Minor Thesis – Research Project (25pts ISYS90044)

A secure innovation process for start-ups: Minimising knowledge leakage and protecting IP

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Abstract

Failing to profit from innovations as a result of knowledge leakage is a key business risk for high-tech start-ups. Innovation is central to the success of a start-up and their competitive advantage in the market place therefore methods to protect intellectual property (IP) and minimise knowledge leakage is crucial. However, high-tech start-ups have limited resources rendering them more vulnerable to knowledge leakage risks compared to mature enterprises. Unfortunately, research on knowledge leakage and innovation processes falls short of addressing the needs of high-tech start-ups. Since knowledge leakage can occur in a number of ways involving many scenarios, organisations typically employ a variety of IP protection and knowledge leakage mitigation methods to minimise the risks. This minor thesis fills the research gaps on innovation processes and knowledge leakage for start-ups. A literature review was conducted into the bodies of research on knowledge leakage and innovation. Following the literature review, a secure innovation process (SIP) model was developed from the research. SIP includes the concept of the risk window which allows a start-up to identify, assess and manage knowledge leakage risks at various stages in the innovation process.

Key Words: entrepreneurship, innovation, information security, knowledge leakage, start-ups

Declaration

I certify that

- this thesis does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any university; and that to the best of my knowledge and belief it does not contain any material previously published or written by another person where due reference is not made in the text
- where necessary I have received clearance for this research from the University's Ethics Committee (Approval Number: N/A) and have submitted all required data to the Department
- the thesis is 8,267 words in length (excluding text in images, table, bibliographies and appendices)

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Sam Pitruzzello (613945)

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To my wife and daughter for their love, patience, understanding and enduring support.

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1.0 Introduction

Entrepreneurship is challenging, innovating is difficult and starting a new business venture is highly risky. A core business risk for start-ups, more so than mature enterprises, is failing to profit from their innovation as a result of knowledge leakage. Since innovation is central to the success of commercial organisations and their competitive advantage in the market place, putting in place methods to protect intellectual property (IP) and minimise knowledge leakage is crucial (Blank, 2013; Denning and Dunham, 2006; Park, 2005; Van de Ven et al, 1984). While large firms go to great lengths to protect their IP and have the available resources to do so, start-ups are not as fortunate. The dilemma of limited resources suggests that start-ups are more vulnerable to knowledge leakage. Start-ups also need to clearly understand the risks of failing to adequately protect their innovations and minimise knowledge leakage during the innovation process (Amara et al., 2008; Hsu, 2006; Olander, et al., 2011; Park, 2005). Since many disruptive innovations have emerged from entrepreneurial high-tech start-ups and failure rates are high, more research is needed into appropriate processes and methods that can assist start-ups to successfully and securely innovate (Denning and Dunham, 2006; Hsu, 2006; Park, 2005; Van de Ven, 2005).

While there is ample research on innovation, the discourse is either of a general nature or relates to large mature organisations. This also applies to research on knowledge leakage. The research on knowledge leakage and innovation processes falls short of addressing the specific needs and impacts of these important risks and issues on the high-tech start-up (Niammuad et al., 2014; Park, 2005; Teece, 1986; Van de Ven et al., 1984). Furthermore, there is little research on how knowledge leakage risks change during the innovation process.

Knowledge leakage and failure to adequately protect organisational intellectual property (IP) can negatively impact the prospects of a start-up and limit their ability to adequately profit from innovations (Olander, et al., 2011; Teece, 1984). Knowledge leakage can occur in a number of ways from staff inadvertently or intentionally divulging knowledge to outsiders, employee turn-over where staff move on to work with competitors and collaboration with external organisations (Ahmad, et al., 2014; Shedden et al., 2016; Olander, et al., 2011). IP theft, industrial espionage and imitation are other methods used by competitors to access a firm's innovations and offer competing solutions in the market (Amara et al., 2008; Snyder and Crescenzi, 2009). IP protection methods are employed to minimise knowledge leakage. Amara, et al. (2008) and Olander, et al. (2011) suggest there are two types of IP protection methods – formal and informal. Formal methods involve legal constructs and include patents, copyright, trademarks, registration of design patterns and confidentiality agreements. Informal protection methods cannot be protected through legislation and include trade secrets, complexity of design and lead-time advantages.

This minor thesis fills the research gaps on innovation processes and knowledge leakage relating to start-ups by answering two key research questions:

1) What process should entrepreneurial high-tech start-ups engage to securely develop their innovations?

2) How should high-tech start-ups manage the knowledge leakage risks and protect IP at various stages during the innovation process?

This minor thesis consists of two main parts. The first is a literature review on the bodies of research around knowledge leakage and innovation. Following the literature review, a secure innovation process (SIP) model was developed. This was achieved by applying a set of knowledge leakage and IP Protection criteria to a general innovation process derived from the knowledge leakage and innovation research.

2.0 Research Methodology

Most of the research on innovation largely ignores the role played by entrepreneurial high-tech start-ups in industry. This changed with the dawn of the new millennium. Search results of "Entrepreneurial start-ups and innovation" yielded over 250 results between 1984 and 2015. When the search was restricted between the years 2000 to 2015, 243 papers were listed, 95% of which were written since the 1980's. The research in this minor thesis focused on: a) seminal works on technology innovation, b) research on innovation in start-ups and c) research on knowledge leakage and the protection of IP. A broad range of topics are covered including information systems, information technology, information security, innovation and entrepreneurship.

A variety of databases such as ACM Digital Library, Compendex and Scopus were used for computing and information systems research. In addition, University of Melbourne's Discovery (EBSCO) tool was used to find research in broader areas such as business, management and entrepreneurship. In order to focus the research on relevant papers, the search terms used included: Entrepreneurial start-ups and innovation, innovation models, innovation in start-ups, how firms innovate, innovation processes, commercialization of innovation, commercialization of technology, knowledge leakage, knowledge leakage in start-ups, innovation knowledge leakage, innovation and information security. Over 160 papers were found as a result of the searches. The papers were scanned by reviewing their titles and abstracts and focusing only on quality journals. This reduced the number of papers to just over 65. Each one was downloaded, scanned and checked for further relevance.

Papers on knowledge leakage and information security were also sourced from Manhart and Thalmann's (2015) literature review on knowledge protection. The reference list was checked for papers which covered knowledge leakage and information security in start-up organisations by using a two-step process. First, the titles of each reference in quality journals were checked for key words including information security, protection or knowledge leakage AND start-up, entrepreneur, innovation, small business and SME. This narrowed the number of papers down to seven (7). Each paper was then downloaded, scanned and checked for relevance. The result from the literature search yielded a total of 72 papers. Each paper was downloaded for review and 48 are cited in this minor thesis research project.

Two bodies of research, knowledge leakage and innovation processes, were covered independently in the literature review. The focus of knowledge leakage research was to determine what methods are used to minimise knowledge leakage and protect IP. These methods were constructed into a set of knowledge leakage mitigation methods and applied to a general innovation process model. The general innovation process model was developed from the innovation literature. The result is a new secure innovation process (SIP) model that can be used by start-ups to assist them to manage knowledge leakage risks as they go through the process of innovation.

3.0 Literature Review

The literature review focused on two bodies of research in order to answer the research questions. Since this minor thesis focuses on the impact of knowledge leakage on high-tech start-ups and how it affects their prospects for successful innovation, the initial aim was to find research on knowledge leakage and innovation processes that apply to high-tech start-ups. However, it was found that there was little research on the risks and impacts of knowledge leakage on innovation with respect to start-ups. Therefore, independent research was conducted on knowledge leakage and innovation in general.

3.1 Knowledge leakage

Knowledge leakage is not information leakage. Ahmad, et al. (2014, p. 27) suggest that information can leak through unknown channels so information leakage is a concern for organisations and how they manage information (Ahmad and Ruighaver, 2005). However, knowledge is more than information and can be described as the "fluid mix of framed experiences, values, contextual information and expert insight" (Ahmad, et al., 2014). Knowledge consists of explicit and tacit knowledge, the former which can be codified and stored in an organisation's information systems, documents and records while the latter is difficult to codify and resides in the minds of people. Tacit knowledge mainly consists of a person's 'know-how' in terms of how they go about their work with the added complication and difficulty of being able to explain and communicate that knowledge (Ahmad, et al., 2014; Shedden et al., 2011; Olander, et al., 2011).

3.1.1 The impact of knowledge leakage

Knowledge leakage and the failure to protect organisational IP can have negative impacts on an organisation. Impacts include loss of revenue due to the replication of the innovation by competitors, reputational damage and legal costs to mount an IP protection defence (Ahmad, et al., 2014; Manhart and Thalmann, 2015). This can lead to the firm failing to profit from their innovation and weaken their competitive position in the market place (Olander, et al., 2011; Teece, 1984).

Knowledge leakage occurs in a number of ways. First, staff may inadvertently or intentionally divulge knowledge to outsiders. Employee turn-over and staff leaving to work for competitor firms also raises the risks of knowledge leakage (Ahmad, et al., 2014; Olander, et al., 2011). Collaboration and partnerships with external organisations, especially those that operate in similar markets and with the same market objectives also poses knowledge leakage risks (Ahmad, et al., 2014; Shedden, et al., 2016; Norman, 2004; Olander, et al., 2011). Finally, IP theft and loss through industrial espionage and imitation (including reverse engineering) are methods used by competitors to access a firm's innovations with the intention of releasing competing offerings in the market to gain profits (Amara et al., 2008; Snyder and Crescenzi, 2009).

3.1.2 Minimising knowledge leakage

IP protection methods are employed to minimise knowledge leakage. IP is defined as "the creation, ownership and control of original ideas as well as the representation of those ideas." (Whitman and Mattord, 2014, p. 52). According to Amara et al. (2008) and Olander, et al. (2011), there are two types of IP protection methods – formal and informal. Formal methods involve legal constructs and include patents, copyright, trademarks, registration of design patterns and confidentiality agreements.

Legislation generally does not exist for informal IP protection methods. Therefore firms tend to build protection into their innovation and commercialisation processes by implementing informal protection methods which include trade secrets, complexity of design and lead-time advantages.

Amara et al. (2008) and Brouwer and Kleinknecht (1999) conducted separate research studies to determine what IP protection measures firms employed. Amara et al's (2008) research focused on knowledge based service firms while Brouwer and Kleinknecht's (1999) research was more general in terms of industries and covered the measures employed by organisations to protect their innovation from imitation. While there are a common set of IP protection measures in each author's research, namely patents, trademarks, copyrights, secrecy, design complexity and lead-time advantages, there were also differences. Brouwer and Kleinknecht (1999) highlighted keeping qualified people in the firm and certification by standard bodies as other means to protect IP and Amara et al. (2008) considered design pattern registration and confidentiality agreements.

Amara et al. (2008, p. 1532) present a table or matrix (refer to table 1 below) which allows an assessment of the IP protection measures an organisation should consider based on the nature of their innovation output with the type of knowledge inputs into the innovation. Amara et al. (2008) refer to two variables in their model – the level of output tangibility of the innovation and the level of knowledge codification. Once a firm understands the nature of their innovation with respect to these two variables, they simply determine which quadrant their innovation sits and consider the IP protection methods recommended in the relevant quadrant. For example, innovations with high levels of codified knowledge and an intangible output are best served by implementing copyrights as a primary protection mechanism complemented with trademarks and confidentiality agreements (quadrant 2). Examples of innovations with intangible outputs include consulting services, some software services in particular cloud-based services and other professional services. Tangible innovations include products that come in the form of hardware, software embedded in hardware devices and industrial software applications that perform automated or semi-automated tasks. In general, tangible innovations are expressed in the form of products while intangible innovations are delivered as services.

Level of knowledge codification	Level of output tangibility	
	Tangible	**Intangible**
Codified	1. Patents as primary mechanism complemented with copyrights, trademarks and confidentiality agreements	2. Copyrights as primary mechanism complemented with trademarks and confidentiality agreements
Tacit	3. Informal protection mechanisms such as secrecy, complexity of design, lead-time advantage on competitors complemented with confidentiality agreements and trademarks	4. Trademarks as primary mechanism complemented with secrecy, lead-time advantage on competitors and confidentiality agreements

Amara et al. (2008, p. 1532)

Table 1: Knowledge regimes and appropriability of benefits

Olander, et al. (2011) extends knowledge protection beyond the formal and informal methods. The authors suggest that organisations, especially start-ups with fewer resources available for formal knowledge protection methods, need to focus on human resource activities to minimise knowledge leakage. Ahmad, et al. (2014) and Brouwer and Kleinknecht (1999) support this view. Olander, et al. (2011) claims that protecting knowledge assets begins with recruitment by selecting the right employees. The organisation needs to ensure that all employees are trained and educated on information security practices and how to appropriately manage and protect organisational knowledge.

As the firm grows, engages more with external firms and begins sharing its innovation more broadly in the community, knowledge flows into and out of the organisation need to be monitored more closely (Ahmad, et al., 2014; Olander, et al., 2011). Norman (2004) and Olander, et al. (2011) also suggests that codified knowledge needs to be captured in organisational information systems and tacit knowledge should be diffused by encouraging informal communication between employees.

In summary, research highlights that knowledge leakage is a concern for firms, especially high-tech start-ups embarking on developing innovations to gain profits and obtain a competitive market position. The next section focuses on innovation in general and the various innovation models and processes that have been developed over time.

3.2 Innovation models and processes

Park (2005, p. 744) defines innovation as "the combination of technology with market need to create a profitable opportunity." Denning (2004, p. 15) offers an alternative perspective on innovation and defines it "…to mean the adoption of a new practice in a community. Innovation is therefore a social transformation in a community." Innovation, particularly when it is generated by high-tech start-ups, is closely linked to entrepreneurship. Freeman and Engel (2007, p. 101) define entrepreneurship as the process of starting a new business venture and claim that start-ups are entrepreneurial ventures which focus on technology or business innovation that have the potential for fast and high growth.

Innovation can be view from two perspectives. The first is the adoption or diffusion of an innovation by individuals, organisations or society (Christensen and Rosenbloom, 1995; Rogers, 1962; Rogers, 2003) and the second is the creation of innovation by firms by commercialising new technologies for profit and competitive advantage (Abernathy and Utterback, 1978; Barney, 1991; Teece, 1986; Tushman and Anderson, 1986). Innovation research during the 1980's and 1990's can be classified into three broad areas: technology life-cycle and disruptive innovation, the resource-based view (RBV) of the firm and archetypes of technology adoption (Abernathy and Utterback, 1978; Anderson and Tushman, 1990; Barney, 1991; Christensen and Rosenbloom, 1995; Rogers, 1962; Rogers, 2003; Teece, 1986; Tushman and Anderson, 1986; Tushman and Rosenkopf, 1992; von Hippel, 1986).

Since the turn of the century, innovation research shifted in two ways. First, there were disputes on the completeness and applicability of the technology life-cycle and RBV models. Some critics claim that these models don't have predictive power in determining which innovations will be successful and the importance of business models were largely ignored (Danneels, 2004; Teece, 2006). Some authors defended their positions (Christensen, 2006) while others improved their theories and models (Teece, 2006; Teece, 2010). Secondly, there was more focus on start-ups and entrepreneurship with a sharp increase in research covering the role that entrepreneurs and start-ups play in disrupting industries and shaping economies (Blank, 2013; Chesbrough and Rosenbloom, 2002; Freeman and Engel, 2007; Weiblen and Chesbrough, 2015).

Innovation models can be structured in two ways – as a static model or a process model. A static model presents a 'what to do' approach while a process model provides a methodology or a 'how to' solution. Innovation research over the last fifteen years covered static models such as spin-offs and business models (Andersson et al., 2012; Casadesus-Masanell and Zhu, 2013; Chesbrough, 2010; Chesbrough and Rosenbloom, 2002; Christensen, 1997; DaSilva et al., 2013; O'Reilly et al., 2009; Teece, 2010). The literature covered a broader range of innovation process models including the lean start-up (Blank, 2013; Reis, 2011), opportunity recognition (Lyytinen and Rose, 2003; Niammuad et al. 2014; Park, 2005), innovation networks (Rehm et al., 2016; Van de Ven, 2005; Weiblen and Chesbrough, 2015) and the venture capital (VC) driven start-up (Freeman and Engel, 2007; Hsu, 2006). In addition, there is research into the entrepreneurial qualities and practices required for successful innovation (Denning, 2006; Denning, 2007; Denning and Dunham, 2006; Park, 2005).

To answer the first research question, 'What process should entrepreneurial high-tech start-ups engage to securely develop their innovations?' the focus needs to be on innovation processes rather than static models. The research suggests that the most common innovation processes are entrepreneurial practices, opportunity recognition, the lean start-up, innovation networks and VC driven start-ups. Each of these processes will be examined in further detail in the following sections.

3.2.1 Foundational practices for entrepreneurs

Denning (2004) and Van de Ven et al. (1984) claim that innovation is a core competence, changes practices in communities and can be learned. Denning and Dunham (2006) propose a seven stage framework which can guide entrepreneurs through the innovation process. The author's argue that each component in the framework is a personal foundational practice which needs to be mastered. Figure 1 below illustrates Denning and Dunham's model.

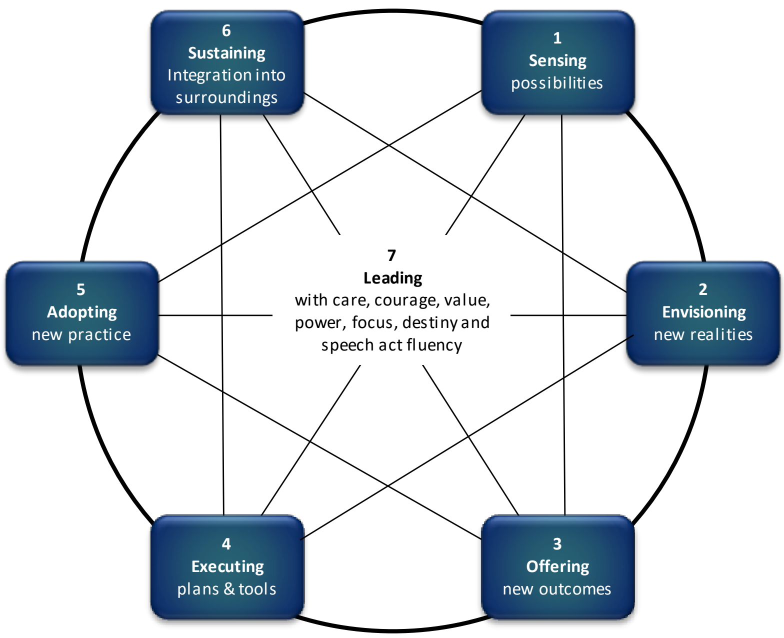

Figure 1 – Seven stage innovation process model (Denning and Dunham, 2006)

3.2.2 Opportunity recognition

According to Park (2005), opportunity recognition has emerged as a field of entrepreneurship in its own right. Opportunity recognition requires entrepreneurs to continually look for opportunities and understand their market potential (Niammuad et al., 2014; Park, 2005). Denning and Dunham (2006) and Lyytinen and Rose (2003) also suggest that innovators need to scan the environment for emerging technologies and changing trends. This requires a deep understanding of how to apply technology to meet the needs of society and address behavioural changes towards new technology. Park (2005) proposes a three component process model which includes entrepreneurial qualities (skills, knowledge, risk tolerance and experience), knowledge and experience of the firm and technology. Each process component interacts organically resulting in an innovation. Park's (2005) model is an extension of Cohen and Levinthal (1990) concept of absorptive capacity which is the ability for people and organisations to recognise and exploit new information, understand its potential value and assimilate it to successfully innovate. Figure 2 below illustrates Park's (2005) opportunity recognition process model.

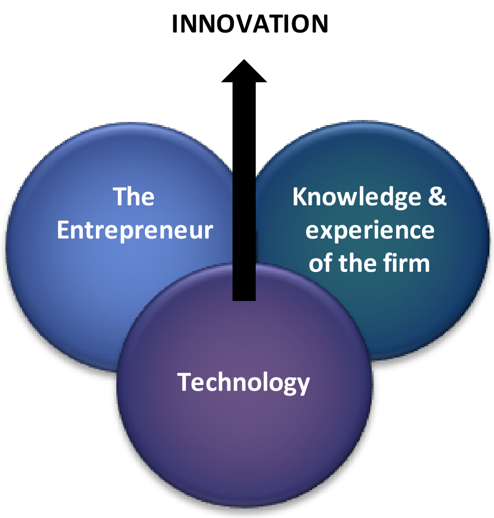

Figure 2 – A model for opportunity recognition processes (Park, 2005, p. 747)

While the descriptions of each process component are detailed and well researched, the model is simplistic. It also doesn't cover the role of funding in start-ups (Freeman and Engel, 2007; Hsu, 2006), the importance of market testing the innovation (Blank, 2013; Reis, 2011) and the idea of establishing business networks. Business networking, commonly referred to innovation networking in the innovation literature (Rehm et al., 2016; Van de Ven, 2005; Weiblen and Chesbrough, 2015), is discussed in the next section.

3.2.3 Innovation networks

Innovation networks are a network of entrepreneurs who come together to collaborate and learn from each other by sharing knowledge and experience. Niammuad et al. (2014) suggest that business incubators facilitate collaboration. Amara et al. (2008) and Van de Ven (2005) claim the rise of knowledge-intensive services and technologies lead to greater challenges in developing innovations making it more difficult for entrepreneurs to venture out alone. Innovation networking offers a range of strategic benefits including the ability to reach new markets, knowledge sharing and developing long-term relationships that could lead to future innovations (Rehm et al., 2016; Van de Ven, 2005). Rehm et al. (2016) provide empirical evidence of a successful innovation that arose from three innovation networks each with specialities from different industries that led to a new medical device. Figure 3 below illustrates a process for innovation networking derived from the research conducted by Rehm et al. (2016) and Van de Ven (2005). The process model includes a network information management strategy to share and assimilate knowledge throughout the network and agile project management. Agile, a concept used in the lean start-up methodology developed by Blank (2013) and Reis (2011), is the next topic of discussion.

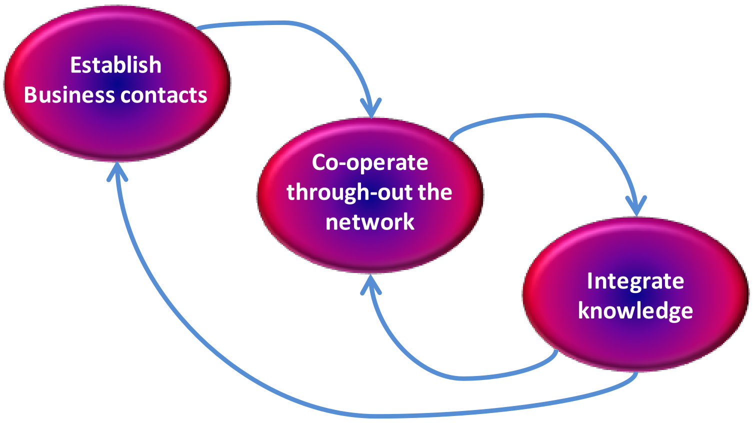

Figure 3 – Model of innovation networking (adapted from Rehm et al., 2016 and Van de Ven, 2005)

3.2.4 The lean start-up

Blank (2013) and Reis (2011) along with their colleagues are considered the originators of the lean start-up methodology. However, there are many similarities between the lean start-up and Van de Ven et al's (1984) five stage development model even though they were written thirty years apart. Both models suggest that entrepreneurs need to spend less time on detailed business plans, spend more time with potential customers and employ agile development, which is a form of iterative design.

Figure 4 on the next page illustrates the lean start-up methodology (Blank, 2013). The methodology consists of a series of development cycles that result in a minimum viable product (MVP). The number of cycles to be repeated depends on many factors including customer requirements, skill of development team, complexity of the project and overall firm performance. Each cycle consists of six phases – planning, requirements gathering, analysis and design, implementation, testing and evaluation. Deployment of the MVP occurs during the implementation and testing phase as customer feedback is gathered and integrated back into product design Blank (2013) and Reis (2011).

The lean start-up methodology is a process for developing a product. It does not consider the structure of the start-up nor does it cover how to build a development team. The lean start-up methodology also doesn't discuss how to fund the business venture. The topic of start-up funding and financing is discussed in the following section on Venture Capital.

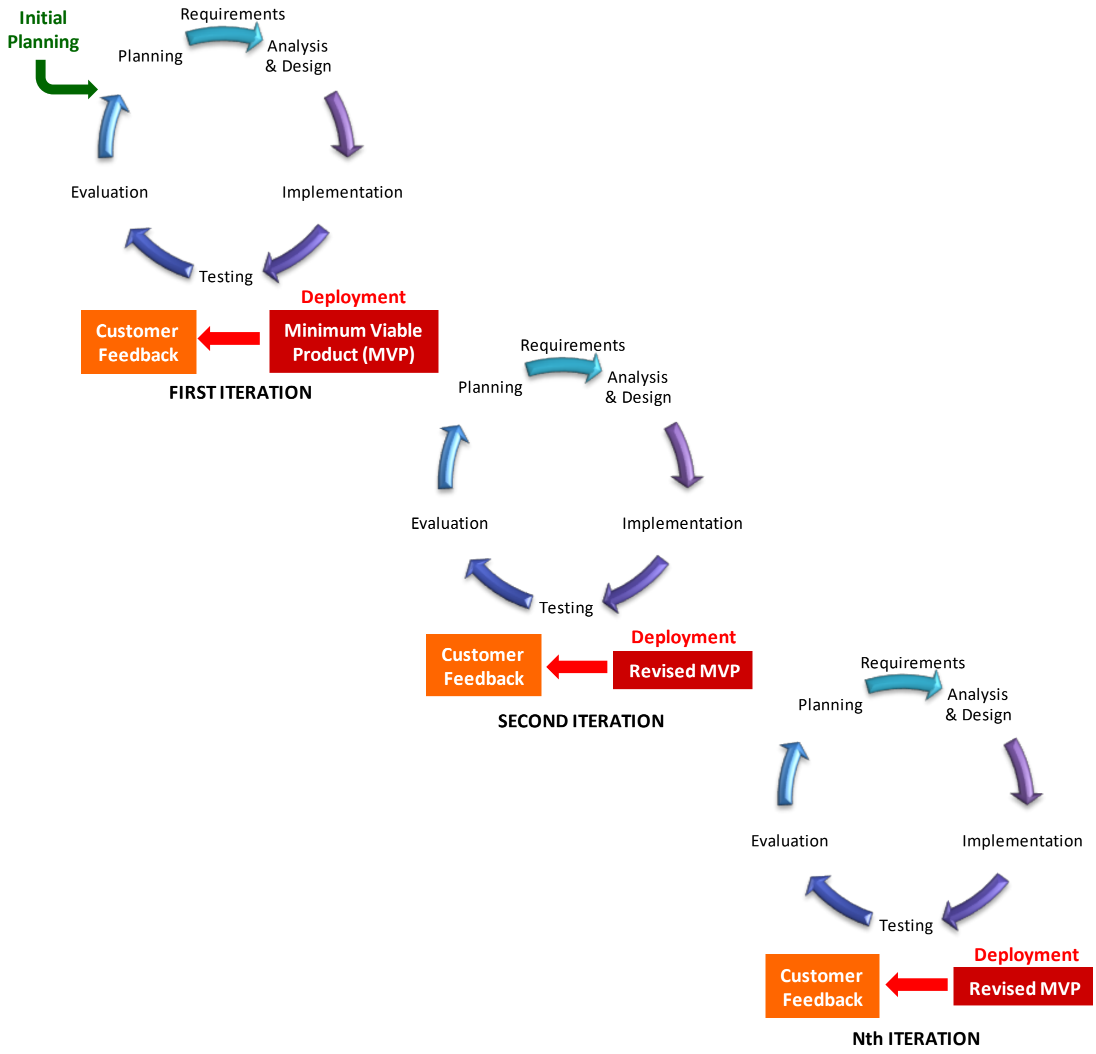

Figure 4 – The lean start-up methodology (Blank, 2013)

3.2.5 The role of Venture Capital

While many papers mention the role of Venture Capital (VC) in start-ups (Blank, 2013; Chesbrough and Rosenbloom, 2002), Hsu (2006) dedicated an entire paper on the topic and Freeman and Engel (2007) discuss the impact and influence of VC's on a start-up's evolution. Hsu (2006) suggests that start-ups face many difficulties when considering innovation networks and collaborating with other firms and entrepreneurs. Issues include the cost, time and effort required, fear of their innovation being stolen and the inability for the entrepreneurs to assess the quality of potential partners. Hsu (2006) argues that the right VC firm can provide a start-up with value-added services and guidance beyond financing.

Hsu (2006) conducted a study of 696 start-ups in the USA split into three groups – those funded by traditional VC firms, those funded by a government grant and those funded by both. The results suggest that start-ups funded by VC firms were more active in establishing collaborative partnerships and more likely to list on a stock exchange significantly increasing the value of the firm. Freeman and Engel (2007) claim VC firms influence the organisational structure of a start-up. Since many high-tech start-ups need on-going capital, VC funds come with strings attached. This includes the requirement for the start-up to build a management team, VCs appointing board of directors and the erosion of the entrepreneurs' equity in the business. On the positive side, Freeman and Engel (2007) and Hsu (2006) suggest that VC's provide access to their industry networks and contacts allowing the start-up to grow sales faster than it could without assistance. In addition, VCs provide finance and business administration skills including associated systems and resources.

This concludes the literature review. In order to develop a new process model, research linking the two fields of knowledge leakage and innovation was conducted. To the best of my knowledge, there is no research linking these two fields of research. A discussion on the research is provided along with how a new secure innovation process model was developed is covered in the next section.

4.0 Discussion

The literature review provided insights into research on knowledge leakage and innovation. The main gaps in the research revolve around knowledge leakage risk at various stages during the innovation process, how to best mitigate knowledge leakage and how the impact of knowledge leakage effects innovation in start-ups. By ignoring these issues, the research assumes that knowledge leakage risks are constant during the development of innovations. This assumption cannot be made for high-tech start-ups, or any organisation for that matter, as the risks of knowledge leakage and how they impact innovation changes as the firm grows, develops, hire new employees, loses employees and extends out into the business community.

In this section, a secure innovation process (SIP) model is presented that provides high-tech start-ups with a methodology to protect IP as they embark on their journey of innovation. To arrive at the SIP model, the discussion begins with the development of the 'risk window', a method that can be used to manage knowledge leakage. This is followed by the general innovation process model was derived from the research. The risk window is then applied to the general innovation process model which leads to the development of the complete SIP model. The SIP model is then explained in detail with an example innovation to illustrate a practical application.

Research from Ahmad, et al. (2014), Amara et al. (2008) and Olander, et al. (2011) has been used to derive a set of knowledge leakage and IP protection (KLIPP) criteria. The criteria can be applied to the innovation stages to assess and manage knowledge leakage risks. This set of criteria is by no means exhaustive. However, it covers the primary knowledge leakage mitigation methods found in the literature. The KLIPP criteria, referred to as the 'risk window', extends Amara et al's (2008) IP protection matrix to include six additional methods based on people and systems to strengthen the eight core protection methods. It's important to state that Amara et al's (2008) study has its limitations since it excludes companies with less than 15 employees and turnover under $250,000 – many high-tech start-ups fall in this category. However, the research is broad and covers service-based companies which make up a large part of modern economies (Gallouj, 2002; Gummesson and Lovelock, 2004). Since many modern high-tech start-ups develop innovative services, the research and strategies proposed by Amara et al. (2008) are applicable to high-tech start-ups. The research from Ahmad, et al. (2014), Amara et al. (2008) and Olander, et al. (2011) provides a good sample of leading research in the field of knowledge leakage. Furthermore, the criteria are clear, simple and easy to apply to innovation processes.

4.1 Managing knowledge leakage – the risk window

In this section, the second research question is addressed – how should high-tech start-ups manage knowledge leakage risks and protect IP at various stages during the innovation process? To answer this question, the concept of the 'risk window' was developed. The risk window is a methodology allowing knowledge leakage risks at each stage of the innovation process to be identified and mitigated. The top part of the risk window, based on Amara et al's (2008) matrix, determines the most appropriate IP protection methods based on the innovation. The lower part of the risk window, people and systems, is used to determine what knowledge leakage mitigation methods should be implemented at different stages during the innovation process. Table 2 below illustrates the risk window.

<table>
<tr><th></th><th colspan="3">Tangible</th><th colspan="2">Intangible</th></tr>
<tr><td>Codified</td><td colspan="3">1. Patents as primary mechanism complemented with:
• copyrights
• trademarks
• confidentiality agreements

Typical innovations include hardware products and software products embedded in hardware</td><td colspan="2">2. Copyrights as primary mechanism complemented with:
• trademarks
• confidentiality agreements

Typical innovations include consulting and other professional services and cloud-based services (software-as-a-service)</td></tr>
<tr><td>Tacit</td><td colspan="3">3. Informal protections - secrecy, design complexity, lead-time advantage complemented with:
• confidentiality agreements
• trademarks

Typical innovations include hardware products and software products embedded in hardware</td><td colspan="2">4. Trademarks as primary mechanism complemented with:
• secrecy
• lead-time advantage
• confidentiality agreements

Typical innovations include consulting and other professional services and cloud-based software services (software-as-a-service)</td></tr>
<tr><td rowspan="2">People & systems</td><td colspan="2">☐ Capture codified knowledge</td><td colspan="2">☐ Recruitment</td><td>☐ Monitor knowledge flows</td></tr>
<tr><td colspan="2">☐ Diffuse tacit knowledge</td><td colspan="2">☐ Training & education</td><td>☐ Monitor communication</td></tr>
</table>

Adapted from Amara et al. (2008), Ahmad, et al. (2014) and Olander, et al. (2011)

Table 2: The risk window – assessing and managing knowledge leakage

Applying the risk window involves two steps. The first is determining which quadrant the innovation sits – is the innovation tangible or intangible and is the knowledge embedded codified or tacit? An innovation can fit into more than one quadrant if it consists of a mix of tangible and intangible outputs and a combination of codified and tacit knowledge. If this is the case, it's up to the entrepreneur to determine the best mix of IP protection methods. Cost, time and resources will dictate the final decision. A traffic light colour scheme provides a visual to highlight which quadrant the innovation is located. Green is an almost 100% fit while red is close to 0%. Yellow suggests a balanced 50% fit.

The second step requires evaluating the people and systems criteria located at the base of the risk window. There are a number of knowledge leakage scenarios and methods to mitigate these risks. Due to scope limitations in this minor thesis, consideration is only given to a set of primary risks and mitigation strategies. These include knowledge management systems, managing leakage via training and education and monitoring knowledge flows. As the start-up progresses through the innovation stages, the mitigation strategies that apply also change. For example in the first stage, the start-up will consist of only the entrepreneur and perhaps a business partner. Therefore recruitment, training and monitoring of knowledge and communications isn't applicable.

Knowledge management includes capturing and storing codified knowledge in information systems, records and documents. Recruitment, training and education are preventative measures to ensure that the right people are employed followed by ongoing information security and knowledge management education. Finally, monitoring knowledge involves keeping track of employee communications and knowledges flow into and out of the organisation. The next section discusses a general innovation process model, which is a precursor to the development of the secure innovation process (SIP) model.

4.2 General innovation process model

In developing a new process model, it's important to determine the limits, that is, where should it begin and end. Denning (2004) states that, "… ideas have no impact unless adopted into practice…" Since idea generation is a prerequisite to invention, it follows that idea generation is not innovation nor is invention innovation. In this minor thesis, the innovation process begins when an entrepreneur either takes or comes up with an idea or invention and develops it, at least in their own mind, to the point where it can be commercialised (Denning and Dunham, 2006; Freeman and Engel, 2007). The commercialisation process is out of scope. A general innovation process model has been derived from innovation research and each paper has been included in the model for its relevancy and contribution of key process elements.

4.2.1 Three stages of the general innovation process

The general innovation process consists of three stages – opportunity recognition, innovation building and innovation networking. The first, opportunity recognition is a common theme in research on entrepreneurship. Models have been developed to explain how entrepreneurs exploit trends in technology and markets by applying knowledge and experience to develop innovations (Denning and Dunham, 2006; Niammuad et al., 2014; Park, 2005). Opportunity recognition requires entrepreneurs to clearly understand the market potential for an innovation and the technology required to build it. While opportunity recognition explains the mindset and practices of entrepreneurs, it doesn't describe how to build a start-up in the early stages of development. Therefore, the general innovation process model extends opportunity recognition to building the development team, sourcing funds and developing early releases of the innovation. This stage is called innovation building.

Innovation building involves two key activities. The first is building the technology team to develop a prototype or MVP. The second activity involves deciding what technology needs to be acquired or built to develop the innovation. An important ingredient is required in the innovation building stage – capital. Nothing happens without money and in the early days of a start-up's life entrepreneurs only have a few sources of funds including family and friends, their own savings and early stage seed investors also known as angel investors. Larger VC firms are generally not interested in early stage start-ups unless the innovation is ground breaking and the entrepreneurs have a high profile and successful track record. Assuming the start-up has been successful at raising funds and a prototype or MVP has been developed, the next stage is innovation networking.

Innovation networking requires the entrepreneurs to build collaborative partnerships, expand the customer base and engage suppliers including banks, investors, legal firms and other professional advisors. Successful partnerships require collaboration with external firms that have complementary skills, knowledge, assets and resources (Rehm et al., 2016; Teece, 1984; Van de Ven (2005). Van de

Ven (2005) also suggests that entrepreneurs need to be 'politically savvy' in order to ensure that they not only get the best out of their partners, but to also offer value to their partners. Innovation networking requires deep relationships, trust and sharing of knowledge. Despite the knowledge leakage risks inherent with innovation networking, the benefits can outweigh the downsides. The popularity of innovation networking is growing and it is more likely to occur in start-ups that have engaged VC firms (Freeman and Engel, 2007; Hsu, 2006). Figure 5 below illustrates the general innovation process model derived from the research. In the next section, the general innovation process model is expanded to include the risk window leading to the complete SIP model.

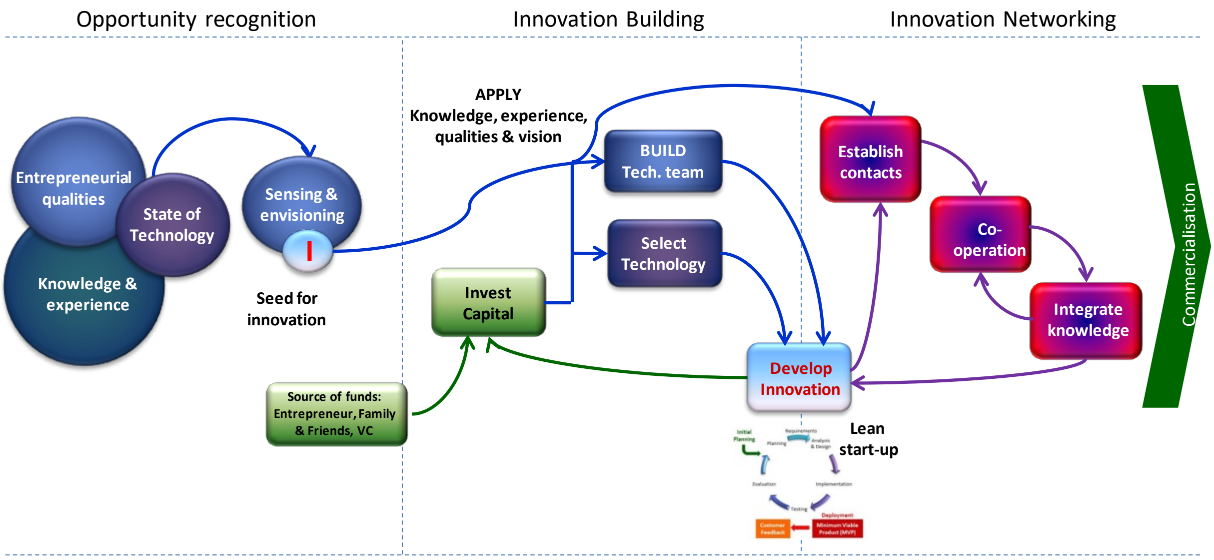

Figure 5 – General innovation process model

4.3 Secure Innovation Process (SIP) Model

The secure innovation process (SIP) model builds on the three stages of the general innovation process model. The risk window, introduced in section 4.1, has been applied to each stage of the general innovation process model. The risk window illustrated in the SIP model is based on the example used in the following section. Figure 6 on the following page illustrates the SIP model.

4.3.1 Opportunity Recognition

The opportunity recognition stage builds on the model proposed by Park (2005) and integrates ideas from Denning and Dunham (2006) and Van de Ven et al. (1984). Park's model has been modified in two ways. First, the size of each process component (entrepreneurial qualities, knowledge and experience and state of technology) is shown differently to highlight the varying importance of each activity. Determining how a start-up should size the effort for each component depends on their situation. For example, if the start-up consists of two high experienced entrepreneurs yet the technology they require to develop the innovation isn't available, building new technology would require more time and effort hence the circle would be larger compared to the others. Secondly, the first two steps in Denning and Dunham's (2006) seven stage process model have been added and are extensions to the entrepreneurial qualities – sensing possibilities and envisioning new realities.

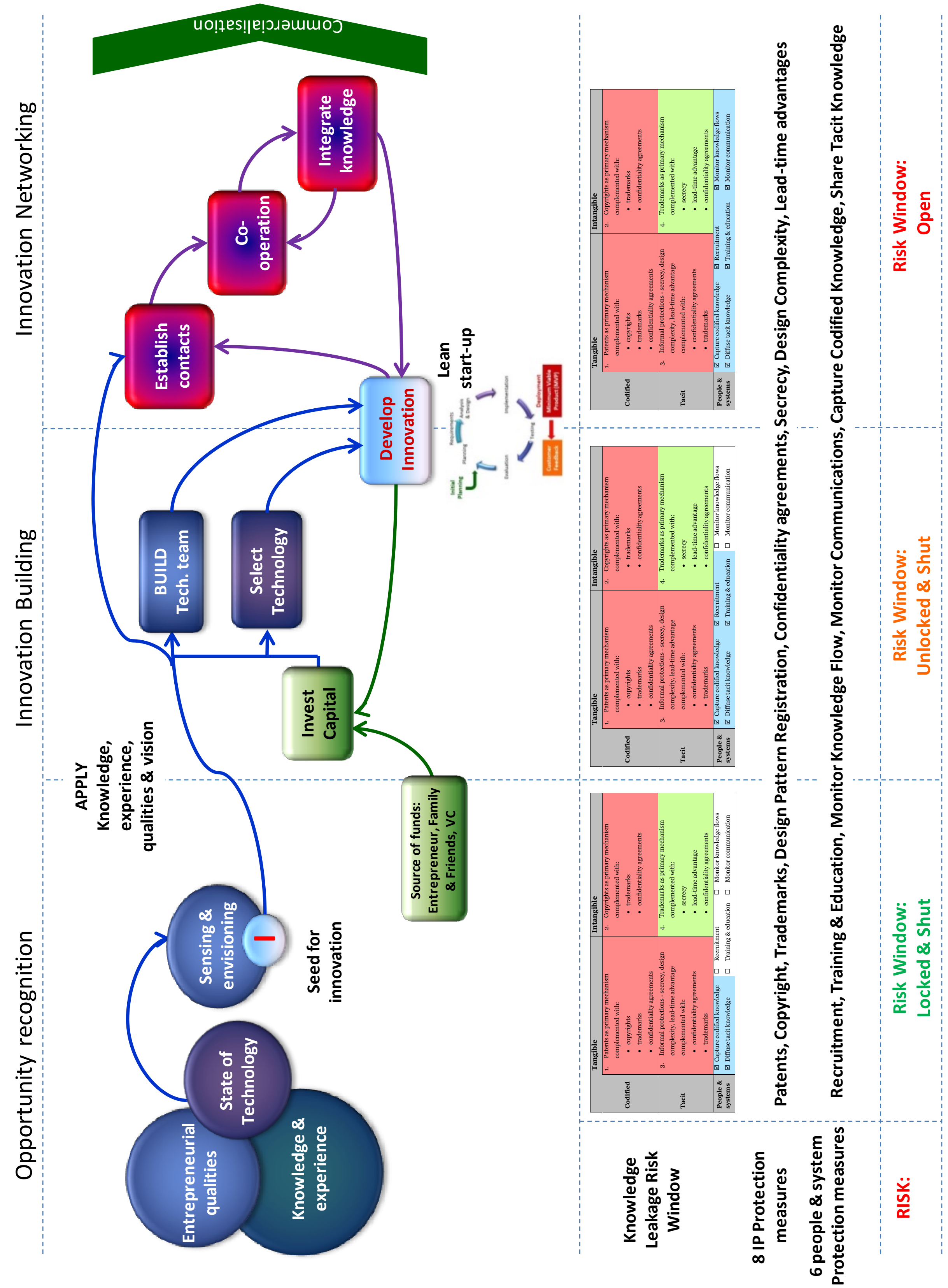

Figure 6 – Secure innovation process (SIP) model

Entrepreneurial qualities

Research suggests that an entrepreneurs risk appetite and background are indicators in determining the success of a start-up as opposed to personality traits. There is no evidence that entrepreneurs have special personality traits that makes them successful. Instead, highly motivated entrepreneurs who demonstrate high levels of commitment by investing their own money into the venture tend to be more successful compared to those that don't (Park, 2005; Van de Ven et al., 1984). There is general agreement on entrepreneurial qualities which determine the level of success for start-ups with the most common being motivation, commitment, vision, high risk tolerance and alertness or sensing possibilities (Denning and Dunham, 2006; Park, 2005; Van de Ven et al., 1984). Interestingly, leadership was only mentioned by Denning and Dunham (2006).

Knowledge and experience

Having the right level of experience and knowledge improves the chances that an entrepreneur will succeed in their venture. Level of education and relevant work experience also determines success. It was also found that entrepreneurs with experience in large organisations generally did better compared to those who only worked in small companies or had less overall work experience (Park, 2005; Van de Ven et al., 1984).

State of technology

Technology is not innovation – innovation is the result of combining technology with a market need to exploit opportunity. In order to ensure success, the entrepreneur needs to assess and understand the trends evolving in technology and industry. In the early stages of innovating, essentially before anything has been developed, the entrepreneur is faced with many technology options. The options will narrow in future stages and as the innovation is developed.

Sensing and envisioning

The three components described, entrepreneurial qualities, knowledge and experience and technology lead the entrepreneur to sense possibilities and envision new realities for a future world. The innovation is now a seed in entrepreneur's mind. However, it's more than an idea. The innovation is a vision complete with details on its market potential, impact on society and the technology required to make it a reality.

The practice of sensing and envisioning is the first step in articulating opportunities and their potential value. Sensing and envisioning relies on the entrepreneurs' knowledge, experience and qualities. Once an entrepreneur has articulated opportunities, they need to speculate about the future and deeply understand the process required to reach that future (Denning and Dunham, 2006).

Knowledge leakage mitigation – risk window assessment

During the opportunity recognition stage, there is usually no team – just the entrepreneur and perhaps a partner or two. Therefore, the risk of knowledge leakage is low and the risk window can be considered locked and shut. However, the entrepreneurs need to begin thinking about how to protect their innovation from knowledge leakage early on. This allows time to plan and implement sound processes, systems and technologies to manage these risks as the business grows.

As described in section 4.1 'Managing knowledge leakage – the risk window', the first step in applying the risk window requires understanding the innovation in terms of the type of knowledge that will go into developing it (codified or tacit) and whether it provides tangible or intangible outputs. Applying the risk window is straightforward and an example is given in Table 3 below. In this example the innovation, highlighted in green, is an intangible product or service with predominately tacit knowledge inputs. A good example is service innovation developed by consulting services firms. The contents of the green cell suggest that trademarks should be considered as the primary mechanism for IP protection complemented with secrecy, lead-time advantage and confidentiality agreements. However, given the early stage of the start-ups development, implementing confidentiality agreements and maintaining secrecy may not be necessary. Lead-time advantage also isn't applicable however it will most likely be a key strategy moving forward.

<table>
<tr><th></th><th colspan="3">Tangible</th><th colspan="2">Intangible</th></tr>
<tr><td>Codified</td><td colspan="3">1. Patents as primary mechanism complemented with:
• copyrights
• trademarks
• confidentiality agreements

Typical innovations include hardware products and software products embedded in hardware</td><td colspan="2">2. Copyrights as primary mechanism complemented with:
• trademarks
• confidentiality agreements

Typical innovations include consulting and other professional services and cloud-based services (software-as-a-service)</td></tr>
<tr><td>Tacit</td><td colspan="3">3. Informal protections - secrecy, design complexity, lead-time advantage complemented with:
• confidentiality agreements
• trademarks

Typical innovations include hardware products and software products embedded in hardware</td><td colspan="2">4. Trademarks as primary mechanism complemented with:
• secrecy
• lead-time advantage
• confidentiality agreements

Typical innovations include consulting and other professional services and cloud-based software services (software-as-a-service)</td></tr>
<tr><td rowspan="2">People & systems</td><td>☑ Capture codified knowledge</td><td colspan="2">☐ Recruitment</td><td colspan="2">☐ Monitor knowledge flows</td></tr>
<tr><td>☑ Diffuse tacit knowledge</td><td colspan="2">☐ Training & education</td><td colspan="2">☐ Monitor communication</td></tr>
</table>

Adapted from Amara et al. (2008), Ahmad, et al. (2014) and Olander, et al. (2011)

Table 3: The risk window – Opportunity recognition

The second step in applying the risk window requires determining what people/human resource processes and information systems need to implemented to mitigate knowledge leakage risks. This set of criteria is located at the base of the risk window. Once again, since this is the first stage in the innovation process, it can be assumed that there are no employees other than the founders. Therefore, only two activities may be applicable – capturing codified knowledge and diffusing tacit knowledge. This process can occur both formally and informally between the entrepreneurs, assuming the start-up is a partnership.

Outcome – Seed for innovation

At this point, the seed for the innovation is ready to sow and the entrepreneur can embark on the next stage – innovation building. All of the elements in opportunity recognition interact in a fluid and organic way allowing the entrepreneur to clarify their vision for the innovation, evaluate its technical viability, determine the technology required and assess its market potential.

4.3.2 Innovation Building

Stage two is innovation building and involves building the core of the start-up to begin developing the innovation. Therefore, the development team and the main technologies to be used in developing the innovation will need to be employed. Although this stage predominately involves team building and product/service development, it requires some business networking mainly with recruitment agencies, technology providers, banks, investors and other professional advisors.

Build technology team

The entrepreneur needs to apply their knowledge and experience to make sound hiring decisions when employing developers. While staff hiring primarily focuses on technical development teams during this stage, if a VC has been engaged, they may insist on implementing finance and administration teams and establishing a board of directors (Freeman and Engel, 2007; Hsu, 2006).

Select technology

Selecting and/or building the right technology to enable the innovation to be built is a crucial activity that requires many decisions to be made. The quality of the decisions will have a direct impact on the success of the innovation. Start-ups need to adopt a diversified portfolio of technologies that will provide options and minimise risks in the event of significant changes in the industry and markets (Park, 2005; Rehm et al., 2016; Van de Ven, 2005).

Invest capital

As discussed earlier, investment capital can come from a number of sources including friends and family, business angels and the entrepreneurs themselves (Freeman and Engel, 2007; Hsu, 2006). At some point, with the exception of highly successful and wealthy entrepreneurs, start-ups will need to turn to external sources for funds such as VCs. Freeman and Engel (2007) and Hsu (2006) suggest that engaging with VCs opens the door to the broader business community, however VC's tend to have a strong influence on the direction and development of the start-up as it matures.

Knowledge leakage mitigation – risk window assessment

During this stage in the process, the development teams and possibly finance and administration teams will be employed. The risk window can be considered unlocked and possibly shut as control of information and knowledge management practices can be closely monitored. However, the risk of knowledge leakage has now increased.

Assuming there are no drastic changes to the innovation, there should be no change to which quadrant the innovation is located. However, there will be changes to people/HR processes and information systems section of the risk window given that the start-up has commenced hiring. Assuming the number of employees is small the entrepreneurs may decide not to implement monitoring technologies. This decision would be based on the culture, level of trust and risk tolerance of the entrepreneurs. However, exceptional recruitment and training/education is crucial during this stage. It is also important to scale up systems and processes for capturing codified knowledge and fostering an environment encouraging appropriate knowledge sharing between staff to diffuse tacit knowledge. Table 4 below shows the risk window for innovation building.

	Tangible	Intangible
Codified	1. Patents as primary mechanism complemented with: • copyrights • trademarks • confidentiality agreements Typical innovations include hardware products and software products embedded in hardware	2. Copyrights as primary mechanism complemented with: • trademarks • confidentiality agreements Typical innovations include consulting and other professional services and cloud-based services (software-as-a-service)
Tacit	3. Informal protections - secrecy, design complexity, lead-time advantage complemented with: • confidentiality agreements • trademarks Typical innovations include hardware products and software products embedded in hardware	4. Trademarks as primary mechanism complemented with: • secrecy • lead-time advantage • confidentiality agreements Typical innovations include consulting and other professional services and cloud-based software services (software-as-a-service)
People & systems	☑ Capture codified knowledge ☑ Recruitment ☑ Diffuse tacit knowledge ☑ Training & education	☐ Monitor knowledge flows ☐ Monitor communication

Adapted from Amara et al. (2008), Ahmad, et al. (2014) and Olander, et al. (2011)

Table 4: The risk window – Innovation building

Outcome – Develop the innovation

Innovation building leads to early versions and releases of the innovation in the form of prototypes or MVP's based on the lean start-up methodology (Blank, 2013; Van de Ven et al., 1984). The start-up is now ready to move onto innovation networking, which involves establishing broader customer contacts, collaborating with industry peers and extending further into the business community.

4.3.3 Innovation Networking

Innovation networking has three components and a number of feedback loops. The three steps include establishing business contacts, co-operation and integrating knowledge back into the organisation and the innovation (Rehm et al., 2016; Van de Ven, 2005).

Establish business contacts

When establishing contacts, the most important relationships will be with potential customers, innovators and early adopters. These people provide valuable feedback and guide the start-up through the early stages of development (Blank, 2013; Rehm et al., 2016; Rogers, 2003; Van de Ven, 2005). The entrepreneur also needs to establish contacts and build relationships with a range of businesses including banks, lawyers and accountants. In terms of knowledge leakage risks, there is minimal risk of the start-up in dealing with these businesses as they are generally not required to divulge sensitive innovation, technology or product details in their day-to-day dealings with these organisations.

Co-operation with contacts and Integrate knowledge

Co-operating with business contacts and integrating the knowledge gained from the interactions is a tightly integrated process and highly fluid. Collaboration is a core activity and the start-up would typically be dealing with industry peers. The feedback loop is ongoing, iterative and requires integrating knowledge into the innovation, development processes and the organisation as a whole (Rehm et al., 2016; Van de Ven, 2005).

Knowledge leakage mitigation – risk window assessment

During innovation networking, it's likely that the start-up will experience growth and continue hiring employees. This process, along with forging external networks, exposes the start-up to greater knowledge leakage risks. This may be further complicated if the start-up has experienced staff turnover especially if ex-employees go on to work for competitors. During this stage, the risk window can be considered open. Once again, it's assumed there are no drastic changes to the innovation hence it will be located in the same quadrant. However, there will be changes to people/HR processes and information systems section of the risk window. Information and knowledge is now flowing into and out of the organisation at a greater rate therefore information and knowledge monitoring processes should be implemented. Table 5 below shows the completed risk window for innovation networking.

	Tangible	**Intangible**
Codified	1. Patents as primary mechanism complemented with: • copyrights • trademarks • confidentiality agreements Typical innovations include hardware products and software products embedded in hardware	2. Copyrights as primary mechanism complemented with: • trademarks • confidentiality agreements Typical innovations include consulting and other professional services and cloud-based services (software-as-a-service)
Tacit	3. Informal protections - secrecy, design complexity, lead-time advantage complemented with: • confidentiality agreements • trademarks Typical innovations include hardware products and software products embedded in hardware	4. Trademarks as primary mechanism complemented with: • secrecy • lead-time advantage • confidentiality agreements Typical innovations include consulting and other professional services and cloud-based software services (software-as-a-service)
People & systems	☑ Capture codified knowledge ☑ Diffuse tacit knowledge ☑ Recruitment ☑ Training & education	☑ Monitor knowledge flows ☑ Monitor communication

Adapted from Amara et al. (2008), Ahmad, et al. (2014) and Olander, et al. (2011)

Table 5: The risk window – Innovation networking

Outcome – Fine-tune innovation

The main outcome for innovation networking is an improved MVP – ideally one that has been through a few iterations and is ready to be implemented by customers. At the end of this stage, it is unlikely that the innovation will be ready for full scale commercial production. However, the start-up should be in a position to start earning revenue from the first group of innovative customers.

Feedback loops

There are a number of feedback loops in innovation networking. In addition to the feedback loop between co-operation and knowledge integration, revenues are invested back into the business along with other investment sources. Additional VC funds may be required as the business grows (Freeman and Engel, 2007; Hsu, 2006). There is also an implied feedback loop that is complex to illustrate. It relates to the entrepreneurs' personal and professional development in terms of their skills, leadership, knowledge and experience as they go through the journey of building a business.

The start-up is now in a strong position to commercialise their innovation. As stated by Freeman and Engel (2007) and Hsu (2006), the future and the role of the entrepreneurs depend on their personal growth and how much equity and control they've given up to VC's over the journey.

5.0 Conclusion

Failing to profit from innovations as a result of knowledge leakage and loss of IP is a core business risk for high-tech start-ups. Therefore it is crucial that high-tech start-ups clearly understand these risks and implement measures to minimise knowledge leakage during the innovation process. Most of the research on knowledge leakage and innovation focuses on large organisations and falls short of addressing the needs of high-tech start-ups. This is unfortunate since the failure rate for high-tech start-ups is high yet industries have and continue to rely on disruptive innovations produced by high-tech start-ups. Focusing more research on high-tech start-ups will improve the overall outcomes for this important group of businesses in the economy.

The research showed that knowledge leakage can occur in many ways including actions by staff, employee turnover and collaboration with external firms. However, research falls short on demonstrating how knowledge leakage risks change during the innovation process. IP theft is another form of knowledge leakage and is a result of industrial espionage and imitation by competitors. A range of IP protection methods are typically employed by organisations given the multiple ways that knowledge and IP can be lost or stolen. The idea of an IP protection matrix allows an organisation to evaluate the nature of their innovation and match it with a set of appropriate IP protection methods. The nature of the innovation is based on whether the output is tangible or intangible and consists of codified or tacit knowledge. In terms of innovation research over the last fifteen years, the literature review revealed five commonly discussed process models. They include entrepreneurial practices, opportunity recognition, the lean start-up methodology, innovation networks and the VC driven start-ups. Each of these processes and methodologies form the basis of the general innovation process model.

This minor thesis fills the research gaps on knowledge leakage and innovation processes relating to high-tech start-ups by answering two research questions:

1) What process should entrepreneurial high-tech start-ups engage to securely develop their innovations?

2) How should high-tech start-ups manage the knowledge leakage risks and protect IP at various stages during the innovation process?

To answer these research questions, a secure innovation process (SIP) model was developed. SIP extends the general innovation process model, derived from innovation research, to include the concept of the risk window. The risk window was developed from knowledge leakage research and builds on the IP protection matrix to include internal organisational knowledge leakage mitigation methods. The configuration of the risk window is different at each stage of the innovation process since the risks of knowledge leakage change as the start-up progresses through the innovation process.

5.1 Contribution

This thesis makes the following contributions:

a) The concept of the risk window has been developed from knowledge leakage research. It provides a method to assess the type of innovation being developed, the knowledge leakage risks at each stage of the innovation process and what IP protection and knowledge leakage mitigation methods can be employed to protect the innovation.
b) A new secure innovation process (SIP) model has been developed by applying the risk window to a general innovation process. SIP offers high-tech start-ups with a knowledge leakage methodology to enable the secure development of innovations.

5.2 Limitations

This minor thesis is limited as it is based on a literature review and doesn't include quantitative or qualitative research which would strengthen the development of the process model. Furthermore, the innovation process layer in the SIP model is abstract and needs to be further developed in order for it to be applied in practice.

5.3 Future research

To address the limitations stated above, the SIP model can be further developed by applying business process methodologies so that it can be applied in practice. Field and case study research should be conducted to validate and improve the risk window and SIP model. In addition, further research into entrepreneurship theories and entrepreneurship in practice can strengthen the SIP model and provide further evidence into the success factors for start-ups based on the qualities of the entrepreneur. For example, is it possible to determine whether an aspiring entrepreneur has the qualities to succeed in a new venture? If so, is there a way to measure their readiness? This research could lead to development of an 'entrepreneur readiness assessment' that can allow aspiring innovators to assess their ability of undertaking the task of building a successful high-tech start-up.

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