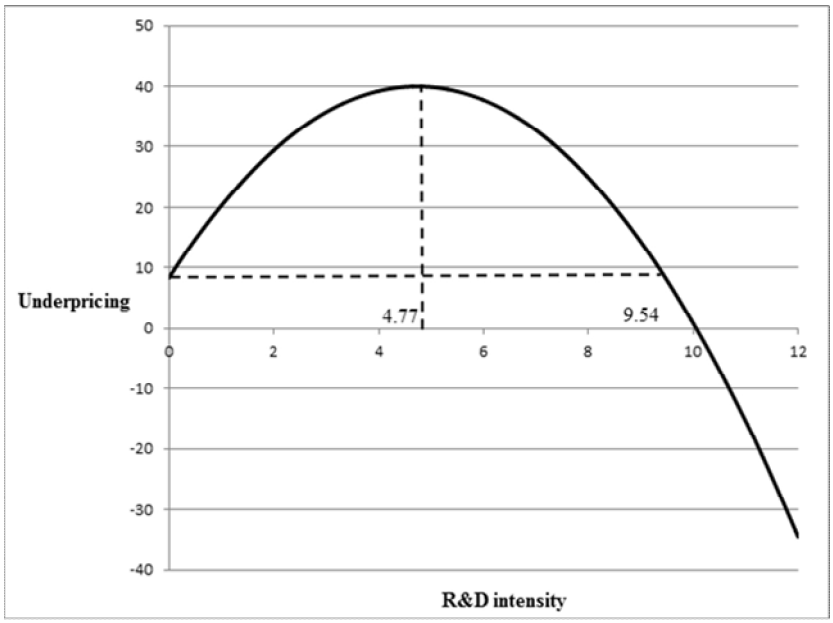
b Logarithm

c * p <.05 **p < .01 ***p < .001

In examining the effect of R&D intensity on IPO underpricing, we found a significant curvilinear effect in the complex product technology industries but no significant effect in the discrete product technology industries, meaning that the information asymmetry caused by R&D expenditure did not cause IPO underpricing in the industries with transparent links between innovation and value appropriation (Model 2). Figure 5 depicts the relationship between R&D intensity and IPO underpricing in the complex product technology industries. The absolute effect of R&D intensity on underpricing was positive until the level of R&D intensity reached 139.7 (ln [R&D intensity*100 +1] =9.54). In our sample, this value is above the 99th quantile in the R&D intensity distribution, meaning that the impact of R&D intensity on IPO underpricing is positive for most cases in the complex product technology industries in Model 2. According to the result of log-rank tests, the impact of R&D intensity on IPO underpricing is stronger in a complex product technology industry; thus, we found support for Hypothesis 1.

In looking at the effect of patent stocks, we found a significantly negative effect ($p < 0.05$) on reducing IPO underpricing in the discrete product technology industries but not in the complex product technology industries. The result of log-rant tests also shows that the impact of patent stock on reducing IPO underpricing is stronger in the discrete product technology industries. This result is qualified to support Hypothesis 2. Moreover, in Model 2, the result also revealed negative effect ($p < 0.05$) of endorsing legitimacy on IPO underpricing in the complex product technology industries but no significant effect in the discrete product technology industries, supporting Hypothesis 3a (the result of log-rank tests supported this hypothesis). Young ventures with endorsing legitimacy in the complex product technology industries can mitigate IPO underpricing.

Figure 5 Plot of regression slope for Underpricing against R&D intensity [a] in the complex product technology industries



[a] Underpricing is a percentage and R&D intensity is a logarithm

In Model 3, we examined the impacts of alliance partners' technological status on reducing IPO underpricing caused by high R&D expenditures in the complex product technology industries. We found no significant moderating effect of alliance partners' technological status; thus there is no support for Hypothesis 3c.

To examine the moderating impacts of alliance relationships on reducing underpricing caused by innovation-based information asymmetries in the complex product technology industries, we further separated the sample into two groups, one with alliance partners and one without alliance partners. For young ventures with alliance partners, Table 22 shows no support for the positive relationship between R&D intensity and IPO underpricing; whereas, for ventures without alliance partners, higher R&D intensity was a significant cause of their IPO underpricing (Model 7). Thus, this result supports Hypothesis 3b (the result of log-rank tests supported this hypothesis).

Table 22 The impact of alliance relationships on reducing underpricing which caused by high R&D expenditures in the complex product technology industries [a]

	Model 6		Model 7	
	With alliances	Without alliance:	With alliances	Without alliances
Intercept	-0.583	-0.663 *	-0.952	-0.844 *
	(0.562)	(0.317)	(0.642)	(0.325)
Hot market	0.001	-0.005	0.001	-0.005
	(0.006)	(0.004)	(0.006)	(0.004)
Technology dummy (Low technology)	-0.257	0.008	-0.160	0.027
	(0.349)	(0.133)	(0.356)	(0.132)
Technology dummy (High technology)	-0.015	0.111	-0.049	0.068
	(0.140)	(0.082)	(0.143)	(0.083)
Venture capital backing	0.120	0.210 ***	0.113	0.197 ***
	(0.097)	(0.056)	(0.097)	(0.058)
Underwriter reputation	0.026	-0.004	0.025 *	-0.006
	(0.011)	(0.006)	(0.011)	(0.006)
Assets[b]	-0.022	0.014	0.003	0.033
	(0.028)	(0.018)	(0.034)	(0.019)
Age[b]	0.019	-0.032	0.027	-0.032
	(0.059)	(0.027)	(0.059)	(0.027)
Lagged market returns	3.134	8.949 **	4.118	9.993 **
	(4.813)	(3.009)	(4.890)	(3.014)
Sectoral patenting trend[b]	0.043	0.067 *	0.046	0.062 *
	(0.051)	(0.031)	(0.051)	(0.031)
(R&D intensity+1)[b]			0.112	0.148 **
			(0.082)	(0.052)
(R&D intensity+1)[b] squared			-0.009	-0.017 **
			(0.008)	(0.006)
Adjusted R2	0.092	0.332	0.092	0.342
F	1.756 *	12.034 ***	1.677 *	11.484 ***
n	143	445	143	445

[a] Values are regression coefficients with standard errors in parentheses; all regressions include annual dummies.

[b] Logarithm

[c] * p <.05 **p < .01 ***p < .0001

4.5.3 Supplemental analysis

To investigate the effect of endorsing legitimacy further, we compared the impacts of effective alliances and announced alliances (parts of them were in the pending phrase). In Model 5 in Table 21, we found that both of them can significantly reduce IPO underpricing. Thus, the respective impacts of effective and announced alliances are no different.

4.6 Discussion and Conclusions

Previous research has established how information asymmetries cause IPO underpricing, especially because of the information gap resulting from high R&D

expenditures (Guo et al., 2006; Heeley et al., 2007). We have contributed to the further exploration of how the level of this innovation-based information asymmetry changes in different industrial contexts and eventually has a different impact on IPO underpricing. In addition to examining how the level of information asymmetries increases/decreases, we consider how to mitigate this underpricing by delivering positive quality signals (e.g., patent stocks and endorsing legitimacy).

Our results show the level of information asymmetries on IPO underpricing is context-dependent. In the discrete product technology industries, information asymmetries are reduced. Even though R&D expenditures increase, ventures' offering prices on their IPOs are not significantly discounted. In contrast, in the complex product industries, innovation activities increase the need for firm-specific information; thus, information asymmetries and underpricing increase. In looking at the impact of quality signals on bridging information gaps between corporate insiders and outsiders, we consider how investors actually render these signals in different contexts. Firstly, the signalling effect of patents is contingent on the transparency of innovations to value appropriation. In the discrete product technology industries, the value of one commercializable product consists of a relatively small innovation number (Levin et al., 1987) and the technologies applied in a discrete product technology market can usually be precisely transmitted across firms (Rycroft & Kash, 1999). Thus, in this case, increasing patenting is a signal of higher profit-earning potential and a strong safeguard of monopoly rent from innovation investments, which reduces information asymmetries associated with underpricing. Conversely, in the complex product technology industries, the value of patents is constrained by industrial appropriability regimes and the complexity of technologies. Because the quantity of knowledge on which a product relies is too large and diverse to be understood by an individual (Rycroft & Kash, 1999), it is difficult

to conceive of each innovation's usefulness in the future and to transfer technologies across firms. Due to the imperfect function of the market for technology, many technologies lack a predictable market (Kash & Kingston, 2001). Thus, even though patents are intermediate outputs of innovation, patenting is only linked with higher R&D expenditures and an absence of clear potential profits.

Secondly, this research introduces an institutional perspective to the debate. When the market for technology is imperfect (such as in a complex product technology industry), patents cannot guarantee a positive cash flow in the future. The importance of endorsing legitimacy, hence, becomes more prevalent for ventures. Affiliations communicate the positive information by showing that ventures are able to access more resources which increase their survival prospects and growth opportunities (Reuer & Tong, 2010; Singh & Mitchell, 2005). Thus, in this case, signalling legitimacy can help young ventures to convince investors about their earning potential. Moreover, effective alliances and announced alliances deliver the same positive information to the investment community. Even though parts of announced alliances will not turn out to be a real cooperation, the announcements are strong enough to increase IPO market evaluations of a venture's value.

In examining the moderating impacts of quality signals, including alliance affiliations and alliance partners' technological status on reducing IPO underpricing caused by high R&D investments, young ventures' affiliations do establish confidence about their quality and significantly reduce innovation-based information asymmetries. However, we do not find significant support for the effect of partners' technological status. The possible reason is that only a very small portion of ventures' partners have patent citations (only 17.5% in the full sample and 15.6% in the group characterized as forming a complex product technology industry). Therefore, the sample size is too small to analyse the impact of partners'

technological status on reducing innovation-based information asymmetries. Besides, some alliances were built to create new technologies or products (e.g., exploration alliances); while some alliances were used to refine existing technologies and products (e.g., exploitation alliances) (Rothaermel, 2001). Exploitation alliances focus on coupling one firm's technology with the complementary assets (e.g., distribution, manufacturing) of a partner to extend the scope of an existing technology; thus, those partners (e.g., distributors) might not have high technology status (Levitas & McFadyen, 2009). However, because our data is across industries, our data set cannot distinguish alliances into exploration alliances and exploitation alliances.

In considering endogenous bias, one criticism might be that high quality ventures normally experience less underpricing because of their intrinsic quality, not because of the effects of quality signals such as endorsing legitimacy which ventures reveal to investors. However, previous research has confirmed that underpricing is also one of the quality signals for high quality ventures to distinguish themselves from poor competitors (Allen & Faulhaber, 1989; Garfinkel, 1993). Information asymmetries do exist in the IPO market. Low quality ventures usually imitate all the strategies which high quality ventures use to beautify their value. Underpricing is the only signal which is too costly for low quality ventures to mimic. Good ventures are confident in their growth prospects which will be at least partly revealed in the future; thus, they know that a loss on the IPO market can be recouped after their performance is realized. In contrast, the managers of low quality ventures know that they cannot recoup the initial loss at some future date, so they cannot afford to use this signal. In other words, if high quality ventures cannot find a better signalling proxy to differentiate themselves from low quality competitors, underpricing is one option for them to attract the investment community. Therefore, an endogeneity problem does not exist.

This research contributes to information asymmetry theory in two ways. Firstly, we introduce institutional theory to the debate. In the IPO market, underpricing is not the only way for firms to induce investors. Previous research overlooked the impact of institutional factors. The endowment of legitimacy is a critical quality signal for young ventures, especially for high-tech IPOs to increase investors' assessments of their value. Secondly, we contextualize information asymmetry theory in different appropriability regimes. The level of information asymmetries in IPO markets is not uniform across industrial contexts. In the industries with a transparent link between innovations and value creation, the level of information asymmetry, proxied by the R&D expenditures of those ventures, does not have a negative impact on IPO underpricing. Therefore, the judgment of value creation from innovation is only meaningful within a context.

Our results also extend institutional theory by considering how evaluators actually render legitimacy and by showing how this theory contributes most to our understanding of firm behaviour in the absence of well-functioning markets (such as the market for technology). Previous literature focussed mostly on how a firm establishes its legitimacy in terms of increasing its survival prospects. However, from this point of view, evaluators, thus, only play passive roles and are placed on the receiving end of discourse. This research considers evaluators' active cognitive processing and how their evaluations of an IPO firm change because of the quality signals they receive. In addition, our results show the function of institutional factors when the market for technology is imperfect. Endorsing legitimacy serves as an important proxy to mitigate information asymmetries and makes the market for technology a potential option for investors.

CHAPTER 5 - CONCLUSION

This dissertation examines the emergence of opportunities, the early development of new ventures, and the legitimation strategies of young ventures to gain resources from targeted resource-holders. In this investigation, I contextualise the entrepreneurship process, thereby unpacking the micro-foundations of entrepreneurial actions and new ventures' investor communications through quality signals to finance their growth path.

5.1 Review and Focus

Entrepreneurial actions are complex and include considerable variation in the process associated with these actions and their outcomes (Iversen, Jørgensen, & Malchow-Møller, 2008). This implies that entrepreneurship research needs a richer set of indicators of these variables to reflect the complexity of the entrepreneurial activities, including differences in entrepreneurial motives, multidimensionality of the entrepreneurial process itself, diverse decision making processes, etc. (Zahra & Wright, 2011). In the past couple of decades, abundant empirical studies based on either an economic or a psychology perspective have been conducted. Research based on different theoretical foundations (e.g., an economic perspective or a psychology perspective) applies different definitions of entrepreneurship and measures to tackle different issues associated with entrepreneurship (Westhead et al., 2011). However, the studies of the associations between different measures have been minimal. Entrepreneurship has been long conceptualized as a process (Bhave, 1994; Davidsson, 2003; Gartner, 1985, 1990), including one's cognitive process of opportunity identification, judgment decisions about opportunities (Choi & Shepherd, 2004; Gruber et al., 2008, 2013; McMullen & Shepherd, 2006), and entrepreneurial actions to exploit opportunities (Autio et al., 2013; Minniti & Bygrave, 2001). Both psychological cognition and economic concerns are part of entrepreneurship. The dialogues between psychology-based and economics-based

entrepreneurship research is necessary to enrich the understandings of entrepreneurship. Extant research has not yet paid sufficient attention to the types and variety of opportunities that entrepreneurs might recognize through a single discovery (Dimov, 2011), the way that entrepreneurs motivated by different entrepreneurial determinants organize their firms or apply new business models to exploit opportunities (George & Bock, 2011), how the entrepreneurship process changes in different contexts, and the micro-foundations of entrepreneurship (Zahra & Wright, 2011).

In addition, even though contextual influences on entrepreneurial actions have long been acknowledged (Aldrich, 1999; Aldrich & Fiol, 1994; Welter, 2011), research on entrepreneurial behaviours tends to provide "general laws" of entrepreneurship (Autio et al., 2014; Hjorth et al., 2008; Zahra & Wright, 2011). Overlooking contextual impacts empirically contradicts the widespread conceptual recognition of the importance of studying the context of entrepreneurial activities. Salience of research questions, theoretical merits of an argument, and the identification of casual relationships are usually context-specific (Van de Ven, 2007). Rather than treating contextual issues as a control variable, researchers may enrich the findings of entrepreneurship studies by including contexts into the story. Besides, environmental contingencies not only determine the entrepreneurship process but also the growth path of ventures. Current research has highlighted how resources endowments are related to venture growth (Clarysse, Wright, et al., 2011; Ensley et al., 2002; Heirman & Clarysse, 2004; Hindle & Yencken, 2004) but pays less attention to how ventures grow (McKelvie & Wiklund, 2010) and how contextual issues influence the configuration of resources (Clarysse, Bruneel, et al., 2011; Dess & Beard, 1984).

In this dissertation I distinguish the contextual influences on the entrepreneurship process between effects on entry behaviours and effects on post-entry behaviours (Autio et al.,

2013). The most general motivation of this dissertation was to develop process theories of entrepreneurship in particular on:

1. Entry behaviours – The impacts of entrepreneurial determinants on the decision making associated with entrepreneurial tasks
2. Post-entry behaviours – the micro-foundations of entrepreneurial phenomena and new venture legitimation strategies to gain resources

5.2 Findings

5.2.1 Entry behaviour – The impacts of entrepreneurial determinants on the decision making associated with entrepreneurial tasks

Chapter 2 addresses research focus 1: How the variance in entrepreneurial determinants influences entrepreneurs' cognitive-processes to approach different entrepreneurial opportunities. This question aims to fill in the gap that what specific mental connections are influential in spurring a certain type of opportunity idea in the first place. To explore this question, I integrate research about the nature of entrepreneurial opportunities with cognitive research and focus on two opportunity characteristics – the superficial and the structural similarities between new ventures' current technology and market knowledge and the knowledge required in a target market where they will operate.

Our findings illustrate three types of entrepreneurial determinants – technology-driven, operation-driven, and user-driven determinants – which direct the process of opportunity recognition. Ventures driven by technology aimed to look for a new market to exploit current technologies; ventures driven either by the founders' past operational experiences or personal frustration in using current products were looking for a technical solution to satisfy unmet needs in a particular market (in this case, the mHealth market). Technology-driven ventures

used their current technologies as a basis to search opportunities. As such, the opportunities they pursued usually had high technology similarities with their current knowledge. In addition, to avoid operating their new business from scratch, they preferred opportunities with at least a medium level of structural similarities in terms of market knowledge. Operation-driven ventures were established to solve the problems found in their founders' past careers. Therefore, the opportunities they pursued tended to have high technology and market similarities with their prior knowledge and their prior knowledge helped them to evaluate the feasibility of the opportunities. User-driven ventures were established because of their founders' dissatisfaction with current products. This entrepreneurial determinant directed their attention to solve the problems they faced even if these tasks had no obvious connection with their prior knowledge. In addition, they tended to generalized market demands from their own needs and relied on their knowledgeable peers to evaluate technological feasibility of the opportunities they targeted.

5.2.2 Entry and post-entry behaviour

The micro-foundations of entrepreneurial phenomena

Chapter 3 addresses research focus 2-1 and 2-2: how entrepreneurs come up with entrepreneurial ideas and how entrepreneurial behaviours conducted in one phase impact on entrepreneurial behaviours in the next phase, which eventually turns an idea to a real business. These questions aim at filling the research gap in the lack of an integral study to unpack the micro-foundations of entrepreneurial phenomena to turn opportunity ideas to real business. To explore this question, we contextualized entrepreneurship in a particular market setting to know how entrepreneurs identify opportunities and how their ventures exploit opportunities.

Our findings unpack empirically the influences of entrepreneurial determinants for new firm creation to opportunity identification and opportunity exploitation. In an almost

homogeneous environment, entrepreneurs with different entrepreneurial determinants take different paths to identify opportunities. Three of the seven ventures in our sample can be labelled as “technology-driven ventures”. They start with a particular technical prototype and only exploit opportunities after rigorous opportunity search and evaluation. Therefore, their entrepreneurship process is more like a planned behaviour (search-evaluation-exploitation). In contrast, four of the seven ventures in our study begin with a perception of unmet needs in a particular market. Two of them are motivated by founders' operational experience and two are motivated by founders' personal frustration in searching for a satisfactory product. We label them as “operation-driven ventures” and "user-driven ventures" respectively. Both of them focus on the search for a technical solution to solve a particular problem their founders observed, e.g. by using mobile technology. The entrepreneurs of these four ventures had a very clear goal in mind before they started their companies such that they do little market research and have few interactions with customers in their “first” product development. In this case, related market experiences and knowledge become critical. In addition, our results indicate the impacts of entrepreneurial determinants on new ventures' resource application strategies. Entrepreneurs starting with different entrepreneurial determinants have different mindset to exploit opportunities, which direct their attention to apply particular resources and eventually leads to different exploitation modes (e.g., pivoting, diversification, business model refining).

New venture legitimation strategies to gain resources

Chapter 4 addresses research focus 3-1: How the signalling of patent stocks and endorsing legitimacy affects a venture’s IPO price when taking into account the level of information asymmetry and research focus 3-2: How the appropriability regime of the industry in which the venture operates moderates the importance of patent stocks and

endorsing legitimacy. These questions aim at filling the research gap in that current research pays less attention to the impact of quality signals (patent stocks, and endorsing legitimacy) on mitigating the underpricing caused by innovation-based information asymmetries in different appropriability regimes and how public investors actually render the information delivered by those quality signals.

Empirical results from a sample of 770 IPOs issued by manufacturing firms during 1995-2006 support the hypothesis that the link between R&D expenditures and value appropriation plays a more important role than initially thought. In industries with a tight appropriability regime, the level of innovation-based information asymmetry does not even have a negative impact on IPO underpricing and a venture's patent stock is an effective quality signal to mitigate public investors' doubt of the venture's future prospects. In contrast, when the transparency of innovations to future returns is unclear, affiliations are more prevalent in serving as a credible and observable signal for the investment community to make an accurate assessment of firm value.

5.3 Contributions

This dissertation developed process theories of entrepreneurship by unpacking the interrelationships between entrepreneurial decisions made in different phases of entrepreneurship process and by bridging economics-based and psychology-based research on entrepreneurship. This dissertation reveals how entrepreneurial determinants affect new ventures' occupational choices and their attitude toward risks. I also integrate psychological and economic concerns of entrepreneurship to investigate their combining impacts on new ventures' decision making and entrepreneurial actions to exploit opportunity. In addition, I further investigate how environmental contingencies determine ventures' growth path and how ventures finance their innovation.

Firstly, this dissertation contributes to the theory of entrepreneurial cognition by showing how different cognitive frameworks and varying entrepreneurial determinants lead to different entrepreneurial decisions. Opportunity identification is not simply the result of alertness and connecting dots but a reflection of people's situated cognition (Haynie, Shepherd, Mosakowski, & Earley, 2010). I revisit the role of entrepreneurial determinants and indicate three entrepreneurial determinants for new firm creation and how different determinants lead to different processes of opportunity recognition and evaluation. In addition, we integrate cognitive research with the nature of entrepreneurial opportunities to show how different entrepreneurial determinants eventually lead new ventures to pursue opportunities with different levels of similarities with their current knowledge.

Secondly, this dissertation contributes to theories of the evolving entrepreneurial process and micro-foundations by investigating empirically the interrelationships between entrepreneurs' decisions made in each phase of the entrepreneurial process and the entrepreneurial actions conducted in the next phases, which eventually leads new ventures exploit opportunities in diverse ways.

Thirdly, our research bridges entrepreneurial theories with strategy and organizational theories. Our results show that founding decisions have lasting effects on shaping the ventures' evolution to generate innovative possibilities, which explains the inter-firm differences in the strategies of their business development. In addition, our research enriches the knowledge on the factors determining one's subjective perception of selecting particular resources to develop a new product. We associate the literature of competence-based new product innovation and the literature of opportunity identification and further consider the role of entrepreneurial determinants in the interrelationships between opportunity identification, resource application, and new product innovation.

Fourthly, this dissertation shows the impacts of the industrial, technological, and institutional contexts on the innovation development of young ventures by showing how institutional pressure forces pre-IPO firms, especially firms with high R&D expenditures, to conform to expected structures and behaviours as the mechanism to gain legitimacy. Also I indicate the impact of appropriability regimes on young ventures' strategic choices to finance their growth path. In addition, this dissertation further considers the interactions between young ventures and external parties. By targeting one of the external parties, public investor communities, this dissertation illustrates how ventures interact and communicate with external societies through quality signals to gain necessary resources and how signals revivers actually render the information that young ventures deliver.

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