Technology Venture Assessment for Early-Stage Decisions

This thesis is submitted for the degree of Doctor of Philosophy.

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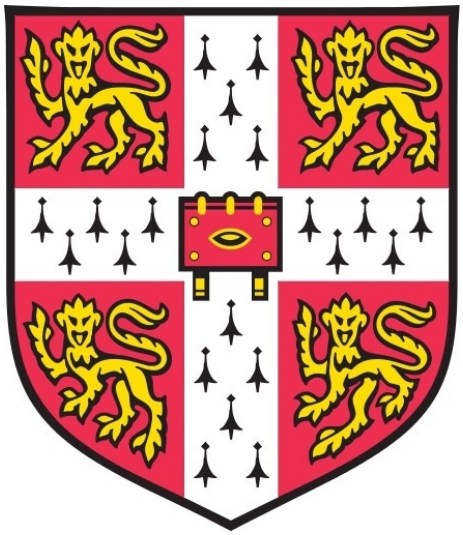

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Abstract

This research aims to help technology entrepreneurs conduct effective assessments for three important early-stage decisions, namely: (1) whether to pursue a business opportunity, (2) which process to follow to define the launch product to get the business off the ground in the short term, and (3) how to strategically align technology and market development at the early stage to build competitive advantage in the longer term. As previous studies suggest that people make decisions based on judgements of certain questions, this research focuses on understanding: (a) what key questions technology do entrepreneurs consider and what underlying rationale do they follow when making the three focal decisions, and (b) how may technology entrepreneur conduct effective the key questions in an entrepreneurial environment?

To understand these two main questions, the researcher selected case studies as the research method and interviewed 20 entrepreneurs from 17 technology-based firms, asking how they approached these three decisions at the early stage of their company's development. Through case studies, this research (a) identified a set of key questions relating to each focal decision, and (b) proposed a method to help technology entrepreneurs achieve effective these questions. The findings were then developed into a tool to test with technology entrepreneurs and other stakeholders of technology entrepreneurship such as venture capitalists and incubator managers. Their positive feedback verified the main findings and highlighted a number of possible implications of this research.

This research contributes to existing knowledge in both practical and theoretical perspectives. Practically, this research helps technology entrepreneurs conduct effective assessments for the three early-stage decisions. With respect to theoretical contributions, this research challenges conventional understandings of 'what determines decision quality' by claiming that high quality decisions do not depend principally on accurate answer to key questions, but rather require entrepreneurs' appropriate understanding of the reliability of the answer they gave.

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I truly consider my experience of being a PhD student at Cambridge University as a privilege. With even greater fortune, I have been honored to enjoy the guidance and support of various individuals throughout my PhD journey. I would like to take this opportunity to express my sincere gratitude to these people, who, collectively, have made this work possible.

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Finally, I want to thank my parents for their love and belief in me. Their optimistic attitude to life has deeply influenced me. From them, I have learned how to embrace difficulties and use them to expand my understanding of this world, which they have brought me to.

Preface

Except for commonly understood terms and accepted ideas, or where specific reference is made, the work reported in this thesis is my own and does not include the outcome of work done in collaboration. No part of the dissertation has been previously submitted to any university for any degree, diploma or other qualification.

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Chapter 1 Introduction

Chapter Overview

The main objective of this chapter is to explain how the preliminary research questions were formulated. In the technology entrepreneurship processes, tremendous waste in terms of time and human, natural and financial resources occur due to poor quality decisions made by entrepreneurs. This research aims to reduce this waste by helping technology entrepreneurs make higher quality decisions during the early stages of venturing. This study considers three key early stage decisions: (1) whether to pursue a business opportunity, (2) which process to follow to define the launch product to get the business off the ground in the short term, and (3) how to strategically align technology and market development in the early stages to build competitive advantage in the longer term. To improve decision quality, this research focuses on the base of decision-making, defined here as assessment, to understand how technology entrepreneurs may conduct effective assessment in the three decisions.

Section 1.1 briefly explains the context of technology entrepreneurship, including its importance to social and economic development. Section 1.2 introduces the motivation behind and the aims of this research. Section 1.3 explains the research focus and the practical challenges of entrepreneurial decision-making. Preliminary research questions and objectives are formulated in Section 1.4. These preliminary research questions are the starting point for further investigation and the structure of the remaining thesis is briefly explained in Section 1.5.

1.1. Background

Entrepreneurship is of vital importance to social and economic development (Shane and Venkataraman, 2000; Venkataraman, 1997; Schumpeter, 1934). Through entrepreneurship, natural, financial and intellectual capital are transformed into new products and services (Dorf and Byers, 2008), and inefficiency in the economy is discovered and mitigated (Kirzner, 1997). Entrepreneurship serves as the crucial engine driving changes in society and creating new opportunities (Shane, 2012; Schumpeter,

1934). In the US, it has been estimated that new ventures account for between one-half to two-thirds of new jobs created over the past two decades (Stangler, 2017).

Technology entrepreneurship, a particular field of entrepreneurship, focuses on converting scientific and technological knowledge into value (Runge, 2014). Technology entrepreneurship contributes a large portion of national and global economic growth (Runge, 2014; Dorf and Byers, 2008). Besides creating jobs and generating wealth for the society, technology entrepreneurship nurtures abundant technology innovation and changes society through technological revolution (Bell and McNamara, 1991).

There are many definitions of technology entrepreneurship in the literature. For example, Dorf and Byers (2008, p. XV) defined technology entrepreneurship as:

> *a style of business leadership that involves identifying high-potential, technology-intensive commercial opportunities, gathering resources such as talent and capital, and managing rapid growth and significant risk using principled decision-making skills.*

For Bailetti (2012, p. 9), technology entrepreneurship is:

> *an investment in a project that assembles and deploys specialized individuals and heterogeneous assets that are intricately related to advances in scientific and technological knowledge for the purpose of creating and capturing value for a firm.*

From the various and varied definitions of technology entrepreneurship, two common emphases are identified. The first is the intensity of scientific and technology knowledge associated with a product that distinguishes technology entrepreneurship from other types of entrepreneurship. More specifically, Runge (2014) proposed that in technology entrepreneurship, technology issues have a significant impact on other management issues, and so technology strategy plays an important role for technology-based ventures. Therefore, the emphasis on technology strategy differentiates technology entrepreneurship from other types. Accordingly, in this research, technology-based firms are defined as firms to whom technology is of strategic importance throughout its development, which requires an emphasis on technology strategy and improvement of technology capability as the firm grows. Second,

technology entrepreneurship can be associated with either starting new technology-based firms or creating new technology-based projects in existing firms. However, this research focuses solely on the former, termed 'technology ventures' in this thesis. Accordingly, the term 'technology entrepreneurs' will refer to entrepreneurs in technology ventures.

1.2. Research Motivation and Aims

As discussed above, technology entrepreneurship plays an important role in the economy. However, tremendous waste exists in technology entrepreneurship in terms of time, human, natural and financial resources (Ries, 2011; Pfeffer, 2010). For example, it happens often that entrepreneurs devote enormous time and effort to develop products that are eventually rejected by the market place. These resources invested in entrepreneurship are valuable to entrepreneurs and to the wider society and should not be wasted. Therefore, the motivation of this research is to reduce the waste that is often generated in technology entrepreneurship.

This research defines 'waste' as the difference between the minimal amount of resources entrepreneurs have to invest to validate or disprove a business idea (noted as R_0) and the actual amount of resources spent by entrepreneurs to validate or disprove the idea (noted as R). Here, note that R_0 is a theoretical concept, in the sense that the minimum is not actually known, but one wants to head towards this theoretical minimum to reduce waste.

$$Waste = R - R_0$$

This research pays attention to 'waste' because it is considered a more essential expression than 'failure' to describe the problems encountered in entrepreneurship. Given the high level of uncertainty entrepreneurs face, the legitimacy of failure in entrepreneurial process should be acknowledged. Paying attention to 'waste' allows this legitimacy and, moreover, it points out that what entrepreneurs should try avoid or reduce is 'waste' rather than 'failure' in the entrepreneurial process.

Focusing on ‘waste’ gives a novel way to consider decision quality. According to the definition of waste, decision quality does not depend on the outcome of the decision; instead, it is about whether the decision causes extra expenditure on resources that could have been avoided given the information available at that time. Accordingly, in this research high quality decisions are defined as decisions that lead to low levels of waste, while low quality decisions are those leading to high levels of waste. For example, if a decision leads to disproving an idea but entails minimum cost, then no waste is considered to have occurred and the decision is evaluated as high quality; conversely, if a decision eventually leads to a success but with costs deemed too high, then waste exists and the decision is considered low quality. This indicates that failure does not necessarily imply waste or poor decisions and success is not a sign of no-waste or good decisions. Focusing on the level of waste a decision causes rather than its outcome provides a new angle to consider the quality of entrepreneurial decision-making, given the inherently exploratory nature of entrepreneurship.

The motivation of this research is to reduce waste in technology entrepreneurship. Given high quality decisions are defined as decisions that lead to low waste, then reducing waste is equivalent to improving the quality of decisions. Therefore, the aim of this research is to help technology entrepreneurs to improve the quality of decisions. Specifically, this research considers three important early-stage decisions, namely: (1) whether to pursue a business opportunity, (2) which process to follow to define the launch product to get the business off the ground in the short term, and (3) how to strategically align technology and market development at the early stage to build competitive advantage in the longer term.

These three decisions were selected through the following process. The researcher interviewed 20 technology entrepreneurs from 17 companies, asking about the key decisions they have made throughout company’s development from the conception of an idea to its current stage. Through analysing key decisions entrepreneurs have made across cases, the researcher found that the above three decisions were mentioned in every case, in addition to other, diverse, decisions. This indicated that it is necessary for every technology entrepreneur to consider these three decisions when establishing technology ventures. Therefore, understanding how to make these three decisions can help reduce waste from the very beginning of the entrepreneurial journey.

The first decision is also known as the ‘market entry decision’. This research proposes that an entrepreneur has decided to pursue a business opportunity if he or she evaluates the business opportunity as attractive and decides to develop an enduring business around it. In some cases, entrepreneurs decide to pursue a business opportunity or enter a market, while in other cases entrepreneurs decide not to. This research aims at understanding why technology entrepreneurs make different decisions and at helping them to assess whether a business opportunity is worth pursuing or not. It is necessary to note that this research does not consider opportunity recognition, but focuses on assessment of a given opportunity.

With respect to the second decision, it is important to note that ‘defining’ a launch product is different from ‘developing’ a launch product, as the former aims at the complete design of the product with no requirement on actually delivering it. In this research, a product is considered defined if the design of the product is complete and no further changes are expected. In practice, some entrepreneurs define their launch product through iterative trials and experiments, while others define it directly. This research will investigate why technology entrepreneurs choose different processes to define the launch product and provide suggestions on which process to follow in different situations.

For the third decision, technology entrepreneurs set out different strategies to align technology and market development in the early stages of company development. For example, some entrepreneurs concentrate on developing technology and leveraging the market through technology advancement; some choose to develop the market when the technology is developed to a sufficient level and use market advantage to push technology development; and some choose to develop technology and market in parallel, simultaneously. This research will investigate the determinants of different strategies and suggest appropriate strategies to technology entrepreneurs given their situation.

1.3. Research Focus and Practical Challenges

Previous studies suggest that decisions are made based on the judgement of a series of decision-related questions (Shepherd et al., 2015; Hogarth and Karelaia, 2012; Hastie, 2001; Pielke et al., 2000). This implies that decision-making processes can be modelled as comprising three steps:

i) Identifying decision-related questions
ii) Making judgements on the identified questions
iii) Making a decision based on i) and ii)

This research focuses on the first two steps as they construct the basis of decision-making. In this research, the basis of decision-making is defined as 'assessment' and assessment that leads to high quality decisions is defined as 'effective assessment'.

To make decisions, entrepreneurs need to (1) identify decision-related questions, and (2) make judgements on these questions. When making decisions in an ideal situation, where decision makers know all current and future information with no cost, they can take all decision-related questions into consideration and judge every question accurately. Based on the complete consideration of decision-related questions and accurate judgements, decision makers know the future result of a decision precisely and therefore make high quality decisions.

However, in an entrepreneurial environment, these conditions rarely, if ever, hold: information can be unavailable or limited, costly and time-consuming to obtain and the future can be highly uncertain. This implies that (1) not all decision-related questions can be identified and considered, and (2) judgements on questions can be inaccurate. Given these two points, the prediction of the future result of a decision can be potentially inaccurate and thus might lead to low quality decisions. Therefore, making decisions in entrepreneurial environment is inherently challenging.

1.4. Preliminary Research Questions and Objectives

Given these practical challenges, entrepreneurs need to understand (1) what questions are important and need to be considered for the three decisions, and (2) how to effectively judge these questions in the entrepreneurial environment. In this research, 'key questions' for a decision are defined as a set of question that entrepreneurs consider important for the decision; a judgement on a question is defined as an 'effective judgement' if it does not lead to low quality decisions. Accordingly, the preliminary research questions are formulated as:

1. How may technology entrepreneurs conduct effective assessments to decide whether to pursue a business opportunity?
    - 1a) What are the key questions and underlying rationale for market entry decisions?
    - 1b) How may technology entrepreneurs conduct effective judgements on the key questions in the entrepreneurial environment?

2. How may technology entrepreneurs conduct effective assessment to decide the process to define the launch product?
    - 2a) What are the key questions and underlying rationale for deciding the process to define the launch product?
    - 2b) How may technology entrepreneurs conduct effective judgements on the key questions in entrepreneurial environment?

3. How may technology entrepreneurs conduct effective assessments to strategically strategic align technology and market development at the early stage?
    - 3a) What are the key questions and underlying rationale for deciding the strategic alignment of technology and market development at the early stage?
    - 3b) How may technology entrepreneurs conduct effective judgements on the key questions in the entrepreneurial environment?

Questions 1a, 2a and 3a refer to identifying key questions and their underlying rationale for each focal decision, and questions 1b, 2b, and 3b consider the method deployed to enable effective judgements of the key questions. Figure 1 shows the structure of the preliminary research questions.

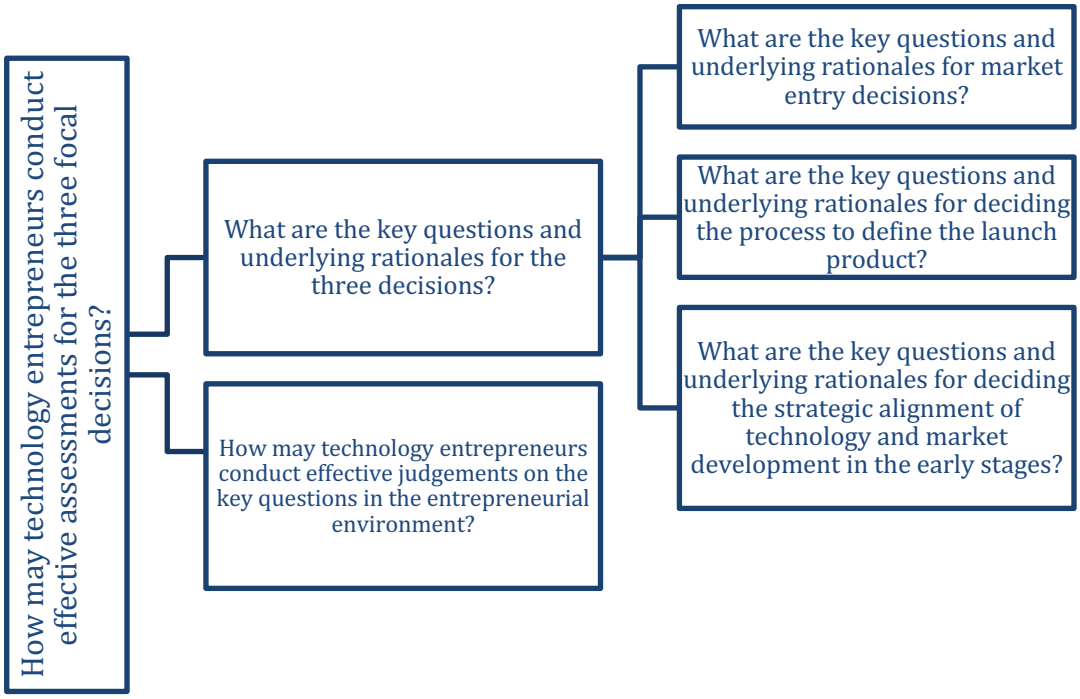


Figure 1 Structure of preliminary research questions

According to the preliminary research questions, the two objectives of this research are: (1) to identify key questions and the underlying rationales for the three early stage decisions, and (2) to understand the key to and method for making effective judgements on the key questions in the entrepreneurial environment. Table 1 provides a summary of the research motivation, aims, focus, preliminary research questions and objectives.

Table 1 Summary of research motivation, aims, focus, preliminary research questions and objectives

Phenomenon	Tremendous waste in terms of time, human resources (effort and intelligence) and financial resources occur in technology entrepreneurship processes.		
Research Motivation	To reduce waste in the entrepreneurship process.		
Research Aim	To improve the quality of three early-stage decisions for technology ventures.		
Three Early Stage Decisions	Whether to pursue a business opportunity?	Which process to follow to define the launch product in the short term?	How to strategically align technology and market development in the early stages?
Research Focus	Understanding how to achieve effective assessment for the three decisions, i.e. what are the key questions and the underlying rationales for these decisions and how to conduct effective judgements on these questions?		
Preliminary Research Questions	How may technology entrepreneurs conduct effective assessments to decide whether to pursue a business opportunity?	How may technology entrepreneurs conduct effective assessments to decide the process to define the launch product?	How may technology entrepreneurs conduct effective assessments to decide the strategic alignment of technology and market development in the early stages?
	1) What are the key questions and the underlying rationales for market entry decisions?	1) What are the key questions and the underlying rationales for deciding the process to define the launch product?	1) What are the key questions and the underlying rationales for deciding the strategic alignment of technology and market development at the early stage?
	2) How may technology entrepreneurs make effective judgements on the key questions in the entrepreneurial environment?	2) How may technology entrepreneurs make effective judgements on the key questions in the entrepreneurial environment?	2) How may technology entrepreneurs make effective judgements on the key questions in the entrepreneurial environment?
Research Objectives	1) To identify key questions and underlying rationale for the three early stage decisions; 2) To understand the key to and method for achieving effective judgements		

The key concepts and terms outlined thus far are summarised in Table 2. Other concepts will be introduced in the remaining chapters of the thesis as and when required. All key concepts and terms defined by this research are listed in the Glossary in Appendix I.

Table 2 Definition of key concepts in this research

Key Concept	Definition
Waste	The difference between the minimal amount of resources entrepreneurs have to invest to validate or disprove a business idea and the actual amount of resources spent by entrepreneurs to validate or disprove the idea.
High quality decision	Decisions that lead to low waste.
Effective assessment	The base of high quality decisions.
Key question	Question that entrepreneurs consider important for certain decision.
Effective judgement	Judgement of a key question that does not lead to low quality decisions.
Technology-based firm	Firms for which technology is of strategic importance throughout its development. In this research, technology-based firms are characterized by their emphasis on technology strategy and the improvement of technology capability as the firm grows.
Technology ventures	Newly established technology-based firms
Technology entrepreneur	An individual or a team of individual in technology ventures.

1.5. Structure of the Remainder of the Thesis

Keeping the preliminary research questions and objectives in mind, this researcher review the relevant literature in Chapter 2 to understand what is known and what is unexplained in the field. The unexplained part is identified as the research gap, from which four specific research questions are formulated at the beginning of Chapter 3. According to these research questions, the research strategy and method are justified. The researcher's interpretation of the research method is then clarified, having adopted a post-positivist philosophical position. This interpretation influences the research design, which will also be explained in detail in Chapter 3. Following the methodological discussion, 10 cases from eight companies are described and analysed individually in Chapter 4, providing a basis for the cross-case analysis in Chapter 5. In Chapter 6, the research findings from the cross-case analysis are developed into a tool and the findings are justified by testing the tool with independent technology entrepreneurs and other stakeholders in technology entrepreneurship. Chapter 7 discusses the findings of the research, outlines its limitations and proposes possible future research opportunities building on this work. Chapter 8 briefly summarises the overall research.

Chapter 2 Literature Review

Chapter Overview

Given the preliminary research questions identified in Chapter 1, this chapter reviews literatures to understand what has been answered by previous studies and what remains unexplained. This chapter constructs a knowledge basis for this research to build on and identifies a research gap which this research aims to fill.

2.1 Method for Searching Literature

The method used for searching the literature relevant to the preliminary research questions is explained as follows. The search started with keywords. The main sources used in this research were Google Scholar, Cambridge University Online Resources, Web of Science, and Science Direct. Each time a keyword was searched, the result was sorted three times, by number of citations, relevance and publication date (from most recent). This is because the number of citations can be a useful measure of importance for older literature, but simply relying on this measure can lead to the omission of more recent literature and literature that is less influential in general but yet still relevant to this research. A scan of the search results by title, keywords, and abstract provided a list of literature that was thought might be relevant to the research focus. This literature was then reviewed carefully to identify relevant papers for this research. Additionally, the citation network (references cited and citing articles) of the relevant papers was another important source for searching the relevant literature to fill gaps not covered by the keyword search. Figure 2 shows the method for searching the relevant literature used in this research.

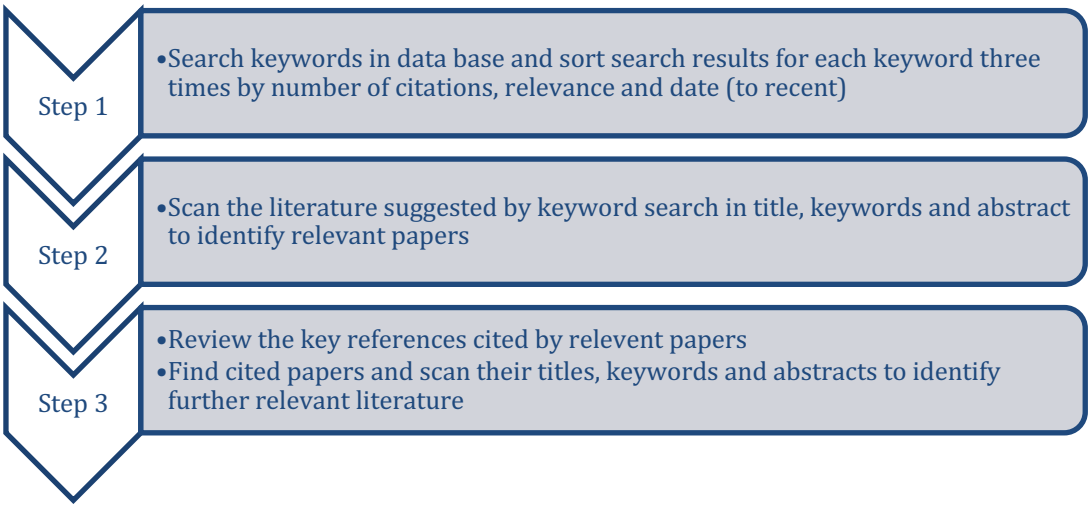


Figure 2 Methods for searching relevant literature used in this research.

Once relevant papers were identified, they were carefully reviewed and classified according to particular research areas. The keywords used and research areas reviewed for each question are summarised in Table 3, with section numbers.

Table 3 Keywords used and research areas reviewed for the research questions

Question	Keywords	Research Area	Section Number
What are the key questions and underlying rationale for market entry decisions?	Technology venture assessment, technology venture performance, technology evaluation, technology selection, entrepreneurial opportunity assessment, early-stage company evaluation, venture performance	Studies in understanding relationship between certain factors and technology ventures performance	Section 2.2.1 - 1
		Research identifying the selection criteria venture investors use when evaluating technology ventures	Section 2.2.1 - 2
		Tools for evaluating early-stage technology-based projects	Section 2.2.1 - 3
What are the key questions and underlying rationale for deciding the process to define the launch product?	New product development, lean startup, customer development	Different new product development approaches	Section 2.2.2
What are the key questions and underlying rationale for deciding the strategic alignment of technology and market development at the early stage?	Technology strategy, market strategy, strategy, competitive advantage, company strategy	Strategy literature on building competitive advantage	Section 2.2.3
How may technology entrepreneurs conduct effective the questions in the entrepreneurial environment?	Entrepreneurial decision-making, entrepreneurial management, entrepreneurial process, judgement, decision-making	Different new product development approaches	Section 2.3.1
		Evidence-based management	Section 2.3.2

2.2 Key Questions and Underlying Rationale for the Three Decisions

The purpose of this section is to understand, from the literature, the key questions and underlying rationale for the three focal decisions, namely (1) whether to pursue a business opportunity, (2) which process to follow to define the launch product in the short term, and (3) how to strategically align technology and market development at the early stage to build competitive advantage for longer-term development.

2.2.1 Key Questions and Underlying Rationale for Market Entry Decisions

This section reviews the literature to understand the key questions technology entrepreneurs need to consider when deciding whether to pursue a business opportunity. The keywords used for searching relevant literatures include both technology-related terms such as technology venture assessment, technology venture performance, technology evaluation, technology selection, and general terms such as entrepreneurial opportunity assessment, early-stage company evaluation, venture performance. By reviewing these literatures, studies that are considered relevant to this research interest are classifies into three groups:

1) Research into understanding the relationship between certain factors and the performance of technology ventures;
2) Research into identifying the criteria venture investors use when evaluating technology ventures;
3) Research into developing methods and tools to help technology entrepreneurs to assess business opportunities.

These three research domains are reviewed in the following sections for the purpose of understanding the key questions and underlying rationale for market entry decisions.

1. Relationship between Certain Factors and Technology Venture Performance

Research into understanding the relationship between certain factors and the performance of technology ventures is considered relevant because market entry decisions, as investment decisions, are made based on the prediction of companies' future performance (Williams, 1938). Therefore, technology entrepreneurs are expected to consider questions relating to these factors to make market entry decisions.

Cooper and Bruno's paper (1977) "Success Among High-Technology Firms" is one of the earliest studies that attempted to understand the factors that relate to the success and failure of new high-technology firms (Roure and Maidique, 1986). Cooper and Bruno chose to tackle this problem by analysing the characteristics of founders. Based on an investigation of 250 high-technology firms, they found that companies with multiple founders, with at least one having experience in the market or technology, are more likely to be successful. In addition, the data showed that entrepreneurs with experience of working in large organisations are more likely to establish successful ventures.

Van de Ven et al. (1984) reviewed prior studies in start-up success and early-stage development and critically pointed out that previous research had tended to focus on one of three perspectives: entrepreneurial, organisational, or ecological. Research from the entrepreneurial perspective mainly focused on how background characteristics and the psychological attributes of founding individuals affect venture performance. Cooper and Bruno's paper (1977) is an example of this type of research. Studies from the organisational perspective tended to concentrate on the effect of planning and organisational activities on early-stage firm development, and research from the ecological perspective mainly considered the impact of external support and resources in the industry on start-up development. Van de Ven et al. critiqued that although these studies contributed interesting findings, focusing only on one perspective limited our understanding of the determinants of technology venture performance. Therefore, they integrated the three perspectives to provide a more comprehensive understanding, summarised as follows.

A total of 14 early-stage software companies were investigated from the three perspectives. From the entrepreneurial perspective, four characteristics were found positively related to success and development of the sample. They were (1) education experience, (2) internal locus of control and number of ways to reduce risk, (3) breadth of business idea and clarity of product focus, and (4) degree of personal investment in the firm. From the organisational perspective, the data showed that success was positively related to (1) the involvement of potential customers and professionals in planning and market assessment, and (2) execution of the plan. From the ecological perspective, the data indicated that the level of competitiveness in the environment

accelerates the speed of firm development, but no significant influence on firm success was found. Table 4 lists the factors from the three perspectives.

Table 4 Determinants of technology venture performance, adapted from Van de Ven et al. (1984)

Perspective	Factor
Entrepreneurial Perspective	Education experience
	Internal locus of control and number of ways to reduce risk
	Breadth of business idea and clarity of product focus
	Degree of personal investment in the firm
Organisational Perspective	Involvement of potential customers and professionals in planning and market assessment
	Execution of the plan
Ecological Perspective	Level of competitiveness in the environment

Sandberg and Hofer (1987) researched the experience of venture capitalists to understand influential factors of new venture performance. They classified the criteria venture capitalists used when evaluating new venture proposals into three categories: (1) personal characteristics, (2) structure of the industry, and (3) business strategy. Accordingly, they proposed that the performance of new ventures is a function of the founding entrepreneurs (E), industry structure (IS) and venture strategy (S), as shown below.

$$New\ Venture\ Performance = f\ (E, IS, S)$$

The authors analysed 17 new ventures, both technology-based and non-technology-based ones, and arrived at the following findings. First, the interacting effects of the entrepreneur, industry structure and strategy had the most significant impact on new venture performance compared to any of these variables in isolation. This finding supported the view that business venturing is a complex process involving multiple interrelated factors. Second, industry structure had a higher level of impact on new venture performance than either strategy or the characteristics of the entrepreneur. This indicated the importance of timing to new venture success. Third, the combined impact of strategy and industry structure was significant, indicating that the company whose business strategy fits its industry development stage tends to have better performance. Fourth, the biographical characteristics of the entrepreneurs in technology-based ventures had a larger impact in new venture performance than in non-technology-based

ventures. The factors identified as significant to describe entrepreneurs, industry structure and business strategy are summarised in Table 5.

Table 5 Determinants of technology venture performance, adapted from Sandberg and Hofer (1987)

Category	Factor
Entrepreneur	Prior entrepreneurial and start-up experience
	Managerial experience in related industries
	Education
Industry Structure	Sector of the economy
	Stage of evolution
	Competition
	Presence or absence of disequilibrium
	Barriers to entry
Business Strategy	Suitability of business strategy with industry structure

The three perspectives identified by Van de Ven et al. (1984) and the three considerations proposed by Sandberg and Hofer (1987) are consistent at the abstract level, emphasising the impact on technology venture performance of (a) the entrepreneur team, (b) organisation (internal control and business strategy) and (c) external environment. This three-perspective analysis can be implicitly or explicitly found in many studies in this field. For example, Stuart and Abetti (1987) adapted studies of new product success to apply to technology venture success. They analysed 24 technology ventures and identified five major factors that contributed to their initial success. The results showed that the initial success of technology venture was more likely to be attributable to (1) higher entrepreneurship capability, (2) high degree of congruence between the venture and the entrepreneurs' previous experience, knowledge base and relevant skills in technology and the market, (3) tighter control of the organisation, (4) less R&D intensity but a higher portion of its limited resources devoted to marketing, and (5) more stable market conditions. The first two are entrepreneur-related factors, the third and fourth refer to organisational control and strategy of technology and market development, and the last one is related to the external environment of the firms. These factors are listed in Table 6.

Table 6 Determinants of technology venture performance, adapted from Stuart and Abetti (1987)

Perspective	Factor
Entrepreneurial Perspective	Entrepreneurial capability
	Congruence between the technology venture and the entrepreneurs' previous experience
Organisational Perspective	Control of the organisation
	Strategy of technology and market development
Environmental Perspective	Environment of firms

Roure and Keeley (1990) systematically reviewed the previous literature in organisational behaviour, industrial organisation, and strategic management, and identified 11 attributes describing management, firm strategy and environment as possible predictors of technology venture success. They tested these 11 attributes with 36 technology ventures in electronic and information technology sectors and found seven qualities that had significant influence on the performance of new technology ventures. These qualities are detailed in Table 7. The research concluded that venture success required an appropriate choice of management, industry and strategy.

Table 7 Determinants of technology venture performance, adapted from Roure and Keeley (1990)

Aspect	Quality	Description
Management Team	Team completeness	Functional managers for key positions
	Prior joint experience	The extent to which the founders had previously worked together
Environment	Level of competition	Strength of industry competition
	Projected market share	Forecast market share in mid-term
	Level of buyer concentration	The number of potential customers in the target market at the early stage
Strategy	Product superiority	The superiority of the product (technology superiority and/or cost advantage) compared with its competitors or potential substitutes

By comparing the findings of above studies, the impact of three aspects on venture performance are recognised, namely (1) entrepreneurs/management team, (2) business strategy and control, and (3) market and industrial environment. It is agreed that a venture with a capable team and a suitable firm strategy in a given environment is more likely to succeed. As these aspects and factors are related to technology venture performance, it is anticipated that they are worth considering for market entry decisions. In other words, these aspects and factors should be covered by the key questions for market entry decisions.

2. Criteria used by Venture Investors

This section summarises the criteria used by venture capitalists (VCs) when evaluating venture projects. VCs assess the potential business opportunities of early-stage companies to make investment decisions. The business opportunity assessment VCs make is essentially the same as that made by technology entrepreneurs when they consider market entry decisions. Therefore, the criteria used by VCs are expected to relate to the key questions for market entry decisions.

The two most citied papers relating to the criteria used by VCs when evaluating venture performance are Tyebjee and Bruno's (1984) paper "A Model of Venture Capitalist Investment Activity" and MacMillan, Siegel, and Narasimha's (1985) work "Criteria Used by Venture Capitalists to Evaluate New Venture Proposals". These two papers are reviewed in detail here because they provide a foundation in this area for the following research to build on and the criteria generated from these two studies are sufficiently complete.

Tyebjee and Bruno summarised 23 characteristics of ventures that are considered important in investment decisions in the literature. Based on these 23 criteria, 41 VCs were asked to rate ventures in electronics industry, provide an assessment of the potential returns and perceived risks of each project, and decide whether to invest. Through factor analysis, 16 of the 23 criteria were identified as significant in evaluating venture performance. The 16 criteria were grouped under four dimensions: (1) Market Attractiveness, (2) Product Differentiation, (3) Managerial Capabilities, and (4) Environmental Threat Resistance. Table 8 shows the 16 factors under the four dimensions.

Table 8 Criteria venture capitalists use for evaluating technology ventures, adapted from Tyebjee and Bruno (1984)

Dimension	Criteria
Market Attractiveness	Size of market
	Market need for product
	Growth potential of market
	Access to market
Product Differentiation	Uniqueness of product
	Patentability of product
	Technical edge
	Profit margins
Managerial Capabilities	Management skills
	Marketing skills
	Financial skills
	Creditability of the entrepreneur
Environmental Threat Resistance	Protection from competitive entry
	Protection from technological obsolescence
	Resistance to economic cycles
	Protection against down-side risk

MacMillan, Siegel and Narasimha (1985) broadened Tyebjee and Bruno's (1984) study by using a larger sample size and attaching weightings to the criteria. Table 9 lists 13 key criteria they identified important to venture performance. These criteria are classed into four groups, namely (1) entrepreneur's personality, (2) entrepreneurs' experience, (3) characteristics of product or service, and (4) market characteristics.

Table 9 Criteria venture capitalists use for evaluating technology ventures, adapted from MacMillan, Siegel, and Narasimha (1985)

Entrepreneur's personality	Capability of sustained intense effort
	Ability to evaluate and react to risk
	Communication and articulation
	Attention to detail
Entrepreneur's experience	Relevant track record
	Degree of familiarity with target market
	Demonstrated leadership ability
Characteristics of product/service	Product protection
	Market acceptance of the product
	Product readiness level
Market characteristics	Market need
	Market growth rate
	Threat of competition

In Shepherd's (1999) critique, as with the above two papers, the majority of research in this field tended to focus on deriving criteria from empirical evidence while few studies explained why certain criteria were important in evaluating new venture performance or survival chances from a theoretical viewpoint. Shepherd, instead, explained new venture survival through "industrial organisation" and "population ecology"

perspectives in strategy research. The industrial organisation perspective deals with the competitive positioning of the firm, while the population ecology perspective considers factors that affect the survival of a new firm. From the strategy literature, Shepherd identified three factors - (1) the nature of the markets, (2) industry competition, and (3) management capability – that affect a new venture's survival chances. These three aspects are explained below.

According to Andrews (1987), the nature of the market determines the key factors required to successfully compete in a particular industry, and superior performance arises when a venture's competencies fit these key success factors. Therefore, ventures should be able to identify and commit to these key success factors to be able to compete in an industry (Slater, 1993). Additionally, as the nature of the market and thus the key success factors are susceptible to change over time, ventures are required to be able to adapt to the changing environment to maintain the fitness.

The strategy literature also explains how advantage is obtained and reduced through changes in industry competition. When an industry is emerging, pioneers can enjoy higher returns due to limited competitive rivalry at this stage (De Castro and Chrisman, 1995). However, at the same time there is a higher risk of failure due to the higher level of uncertainty in, for example, market needs, market potential and technology feasibility (Lambkin and Day, 1989; Aaker and Day, 1986). Successful pioneers build entry barriers to protect their leading position against new entrants. Entry barriers can take many forms, such as technological leadership (Lieberman and Montgomery, 1988), customer-based information advantage (Schmalensee, 1982) and exclusive access to certain distribution channels (Karakaya and Kobu, 1994). Higher barriers to entry can afford pioneers more time to gain abnormal returns with relatively low levels of competition. This high return attracts new competitors to enter the industry, which raises the level of competition and reduces first-mover advantage (Lieberman and Montgomery, 1988).

In addition to the nature of the market and industry competition, management capability is also considered important for venture performance. To construct market legitimacy, new ventures need to overcome market ignorance (Slater, 1993). This requires certain resources, knowledge and skills on behalf of the management team. Specifically,

research suggests that ventures with management teams that have industry-related experience are more likely to succeed (Roure and Maidique, 1986), indicating that industry-specific human capital is a significant determinant of venture survival (Bruderl et al., 1992).

In summary, this section has reviewed two fundamental papers in identifying criteria VCs use for evaluating ventures. Papers in strategy research were then reviewed to understand why certain considerations are considered important to venture survival and performance. Integrating findings from previous studies, a venture is expect to enjoy a positive performance if the management team is capable of setting and implementing a business strategy in an attractive market and that fits the nature of the market and industry competition. Compared with the findings in Section 1, here, market attractiveness emerges as a new factor in business opportunity assessment, and is therefore reflected in the key questions behind market entry decisions.

3. Methods for Evaluating Early-Stage Technology-Based Projects

This section reviews methods for evaluating early-stage technology-based projects for investment decisions. After reviewing the relevant literatures using a keyword search, this research classified methods proposed by previous those literatures into three categories: (1) financial methods, (2) index-based scoring methods, and (3) context-based analytical methods. This way of classification refers to numerous review papers, such as Tran and Daim's study (2008) "A taxonomic review of methods and tools applied in technology assessment".

1) Financial Methods

Financial methods evaluate technology projects using monetary values (such as net present value), financial ratios (such as returns to investment and internal rates of return) and other measures (such as time-to-breakeven) to support investment decisions. As financial ratios and other measures can be derived from monetary values, this section chooses to focus on methods for calculating the monetary value of projects, which are the Net Present Value (NPV) and Real Option (RO) methods.

In NPV, the value of a project is the present value of all future net cash flows over the lifetime of the project (Pastor, 2000). If the NPV of a project is positive, then this project is considered worth investing in. NPV is calculated thus:

$$NPV = \sum_{t=0}^{n} \frac{C_t}{(1+i)^t}$$

where i is the discount rate, n is the lifetime of the project, t is the time that cash inflows or outflows, and C_t is the net cash flow at time t.

NPV is the most commonly used method for calculating project value because it is relatively simple to understand (Lawrence et al., 2007). However, NPV does not capture the value of management flexibility during the project's lifetime as it assumes a project, once invested in, will continue until the end of its lifetime (Kodukula and Papudesu, 2006). However, in practice, the management can, for example, terminate a project if key milestones are not achieved or if it is anticipated that satisfactory returns will not be generated. In this example the management team is considered to be holding an option, i.e. having a right, but not an obligation, to invest. This option has value, and therefore should be counted as part of the project value (Bowman and Moskowitz, 2009; Perlitz, ManfredPeske, 1999; Luehrman, 1998).

In contrast, the RO method recognises the value of management flexibility and claims that project value can be calculated using option-pricing model. This model was published by Fischer Black and Myron Scholes (1973) for pricing financial options in the stock market. Early-stage investments in technological R&D are somewhat similar to financial options, as funding the next phase of development 'buys' the option (but not the obligation) to continue with the innovation – termed 'real options' to distinguish them from financial options. The value of a project using RO is calculated as:

$$Real\ Option\ Value = N(d_1)NPV - N(d_2)Xe^{-rT}$$

$$d_1 = \frac{\ln\left(\frac{NPV}{X}\right) + (r + 0.5\sigma^2)T}{\sigma\sqrt{T}}$$

$$d_2 = d_1 - \sigma\sqrt{T}$$

where NPV is the net present value of the project at the present time, T is the time from now to the next decision point, X is the investment required at T, r is the risk free interest rate[1], σ is the variance of the value of the project from now to T, and $N(d_1)$ and $N(d_2)$ are the value of the standard normal distributions at d_1 and d_2.

Although different financial methods calculate project value in different ways, the commonality is that they process a set of inputs through a function to deliver monetary outputs, which is assumed to represent the economic value of the project. This indicates that the validity of the underlying model and input data determines the accuracy of the output, i.e. the monetary value. However, financial models are established on certain assumptions that simplify reality, and in the context of early-stage technology assessment input data such as future cash flows can be difficult to estimate due to high levels of technology and market uncertainty. Therefore many researchers point out that solely relying on financial methods can lead to inaccurate valuations and poorer decisions (Cooper et al., 2001). Therefore, qualitative methods are required to provide alternative perspectives.

2) Index-Based Scoring Methods

Instead of aiming at estimating the monetary value of a project, index-based scoring methods use a list of metrics to understand the value of a technology project. The Bell-Mason Diagnostic model is one of the earliest models designed to evaluate high-tech ventures at the early stages. This model was developed by Gordon Bell and Heidi Mason over a five-year period based on their experience with more than 100 ventures. In this model, technology ventures are measured against 12 dimensions, which are held to *"cover every aspect of a company in a complete, independent, and non-overlapping fashion"* (Bell and Mason, 1992, p. 621). Figure 3 shows the Bell-Mason Diagnostic model with its 12 dimensions. Technology entrepreneurs are asked to evaluate each by answering certain questions. Table 10 shows a number of examples questions for evaluating certain dimensions.

[1] The risk-free interest rate is the rate of return of a hypothetical investment with no risk of financial loss, over a given period of time.

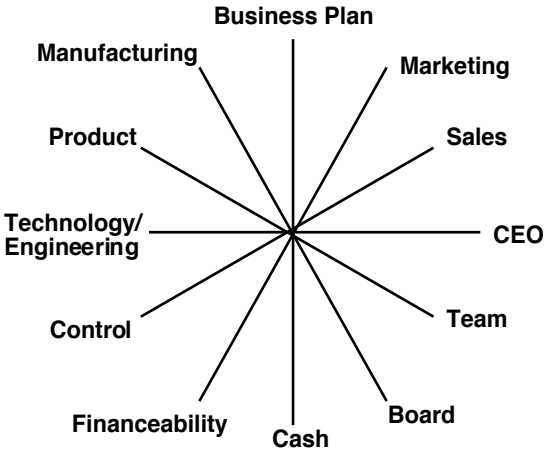


Figure 3 The 12 dimensions of the Bell-Mason Diagnostic model, Bell and Mason (1991)

Table 10 Examples of questions for evaluating certain dimensions, Bell and Mason (1991)

Dimension	Question
Technology/ Engineering	Does the company have a fundamental, defensible, and measurably superior technology that enables the sustained conversion to its products by an engineering group of proven capability?
Product	Does the product have well-defined and unique features, functions, and benefits to support the price and match the competitive market requirement?
	Can the company build the next generation of follow-on products?
Marketing	Does the company have a complete strategic and tactical market plan, together with the leader and organisation to implement it?
Team	Is the top-level team composed of high-quality individuals with measurable experience and expertise in the various areas capable of attracting, leading and managing the respective functions?
	Can each of the team members play several positions in his or her team as opposed to solely managing a team of players?
	Do the members function collectively as a team in an integrated fashion as opposed to operating as a group of egocentric or warring individuals?

The Bell-Mason Diagnostic model identifies key factors and questions for technology venture assessment, but it does not explicitly explain the relationship between these factors and venture performance. In another index-based scoring method, the Opportunity-Feasibility (OF) model, this relationship was established. As the authors (Mitchell et al., 2014, p.30) claimed:

> *Opportunity is a measure of the value that may result from the project, while Feasibility (or strictly its inverse, Difficulty) assesses the investment that may be required to bring it to fruition. Thus the product of the two scores Opportunity x Feasibility is a rough indication of potential Value/Investment, or return of investment.*

Therefore, in the OF model, factors are separated into two considerations: Opportunity and Feasibility. Suggested factors of Opportunity and Feasibility relating to technology venture assessment are listed in Table 11 and Table 12 below.

Table 11 Suggested factors for Opportunity, adapted from Mitchel et al. (2014)

Dimension	Factor	Explanation
Volume	Market size	How big is the potential market or the number of potential adoptions reasonably available to the venture?
	Sales potential in a given time	What is the anticipated sales volume or number of adoptions in a defined time?
	Customer benefit	Does the venture provide identifiable benefit to customers (internal or external) or potential adopters?
	Competitive intensity in market	How intense is the competition?
	Industry/market readiness	How easy will it be for customers or adopters to take up the product? Do they have to change their behaviour or processes?
Future Growth	Market growth	What is the anticipated growth rate of the market?
	Future potential	Will the product open new markets beyond the project timeframe?

Table 12 Suggested factors for Feasibility, adapted from Mitchel et al. (2014)

Dimension	Factor	Explanation
Characteristics of the product	Product differentiation	How well is the product differentiated from those of major competitors?
	Sustainability of competitive advantage	Does the team have the ability to sustain their competitive position?
	Technical challenge	How much is the proposed product technically feasible?
Skills and knowledge Business	Market knowledge	Does the team understand the size and requirements of the market?
	Technical capability	Does the team have the required technical competences to complete the project?
Business processes	Sales and/or distribution	Does the team have sales competences and/or the distribution chain?
	Manufacturing and/or supply chain	Does the team have the ability to manufacture or supply the product?
	Finance	Does the team have the availability of finance?

The OF model is an attempt to explain why and how certain dimension/factors affect the performance of early-stage technology-based projects through (1) classifying factors into either opportunity-oriented or feasibility-oriented, and (2) establishing a relationship between opportunity, feasibility and return of investment. However it does not explain the mechanism between these factors, i.e. how these factors interact to determine business decisions? A number of researchers have emphasised the importance of understanding the mechanism of decision-making and developed context-based analytical methods, which are explained as follows.

3) Context-Based Analytical Methods

Context-based analytical methods, instead of simply numerating key dimensions/factors, emphasise that understanding how they fit with business logic is important for evaluating business opportunities and making decisions. Two widely used context-based methods are the Business Model Canvas and Roadmapping, summarised below.

A number of researchers advocate that a business opportunity can be better evaluated if entrepreneurs understand the business model (Achtenhagen et al., 2013; Baden-Fuller and Haefliger, 2013; Evans and Johnson, 2013). Business models "*describe the rationale of how companies create, deliver, and capture value in certain contexts*" (Osterwalder and Pigneur, 2010, p. 14). Previous studies have proposed many tools to help entrepreneurs develop a business model. Gassmann & Frankenberger's (2015) 'Business Model Navigator' provides a taxonomy of business models which, together with Osterwalder and Pigneur's Business Model Canvas (BMC), are popular and practical examples of many conceptualisations of business models in the literature. Here, BMC is used as an example to explain how a business opportunity may be better understood through business model analysis.

As shown in Figure 4, BMC consists of nine building blocks, including customer segments, value propositions, channels, customer relationships, revenue streams, key resources, key activities, key partners, and a cost structure. BMC differs from index-based methods because it does not just numerate these building blocks but also emphasises the business logic that runs through them. Starting with the customer segments, these are people or organisations for which value is created. For each segment, a company should have a specific value proposition, which are products or services that create value for customers. Channels describe how a company interacts with customers and delivers value. Customer relationships outline the relationships a company needs to establish with customers. Revenue streams clarify how and through which pricing mechanism the company can capture value. Once the above building blocks are defined, the company needs to describe the infrastructure to create, deliver and capture value. Key resources and activities show the most important assets and actions required to make the business model work. As few companies can own all the required resources or perform all required activities, they need to leverage them from

key partners. Once the infrastructure of the business model is understood, the company can work out its cost structure accordingly. As these nine building blocks cover the four main areas of business in terms of the customer, offer, infrastructure, and financial viability, they can help users achieve a comprehensive understanding of their business and enable an effective evaluation of the business opportunity to be made. Figure 4 shows BMC with its nine building blocks and suggested questions (Blank, 2013).

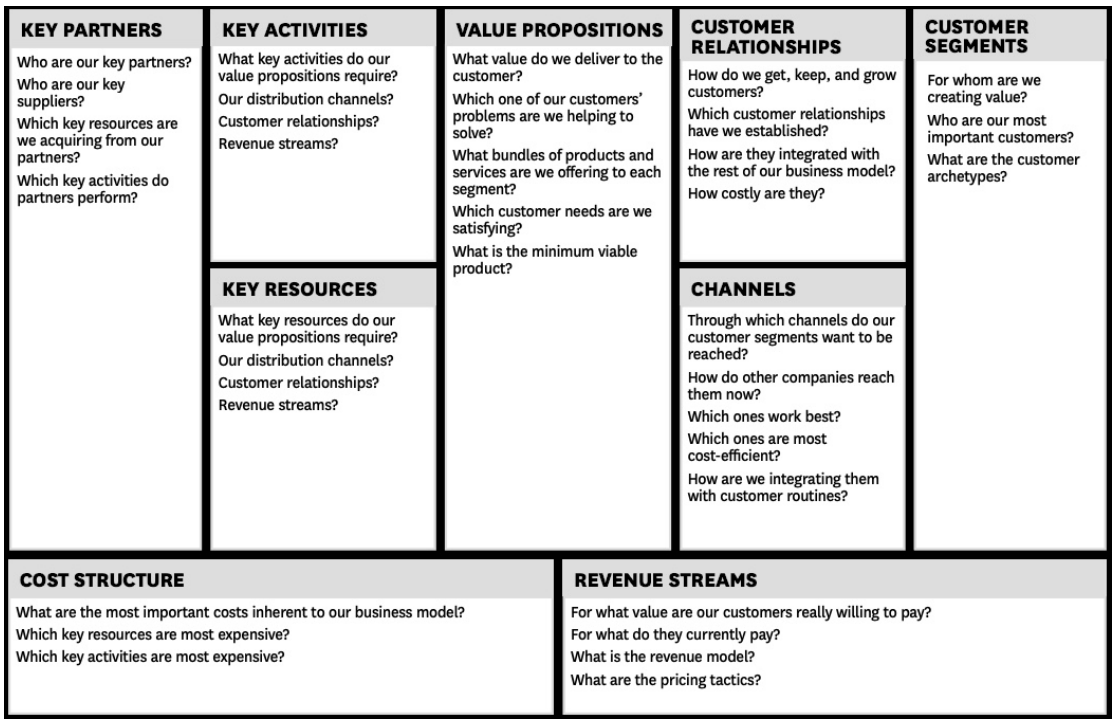


Figure 4 The Business Model Canvas with nine building blocks and suggested questions (Blank, 2013)

Another widely used method that emphasises the importance of understanding the complexity of the business context for technology evaluation is Roadmapping. Roadmapping, which originated from supporting industrial strategic technology planning at the product-level (Groenveld, 2007; Garcia and Bray, 1997; Willyard and McClees, 1987), has been increasingly applied at corporate (Cooper, 2000) and project levels (Hunt et al., 2004). The distinguishing feature of Roadmapping compared to other management tools such as BMC is the integration of the time-dimension (Phaal, 2004). A 'self-facilitating' roadmap template for early-stage technology venture/project evaluation and planning is depicted in Figure 5 (Phaal et al., 2015). The horizontal axis describes the time dimension, in terms of current, short-, medium-, and long-term future time frames, and the vertical axis includes perspectives on the market ('know-why'),

product ('know-what') and capability ('know-how'). The two axes together form a structured representation that enables the communication of the relationships between markets, products, and technology over time for strategy and innovation (Geum et al., 2013). Users typically start by considering the future prospects in terms of market conditions, product functions, performance and features, and required capabilities for developing and selling the proposed product. Then, the current status of these aspects is assessed to identify the gap between the current situation and the future vision. Finally, short-, medium- and long-term plans are designed to drive the company form where it is today to where it is supposed to be in the future.

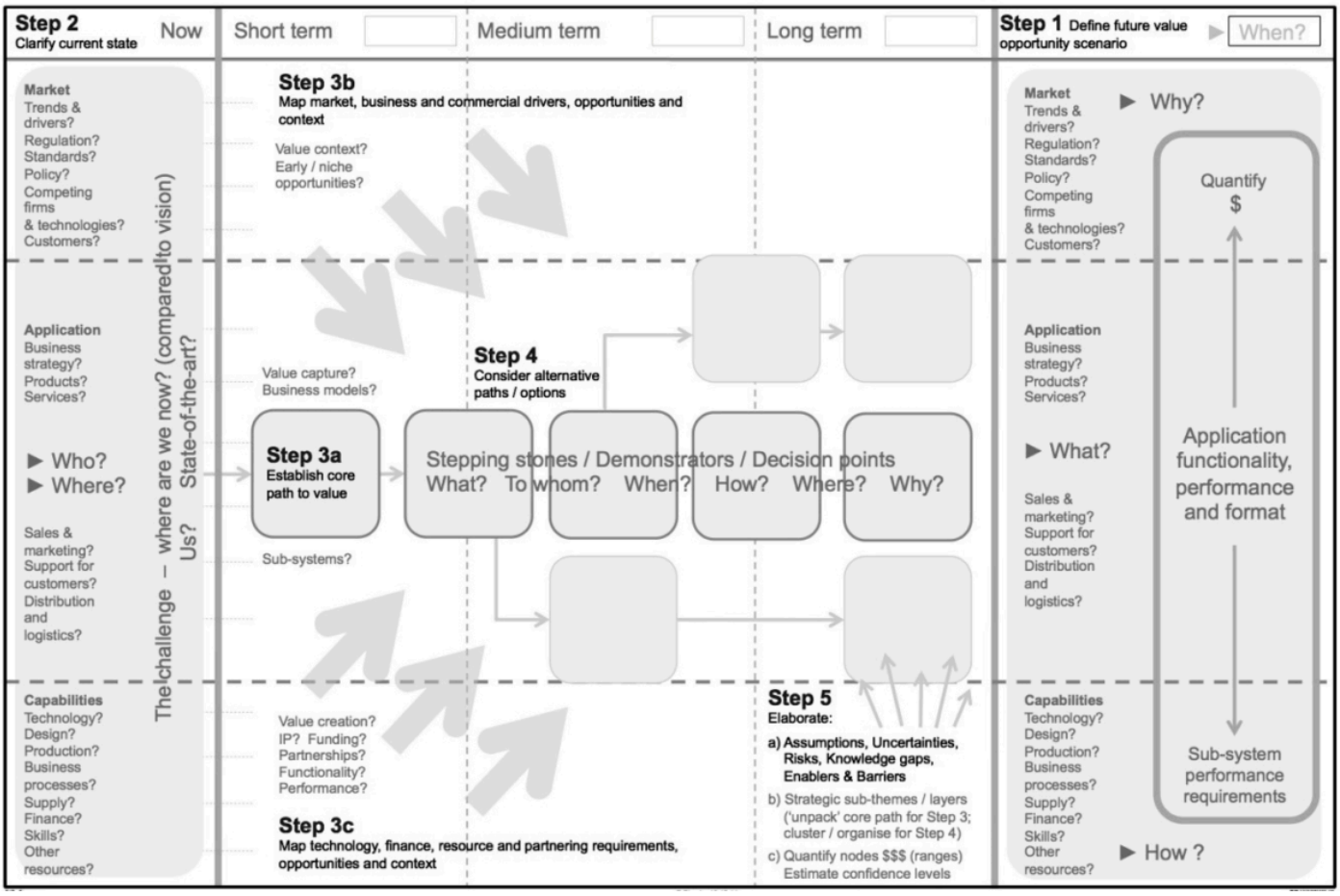


Figure 5 A 'self-facilitating' roadmap template for early-stage technology venture/project evaluation and planning (Phaal et al., 2015)

The BMC and Roadmapping methods clarify the rationale for business models and planning. Compared with index-based methods, context-based analytical methods analyse key dimensions and factors in a logical and structured way so that entrepreneurs can have a better understanding of their business. Such methods are not mutually

exclusive, and can be combined together to better inform decision makers, with each providing complementary views.

4) Discussion and Summary

Section 2.1.1 has reviewed previous literatures to understand key questions in business opportunity assessment for market entry decisions. For this purpose, relevant literatures are classified into three groups: (1) research into understanding relationships between certain factors and technology ventures performance; (2) research into identifying the criteria venture investors use when evaluating technology ventures; and (3) research into developing methods and tools to help technology entrepreneurs to assess business opportunities.

Studies in the first group suggest the relationship between certain factors and venture performance relies on statistical methods. Therefore, the conclusions are subject to the characteristics of chosen samples such as size and industry. For example, Stuart and Abetti (1987) analysed 24 technology ventures and found that the initial success of technology venture is more likely with less R&D intensity but a higher portion of its limited resources given to marketing. From the perspective of an individual entrepreneur, when applying this finding in predicting venture performance, they should be careful about its generalisability as the conclusion might not fit their situation.

Research in the second group and some in the third group (such as the Bell-Mason Diagnostic model) tends to propose a list of dimensions with factors which can be used by entrepreneurs as a checklist to evaluate the potential of business opportunities. Checklists highlight ‘what’ are important to consider in venture assessment, but they do not explain the underlying rationale of ‘why’ they are important. Therefore, entrepreneurs might feel overwhelmed by many proposed factors while lost when it comes to establishing their business logic. Context-based analytical methods such as BMC and Roadmapping can address this limitation, with the key dimensions, questions and underlying rationale integrated and clarified in one template.

In summary, previous studies have proposed many determinants for business opportunity assessment, but most of them are developed from regression or investors’

experiences and few of them are developed from the entrepreneurs' perspective. In contrast, this research will use empirical evidence from technology ventures to understand what questions technology entrepreneurs actually consider important in business opportunity assessments in practice. In addition to the key questions, previous studies have also proposed various rationales for business opportunity assessment that serve certain purposes. For example, the rationale embedded in BMC is helpful for developing business models, while the rationale underlying Roadmapping aims at business planning. As the previous literature does not suggest a rationale suitable for the purposes for this research, which is helping technology entrepreneurs make three focal decisions (whether to pursue a business opportunity, which process to follow to define the launch product in the short term, and how to strategically align technology and market development in the early stages to build competitive advantage for longer-term development), this research will develop one to address this gap.

2.2.2 Key Questions and Underlying Rationale for Deciding the Process to Define the Launch Product

In this research, a product is defined if the design of the product is complete without further changes expected. It is important to note that defining the launch product is different from developing the launch product, as product definition aims at a complete design of the product, with no requirement to deliver the defined product. In practice, entrepreneurs follow different processes to define the launch product. For example, some entrepreneurs define launch products through iterative trials and experiments, while others define it directly. The objective of this section is to understand the determinants of entrepreneurs' choice about which process to follow to define a launch product. As product definition is closely related to new product development (NPD), different product development processes are reviewed to identify the determinants. In NPD literature, product development processes exist on a continuum from linear to iterative process. These two processes are reviewed and compared in the following sections.

1. Linear Product Development Process

NPD has been heavily influenced by the Stage-Gate model developed by Cooper (1988, 1990). The Stage-Gate model breaks the product development process down into six stages (where activities are conducted) and five gates (where evaluations and Go/Kill decisions are made) (see Figure 6). The stages are defined by the activity within it, from idea discovery, scoping, building the business case, development, testing and validation, through to launch. The six stages and main activities are summarised in Table 13 according to Cooper's definition.

Figure 6 The Stage-Gate model developed by Cooper (1990)

Table 13 Six stages and main activities identified by the Stage-Gate model, adapted from Cooper (1990)

Stage Number	Name of the Stage	Main Activities
Stage 0	Idea Discovery	Pre-work designed to discover and uncover business opportunities and generate new ideas
Stage 1	Scoping	Quick, inexpensive preliminary investigation and scoping of the project – largely desk research
Stage 2	Building the Business Case	Detailed investigation involving primary research – both market and technical – leading to a Business Case, including product and project definition, project justification, and the proposed plan for development
Stage 3	Development	The actual detailed design and development of the new product and the design of the operations or production process required for eventual full-scale production
Stage 4	Testing and Validation	Tests or trials in the marketplace, lab, and plant to verify and validate the proposed new product, brand/marketing plan and production/operations
Stage 5	Launch	Commercialisation – beginning of full-scale operations or production, marketing, and selling

In addition to the general Stage-Gate model shown in Figure 6, Cooper (2007) developed the Technology Development Stage-Gate model specifically for new product development in technology-based projects. The process is shown in Figure 7, with the four stages and main activities summarised in Table 14.

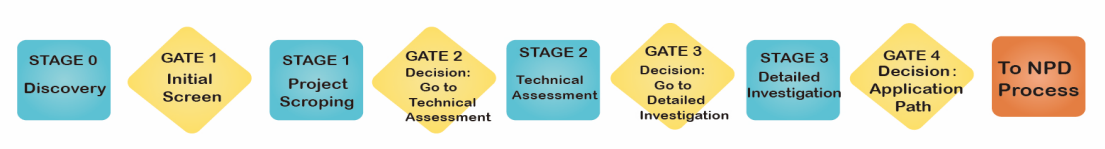


Figure 7 Technology Development Stage-Gate model for new product development in technology-based projects

Table 14 Four stages and main activities identified by the Technology Development Stage-Gate model, adapted from Cooper (2007)

Stage Number	Name of the Stage	Main Activities
Stage 0	Idea Discovery	Pre-work designed to discover and uncover business opportunities and generate new ideas
Stage 1	Project Scoping	• Lay out the foundation for the project • Define the scope of the project • Map out the forward plan
Stage 2	Technical Assessment	• Demonstrate the lab or technical feasibility under ideal conditions • Initial or preliminary experimental work
Stage 3	Detailed Investigation	• Implement full experimental plan • Prove technology feasibility • Define scope of technology and value to company • Plan developed for the utilization of results
Stage 4	To NPD Process	Start product development process

The above Stage-Gate models propose a linear new product development process in which the product is defined at pre-development stage and then developed and launched as how it was defined. According to Cooper (2001), this linear product development process was designed for incremental product development and might be inappropriate when applied to breakthrough projects. This is because linear product development processes tend to be rigid, as progress flows in largely one direction through the phases of design, R&D, and testing to commercialisation (Blank, 2013). This indicates that only after developing and launching the product does the venture get to know whether the product fits the market need or not. Therefore, the linear product development process is only appropriate when there are low levels of market and technology uncertainty, so that entrepreneurs can effectively predict the R&D results and market responses to the product before actually developing and launching it. However, in many cases specific customer requirements for proposed products are not available, the target customer segments are not even clear, or which technological solution would be the most appropriate for proposed products is unknown. In these circumstances, linear product development processes are not appropriate as there is no valid basis for

entrepreneurs to predict R&D results and market responses to define the launch product. Therefore, an iterative process is proposed.

2. Iterative Product Development Process

In contrast to the linear product development process, the iterative product development process is proposed to manage NPD under an uncertain environment. Cooper (2014) realised the need for a more flexible process and proposed an adaptive, agile and accelerated modification to his original linear Stage-Gate model (see Figure 8 and Table 15).

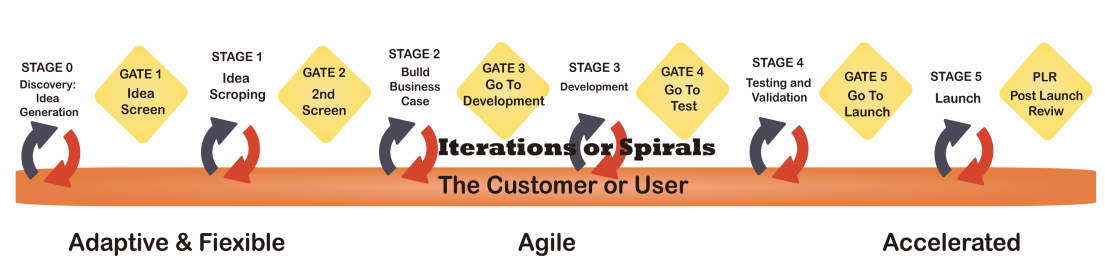


Figure 8 An adaptive, agile and accelerated modification to the original linear Stage-Gate models, adapted from Cooper (2014).

Table 15 Five stages and main activities identified by the modified Stage-Gate model, adapted from Cooper (2014)

Stage Number	Name of the Stage		Main Activities
Stage 0	Idea Generation		Pre-work designed to discover and uncover business opportunities and generate new ideas
Stage 1	Idea Scoping		• Lay out the foundation for the project • Define the scope of the project • Map out the forward plan
Stage 2	Building Business Case	Study of User Needs and Wants	• Face to face, touching real users • Entire project team involved • Aim at identifying needs, "pain points" and requirement
		Full Proposition Concept Test	• Simulated 'sell' with virtual prototypes at pre-development stage • Gauge interest, linking, preference, purchase intent
Stage 3	Development	Rapid Prototype and Test	• Test proposed product early in development • Rapid prototype • Gauge customer reaction and purchase intent
		Working Model	• Develop versions of product much closer to final definition • Keep gauging customer reaction and purchase intent
Stage 4	Testing and Validation		• True prototype tested in actual in-use conditions • Field trials • Beta test
Stage 5	Launch		Launch product

Other typical examples of an iterative product development process are the agile product development process (Stare, 2014; Karlström and Runeson, 2005), lean product development (Ellis, 2016; Jensen et al., 2006; Drejer and Gudmundsson, 2000) and the Customer Development (CD) process (Moogk, 2012; Eisenmann et al., 2011). As the CD process is particularly designed for early-stage companies, which fits the interest of this research, it is analysed in detail to explain the iterative process.

The CD process was developed by Steve Blank, a serial entrepreneur, from his experiences in technology entrepreneurship. According to Blank (2013, p. 5), CD encourages entrepreneurs to:

> *[Go] out and ask potential users, purchasers, and partners for feedback on all elements of the business model, including product features, pricing, distribution channels, and affordable customer acquisition strategies. The emphasis is on nimbleness and speed: new ventures rapidly assemble minimum viable products[2] and immediately elicit customer feedback. Then, using customers input to revise their assumptions, they start the cycle over again, testing redesigned offerings and making further small adjustments (iterations) or more substantive ones (pivots) to ideas that aren't working.*

The fundamental difference between the linear product development process and the CD process is that the former assumes entrepreneurs can make accurate judgements of the market and technology, while the CD process encourages entrepreneurs to consider their judgements as hypotheses that need to be further tested (York and Danes, 2014).

The CD process consists of four interlocking and circular stages (see Figure 9): Customer Discovery, Customer Validation, Customer Creation and Company Building. The first two stages aim at 'searching a business', i.e. defining a new product through learning and discovery, and the last two stages focus on efficient development and execution.

[2] Minimal viable product is a product with just enough features to satisfy early customers and to provide feedback for future product development.

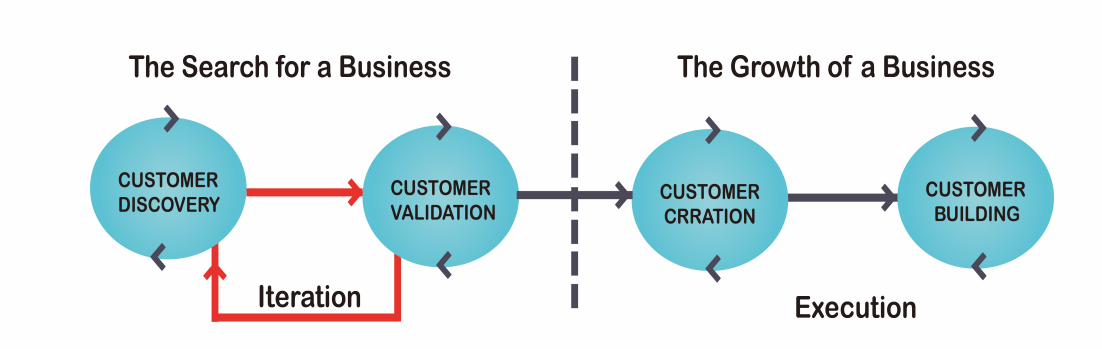


Figure 9 Four interlocking and circular stages in the Customer Development process, adapted from Blank (2013)

The purpose of CD is to preliminarily test the fit between the proposed product and market needs. The founders translate ideas into a series of business model hypotheses and test them with potential customers through minimal viable products. When the product-market fit is preliminarily validated, the founders move to the Customer Validation stage to further validate the product design and hypotheses associated with sales and marketing. Completing the first two stages verifies the market need, identifies target customers, clarifies customers' perceived value derived from the product, establishes a pricing and marketing strategy, and tests the sales cycle and process (York and Danes, 2014). As a result, at the end of the second stage the launch product is defined and the business model is validated.

Only when all hypotheses associated with the business model are adequately validated does the company then proceed to the Customer Creation stage in order to scale up the business through marketing and sales. The last stage is where the company transitions from a learning and discovery mode to efficient execution.

3. Comparison and Summary

New Product development processes exist on a continuum from linear to iterative. The philosophy underlying linear and iterative processes is predictive and adaptive. The linear product development process assumes entrepreneurs can make sufficiently accurate predictions about the market and technology before developing and launching a product to customers. Therefore, the linear process is appropriate when entrepreneurs have sufficient understanding of: (1) the target market and customer requirements, and: (2) an appropriate technology solution to enable the required product.

In contrast, the iterative process relies heavily on hypothesis testing, which implies its underling assumption: that entrepreneurs' predictions about customer requirements and technological solutions are subject to challenge. The reason behind this assumption is that in many cases entrepreneurs are not sure about the target market segment, customer requirements or feasible technological solutions before developing and launching the product to customers. In this circumstance, entrepreneurs lack a valid evidence base to define the launch product. Therefore, gaining an understanding of the target customer, customer requirements and feasibility of different technological solutions is a top priority for defining the launch product. For entrepreneurs facing uncertainty and controlling limited resources, in order to garner a clearer understanding it is essential to maximise the amount of learning gained per unit of resources expended (Eisenmann et al., 2011). The iterative process encourages entrepreneurs to iteratively build prototypes, test them with potential customers and improve them based on customer feedback until customers are satisfied. Compared with the linear process, the iterative process *"favors experimentation over elaborate planning, customer feedback over intuition, and iterative over traditional liner development"* (Blank, 2013, p. 4). Therefore, the iterative process is more appropriate in an entrepreneurial environment where entrepreneurs are able to make accurate judgements due to information availability and/or relatively high levels of future uncertainty.

In summary, previous studies in new product development have implied that the entrepreneurs' choices regarding which process to follow to define the launch product depending on how clear they are about their (1) first target market, (2) customer requirements and (3) technology solution. These proposed determinants will be tested in this research using empirical evidence to develop key questions and identify an underlying rationale for choosing which process to follow to define a launch product.

2.2.3 Key Questions and Underlying Rationale for Aligning Technology and Market Development in the Early Stage

In practice, technology ventures choose different strategies to align technology and market development in the early stage to build competitive advantage for the company in the longer term. For example, some companies choose to develop technology to industry-leading levels and leverage markets through technology advancement; other companies choose to launch and market products when the technology is developed to a sufficient level and then rely on market advantage to enhance technology development; still other some companies choose to develop technology and market in parallel. The objective of this section is to understand the determinants of ventures' strategic choices in aligning technology and market development in the early stage.

As the purpose of aligning technology and market development is to build competitive advantage for the company (Boudreau, 2017), this section reviews the literature in strategy research to understand the sources and ways of gaining competitive advantage for firms. The rationale for technology ventures to build competitive advantage is discussed in order to identify the determinants of ventures' strategic choices in aligning technology and market development in the early stage.

In this research, following Barney (1995, p.23), competitive advantage is defined as "*superior performance relative to other competitors in the same industry or superior performance relative to the industry average in the long term*". Understanding the source of sustainable development for firms has been a major area in strategic management since the 'SWOT' (Strengths-Weaknesses-Opportunities-Threats) framework was proposed in the 1960s (Barney, 1991). The SWOT framework emphasises the relationship between a firm's environmental opportunities and threats and its internal strengths and weaknesses in building competitive advantage, and suggests, in the words of Barney (1991, p. 99), that:

> *Firms obtain sustainable competitive advantages by implementing strategies that exploit their internal strengths, through responding to environmental opportunities, while neutralizing external threats and avoiding internal weaknesses*.

Although strategic management research has evolved greatly since SWOT was first proposed, this fundamental framework is still popular as it highlights the importance of both external environment and internal capabilities in understanding the sources of competitive advantage (Barney, 1995). The following models analysing the external environment and internal resource and capabilities can fit into the SWOT framework. Figure 10 shows the relationship between the SWOT framework, resource-based models and environmental models.

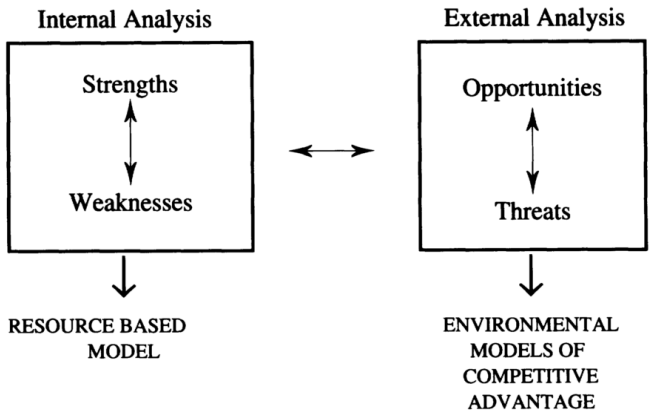


Figure 10 The relationship between the SWOT framework, resource-based model and environmental models, Barney (1991)

Models focusing on analysing firms' opportunities and threats in their competitive environments are classified as environmental models. For example, Porter's (1985) competitive "five forces model" identifies five factors that affect the attractiveness of an industry, suggesting that industry attractiveness is a source of company competitive advantage, as companies in attractive industries tend to have more opportunities and are more likely to obtain a superior performance.

In addition to analysing how the external environment affects a company's competitive position, researchers from the resource-based perspective claim that firms' (scarce and difficult to imitate) resources and capabilities are the main source of competitive advantage (Barney, 1995; Grant, 1991). From the resource-based view, 'resources' are basic inputs of a firm's production process, including human, technology, financial, physical and organisational resources (Barney, 1995; Hofer and Sandberg, 1987). Resources are not productive on their own and require capabilities to coordinate them to enable productive activities (Grant, 1991). Chandler and Hanks (1994) claimed that

firms with abundant resources and a wide variety of resource-based capabilities are expected to achieve competitive advantage. Barney (1991) specified that companies gain competitive advantage through exploiting and organising resources and capabilities that are valuable to opportunity exploitation, rarely owned and costly to obtain for competitors.

In summary, previous research has shown that a favorable external environment and abundant internal resources and capabilities are the two primary sources of competitive advantage. Companies gain competitive advantage by developing and organising their resources and capabilities in exploiting environmental opportunities and neutralising environmental threats. This implies that in order to achieve competitive advantage, entrepreneurs should be able to: (1) understand environmental opportunity and treats; (2) identify resources and capabilities required to exploit the opportunity and neutralise threats, and; (3) obtain required resources and capabilities to exploit the opportunity and neutralise threats.

In the context of this research, strategies for aligning technology and market development describe how companies obtain required capabilities through technology and market development to exploit opportunity and neutralise threats in the longer term. Few previous studies have investigated this particular topic and there is a distinct lack of knowledge regarding the interaction between technology and market development in the development of technology companies and how this interaction affects entrepreneurs' strategic choices in aligning technology and market development in the early stage. This is identified as the research gap to be addressed in this research.

2.3 Key to and Method for Making Effective Judgements

The objective of this section is to understand how entrepreneurs may make effective judgements in an entrepreneurial environment. If it is assumed that high quality decisions are based on effective judgements, then previous studies in 'how to make high quality decisions' is considered relevant to provide insights to answer 'how to make effective judgements'. Section 2.3.1 selects the decision of 'through which process to define a new product' as an example to identify the key for making effective judgements. Analysis shows that one's judgement of a question includes two key elements: (1) one's answer to the question, and; (2) one's understanding of the reliability of their answer, which is reflected in how confident he or she is about the answer. The analysis shows that effective judgements do not require entrepreneurs to provide accurate answers, but to have an appropriate understanding of the reliability of their answers. In other words, by analysing the previous literature, this research proposes that the key for entrepreneurs to make effective judgements is having an appropriate understanding of the reliability of their answers. This finding is consistent with evidence-based decision-making, discussed in Section 2.3.2. In Section 2.3.3, a method to help entrepreneurs gain an appropriate understanding of the reliability of their answers is proposed based on the Toulmin method. Section 2.3.4 summarises this section overall.

2.3.1 Identify the Key to Making Effective Judgements

In this research, effective judgements are defined as judgements that do not lead to low quality decisions. Two opposing approaches for making decisions are the intuitive and rational approaches. In the context of entrepreneurial decision-making, entrepreneurs often lack decision-related information and face time and budgetary constraints, and therefore tend to rely on intuition (York and Danes, 2014). Making decisions based on intuition is fast, automatic, effortless, implicit, and emotional (Stanovich and West, 2000), but faces risks of perceptual biases that may result in poor decisions. Kahnemann (2011), in his book "Thinking, Fast and Slow", noted that expert intuition is reliable in regular and predictable environments but less trustworthy in more unique start-up situations. Schade and Koellinger (2007) review perceptual biases and heuristics that affect entrepreneurial decisions, including selection, representativeness, acquiescence,

confirmation, overconfidence and optimism biases. The descriptions of these biases are presented in Table 16.

Table 16 Perceptual biases in entrepreneurial decision making, adapted from Schade and Koellinger (2007)

Bias	Description
Selection bias	Seeking information from "friendly" confirmatory sources resulting in unrepresentative sampling of the target market(s)
Representativeness bias	Generalising from small, non-random samples of data and/or information from respondents who do not represent the target market(s)
Acquiescence bias	Respondents' tendency to give the answers they believe the entrepreneur wants to hear
Confirmation bias	Interpreting information to confirm prior beliefs
Overconfidence bias	Overestimating the knowledge and precision of customer suggestions and/or the entrepreneurs information
Optimism bias	The entrepreneur's belief that he/she is unlikely to experience negative outcomes or fail

The rational approach refers to reasoning, which is slower, conscious, laborious, explicit, and logical (York and Danes, 2014). However, in the context of entrepreneurial decision-making, the rational approach may be inappropriate due to information availability, future uncertainty, time pressure and budgetary constraints. Therefore, relying solely on intuition or reasoning may lead to poor decisions in an entrepreneurial environment.

Here, the decision of 'which process to follow to define a new product' is used as an example to understand the key to making effective judgements in the context of technology entrepreneurship. According to Section 2.2.2, if an entrepreneur has sufficient valid evidence to answer the key decision-related questions, it is suggested they follow the rational decision-making approach to define the launch product, i.e. to conduct sufficient research to arrive at accurate answers to the key questions (Pfeffer and Sutton, 2006). However, when entrepreneurs are faced with insufficient valid evidence, their answers to certain questions can be potentially inaccurate, which makes the rational approach questionable. In this circumstance, it is suggested that entrepreneurs choose the iterative NPD process. This process encourages entrepreneurs to consider the answers that were made based on insufficient evidence as hypotheses rather than as assured answers. The hypotheses are then tested with potential customers and other relevant stakeholders to gain their feedback (new evidence), based on which entrepreneurs can validate or disprove their initial hypotheses and arrive at more

accurate answers (hypotheses). This iterative hypothesis-testing process continues until all hypotheses are sufficiently verified.

The iterative process follows the Bayesian decision-making process, which was proposed by Fischhoff and Beyth-Marom (1983). In the Bayesian decision-making process, decision makers develop hypotheses based on their experiences or intuition, identify data sources and gather data to evaluate the likelihood of the hypotheses being accurate, and make decisions based on that evaluation. The iterative process seems to integrate intuitive and rational approaches into an iterative process – there is a place for intuition, from which hypotheses may be generated, and rational reasoning can be found during hypothesis testing. York and Danes (2014) suggested that the iterative process can mitigate the perceptual biases listed in Table 16.

The above discussion implies that an entrepreneur's decision as to whether to choose the linear or iterative process depends on his or her understanding of whether existing evidence is sufficient to provide accurate answers. In other words, to choose an appropriate process entrepreneurs should have an appropriate understanding of the sufficiency of the evidence employed and reliability of their answers. This indicates that entrepreneurs' understanding of the reliability of their answers affects their decisions. If we define judgements as the basis for making decisions, then they include not only answers but also entrepreneurs' understanding of the reliability of their answers (see Figure 11).

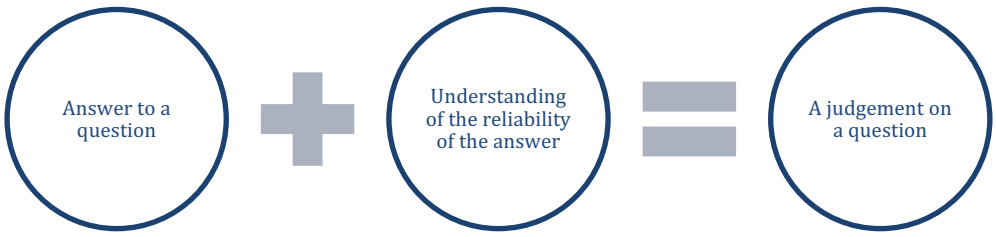


Figure 11 The two key elements of a judgement

As explained above, when there is insufficient valid evidence for entrepreneurs to make accurate answers to certain questions, they are recommended to follow iterative process. This implies that even though entrepreneurs' answers to certain questions are inaccurate, they can still make effective judgements as long as they are aware of the potential

inaccuracy in their answers. In other words, effective judgements do not require accurate answers. This finding might seem inconsistent with the intuition that high quality decisions or effective judgements should be based on accurate answers. Many previous studies have emphasised the idea of hypothesis testing. However, few studies have explicitly claimed that: (1) it is the entrepreneurs' awareness of the potential inaccuracy of their answers that motivates the hypothesis-based process, and; (2) the key for entrepreneurs to achieve effective judgements is to gain an appropriate understanding of the reliability of their answers. This research identifies these two points by reviewing the previous literature and will further validate this finding with empirical evidence.

2.3.2 Evidence-Based Decision Making

Through analysing the linear and iterative NPD process, this research proposes that the key for entrepreneurs to make effective judgements is having an appropriate understanding of the reliability of their answers. This finding is consistent with evidence-based decision-making.

Evidence-based decision-making was first defined by David Sackett and colleagues in their textbook on clinical epidemiology as *"the conscientious, explicit and judicious use of current best evidence in making decisions about the care of individual patients"* (Sackett et al., 1996, p. 71). The thinking of evidence-based decision-making has evolved and has been adopted in management studies (Pfeffer and Sutton, 2006). According to Briner et al., p, 19), evidence-based management:

> *[Is] about making decisions through the conscientious, explicit, and judicious use of four sources of information: practitioner expertise and judgement, evidence from the local context, a critical evaluation of the best available research evidence, and the perspectives of those people who might be affected by the decision*.

Evidence-based management assumes better decisions can be made with better evidence and logic (Reay et al., 2009). Therefore, evidence-based management encourages managers to make decisions based on best available evidence and logic and remain open-minded to seeking new evidence from multiple sources to keep updating

their judgements. Similar to the iterative NPD process, evidence-based management suggests decision makers learn from trial programmes, pilot studies, small experiments and making inferences based on them (Pfeffer and Sutton, 2006). It entails a change in the mind-set of decision makers, from believing to questioning, and from seeking favourable evidence to support their judgements to embracing all available evidence to challenge their judgements (Briner et al., 2009; Pfeffer and Sutton, 2006; Rousseau, 2006).

Evidence-based management delivers high quality decisions not only by knowing more, but also by appreciating how much is *not* known (Pfeffer and Sutton, 2006). Understanding what is known and what is not known about a specific practice-related question is the foundation of evidence-based management (Briner et al., 2009). This perspective is consistent with the finding in the previous section: the key for entrepreneurs to achieving effective judgements is having an appropriate understanding of the validation of evidence employed and the reliability of their answers.

Previous studies investigating the overconfidence in entrepreneurial decision-making also support this finding. Overconfidence refers to "overestimating the probability of being right" (Busenitz and Barney, 1997, p. 10). Researchers (Hogarth and Karelaia, 2012; Forlani and Mullins, 2000; Busenitz and Barney, 1997) have found that it is difficult for entrepreneurs to realise and accept that their answers may be potentially inaccurate. It is often the case that entrepreneurs are overconfident about their answers, which may lead to poor quality decisions (Schade and Koellinger, 2007). This leads to the question of how entrepreneurs may gain an appropriate understanding of the reliability of their answers. One method to address this question is proposed in the following section.

2.3.3 A Method to obtain an Appropriate Understanding of Answers

According to Toulmin (2003), people make claims (or come up with 'answers', in this research) based on certain evidence and assumptions. Evidence is comprised of facts used to support the claims, and assumptions connect evidence to the claim. Assumptions are not always explicitly stated but can be identified by analysing the answers and the evidence employed. For example, in the statement "Steve bought apple juice for himself, so he must like apple juice", the evidence is "Steve bought apple juice for himself", which is a fact, and the answer inferred based on this evidence is "he must like apple juice". The underlying assumption that links the evidence employed and the answer is identified as "people who buy apple juice drink it, which means that they must like it, or else they wouldn't drink it". Figure 12 explains the relationship between evidence, assumption(s) and answer.

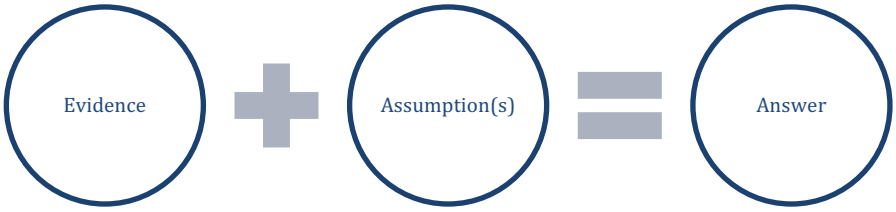


Figure 12 Relationship between evidence, assumption(s) and answer, adapted from Toulmin (2003)

Toulmin suggested that the validity of assumptions is supposed to determine the reliability of corresponding answers and one could better understand an argument by understanding its underlying assumption(s). This inspires the idea that technology entrepreneurs may gain an appropriate understanding of the reliability of their answers by understanding the underlying assumptions. This idea will be further investigated in this research using empirical evidence.

2.3.4 Section Summary

The review has shown that previous studies have recognised the importance of the reliability of answers for decision quality but lack an explicated emphasis of another determinant, namely entrepreneurs' understanding of the reliability of their answers. Through analysing previous research, this section infers two preliminary findings for this research to further investigate: (1) decisions are affected by answers and decision makers' understanding of the reliability of the answers, and; (2) the key for entrepreneurs to achieve effective judgements is having an appropriate understanding of the reliability of their answers. Additionally, a method to help entrepreneurs gain an appropriate understanding of the reliability of their answers is proposed for this research to further investigate.

Chapter Summary

The objective of this chapter has been to (1) construct a knowledge basis for what has been known for this research to build on, and (2) identify a research gap for what has not been explained in previous literature for this research to fill. The first part of this section reviews the literature relevant to understanding the determinants of the three focal decisions: (1) whether to pursue a business opportunity, (2) which process to follow to define the launch product in the short term, and (3) how to strategically align technology and market development in the early stage to build competitive advantage for longer-term development. These determinants, identified from the literature, provide a starting point to understand the key questions for the three decisions. The second part of this chapter aims to understand the key to and method for making effective decisions under different levels of information availability and future uncertainty. By reviewing the existing literature, this research preliminarily proposes that: (i) decisions are affected not only by decision makers' answers to certain questions but also their understanding of the reliability of the answers, and; (ii) the key for entrepreneurs to achieve effective judgements is having an appropriate understanding of the reliability of their answers. Additionally, a method has been proposed to help technology entrepreneurs obtain this appropriate understanding.

The existing knowledge and research gap are summarised in Table 17. The specific research questions will be formulated in Chapter 3, based on these identified research gaps.

Table 17 Existing knowledge and research gap relating to the preliminary research questions

Preliminary Research Question	What are the key questions and underlying rationale for market entry decisions?	What are the key questions and underlying rationale for deciding the process to define the launch product?	What are the key questions and underlying rationale for deciding the strategic alignment of technology and market development in the early stage?	How may technology entrepreneurs conduct effective the key questions in the entrepreneurial environment?
Existing Knowledge	Previous studies have proposed many determinants for business opportunity assessment. Previous studies have also suggested various rationales for business opportunity assessments that serve purposes such as business model development and business planning.	Previous studies in new product development imply that the determinants of entrepreneurs' choices about how to define the launch product are the degree of clarity of entrepreneurs' understanding of their first target market, customer requirements, and technology solutions.	The previous literature on strategy suggests that an important determinant of entrepreneurs' strategic choices for the alignment of technology and market development is required technology and market capabilities to exploit opportunities and neutralise threats.	Many previous studies have emphasised the idea of hypothesis testing in entrepreneurial decision-making. Previous studies have implied that one could better understand an argument by understanding its underlying assumption(s).
Research gap	Most of the determinants are developed from regression or investors' experiences; few of them are developed from the entrepreneurs' perspective. The previous literature does not suggest a rationale that suits the particular purpose for this research.	The determinants implied by new product development processes lack empirical evidence.	The previous research ignores the interaction between technology and market development in the process of technology entrepreneurship and how this interaction affects entrepreneurs' strategic choices for aligning technology and market development.	Previous studies lack an explicated emphasis of the importance of entrepreneurs' understanding of the reliability of their answers for decision quality. Previous research does not suggest how to help entrepreneurs gain anappropriate understanding of the reliability of their answers.

Chapter 3 Research Questions, Method and Design

Chapter Overview

Referring to the research gap identified in Chapter 2, Section 3.1 narrows down the preliminary research questions defined in Chapter 1 to four research questions. According to the nature of the research questions, the research method is justified in Section 3.2. As researchers with different philosophical positions have different interpretations of the method, this study's philosophical paradigm and how it will affect the research design is clarified in Section 3.3. The research design is then explained in detail in Section 3.4, including the overall logic, case selection criteria, data collection techniques, interview design, data analysis, as well as presentation and verification of the research findings.

3.1. Research Questions

The objective of this section is to narrow down the preliminary research questions, referring to the research gap identified in Chapter 2. The current state of knowledge regarding the preliminary research questions is understood through the literature review, which builds the knowledge base and identifies the research gap this study aspires to fill. The research gap reflects the unexplained part of the preliminary questions, and which requires further investigation. The unexplained parts are summarised into four research questions. Table 18 defines the research questions and explains the flow.

Table 18 Preliminary research questions, research gap and research questions

Preliminary Research Question	What are the key questions and underlying rationale for market entry decisions?	What are the key questions and underlying rationale for deciding the process to define the launch product?	What are the key questions and underlying rationale for deciding the strategic alignment of technology and market development in the early stage?	How may technology entrepreneurs conduct effective judgements on the key questions in an entrepreneurial environment?
Research gap	Most of the determinants are developed from regression or investors' experience and a smaller number from the entrepreneurs' perspective; the previous literature does not suggest a rationale that suits the particular purpose of this research.	The determinants implied by new product development processes lack empirical evidence.	There is a lack of research into the interaction between technology and market development in the process of technology entrepreneurship and how this interaction affects entrepreneurs' strategic choices for aligning technology and market development.	Previous studies lack an explicate emphasis on the importance of entrepreneurs' understanding of the reliability of their answers on decision quality. Previous research does not suggest how to help entrepreneurs gain an appropriate understanding of the reliability of their answers.
Research Question	What are the key questions for market entry decisions and how can they be structured to develop a rationale that also helps to consider the other two decisions?	What are the key questions and rationale for deciding the process to define the launch product?	What are the key questions and rationale for deciding the strategic alignment of technology and market development in the early stage?	What is the key to achieving effective judgements of key questions in the entrepreneurial environment? How could entrepreneurs be helped to make effective judgements in the entrepreneurial environment?

In summary, the main research question is:

How may technology entrepreneurs conduct effective assessments to decide (1) whether to pursue a business opportunity, (2) through which process to define the launch product to get the business off the ground in the short term, and (3) how to strategically align technology and market development in the early stage of company development to gain competitive advantage in the longer term?

The four sub-questions are:

1. What are the key questions for market entry decisions and how can they be structured to develop a rationale that also helps to consider the other two decisions?
2. What are the key questions and rationale for deciding the process to define the launch product?
3. What are the key questions and rationale for deciding the strategic alignment of technology and market development in the early stage of company development?
4. What is the key to achieving effective judgements on the key questions in the entrepreneurial environment and how could entrepreneurs be helped to make effective judgements?

3.2. Research Method

The objective of this section is to justify 'grounded theory from cases' as an appropriate method to address the research questions. The nature of the research questions is clarified in Section 3.2.1, as it largely determines the choice of research strategy and methods (Eisenhardt, 1989; Yin, 1981). According to the nature of the research questions, the strategy of 'theory building through qualitative research' and the research method of 'grounded theory from cases' are each justified in Section 3.2.2 and Section 3.2.3. Section 3.2.4 summaries section 3.2.

3.2.1. Nature of the Research Questions

This section discusses the nature of the research questions, as this determines the choice of research strategy and methods (Eisenhardt, 1989; Yin, 1981). The research questions aims at understanding decision-related questions ("what"), their underlying rationale

("why") and the process of making judgements ("how"). Table 19 analyses the nature of the research questions.

Table 19 Nature of the research questions

Research Questions	Nature of the Question
How may technology entrepreneurs conduct an effective assessment to decide (1) whether to pursue a business opportunity, (2) through which process to define the launch product, and (3) how to strategically align technology and market development in the early stage of company development?	**How** – understanding the decision-making process of the three early stage decisions.
1. What are the key questions for market entry decisions and how can they be structured to develop a rationale that also helps consider the other two decisions?	**What** – understanding the key decision-related questions; **Why** – understanding the rationale of considering these questions.
2. What are key questions and rationale for deciding the strategic alignment of technology and market development?	**What** – understanding the key decision-related questions; **Why** – understanding the rationale of considering these questions.
3. What are the key questions and rationale for deciding the strategic alignment of technology and market development in the early stage of company development?	**What** – understanding the key decision-related questions; **Why** – understanding the rationale of considering these questions.
4. What is the key for achieving effective judgements of the key questions in the entrepreneurial environment and how can entrepreneurs be helped to make effective judgements?	**What** – understand the key to making effective judgements. **How** – understanding the method for making effective judgements.

As the research questions are derived from knowledge gaps identified in the existing research, current studies do not provide appropriate and/or comprehensive explanations of these issues. Therefore, the nature of this research is to understand the process and rationale of a complex social phenomenon where existing research has failed to provide any feasible explanations.

3.2.2. Research Strategy – Building Theory through Qualitative Research

Some research strategies are more appropriate than others in a particular research setting, depending on the nature of the research questions (Yin, 2013). Given this study's research questions, the strategy of 'building theory through qualitative research' is considered appropriate and is justified here.

1. Justifying theory building

As the research questions are formed from current research gaps, existing research does not provide sufficient answers to the study's research questions. Therefore, a new theory is required. In other words, the research questions should be addressed by theory-*building* rather than theory-testing research.

2. Justifying qualitative research

In social science, research can be characterised as qualitative, quantitative or mixed. According to Creswell (2002, p. 4), qualitative research is "*an approach for exploring and understanding the meaning individuals or groups ascribe to a social or human problem*", with *"a focus on individual meaning and the importance of rendering the complexity of a situation"* . Quantitative research, on the other hand, is defined as *"an approach for testing objective theories by examining the relationship among variables [which] can be measured and analysed through statistical procedures"*. In other words, qualitative approaches allow theory to inductively emerge from data, while quantitative approach aims at deductively testing theories or hypotheses through analysis of the data. Therefore, as the aim of this research is to understand the process and rationale of a complex social phenomenon where existing theories have not provided an adequate explanation, qualitative approaches are considered appropriate for fulfilling the research objectives.

3.2.3. Research Method – Grounded Theory from Cases

Given the research strategy is chosen as building theory through qualitative research, this section justifies 'grounded theory from cases' as an appropriate method. As the name suggests, 'grounded theory from cases' uses multiple cases as the basis to develop theory inductively and iteratively (Eisenhardt and Graebner, 2007). This research method is justified in two steps: first, grounded theory method is appropriate for building new theory; second, case studies are preferred in order to understand the process and rationale of assessment for early stage decision-making.

1. Justifying grounded theory method

This section explains why Grounded Theory (GT) was selected for theory building in the context of this research. GT has been widely applied in theory building in qualitative research since it was first articulated by Glaser and Strauss in 1967. GT is used to inductively generate theory from empirical data (Strauss and Corbin, 1994; Glaser and Strauss, 1967). Similar to other theory-building methods, the process of GT consists of data collection and data analysis. Data can be collected from various sources, such as interviews and observations as well as secondary sources such as literature, government documents and the news, as long as it can add value to theory development (Corbin and Strauss, 1990). The collected data is then analysed through coding, a fundamental analytical process in qualitative research. Through analysing the data, researchers can identify concepts, group the concepts to form categories, and integrate categories into theoretical frameworks (Corbin and Strauss, 1990).

In contrast to other theory-building methods, GT emphasises (1) theoretical sampling in data collection, and (2) constant comparison in data analysis. Theoretical sampling means that decisions about which data to collect next are determined by the theory-building in progress (Suddaby, 2006), while constant comparison means constantly comparing new data with emerging categories or framework versions to continuously integrate or modify the theory (Glaser, 1992). Theoretical sampling and constant comparison indicate that the data collection and data analysis processes are interrelated and conducted iteratively (Strauss and Corbin, 1994; Glaser and Strauss, 1967). This theoretical sampling and constant comparison is of fundamental importance to GT, as these processes allow the grounded theory to closely adhere to the empirical data, helping to guard against researcher bias and thereby enabling a higher degree of objectivity and impartiality (Eisenhardt and Graebner, 2007; Corbin and Strauss, 1990). Glaser (1978, p.53) claims that GT *"gets through and beyond conjecture and preconception to exactly the underlying processes of what is going on, so that professionals can intervene with confidence to help resolve the participant's main concerns"*.

Theoretical sampling is the process of data collection for generating theory. Gharmaz (1990) suggests that theoretical sampling is best used when some preliminary concepts have been discovered. He recommends that initial data collection can start with, for

example, the literature. Researchers start analysing as soon as the initial data is collected, and the analysis determines what data to collect next (Suddaby, 2006).

Figure 13 shows how the iterative theoretical sampling process enables systematic and recursive data collection.

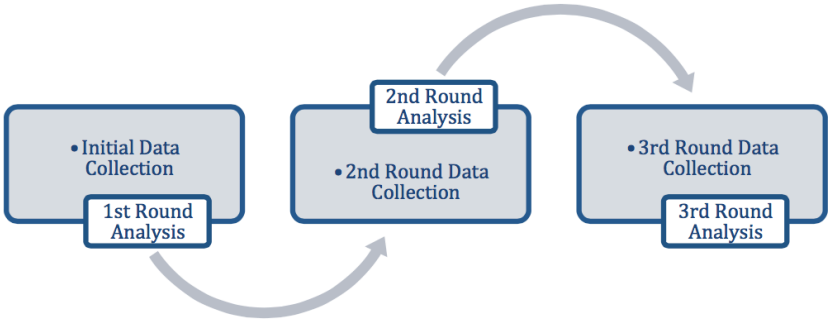


Figure 13 Theoretical Sampling, adapted from Suddaby (2006)

With respect to constant comparison, every category emerging in the research process is initially considered provisional, and each category 'earns its way' into the theory by repeatedly being presented in the data (Corbin and Strauss, 1990). Constant comparison examines the fit and relevance of categories/theoretical framework and data, and ensures all the important concepts and categories are incorporated into the theory (Glaser, 1978). Constant comparison requires researchers to build and test theory all the way through until the end of the research, which therefore indicates that *"inductive and deductive logics are mirrors of one another, with inductive theory building from cases producing new theory from data and deductive theory testing completing the cycle by using data to test theory"* (Eisenhardt and Graebner, 2007, p. 25). Therefore, constant comparison helps to achieve objectivity, precision and consistency in theory building (Corbin and Strauss, 1990). Constant comparison is illustrated in Figure 14.

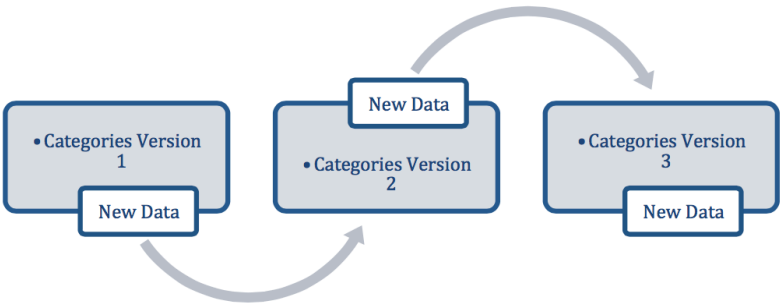


Figure 14 Constant Comparison, adapted from Eisenhardt and Graebner (2007)

The simultaneous and iterative process of data collection and analysis *"systematically and sequentially enables the research process to capture all potentially relevant aspects of the topic as soon as they are perceived",* which is *"a major source of the effectiveness of the GT method"* (Corbin and Strauss, 1990, p. 6). Therefore, this research has selected GT to develop its theoretical framework.

2. Justifying case study method

This section explains the reason for using cases as the basis for theory building. In qualitative research, data can be organised into cases or pooled together for analysis (Eisenhardt and Graebner, 2007). According to Yin (2013), the case study method is preferred to others when: (1) the main research questions are "how" or "why" questions that require an extensive and "in-depth" description of certain social phenomena; (2) the research has little or no control over behavioural events, and; (3) the focus of the study is on contemporary phenomena. Table 20 compares five main methods in the social sciences - experiment, survey, archival analysis, history, and case study - in terms of: (a) the type of research question posed; (b) the extent of control a researcher has over actual behavioural events; and (c) the degree of focus on contemporary as opposed to historical events (Yin, 2013).

Table 20 Comparison of five main research methods in social science

Method	Favoured Research Question	Requires Control of Behavioural Events	Focuses on Contemporary Events
Experiment	how, why?	Yes	Yes
Survey	who, what, where, how many, how much?	No	Yes/No
Archival Analysis	who, what, where, how many, how much?	No	Yes
History	how, why?	No	No
Case Study	how, why?	No	Yes

For this research: (1) the type of research questions aim to understand the assessment process for three early stage decisions in terms of decision-related questions ("what"), underlying rationale ("why") and the process of making judgements ("how"); (2) the researcher does not have control of the entrepreneurs' business opportunity assessment and decision-making during the early stage of the venture, and; (3) this research focuses on contemporary entrepreneurial activities. Therefore, case study method is considered appropriate in this research.

Although single case studies can richly describe the existence of a phenomenon (Siggelkow, 2007), given the theory-building goal multiple-case studies provide a stronger base (Yin, 2013) and create more robust theory due to varied empirical evidence (Eisenhardt and Graebner, 2007). In multiple case studies, each case is considered both an independent analytic unit and, at the same time, replications, contrasts, and extensions of other cases in order to develop a consistent and generalisable theoretical framework (Yin, 2013). Therefore, multiple case study method can enable more accurate and generalisable theory through cross-case comparison that can *"clarify whether an emergent finding is simply idiosyncratic to a single case or consistently replicated by several cases"* (Eisenhardt, 1991, p.623).

Given the justification of grounded theory method for theory building and case study method for qualitative research, 'grounded theory from cases' is justified as an appropriate method to address this study's research questions.

3.2.4. Section Summary

This section first clarifies that the nature of this research is to understand the process and underlying rationale of a complex social phenomenon (early stage assessment), for which existing research does not offer an adequate explanation. Accordingly, this section justifies 'theory building through qualitative research' as an appropriate research strategy and 'grounded theory from cases' an appropriate research method to cope with this research strategy. The next section will discuss the researcher's philosophical position as it determines how the research method is interpreted and implemented.

3.3. The Researcher's Interpretation of the Research Method

Researchers' philosophical paradigms determine their interpretation of research methods and thus affect research design (Levers, 2013; Yin, 1981). Section 3.3.1 introduces this research's philosophical paradigm and Section 3.3.2 explains the study's research design.

3.3.1. Philosophical Position of the Researcher

A paradigm is a basic set of beliefs that guides action built on ontology and epistemology (Guba, 1990). Ontology refers to beliefs about the nature of reality, concerning the philosophy of existence (Crotty, 1998). The core ontological debate is whether reality exists independently of human consciousness or is mentally constructed (Guba, 1990). Epistemology studies the relationships between the researcher and the researched (Denzin and Lincoln, 2005) and asks *"how I know what I know"* (Crotty, 1998, p. 3). Logically, ontological beliefs confine epistemological belifs (Crotty, 1998).

Two opposing extreme ontological views are realism and relativism. Realism is based on the belief that there is a single reality independent of human consciousness. The resulting epistemological belief is objectivism, which declares that reality resides within an object and is independent of a researcher's subjective interpretation of it (Crotty, 1998). Therefore, from the view of objectivism, the researcher and the researched do not influence each other. The opposite ontological view to realism is relativism, where it is believed that reality cannot exist without context and therefore there is no single reality but rather multiple mental constructions of reality (Guba, 1990). The corresponding epistemological believe is subjectivism, which holds that

knowledge is *"always filtered through the lenses of language, gender, social class, race, and ethnicity"* (Denzin and Lincoln, 2005, p. 21), and therefore unaffected and universal knowledge of an external reality is not possible. In other words, from the perspective of subjectivism, the researcher and the researched inevitably and always influence each other. Two opposing paradigms are positivism, founded on a realist ontology with an objectivist epistemology, and interpretivism, which posits a relativist ontology with a subjectivist epistemology.

Lying between the two polar opposite paradigms outlined above, the philosophical paradigm of the researcher is post-positivism, combining a critical realist ontology with an epistemology of modified objectivism. Critical realists posit that reality exists independently of the researcher but that it cannot be perfectly detected. They claim that social phenomena needs to be critically examined in a variety of ways in order for researchers to approximate the closest possible estimation of reality. This implies that findings cannot be proven, but a strong case can be made through triangulation. In other words, if the findings are replicated, they are likely to be true, but are always open to be proven wrong. The corresponding epistemological belief, modified objectivism, values objectivity but it is not considered possible for researchers to maintain a total undiluted distance and independence from the subject being researched. Researchers are encouraged to keep the researched subject as independent as possible, but should also recognise interaction with the researched. Therefore, findings need to be verified in order to be sufficiently objective with an awareness of subjective co-creation. Table 21 summarises the three philosophical positions mentioned above.

Table 21 Ontology and epistemology of positivism, post-positivism and constructivism.

Paradigm	Positivism	Post-positivism	Constructivism
Ontology	**Realism** – a single reality exists and can be discovered and explained.	**Critical realism** – a single reality exists but cannot be perfectly detected.	**Relativism** – there is no single reality; there are multiple mental constructions of reality.
Epistemology	**Objectivism** - the researcher and the researched are independent and do not influence each other.	**Modified objectivism –** an undetected reality is independent from researchers, but the researched is not absolutely independent from the researcher.	**Subjectivism** – the researcher and the researched are not independent and influence each other.

3.3.2. Interpretation of the Research Method in the Post-positivism Paradigm

Grounded theory and case study methods can be relevant to different philosophical paradigms (Ralph et al., 2015; Yin, 2013). The interpretation of grounded theory from cases in the post-positivism perspective is discussed here.

For a critical realist ontology, the researcher holds that reality exists externally but cannot be perfectly detected. Therefore, theoretical sampling and constant comparison is understood as the key to approaching reality through triangulation, and grounded theory *"is an imperfect apprehension of reality and… one of many theories that could emerge as research moves closer to the real reality"* (Levers, 2013, p. 4).

In modified objectivism, the researcher is considered an observer external to the process rather than a creator or participant. As a result, the researcher approaches data with an open and impartial mind-set (Glaser, 1978), allowing case study participants' perspectives to emerge with only the minimum level of intervention so that the theory can emerge in its truest sense (Levers, 2013). The researcher's interpretation of the research method (grounded theory from cases) is reflected in the research design, which is explained in Section 3.4.

3.4. Research Design

Research design presents the sequence that connects the empirical data to a study's research questions and its conclusions (Yin, 2013). The main ingredients in research design are discussed in this section: the overall logic, case selection criteria, data collection, interview design, data analysis as well as the presentation and verification of findings.

3.4.1. Logic of the Research Design

The unit of analysis for this research is technology ventures' assessment of three early stage decisions. An understanding of how to achieve effective assessments for the three decisions can be gained by retrospectively analysing both effective and ineffective assessments.

For effective assessments, this research focuses on understanding (1) the key questions considered and their underlying rationale, and (2) the characteristics of effective judgements made under different levels of information availability and uncertainty. The questions and underlying rationale identified from effective assessments suggest a sufficiently complete framework to consider the three decisions, meaning that analysing the characteristic of effective judgements can help to reveal the key to achieving effective judgements. For ineffective assessments, investigating the reason for their ineffectiveness can add to our understanding of the determinants of assessment effectiveness from other angles.

3.4.2. Data to Collect

Following the overall research logic, the data to collect to address the research questions is summarised in Table 22.

Table 22 Data to collect for the research questions

Research Question	What are the key questions for market entry decisions and how they can be structured to develop a rationale that also helps to consider the other two decisions?	What are the key questions and rationale for deciding the process to define the launch product?	What are the key questions and rationale for deciding the strategic alignment of technology and market development?	What is the key to achieving effective judgements of the key questions in the entrepreneurial environment and how can entrepreneurs be helped to make effective judgements?
Data to Collect	Effectiveness of the assessment retrospectively evaluated by entrepreneurs (see note 1) Key questions entrepreneurs consider for market entry decisions and the reasons for considering each question	Effectiveness of the assessment retrospectively evaluated by entrepreneurs (see note 1) Key questions entrepreneurs consider for deciding the process to define the launch product and the reasons for considering each question	Effectiveness of the assessment retrospectively evaluated by entrepreneurs (see note 1) Key questions entrepreneurs consider for aligning technology and market development and the reasons for considering each question	Answer to each question and the level of confidence entrepreneurs had about the answer at the time of conducting an assessment (see note2) The level of confidence entrepreneurs should have about the answer to each question at the time of conducting an assessment (see note 3); Evidence entrepreneurs employ for judging each question Underlying assumptions that link the evidence and corresponding answers The level of validity of the underlying assumptions at the time of conducting an assessment (see note 4)

Notes:

1. Entrepreneurs evaluate the assessment as effective and ineffective according to the quality of its resulting decisions. As defined in Chapter 1, high quality decisions are decisions that lead to low waste or appropriate moves at that time, and the assessment that enables high quality decisions is an effective assessment. According to this definition, accidental events that affect the result of decisions do not affect decision quality and thus have no impact on assessment effectiveness.
2. The level of confidence entrepreneurs have about the answers at the time of conducting an assessment is measured as 'high' (very confident about the answer) and 'low' (relatively less confident about the answer). The level of confidence reflects how certain entrepreneurs feel about their answers. The more uncertain they think the answer is, the lower confidence level they have.
3. The level of confidence entrepreneurs should have about their answers at the time of conducting an assessment is evaluated retrospectively as 'high' and 'low'. This reflects how certain they feel about their answers given the information availability at that time.
4. The level of validity of the underlying assumptions at the time of conducting an assessment is measured retrospectively as 'high' and 'low'.

3.4.3. Case Selection Criteria

Given the data required to conduct this research, the ideal samples are companies that have developed to a stage where they can fairly accurately evaluate their assessment of the three early-stage decisions. Therefore, in theory, mature technology-based companies would be the best type of company to investigate as they have sufficient evidence to evaluate the effectiveness of the assessment for the three decisions. However, there is a potential risk from using data from mature companies, namely that the interviewees' memories of early-stage assessment might be less accurate due to the relatively long intervening period of time. Therefore, in order to control this risk, this research also includes technology-based companies that had just gone through the early stages. In this research, 'early stage' is defined as the period from the time a business idea emerges ($note\ as\ t_0$), to the point in time when the company's sales revenue breaks even with its accumulated costs. Even though these companies might not mature enough to fairly evaluate the effectiveness of their early-stage assessment, their data compensates with a higher level of accuracy. In other words, there is a trade-off between the fairness of evaluation of assessment effectiveness and the accuracy of assessment data. In order to have a more balanced sample set, this study includes companies at both stages.

In this research, a company is considered as technology-based if its core technology capability develops as the firm grows. The decision to focus on engineering technologies such as materials and information technology, and to exclude biological and medical technology is due to the knowledge background of the researcher and access to these fields.

3.4.3. Sample Cases and Generalisability

As the aim of this research is to help technology entrepreneurs make three early-stage decisions, it is important to understand (1) entrepreneurs' possible choices on the three decisions, and (2) the determinants behind these different choices. This requires the sample cases to be sufficiently diverse to (a) include entrepreneurs' different choices on the three decisions, and (b) cover the main determinants of these different choices. Given the inherent limitations of case study method on generalisability, researchers using this method assume that the study has included sufficient cases to generalise the phenomena when new cases did not contribute new significant findings, i.e. when saturation was reached. Therefore, the researcher continued to interview technology-based companies until new cases neither added new choices on the three decisions nor add new main determinants for these different choices. Saturation was reached at 19 cases provided by 17 technology-based companies from the UK, the EU, the USA and China, across various sectors[3]. Table 23 summarises the information for the 17 technology-based companies in the order of interview date.

Table 23 A list of the 17 technology-based companies interviewed in this research

Company No.	Interview Date	Sector	Main Product	Year of est.	Headquarters	Company Codename
1	04/2015	Information Technology and Services	**Management software** for optimising business activities.	2013	UK	_
2	06/2015	Health and wellness	**Air pacificators** to improve indoor air quality for the medical industry, utilities and homes, logistics, agriculture, etc.	2007	NL	_
3	06/2015	Medical devices	**Pregnancy monitoring system** consisting of patient friendly sensors combined with specific hardware for the processing of measurement signals into clinically relevant information.	2010	NL	_
4	10/2015	Electricity devices	**High performance Metal Oxide Varistors** for high voltage power system.	2005	CN	A
5	10/2015	Electronic devices	**Multi-stable Liquid Crystal Devices** such as E-books, electronic shelf labels, privacy glass, advertising billboards, street window displays, etc.	2007	CN	_
6	08/2016	Network safety	**Secure router software** that runs network services as modular apps.	2015	UK	_
7	08/2016	Automotives	**Advanced hybrid electric vehicle and electric vehicle drivetrain system and control software** to enable vehicle	2006	US	_

[3] Two companies provide two cases each, as their entrepreneurs had considered two different business opportunities in the early stage of company development.

			equipment manufacturers and modifiers to introduce superior hybrid and electric vehicles to the market rapidly and cost effectively.			
8	08/2016	Technology information and services	**Management software** that provides real-time parking information to city planners and parking authorities.	2014	US	F
9	08/2016	Computer software	**Artificially intelligent cloud** built based on cutting edge self-learning intelligent systems to enable intelligent robots.	2015	US	_
10	08/2016	Consumer electronic devices	**Awareness monitoring devices** to help drivers stay alert while driving.	2014	US	H
11	08/2016	Computer software	**Physical animation engine** that lets gamers deeply interact with characters in the virtual world.	2014	US	G
12	08/2016	Computer Software	**Delivery robots** to reduce cost for last mile delivery.	2015	US	E
13	08/2016	Consumer Electronics	**Active-Noise-Cancelling headphones** that provide consumers with super portable, high performance sound quality, secure fit, and hearing protection with Active-Noise-Cancelling technology.	2016	US	B
14	09/2016	Medical devices	**3D printed prostheses and orthoses** using patient images such as CT or 3D scans to enable a 100% customized fit and cut production times by 75% for medical practitioners and patients.	2016	DE	_
15	09/2016	Healthcare devices	**Wearable robotic gloves** to relieve symptoms of neurodegenerative disease such as Parkinson's Disease and reduce obstructions to patients' daily lives.	2015	CN	_
16	09/2016	Nanotechnology	**Standardised system to produce carbon material** for research institutes.	2013	UK	C
17	11/2016	Electric engineering	**Wireless sensor network system** to collect data from power transmission systems for monitoring and management.	2015	UK	D

The researcher found that the findings, derived from analysing the 19 cases, could be explained by a smaller number of cases. In other words, using all 19 cases to explain the above findings would be effective but not efficient. To explain the findings efficiently, the researcher identified a group of representative cases from the minimum number of cases that at the same time covered the diversity of the 19 cases in terms of (1) entrepreneurs' choices on the three focal decisions and (2) the determinants behind the different choices. Based on this standard, 10 cases from eight companies were selected. The eight representative companies are listed with codenames in Table 23 and will be analysed in detail in Chapter 4 and Chapter 5.

3.4.4. Data Collection Techniques – Interviews

This section justifies interviews as an appropriate technique to collect data for this research. There are six sources of data for the case studies: documentation, archival records, interviews, direct observation, participant-observation, and physical artifacts (Yin, 2013). The first five sources, which are relevant to this research, are discussed and compared in Table 24 in terms of strengths, weaknesses and the data collection strategies of this research. According to the table, interviews were chosen as the main source of data for this research (in deeper green), with documentation and archival records for complementary input and triangulation (in lighter green); Direct observation and participant observation were not used in this research.

Table 24 Comparison of different data collection techniques and data collection strategies for this research

Source of Evidence	Example	Strengths	Weaknesses	Strategy
Documentation	Business plans and/or presentation slides used in the early stage for fund raising	Can reflect entrepreneurs' assessment of business opportunity at the early stage	Might not reflect what entrepreneurs truly believe as they can be manipulated to attract investors for fund raising purposes	Try to gain these type of documents from entrepreneurs
	Personal documents such as working notes and diaries wrote in the early stage	Reflects entrepreneurs' assessment of business opportunity in the early stage	Entrepreneurs may be reluctant to provide documents	Do not *ask* for these documents
	Website, news, articles, and other types of documents from internet searches	Easy to access; can contain specific information such as names, dates, and details of an event; can cover many events; effective and costless	Tend to focus on the result of events with less information relevant to business opportunity assessment.	Search relevant information from the Internet
Archival Records	Company records from public data base	Easy to access; precise	Technology ventures only disclose basic information such as time of establishment and names of main shareholders, and are thus less helpful to understanding assessment and decision-making.	Search company records from data base
Interviews	Entrepreneurs' memories of how they made the three decisions based on what assessment	Focus directly on assessment and decision-making; provide explanation of the underlying rationale of assessment and decisions made, as well as personal views on assessment results	Risk of data incompleteness and inaccuracy due to poor memory; risk of losing objectivity as interviewees can be influenced by the interviewer	Conduct semi-structured interviews with entrepreneurs from companies that satisfy the selection criteria in Section 3.4.1.
Direct Observation	Entrepreneurs' action when making the three decisions	Captures actions in real time and thus ensures accuracy; can cover assessment and decision-making context	Must follow companies from pre-venture stage to growth or mature stage to obtain all data, which is time-consuming and costly; difficult to get permission from the company	Do not use
Participant Observation	Entrepreneurs' action when making the three decisions	Captures actions in real time and thus ensures accuracy; can cover assessment and decision-making context	Must follow companies from pre-venture stage to growth or mature stage to obtain all data, which is time-consuming and costly; difficult to get permission from the company; risk of loss of independence due to the participation of the interviewer	Do not use

3.4.5. Design of Interviews

Interview protocols were designed as follows in order to collect the required data and minimise the potential risks of: (1) data incompleteness and inaccuracy due to poor memory, and; (2) data independence, as interviewees may be influenced by the interviewer. In order to avoid incomplete or inaccurate data, interviews are designed in the semi-structured form to ensure all the key points are covered. Additionally, company-related documents and the preliminary framework suggested by the literature were used to help the entrepreneurs recall their memories of past events in the interviews. With respect to objectivity, the interviews were designed carefully with open questions to allow the interviewees to explain their recollections with minimum intervention from the interviewer. The questions and anticipated responses from the interviewees are listed in Table 25.

Table 25 Interview questions and anticipated responses from the interviewees

	Interview questions in sequence	Note
1	Could you please briefly introduce the development of your company from the original idea to the current stage?	The interviewees are expected to naturally mention the key milestones, including the three decisions made in the early venture stages.
2	How do you find the quality of the three decisions?	The interviewees are expected to retrospectively evaluate the quality of the three decisions they made.
3	What questions did you consider when making each of the three decisions? Why did you consider these questions as important?	The interviewees are expected to mention the key questions considered and the reasons for considering these questions.
4	How did you find the effectiveness of the judgement made for each question?	The interviewees are expected to retrospectively evaluate the effectiveness of their judgements on each question.
	Based on what evidence did you judge each question? What was the answer of each question?	The interviewees are expected to explain the evidence employed and answers given at that time.
	How confident did you feel about your answers to these questions?	The interviewees are expected to recall the level of confidence they had to their answers at that time.
	How confident you should have felt about your answers of these questions?	The interviewees are expected to retrospectively evaluate the level of confidence they should have felt at that time.
	How valid do you feel the underlying assumptions were?	The interviewees are expected to retrospectively evaluate the validity of the assumptions underlying their answers.

3.4.6. Data Analysis

Data analysis follows the iterative process proposed by the grounded theory method. Each case serves as a distinct 'experiment', as an individual analytic unit, while at the same time additional cases serve as replications, contrasts and extensions to the emerging theory from previous cases (Yin, 2013; Eisenhardt and Graebner, 2007; Corbin and Strauss, 1990; Glaser, 1978). Therefore, the data is iteratively analysed and the framework is continuously adjusted until sufficiently convergent to be able to explain all the cases. In this research, raw data is analysed and conceptualised through coding process. Appendix 2 shows the traceability of the conceptualisation, using an extract of the interview data of Case D as an example.

3.4.7. Presentation of Findings

As explained in Section 3.4.3, 10 cases from eight companies are presented in detail in this thesis. The findings are presented by individual case analysis in Chapter 4 and cross-case analysis in Chapter 5. The individual cases are presented in a consistent format, which is described at the beginning of Chapter 4. Based on the individual analysis in Chapter 4, Chapter 5 compares and contrasts the 10 cases and proposes the main findings that answer the research questions.

3.4.8. Verification of Findings

In Chapter 6, the main findings are developed into a management tool to help technology entrepreneurs conduct effective assessments for the three early-stage decisions. The findings are verified through testing the tool with technology entrepreneurs and other stakeholders of technology entrepreneurship, including venture capitalists, incubator managers, staff from university technology transfer offices, mentors from technology venture accelerators, and researchers in entrepreneurship venture investors. Technology entrepreneurs provide opinions on whether they think the findings and the tool will help to improve assessment effectiveness and decision quality. Opinions from other stakeholders triangulate the findings from different perspectives and suggest implications to be drawn from the findings.

Chapter Summary

This chapter has specified the research questions, justified 'grounded theory from cases' as an appropriate research method to address the study's research questions, clarified the interpretation of this method as used in this research according to the study's philosophical position, and explained the design of the research in detail. Following on from the research design, the data was collected and analysed carefully, with findings from individual case analysis (Chapter 4) and cross-case analysis (Chapter 5).

Chapter 4 Individual Case Analysis

Chapter Overview

The objective of this chapter is to provide empirical evidence on how technology entrepreneurs make the three early-stage decisions, namely (1) whether to pursue a business opportunity, (2) which process to follow to define the launch product in the short term, and (3) how to strategically align technology and market development in the early stage to build competitive advantage for the company in the longer term. A total of 10 diverse cases from eight technology-based companies are analysed in detail in a consistent format to address the research questions.

Instructions for Reading Individual Case Analysis

The presentation and analysis of cases are organised in a consistent format. For each company, the analysis starts with the company's background information, including the year of establishment, main product(s), core technology, background of founders, and industry maturity at the time of starting the business. This is followed by a description of how the company developed throughout the early stage, i.e. from the initiation of ideas (a time point noted as t_0 in this research) until all three decisions have been made, with particular emphases on explaining the key questions considered and the underlying rationale for making the three decisions. A summary is then provided to conclude each case.

For each case, market entry decisions made at different time points are analysed in detail, including key questions considered, corresponding judgements, evidence employed and underlying assumptions. The template is shown in Table 26.

Table 26 Template for business opportunity assessment

Question	Evidence Employed	Assumption	Judgement
Q1	EE1	A1	"…"/ Y/ N
Q2	EE2	A2	"…"/ Y/ N
Q3	EE3	*A3*	"…"/ Y/ N
Q4	EE4	*A4*	"…"/ Y/ N
Q5	EE5	A5	?

In the template in Table 26, the questions considered by entrepreneurs are listed in the left-hand column. The entrepreneurs' judgements on these questions are presented in the fourth column. According to each entrepreneur's retrospective evaluation of their previous judgements, those evaluated as effective are shown in black and ineffective ones are in red. It is important to recall here that 'an entrepreneur's judgement to a question' includes 'the answer to the question' and 'the entrepreneur's understanding of the reliability of the answers'. Answers can be positive (Y), negative (N), not sure (?) or a statement ("…"), depending on the question, while the entrepreneurs' understanding of the reliability of the answers is measured by their confidence level. In Table 26, red and green background colours have been used to represent high and low levels of confidence the entrepreneurs feel about their answers at the time of conducting the assessment; blue colour is used to highlight the answer 'not sure'.

Evidence employed to answer the questions is presented in the second column, respectively. Underlying assumptions that link answers and evidence employed are presented in the third column. According to each entrepreneur's retrospective evaluation of the level of validity of underlying assumptions, those considered at a high level of validity are shown in normal font, while less valid assumptions are given in *italics*.

During the interviews, in addition to recalling the answers and corresponding level of confidence they had about their answers at that time, the entrepreneurs were also asked to retrospectively evaluate the level of confidence they should have about their answers at that time. In this research, the confidence level they had at time t is noted as c_t, and the confidence level they should have at time t is noted as C_t. In the fourth column, where $c_t = C_t$, the answers are presented in normal font, and where $c_t \neq C_t$, the answers are underlined.

Additionally, for each company, the analysis starts from t_0, when the idea was initiated, until all three decisions have been made. Clarifying the time dimension while analysing the assessment and decision-making is important for the purposes of this research.

Company A

Company Codename	A
Year of Establishment	2007
Headquarters	CN
Product	High-performance metal oxide varistors (MOVs)
Industry Maturity at t_0	Mature
Core Technology	Formula and manufacturing process of mixing metal-oxide
Interviewee	Founder and CEO

1. Background Information

Company A is a traditional manufacturing company in a mature industry producing high-performance metal oxide varistors (MOVs). MOVs are compulsory devices in lightening arresters for protecting electric power systems. The core technology of producing high-performance MOVs is the formula and manufacturing process of mixing metal oxide. Company A was founded in 2007 by Adam, a well-acknowledged industrial expert with deep understanding of the technology, market and industry. At the interview date, the company was in the mature stage of its development.

2. Company Development in the Early Stage

Before establishing Company A, Adam was a technology VP in Company M, which is a leading research institute for high-performance MOVs in China. He had been working on the technology for 18 years in Company M and was acknowledged as a leading expert in this field. As the core technology was mainly developed by Adam, it was agreed that the intellectual property of high-performance MOVs was 100% owned by him, while Company M had exclusive rights to manufacture and sell them. The agreement worked well until 2006, when a new CEO was appointed and requested him to sell his intellectual property to company M. He rejected his request and began to

consider leaving Company M to start his own business. At that time, China's megavolt power transmission project was near to launch and the China Power System had announced a bid for megavolt MOV suppliers in six month, including clear requirements on product performance and the quantity of demand. Given this information, Adam began to consider establishing Company A to manufacture megavolt MOVs. He assessed this business opportunity as follows.

1) Assessment and decisions made at t_0

According to the interview, the key questions Adam considered for market entry decision at t_0 are:

(1) Will there be a market need for megavolt MOVs in the short term?
(2) Will I be able to develop and sell the required megavolt MOVs in six months? i.e. what are the required capabilities to develop and sell the required megavolt MOVs and will I gain these required capabilities in the short term?
(3) Will the company maintain healthy operations in the short term?
(4) Will the market size for megavolt MOVs be large enough to provide a chance for the company to develop in the longer term?
(5) Will I be able to build competitive advantage for the company to compete in the industry in the longer term? i.e. what are the required capabilities to develop competitive advantages for longer-term development and will I gain these required capabilities?
(6) Will I be able to manage the company in the longer term?

These six questions are classified into two groups according to whether the question is short-term oriented or longer-term oriented. The first three questions relate to the chances for the company's short-term survival, while the latter three questions refer to the company's longer-term development. If assuming companies' short-term survival and longer-term development together define a sustainable business, then Adam's rationale for making market entry decisions can be formed as in Figure 15.

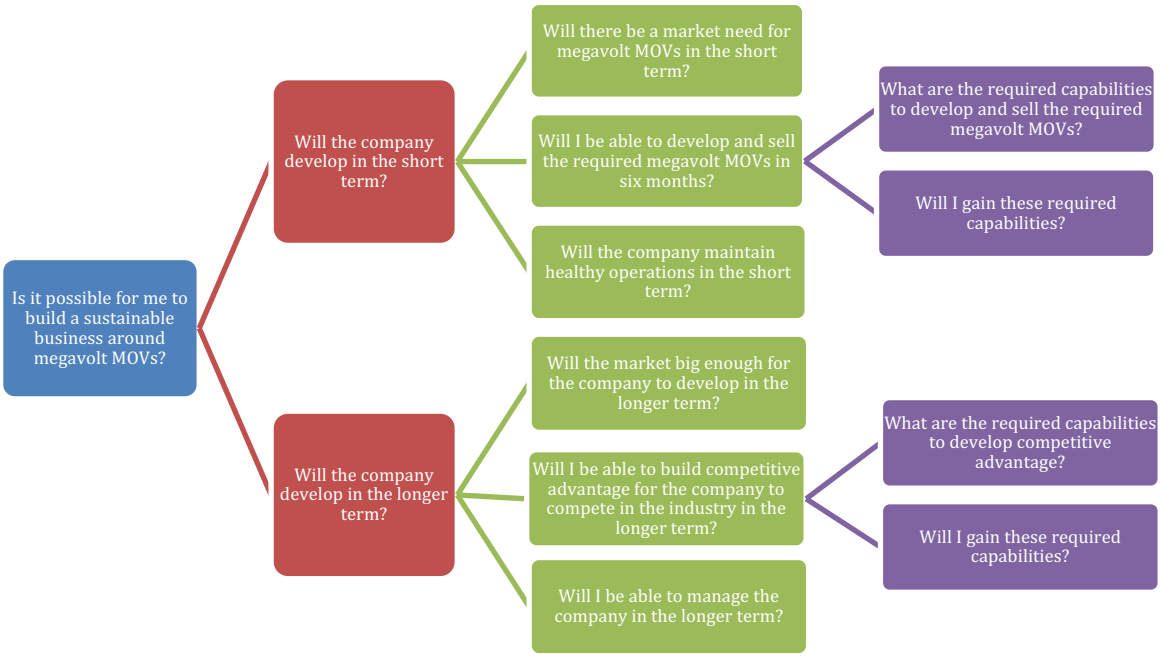


Figure 15 Key questions and underlying rationale Adam considered and followed for making market entry decisions

Adam judged the above questions as follows:

(1) Will there be a market need for megavolt MOVs in the short term?

In 2006, China's megavolt power transmission project was near to launch and a bid for MOV suppliers was expected within six months. Based on this information, Adam was confident that there would be a large demand for megavolt MOVs in six months.

(2) Will I be able to develop and sell the required megavolt MOVs in six months? i.e. what are the required capabilities to develop and sell the proposed product and will the team gain these required capabilities?

The China Power System called for high performance MOVs at a certain quantity of demand. This required leading technology capability and sufficient production capacity. Although price requirements had not been explicitly stipulated, the rule for bidding indicated that a competitive price would be preferred. This required effective cost control. According to this requirement, Adam understood that sales mainly depended on product competitiveness, which lies on product performance and competitive pricing. In other words, the market would come to the company as long as it could develop competitive products. Therefore, marketing capability was considered trivial in this business

in the early stage. In summary, the required capabilities for developing and selling the required megavolt MOVs were identified as leading technology capability, sufficient product capacity and effective cost control.

Adam had a track record in capable technology development and cost control. He had been working on developing high performance megavolt MOVs at Company M for more than four years, since 2002. Previous records show that the megavolt MOVs produced using his technology had the same level of performance as those of world-leading companies but with much lower costs. The lower cost was attributable to (1) the high yield enabled by a deep understanding of the technology, and (2) relatively low manufacturing costs in labour and plant in local area. As these two factors were expected to remain in the short term, Adam believed that he would be able to produce competitive megavolt MOVs of a high quality and at a competitive price in six months.

In terms of production capacity, Adam calculated the production line needed according to projected customer demand, based on which he estimated the total investment required to establish Company A. The large investment, however, was far beyond his personal savings. Purchasing equipment from suppliers on credit might be a solution, but he was not sure whether it would be feasible at t_0.

(3) Will the company maintain healthy operations in the short term?
For Adam, the key to maintaining healthy operations is managing a healthy cash flow. However, he did not have sufficient funds himself. He might be able to borrow money from family and friends, but he was not sure whether it would be feasible to do this at t_0.

(4) Will the market size for megavolt MOVs be large enough to provide a chance for the company to develop in the longer term?
The megavolt MOV market is estimated to reach hundreds of billions of dollars before 2020 in China, Europe and the USA according to industry reports. Adam was thus confident that the market would be large enough to provide the possibility for companies in this industry to develop and grow in the longer term.

(5) Will I be able to build competitive advantage for the company to compete in the industry in the longer term? i.e. what are the required capabilities to develop competitive advantage for longer-term development and will the team gain these required capabilities?

By analysing customer requirements, Adam understood that the company's competitive advantage lay predominantly in product competitiveness, i.e. leading quality and competitive price. This required the company to maintain leading technology capability and effective cost control in the longer term.

Adam had leading technology capability at this stage and was expected to keep this leading position in the long term due to his strong R&D capability and a prudent plan for IP protection. With respect to cost control, the two factors that produced the low cost (deep understanding of the technology and low labour costs and plant rent in local area) were expected to remain in the foreseeable future. Additionally, as a traditional manufacturing company, economies of scale would further reduce costs. Therefore, the company believed it would retain competitive advantage in the long term.

(6) Will I be able to manage the company in the longer term?

As Company A would follow exactly the same business model as Company M, Adam believed his previous experience in management and operations would be transferable to his new business.

The details of Adam's judgement of each question are presented in Table A-0, including evidence employed, underlying assumptions, and answers correlating confidence levels with the results. The judgements show that at t_0 Adam was not sure whether he would be able to resolve the financial issues yet. Therefore, the market entry decision he made at t_0 was conditional upon whether he would be able to purchase production lines on credit and raise enough funds for short-term operation.

At t_0, Adam defined the launch product according to the China Power System's specific requirements. With respect to the strategy on technology and market

development in the early stage, Adam decided to fopcus on core technology development to attract the market with his competitive products while putting limited effort into marketing.

2) Assessment and decisions made at t_1

Adam started seeking financial assistance from equipment suppliers, family and friends. Fortunately, equipment suppliers agreed to sell equipment to Adam on credit due to his established reputation in the industry, and a friend of Adam's agreed to loan him an amount of money to start and operate his business. This new evidence updated previous judgements of certain questions and the updated parts are presented in Table A-1. With the financial restriction thereby removed, Adam decided to establish Company A to enter the megavolt MOV market.

3) Implementation and results

Following the three decisions, Adam concentrated on developing core technology to develop his first product. After six-months of development, Adam had successfully produced high performance megavolt MOVs at a large scale with costs controlled below budget for competitive pricing purposes. Meanwhile, production lines were equipped and tested for mass production. As Adam expected, Company A won the bid. The cash flow generated from this deal pushed the company through breakeven. Moreover, winning the bid for the China megavolt power system was an endorsement of Company A, which helped it to build brand and attract more customers.

3. Summary

In this case, there was sufficient valid evidence to support the existence of market need and promising market potential at t_0. This indicated great market opportunity with a low level of uncertainty. Given the market opportunity, Company A needed certain capabilities to turn it into an opportunity. The required capabilities were (1) the capability to develop and sell the product in the short term, and (2) the capability to build competitive advantage in the longer term. In this case, the required capabilities are identified according to customer requirements provided by the China Power System. In addition to these capabilities, capabilities in managing the company's short-term and

longer-term operations were also considered to be of crucial importance to building a sustainable business. At t_0, Adam was confident about his technology and managerial capabilities, but he was not sure if he could get financial support to establish Company A. As a result, he sought assistance from potential suppliers, family and friends, aiming to remove the financial constraints. When the financial support was guaranteed at t_1, Adam decided to enter the MOV market.

Although the market entry decision was made at t_1, the other two decisions were made at t_0. Adam was able to define the launch product at t_0 according to the specific customer requirements provided by the China Power System. The decision about aligning technology and market development in the early stage was also made at t_0 based on analysis of the required capabilities for the short- and longer-term development of the company.

Table A-0 Business opportunity assessment at t_0

Question			Evidence Employed	Assumption	Judgement		
Will the company be able to develop in the short term?	Will there be a need for high quality megavolt MOVs in the short term?		The China power system has announced a bid for megavolt MOVs in 6 months.	The bid will open as planned.	Y		Y
	Will Adam be able to develop and sell the required MOVs to win the bid?	What are the required capabilities to develop and sell the required MOVs?	The potential customer required leading performance at certain quantity of demand; This is a 2B business and sales mainly depend on product competitiveness.	The announced customer requirement is their actual requirement.	The main required capabilities are (1) leading technology capability, (2) sufficient production capacity, and (3) capability of effective cost control. Marketing capability was considered less important in the short term.	Y	
		Will Adam be able to gain the required leading technology capability in the short term?	The performance of the previous MOVs developed by Adam was as good as that of world-leading companies; Adam will apply similar technology to megavolt MOVs.	Adam's technology capability will stay at world leading level.	Y		
		Will Adam be able to gain capability on effective cost control in the short term?	The price of Adam's previous MOVs were only about 2/3 of their competitors' due to low labour costs in the local area and Adam's in-depth understanding of the technology.	Adam's in-depth understanding of the technology and the low labour costs in the local area will remain in the short term.	Y		
		Will Adam be able to gain sufficient production capacity in the short term?	Adam is a well-acknowledged expert in the industry and enjoys a solid reputation. Adam has kept good relationships with equipment suppliers from his time working at Company M.	*Equipment suppliers would like to sell equipment to Adam on credit.*	Y		
	Will the company keep healthy operation in the short term?		Adam is an expert in MOV, enjoying a solid reputation; The sales revenue from the deal will be sufficient to pay off the payables and loans.	*Family and friends would believe in him and the future of the business; Adam will win the bid.*	Y		
Will the company develop be able to develop in the longer term?	Will the market for megavolt MOVs be large enough to provide a chance to help the company develop in the longer term?		The megavolt MOV market was estimated at hundreds of billions of dollars in 2020 according to the government report of China's megavolt power transmission project.	The data in the government report is reliable.	Y		Y
	Will the company have competitive advantage to compete in the industry in the longer term?	What are the required capabilities to build the competitive advantage of the company in the longer term?	The potential customer values leading performance and competitive pricing.	Sales mainly depend on product competitiveness, i.e. leading performance and a competitive price.	In the longer term, the main required capabilities are leading technology capability and effective cost control.	Y	
		Will Adam be able to maintain leading technology capability in the longer term?	The previous MOVs developed using Adam's formula have enjoyed a world-leading position since the 1990s.	Adam will maintain leading R&D capability in the longer term.	Y		
			The IP has been kept in house and he is the only one who knows the whole process; The previous IP protection method has been effective.	The method will remain effective in the longer term.	Y		
		Will the company be able to keep effective cost control in the longer term?	The price of Adam's previous MOVs has remained approximately 2/3 of his competitors due to low labour costs in the local area and Adam's indepth understanding of the technology; Additionally, as a traditional manufacturing business, costs per unit will decrease as company grows due to the scale of economy.	Adam's understanding of the technology and local labour costs will remain in the longer term.	Y		
	Will Adam be able to manage the company in the longer term?		Adam has been working in the MOV industry for 18 years. He was the vice general manager at his previous company, taking charge of R&D and manufacturing. Company A will be operating in the same market and industry with same business model as Alex's previous company.	Adam's knowledge of the market and industry, management skills and social capital are transferable to his new business.	Y		

Table A-1 Business opportunity assessment at t_1

Question			Evidence Employed	Assumption	Judgement	
Will the company be able to develop in the short term?						Y
	Will Adam be able to develop and sell the required MOVs to win the bid?					Y
		Will Adam be able to gain sufficient production capacity in the short term?	Suppliers agree to sell equipment to Adam on credit.	Suppliers would sell equipment to Adam on credit as agreed.	Y	
	Will the company maintain healthy operations in the short term?		A friend provides a loan to Adam, which is sufficient for at least six-months' operation based on Adam's prediction.	The friend will loan money to Adam as agreed; Adam's prediction of expenditure is reasonable and the money will be used as planned.	Y	

Company B

Company Codename	B
Year of Establishment	2015
Headquarters	US
Product	Active-Noise-Cancelling headphones
Industry Maturity at t_0	Mature
Core Technology	Integration of Active-Noise-Cancelling and acoustic technologies
Interviewee	Co-founder & CEO

1. Background Information

Company B develops good quality active-noise-cancelling (ANC) headphones at an affordable price in a mature industry, targeting customers who have no experience in using ANC headphones. ANC headphones are pre-existing products which can effectively eliminate ambient noise and provide more focused sound than ordinary headphones. The core technology is ANC and acoustic technology, which is considered mature, but incremental improvement is constantly under development. Company B was established in 2015 by Bob, who used to be a technology VP at an acoustic company with an in-depth understanding of the technology, market and industry. At the interview date, the company had just gone through the early stage.

2. Company Development at the Early Stage

Before establishing Company B, Bob was a technology VP at an acoustic company. The main business of this company consisted of fulfilling orders for established brands that wish to outsource their original design and manufacturing (ODM) of headphones. Bob had accumulated, through years of experience in ODM, a deep understanding of the technology, market and industry of headphones and he had begun to consider founding his own business in this industry.

Traditionally, noise cancelling was considered a premier function, and therefore ANC headphone providers mainly targeted the high-end market by providing high quality, high price ANC headphones. However, market reports showed that with the wider use of headphones in everyday life, increasing numbers of people had started using or showed an interest in trying ANC headphones for a better listening experience. Many companies had already started developing affordable ANC headphones for ordinary consumers. However, these headphones were evaluated as low quality-low price. Therefore, Bob began to consider the business opportunities of developing ANC headphones with a good quality and at an affordable price. He assessed this business opportunity as follows.

1) Assessment and decisions made at t_0

The key questions Bob considered and the judgements he made are as follows:

(1) Will there be a market need for the proposed ANC headphones in the short term? Existing affordable ANC headphones on the market were evaluated as low quality-low price. Therefore, Bob believed that if there were ANC headphones with a good quality and at an affordable price, there would be a market need.

(2) Will I be able to build a capable team to develop and sell the required ANC headphones in the short term? i.e. what are the required capabilities to develop and sell the proposed product and will the team gain these required capabilities? As ANC headphones were pre-existing products, the market has a common understanding that quality, design and price are the three main critical factors that can affect the competitiveness of the product. Therefore, for Company B's headphones to be competitive, it had to have a better performance, a good design and an affordable price compared with existing affordable ANC headphones. This required strong capabilities in technology, industrial design and cost control in the short term. Additionally, strong marketing capability was required for this 2C business.

As an experienced technology VP, Bob knew where to source the required talents, and he was therefore confident that he would be able to build a capable team.

(3) Will the company maintain healthy operations in the short term?

Bob would like to invest an amount of money in the company. He also plans to raise more money from his friends as potential co-founders to ensure sufficient cash flow for early stage operation. He was confident that some of his friends would be interested in investing in this business.

(4) Will the market size of affordable ANC headphones be large enough to provide a chance for the company to develop in the longer term?

According to the historical market/industry data, the market demand for ANC headphones has been significantly increasing since 2010 and is expected to reach billions of dollars by 2020. Therefore, Bob believed that this trend would continue and the market would be large enough to provide a chance for companies in this industry to develop and grow in the longer term.

(5) Will the company gain competitive advantage to compete in the industry for longer-term development? i.e. what are the required capabilities to develop competitive advantage for longer-term development and will the team gain these required capabilities?

By analysing existing product and companies in this industry, Bob believed the competitive advantage of headphone companies lay in of product competitiveness (a high quality-price ratio) and marketing. This required the team to keep strong capabilities in technology, industrial design, cost control and marketing capabilities in the longer term.

As an expert in this industry, Bob knew where to source the required talent, and he was therefore confident that he would be able to build a team with the required capabilities.

(6) Will the future team be able to manage the company in the longer term?

Bob had a deep understanding of and rich management experience in the headphone industry, factors transferable to managing his new business. Additionally, he planned to invite two co-founders who had experience in hardware manufacturing as well as marketing and financing to balance the team and manage the company together in the longer term.

The details of Bob's judgement of each question are presented in Table B-0, including evidence employed, underlying assumptions answers with corresponding confidence level. Based on the judgements, Bob decided to establish Company B to enter the affordable ANC headphone market.

At t_0, Bob knew the proposed ANC headphones should be good quality, good design and affordable in price in general. However, he did not know what exactly the launch product would be like because he was unsure about (1) which market segment would be most appropriate to target at first, and (2) what requirements these customers would have. Therefore, in order to define the first product, Bob decided to follow an iterative and experimental process. Specifically, he planned to develop some prototypical ANC headphones and send them to potential customers for a free trial. Comments and suggestions would be collected and analysed for the purpose of understanding customer requirements in different market segments.

With respect to the early-stage technology and market development, Bob decided to develop the technology and the market in parallel. On one hand, Company B would develop technology to provide better affordable ANC headphones, and on the other hand it would undertake great efforts in marketing to promote the products to gain market share. This is because Company B, as a 2C business, was required to be able to develop competitive products and promote their products to enable growth.

2) Implementation and results

According to the required capabilities identified at t_0, Bob built his team with experienced technology developers, industrial designers, a hardware manufacturer (co-founder) and a serial hardware entrepreneur specialised in financing and marketing (co-founder).

With the right people on board, Company B started developing prototypes. The team developed 200 prototypical ANC headphones and sent them to four user groups for free trials. The four groups were (1) professional headphone testers, (2) people who had a large amount of listening experience on ANC headphones, (3) people who had not used

ANC headphones before, and (4) people who did not know much about headphones. User feedback was carefully collected and analysed.

The results were rather surprising. Before the experiments, the team assumed users who had experience of using ANC headphones would value their product most, as they were expected to be able to tell the high performance-price ratio of their headphones. However, the actual feedback indicated that users who had no experience of using ANC headphones showed the greatest interest in Company B's products. Therefore, these people were preliminarily considered as the target customers of Company B.

Based on the feedback from the first generation of prototypes, adjustments and improvements were made on the second generation. Once developed, the second generation was tested through a similar process to collect user feedback from the same four groups, but more attention was given to the third group. This process was iterated until the fifth generation was developed and tested, where (1) there was enough evidence to show users who had not used ANC headphones were the most appropriate market segment to target, and (2) the feedback from these users on the prototypical products approached a sufficiently satisfactory level. As a result, Company B preliminarily defined the fifth version as the launch product and decided to advertise their products as 'your first noise-cancelling headphones' to attract the target customers.

As the team realised that user feedback might not fairly reflect customer requirements in the real market (i.e. customer behaviour in the real market might differ from the testing environment), the team decided to test the preliminary defined product and marketing strategy in a real market environment on a small scale before going to mass production and an official launch.

Company B chose to introduce its products on a famous US crowd-funding platform. On this platform, project creators sell their product in advance to the community for a certain amount of money (funding goal) within a certain period. People who like the product can become backers and pledge money to the company by ordering the products in advance. If the funding goal is successfully achieved, the backers will be charged, and the creator is responsible for delivering the promised products to the

backers; if the funding goal is not achieved, then the backers will not be charged and all orders become invalid.

Company B's funding goal was $30,000 in 30 days. The result was that $9,000 was achieved in less than 24 hours, and the halfway point was reached in fewer than four days. The project was 100% funded in 20 days and eventually ended up with $37,281 and 257 backers. The success on crowd funding validated Company B's design for the launch product and its marketing strategy, pushing it forward to the mass production phase and encouraging it to promote its first product at a large scale. Up to the interview date, the sales generated from the launch product had broken even with Company B's accumulated costs.

3. Summary

In this case, all the three decisions were made at t_0. For the market entry decision, Bob was confident about his answers to the key questions. With respect to the decision on the process for defining the launch product, he chose to follow an iterative and experimental process because at t_0 he was unsure (1) who the target customer would be, and (2) what these target customers would require on the product. He iteratively developed prototypes and used them as vehicles to collect feedback from potential customers. This feedback was used as a basis for identifying target customers and defining the launch product. For the alignment of technology and market development, Bob chose to develop them in parallel, given that both technology and marketing capability were important to Company B.

Table B-0 Business opportunity assessment at t_0

Question			Evidence Employed	Assumption	Judgement		
Will the company be able to develop in the short term?	Will there be a need for ANC headphones with good quality and at an affordable price in the short term?		Existing affordable ANC headphones on the market are characterised as low quality.	Customers will prefer headphones with better quality given the same price.	Y		Y
	Will Bob be able to build a capable team to develop and sell the proposed product?	What are the required capabilities to develop and sell the proposed ANC headphones?	As ANC headphones were pre-existing products, the market has a common understanding that quality, design and price are the three main critical factors that can affect the competitiveness of product; The business is a 2C business.	Existing market and product information provides useful information on customer requirements; Potential customers are rational and will prefer products with better quality and design but at an equally low price; Sales depend on product competitiveness and marketing.	The required capabilities in the short term are (1) stronger technology capability compared with competitors in the affordable ANC headphone market, (2) good capability in industrial design, (3) effective cost control, and (4) strong marketing capability.	Y	
		Will Bob be able to build a team to develop ANC headphones with better quality compared with existing affordable ANC headphones?	Bob is a technology VP at an acoustic company. His current team has technology talents that has strong technology capabilities in developing ANC headphones. He plans to offer better compensation to attract them to join his new company.	Technology talent willing to join his new company will be given better compensation.	Y		
		Will Bob be able to build a team to make a good design?	Bob knows a good industrial designer with rich experience in headphones design. He plans to offer better compensation to attract him to join his new company.	The designer will be willing to join his new company given better compensation.	Y		
		Will Bob be able to build a team to effectively control costs given good quality and design?	Bob has several friends doing business in hardware manufacturing for a number of years, and they have rich experience in hardware cost control. He plans to invite some of them to become co-founders with attractive conditions.	His friends will value this business opportunity and be willing to join his team.	Y		
		Will Bob be able to build a team with strong marketing capabilities?	Bob plans invite a marketing person as one of the co-founders with attractive conditions.	There will be someone proficient at marketing that values this business opportunity and be willing to join his team.	Y		
	Will the company keep healthy operation in the short term?		Bob plans to invest an amount of cash in the company. He also plans to raise more money from each co-founder to ensure early stage operation.	He will be able to find co-founders who value this business opportunity and be willing to invest.	Y		

(Table continuing to the next page)

Will the company develop be able to in the longer term?	Will the market for affordable ANC headphones be large enough to be able to support the company to develop and grow in the longer term?		Market reports show that with the wider use of headphones in everyday life, increasing numbers of people have started using or showed an interest in trying ANC headphones for a better listening experience.	Historical market data has predictive power regarding future market trends.	Y		Y
	Will the company gain competitive advantage to compete in the industry for longer-term development?	What are the required capabilities to build competitive advantage?	Headphone companies developing competitive products with strong marketing capabilities are more competitive than others.	The competitive advantage of Company B will lie on product competitiveness and marketing capability.	Strong capabilities in technology, industrial design, cost control and marketing are required in the longer term.		
		Will Bob be able to build a team that is able to keep leading technology capability in the longer term?	The technology talents Bob plans to recruit have strong R&D capability.	The talent will be willing to join his team and their strong R&D capability will remain in the longer term.	Y	Y	
			Bob will apply patents to protect IP as this method has been commonly adopted in the headphone industry.	The method will be effective in IP protection.	Y		
		Will Bob be able to build a team that is able to maintain good capability in industry design in the longer term?	The designer Bob plans to recruit has rich experience in designing headphones.	The designers will be willing to join his team and their good design capability will remain in the longer term.	Y		
		Will Bob be able to build a team that is able to keep effective cost control in the longer term?	The co-founders Bob plans to cooperate with have rich experience in hardware manufacturing and cost control.	Potential co-founders will be willing to join his company and their capability in hardware manufacturing and cost control will remain in the longer term.	Y		
		Will Bob be able to build a team that is able to keep good marketing capability in the longer term?	The marketing person Bob plans to invite has rich experience in marketing.	The marketing person's capability will remain in the longer term.	Y		
	Will the future team be able to manage the company in the longer term?		Bob had been working in the headphone industry for more than 10 years as technology VP at his previous company. The new company will be operating in the same market and industry as his previous company; Bob plans to build the future team with balanced skills and social capital that can be helpful in managing the business in the longer term.	Bob's knowledge of the market and industry are transferable to his new business; Bob will build a team with balanced skills and social capital that will help to manage the business in the longer term.	Y		

Company C

Company Codename	C
Year of Establishment	2005
Headquarters	UK
Product	Standardised system for growing Nano carbon materials for R&D use
Industry Maturity at t_0	New
Problem to solve	The lack of consistency of self-building systems used in the research community
Core Technology	Temperature and airflow control in the chemical vapor deposition (CVD) process
Interviewee	Senior manager

1. Background Information

Company C is a provider of chemical vapor deposition (CVD) systems that can grow high-quality carbon nanomaterial at lab scale for research use. Before Company C was established, research institutes used to self-build systems to grow required carbon nanomaterial. The problems of self-building systems are that they are time consuming and lack consistency across the research community, which can cause difficulties in replicating experiments. Chris, a senior researcher in material engineering at a world-leading lab, realised this problem and the potential business opportunity of becoming a CVD system provider. In 2005, Chris commercialised the technology of his lab in developing CVD systems and established Company C as a university spin-off. At the interview date, the company was in the mature stage.

Before realising the business opportunity of becoming a CVD system provider, Chris had tried to commercialise a technology for growing a special type of carbon nanotube that can enable high quality field emissions. However, he decided not to enter this market due to the limited market potential. These two cases are analysed in sequence and noted as Case C and C' in turn.

2. Company Development in the Early Stage

2.1. Carbon Nanotubes for High Quality Field Emissions

1) Assessment and decisions made at t_0

When Chris was a PhD student, he had shown great enthusiasm in entrepreneurship. His PhD research focused on developing a special type of carbon nanotube (CNTs) that could enable high-quality field emissions. At the end of his PhD, when the technology was sufficiently demonstrated, Chris started thinking of commercialising this technology and targeted precision instrument manufacturers that need high-quality field emissions. The question considered and judgements made at t_0 for market entry decision are listed below.

(1) Will there be a market need for the proposed CNTs in the short term?

The proposed CNTs can enable higher quality field emissions compared with current devices. Chris knew that a higher quality of field emissions could improve the performance of precision instruments, but he was not sure whether or how much customers would potentially be prepared to pay for the improvement. Therefore, at this stage he only assumed a market need with a relatively low confidence level.

(2) Will I be able to develop and sell the required CNTs in the short term? i.e. what are the required capabilities to develop and sell the proposed product and will the team gain these required capabilities?

At this stage, Chris assumed that customers would require higher field emission performance and reasonable price compared with their current devices. This required leading technology capability and effective cost control. Additionally, as a 2B business with only a small number of potential customers, marketing capability was considered less important in the short term. Chris evaluated his technology capability and estimated cost per unit and believed that he would be capable to develop the proposed product in the short term.

(3) Will the company maintain healthy operations in the short term?

Chris would invest his own money in the company if he decided to enter this market. He also planned to request from potential customers a certain amount

of deposit in advance so as to cover some costs. If this model worked, then Chris would assume that he would be able to remain healthy operations in the short term.

(4) Will the market size for the proposed CNTs be large enough to provide a chance for the company to develop in the longer term?
At this stage, Chris had very limited information about the total demand and profit margins for the proposed CNTs. Therefore, he was not able to judge the market size until more relevant information was gleaned from potential customers.

(5) Will the future team be able to build competitive advantage for the company to compete in the industry in the longer term? i.e. what are the required capabilities to develop and sell the proposed product and will the team gain these required capabilities?
Chris assumed that potential customers would value high quality field emissions conditional on a reasonable price. Accordingly, the required capabilities to build competitive advantage were identified as leading technology capability and effective cost control. As a 2B business with only a small number of potential customers, marketing capability was considered less important. Chris was confident that he would be able to gain required capabilities as he had an in-depth understanding of and strong R&D capability in this technology.

(6) Will I be able to manage the company in the longer term?
Chris considered himself an entrepreneurial person and had long been keen on technology entrepreneurship. He was adamant that he would devote whatever effort it required to realise his dream. Therefore, he believed he would be able to manage the company in the longer term.

The details of Chris's judgement of each question are presented in Table C-0, including evidence employed, underlying assumptions and answers with corresponding confidence level. Due to a lack of important information, Chris was not able to make market entry decisions at t_0. As a result, he decided to talk to potential customers to understand their actual requirements and demand for the proposed CNTs.

At t_0, Chris did not yet know the customer requirements, but he did know that potential customers would be able to provide specific requirements on performance if they were interested in the proposed product. Therefore, he decided to directly ask potential customers about their requirements in order to define the launch product.

With respect to the strategy for technology and market development in the early stage, based on Chris's judgement of the fifth question a preliminary decision was taken to focus on technology development and leverage the market through product competitiveness.

2) Assessment and decisions made at t_1

Chris contacted the main precise instrument manufacturers to pitch his technology and CNTs. According to feedback from potential customers, Chris understood that: (1) they were willing to buy his CNTs in the short term; (2) they had specific requirements on product performance; (3) they offered a price range they would be willing to pay; and (4) the total market demand was estimated at approximately 1000 units. Although Chris was technologically capable of developing the required CTNs, the estimated profit per unit was considered moderate given the estimated costs. Given the total market demand was only around 1000 units, the market would not be able to provide enough profit for the company to develop in the longer term. Therefore, with the new evidence garnered from potential customers, Chris considered this opportunity to be limited and decided to not enter the market. The updated judgements are presented in Table C-1.

2.2. CVD System

Since the 1990s, carbon nanotubes (CNTs) have attracted great interest due to their unique structure and properties. At that time, it was common for research institutes to self-build systems to grow CNTs for research. In 2001, Chris's lab designed a four-year PhD project to build a CVD system to grow high-quality CNTs for the lab, and the system was developed in 2005. Self-building CVD systems had some obvious problems such as a heavy input of time and effort. Moreover, the individually developed systems indicated a lack of consistency, something which could cause difficulties in replicating experiments across the research community. Given these problems, Chris started

considering becoming a supplier of ready-to-use and standardised CVD systems for research institutes.

1) Assessment and decisions made at t_0'

The key questions considered and judgements made at t_0' for the market entry decision are as follows.

(1) Will there be a market need for a standardised CVD system in the short term?

Research institutes would benefit from buying a CVD system for reasons of saving time and effort. Additionally, the research community would benefit from using a standardised system. Therefore, Chris assumed that there would be a market opportunity to develop a standardised CVD system due to the benefits it could bring to individual research institutes and the wider research community.

(2) Will I be able to build a capable team of developing and selling the proposed CVD system in the short term? i.e. what are the required capabilities to develop and sell the proposed product and will the team gain these required capabilities?

Chris expected other research institutes would have similar requirements of the CVD system as his lab. Chris's lab has specific requirements regarding the function and performance of the CVD system but the lab was not price sensitive. Accordingly, Chris identified leading technology capability as the most important capability.

In his lab, two researchers were considered technologically capable. Chris planned to invite them to co-found the company to further develop the system for commercialisation.

(3) Will the company maintain healthy operations in the short term?

Chris planned to charge a deposit to potential customers when ordering the CVD system and use it to cover development costs and operational expenses. If potential customers accepted the model, then Chris would be able to maintain healthy operations in the short term.

(4) Will the market size for CVD system be large enough to provide a chance for the company to develop in the longer term?

There had been an increasing amount of research on carbon nanotubes according to the number of existing research projects, papers published in top journals and the number of research grants allocated to this field. The research trend indicates an increasing demand for a CVD system. Given the assumption that research institutes were not price sensitive and would be both willing and able to pay a reasonable price for a ready-to-use system, the profit gained per unit is potentially considerable. Therefore, Chris estimated that the market size would be large enough for the long-term development of the company.

(5) Will I be able to build competitive advantage for the company to compete in the industry in the longer term? i.e. what are the required capabilities to develop competitive advantage for longer-term development and will I gain these required capabilities?

As Chris's lab values function and performance most, he assumed that potential customers would value the same factors. Accordingly, he identified the main required capability to build competitive advantage was leading technology capability. As the potential team members had strong R&D capability, Chris was confident the team would maintain leading technology capability in the longer term.

(6) Will I be able to manage the company in longer term?

Chris was a senior experienced researcher who had established effective networks across research institutes and he knew how to build business relationships with them. Therefore, he was confident that he would be the right person to manage this business.

The details of Chris' judgement of each question are presented in Table C'-0, including evidence employed, underlying assumptions and answers with corresponding confidence level of the results. At t_0', Chris was not able to make market entry decision as he realised that many of his judgements were based on assumptions regarding customer requirements and motivation to buy, while these assumptions needed to be further tested. Therefore, he decided to talk to some research institutes to further understand their actual requirement demands for the proposed CVD system.

At t_0, Chris did not know potential customers' actual requirements for the launch product but he knew that they would provide specific requirements if they were interested in the proposed product. Therefore, asking potential customers directly would be the most effective and efficient way to define the launch product.

With respect to the strategy for technology and market development, a preliminary decision was taken to focus on technology development to build technology barriers against new entrants and leverage the market through product competitiveness, based on Chris's judgement of the fifth question.

2) Assessment and decisions made at t_1'

Chris pitched his idea to many research institutes and asked if they would be willing to purchase the proposed system. Many research institutes were interested in equipping with the standardised CVD system and two of them showed great interest on buying. Research institutes had clear requirements for the function and performance of the system. Surprisingly, most research institutes required a sufficiently good performance rather than a leading performance, which indicates sufficiently good technology capability would be enough for the launch product. Feedback also confirmed that potential customers were not price sensitive and would be willing to pay a considerable premium for the system and advance a deposit. Given the estimated cost per unit, Chris concluded that the company would be technologically capable of developing the required system and earning a considerable profit margin with the agreed price.

Chris analysed the potential customers' motivation for buying and identified three main benefits that research institutes valued most: (1) good quality guaranteed by the creditability of Chris's lab; (2) the time and resources saved from ordering a system rather than self-building one; and (3) the consistency with Chris's research lab for repeating and following the latest research.

The final point reflected the needs of a smoother knowledge exchange across the research community. This indicated that the value a standardised CVD system could bring to their customers increases with the number of users. In other words, the more research institutes use Company C's CVD system, the more benefit each research

institute would gain from using it. This implies that the competitiveness of an individual CVD system is positively related to the company's market share. This emphasised the importance of market share to the longer-term development of the company, and therefore highlighted the requirement for strong marketing capability in both the short and longer term. As a world-leading research institute, Chris believed that the lab's reputation and networks as well as its first mover advantage would help the company to gain market share.

This new evidence updated Chris's previous judgements and these updated factors are presented in Table C'-1. Based on these judgements, Chris decided to establish Company C and become a supplier of the CVD system. The launch product was defined according to customer requirements with a sufficiently good rather than a leading performance. With respect to the strategy of technology and market development in the early stage, Chris adjusted it from 'focusing on technology development and building technology barriers against new entrants and leveraging the market through product competitiveness' to 'keeping technology to a satisfactory level and making the best use of first mover advantage to develop the market for more market share'.

3) Implementation and results

After three months of development, Company C launched its CVD system. In the meanwhile, the team made great efforts in marketing for the purpose of gaining enhanced market share. The company broke even within one year and was acquired by a world leading CVD provider at high valuation in 2007 as an independent department. By 2016, 70% of the global top universities and research institutes had equipped themselves with the system.

3. Summary

In case C, Chris was not able to decide whether to enter the CNT market at t_0 because he knew that his judgements on market need and customer requirements were based on assumptions that needed to be confirmed by potential customers, and he had scant evidence to make a sound judgement on market size. After communicating with potential customers, Chris realised that the market size was too limited to provide a chance for the company to develop in the longer term. Therefore, he evaluated this business opportunity as limited and decided to terminate the business plan.

In case C', Chris made judgements on market need, market size, customer requirements and price on the proposed product at t_0', but with a low level of confidence. This was because he realised these judgements were based on assumptions that could potentially be invalid and the resulting answers could thus potentially be inaccurate. At this stage, due to the lack of solid evidence, Chris decided to firstly test the idea on a number of research institutes and then make a market entry decision, define the launch product and decide the strategy for technology and market development based on the feedback.

When Chris received customer feedback on his proposed product, he realised that his previous answers to questions about customer requirements and their most valued features on the proposed CVD system were inaccurate. However, these inaccurate answers did not lead to low quality decisions because Chris was aware of the potential inaccuracy at t_0'. The feedback from potential customers at t_1' was treated as solid evidence, according to which Chris decided to enter CVD system market, define the launch product and set the strategy for technology and market development in the early stage.

Table C-0 Business opportunity assessment at t_0

Question			Evidence Employed	Assumption	Judgement		
Will the company be able to develop in the short term?	Will there be a need for the proposed CNTs in the short term?		Hgher quality field emissions can improve the performance of precision instruments.	*Potential customers value high quality field emissions and would be willing to buy CNTs for better performance.*	Y		Y
	Will Chris be able to build a team capable of developing and selling the proposed product?	What are the required capabilities to develop and sell the proposed CNTs?	Higher quality field emissions can enable better performance of precision instruments; The performance of field emissions of current devices used by precision instrument manufacturers is known; The prices of current devices are known; This is a 2B business with only a small number of potential customers.	*Potential customers would be willing to pay for higher quality of field emission;* *The price potential customers would be willing to pay will not be too high compared with the price they pay for current devices;* *Sales mainly depend on product quality and price.*	The required capabilities in the short term are (1) a strong technology capability that can enable higher quality field emissions than current industry standards, and (2) effective cost control. Marketing capability was considered as less important in the short term.	Y	
		Will Chris be able to develop the proposed CNTs in the short term?	Chris has already demonstrated the core technology.	Chris has removed the main technological uncertainty.	Y		
		Will Chris be able to effectively control the cost?	The estimated cost per unit is known.	*The cost will be lower than the price potential customers are willing to pay.*	Y		
	Will the company be able to maintain healthy operations in the short term?		Chris plans to charge a deposit to potential customers when ordering CNTs and use the deposit to cover development costs and operational expenses.	*Potential customers will agree to this payment model.*	Y		
Will the company develop be able to in the longer term?	Will the market for the proposed CNTs be large enough to be able to support the company to develop and grow in the longer term?		Chris has limited information about the total demand and profit margins for the CNTs at this stage.	Relevant information is not available yet.	?		?
	Will the company gain competitive advantage to compete in the industry for longer-term development?	What are the required capabilities to build competitive advantage?	The quality of field emissions is important to the performance of precision instrument; Higher quality field emissions can enable better performance of precision instruments; High quality depends on leading technology capability.	*Potential customers would value high quality field emissions.*	The required capability in the longer term is strong technology capability.	Y	
		Will Chris be able to keep leading technology capability in the longer term?	Chris has strong R&D capability.	Chris's strong R&D capability will remain in the longer term.	Y		
			Chris will apply patent to protect IP as this method has been commonly adopted in the industry.	The method will be effective in IP protection.	Y		
	Will Chris be able to manage the company in the longer term?		Chris considers himself an entrepreneurial person and has long been keen on technology entrepreneurship. He would like to devote whatever effort is required to realise his dream.	Chris has the potential to become a good entrepreneur.	Y		

Table C- 1 Business opportunity assessment at t_1

Question			Evidence Employed	Assumption	Judgement		
Will the company be able to develop in the short term?	Will there be a need for the proposed CNTs in the short term?		The potential customers have expressed a willingness to buy his CNTs in the short term.	Potential customers' feedback accurately reflects their needs.	Y		Y
	Will Chris be able to build a team capable of developing and selling the proposed product?	What are the required capabilities to develop and sell the proposed CNTs?	Potential customers have specific requirements for product performance; Potential customers have offered a price range they would like to pay.	Potential customers' feedback accurately reflects their requirements.	The required capabilities in the short term are (1) strong technology capability that can enable higher quality field emissions than current industry standards, and (2) effective cost control. Marketing capability was considered as less important in the short term.	Y	
		Will Chris be able to effectively control the costs?	The estimated cost per unit is lower than the price potential customers are willing to pay, but the profit margin is limited.	Potential customers' feedback accurately reflects their requirements; Chris's estimation of the cost per unit is relatively accurate.	Y		
	Will the company be able to maintain healthy operations in the short term?		Potential customers agreed to pay a deposit when placing orders and the amount of deposit can cover development costs and some operational expenses.	Potential customers will pay a deposit as agreed.	Y		
Will the company develop be able to in the longer term?	Will the market for the proposed CNTs be large enough to be able to support the company to develop and grow in the longer term?		The total market demand was estimated at approximately 1000 units.	Potential customers' feedback accurately reflects their demands.	N		N
	Will the company gain competitive advantage to compete in the industry for longer-term development?	What are the required capabilities to build competitive advantage?	Potential customers value high quality field emissions conditional on an acceptable price.	Potential customers' feedback accurately reflects their most valued feature of the product.	The required capability in the longer term is strong technology capability.	Y	

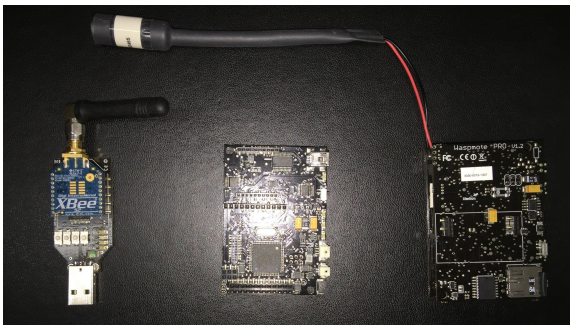
Table C'-0 Business opportunity assessment at t_0'

Question			Evidence Employed	Assumption	Judgement		
Will the company be able to develop in the short term?	Will there be a market need for a standardised CVD system that can save time and effort for research institutes in the short term?		Buying a standardised CVD system from suppliers can save time and effort for research institutes; The research community would benefit from using a standardised system.	*Customers would like buy a standardized CVD system from Company C instead of building their own in-house.*	Y		Y
	Will Chris's future team be able to build a capable team to develop and sell proposed product?	What are the required capabilities for developing and selling a standardised CVD system?	Chris's lab has certain requirements for the function and performance of a standardised CVD system; Chris's lab is not price sensitive when buying equipment.	*Potential customers' requirements will be similar to what are required by Chris's lab;* *Research institutes are not price sensitive;* *Sales mainly depend on product function and performance.*	The main required capability in the short term is leading technology capability and good marketing capability; Cost control is considered less important in the short term.	Y	
		Will the team have the required leading technology capability to develop the proposed CVD system?	Chris's lab has already demonstrated the core technology and developed a CVD system for internal use.	Chris's lab has removed the main technological uncertainties.	Y		
		Will the team have the required marketing capability to promote the proposed CVD system?	Chris is a senior researcher with contacts in many research institutes; Chris is good at communication.	Chris will turn his contacts and communication skills to good marketing capability.	Y		
	Will Company C maintain healthy operations in the short term?		The team plans to charge a deposit to potential customers when ordering the CVD system and use the deposit to cover development costs and operational expenses.	*Potential customers will agree to this payment model.*	Y		
Will the company be able to develop in the longer term?	Will the market for the CVD system be large enough to be able to support the development of the company in the longer term?		There is increasing amount of research on carbon nanotubes according to the number of existing research projects, papers published in top journals and research grants allocated to the field; Apart from CNTs, the technology can be adjusted to produce other carbon nanomaterial.	*The research trend indicates increasing demand for a standard CVD system;* *Research institutes are not price sensitive and would be willing to pay a decent price for a ready-to-use system.*	Y		Y
	Will the company gain competitive advantage to compete in the industry for longer-term development?	What are the required capabilities to build competitive advantage?	Chris's lab values function and performance most.	*Other research institutes would value the function and performance most, as Chris's lab does.*	The required capability in the longer term is strong technology capability.	Y	
		Will the team be able to maintain leading technology capability in the longer term?	The team members have a strong R&D capability.	The team members' strong R&D capability will remain in the longer term.	Y		
			The team will apply a patent to protect IP as this method has been commonly adopted in the industry.	The method will be effective in IP protection.	Y		
	Will the team be able to manage the company in the longer term?		Chris consider himself an entrepreneurial person and has long been keen on technology entrepreneurship. He would like to devote whatever effort is required to realise his dream; Chris was a senior experienced researcher who has built effective networks with research institutes and he knows how to build business relationships with them.	Chris has the potential to become a good entrepreneur.	Y		

Table C'- 1 Business opportunity assessment at t_1'

Question			Evidence Employed	Assumption	Judgement		
Will the company be able to develop in the short term?	Will there be a market need for a standardised CVD system that can save time and effort for research institutes in the short term?		Many research institutes are interested in equipping themselves with a standardised CVD system and two of them have shown a great interest in buying one.	Potential customers' feedback accurately reflects their need.	Y		Y
	Will Chris be able to build a team capable of developing and selling the proposed product?	What are the required capabilities for developing and selling a standard CVD system?	Research institutes have clear requirements on the function and performance of the system; Most research institutes require a sufficiently good performance rather than a leading performance; Potential customers are not price sensitive and would be willing to pay a considerable premium for the system.	Potential customers' feedback accurately reflects their requirement.	The main required capability in the short term is sufficiently sound technology capability; Cost control is considered less important in the short term.	Y	
	Will Company C maintain healthy operations in the short term?		Potential customers would be willing to pay a deposit in advance, as expected.	Potential customers will pay a deposit, as agreed.	Y		
Will the company be able to develop in the longer term?	Will the market for a CVD system be large enough to be able to support the development of the company in the longer term?		Most research institutes Chris has interviewed are interested in equipping themselves with a standardised CVD system; Research institutes are not price sensitive and would be willing to pay a reasonable price for a ready-to-use system, indicating considerable profit per unit.	Potential customers' feedback accurately reflects their need and requirement.	Y		Y
	Will the company gain competitive advantage to compete in the industry for longer-term development?	What are the required capabilities to build competitive advantage?	The three main benefits that research institutes value most were identified as (1) good quality guaranteed by the creditability of Chris's lab, (2) the time and resources saved from ordering a system rather than self-building one, and (3) the consistency within Chris's research lab for repeating and following the latest research.	Potential customers' feedback accurately reflects their motivation to buy.	The required capabilities in the longer term are sufficiently sound technology capability and strong capability in marketing.	Y	
		Will the team gain more market share than competitors in the longer term?	Company C is a spin-off from a world-leading research institute with a sound reputation and rich network resources; Company C is the first company in this industry.	The reputation and network resources of Chris's lab as well as its first mover advantage will help the company to gain more market share.	Y		

Company D



Company Codename	D
Year of Establishment	2015
Headquarters	UK
Product	Wireless sensor network (WSN) system of power systems
Industry Maturity at t_0	Emerging
Problem to solve	Low efficiency of human-based monitoring of power systems
Core Technology	Sensing, wireless communication and machine learning technology
Interviewee	Founder

1. Background Information

The expansion and upgrade of China's power system called for replacing human-based inspection with an intelligent monitoring system. The industry of intelligent monitoring systems was just emerging when the company was established. Although several companies were at the time seeking solutions, the power system operator was not satisfied with existing products due to immature technology. Company D was an early developer of wireless sensor network (WSN) systems which could be deployed in power systems to collect, send and analyse real-time data for monitoring and management purposes. Company D was established by a PhD student at a world-leading university in 2015. After 18-months' R&D, the system had passed a prototype demonstration in a lab environment and completed three months of testing in a real operational environment with the power system operator. At the interview, the company had just gone through the early stage.

2. Company Development at the Early Stage

Power system maintenance includes general monitoring and emergency rescuing. General monitoring ensures the overall condition of the power system to prevent faults,

and emergency rescuing aims at fixing faults when they occur. Traditionally, general monitoring is based on the data regularly collected by technicians. It is time consuming, costly, and, more importantly, the low frequency of data collection can be insufficient for the purpose of predicting and preventing faults in advance. With respect to emergency rescuing, when a fault occurs, it can take a lengthy amount of time for technicians to locate the fault from a complicated power system. Therefore, traditional human-based inspection is considered ineffective, inefficient and uneconomical. With the expansion and upgrade of China's power system, the increasing complexity forced the operator to consider replacing human-based inspection by an intelligent monitoring system that can automatically collect and analyse real-time data to effectively predict and locate faults. The wireless sensor network (WSN) system was considered the most applicable solution to enable intelligent monitoring. It consists of three main parts: data collection, data transmission and data analysis. Data is collected by sensing components installed on the power system, and then sent through wireless communication to the cloud. The data stored in the cloud are then analysed using machine-learning technology, which assists the analysis of vast quantities of data to enable self-diagnosis of the power system.

1) Assessment and Decisions made at t_0

In 2014, David did an internship in Company P, the operator of the China Power System. During the internship, he noticed that Company P had a strong intention to deploy a WSN system on their power system. Managers told David that there would be a trend for the whole power system to equip itself with an intelligent monitoring system, and they had been constantly looking for capable solution providers and would like to provide data and feedback for co-development. However, due to technological difficulties, current WSN systems on the market were not able to meet Company P's requirements. Company P required that the intelligent monitoring system be reliable, easy to use, and have a long battery life and effective self-diagnostic function. David also understood that Company P was not price sensitive and would be willing to pay a good price as long as the system could meet their requirements.

According to the requirements of Company P, David assessed the level of technology difficulty as high but not unachievable based on his knowledge of engineering. Therefore, he believed that there would be a good business opportunity if he could

overcome the technological difficulties and develop the required system before competitors did. To assess this business opportunity, David considered following questions:

(1) Will there be a market need for the proposed WSN system in the short term?
Managers from Company P had confirmed that they needed an intelligent monitoring system.

(2) Will the future team be able to develop and sell required WSN system in the short term? i.e. what are the required capabilities to develop and sell the proposed product and will the team gain these required capabilities?
In order to fulfill Company P's requirements, the team had to have leading technology capability. The requirements also indicated that sales would mainly depend on system performance, and therefore cost control and marketing capabilities were considered less important in the short term. Additionally, as WSN systems for power systems are very much in the preliminary stages of development, product development would be an exploratory process and feedback from Company P would be necessary throughout the product development process. Therefore, the capability to maintain effective cooperation with Company P for co-development was also required.

David was confident that he would be capable of managing the co-development along with Company P. With respect to the required technology capabilities, although David did not have all of them, he knew technology experts in related areas. David believed that this opportunity would be attractive enough for them to join the team.

(3) Will the company be able to maintain healthy operations in the short term?
David planned to raise equity finance to ensure the short-term operations of the company. He believed that if he were able to build a capable team, this project would be attractive to venture investors.

(4) Will the market size for a WSN system be large enough to provide a chance for the company to develop in the longer term?

David believes there will be a trend to replace human labour by intelligent monitoring systems. Given the scale of China Power System, future demand would be enormous. Additionally, the core technology of a WSN system could be applied to many other scenarios such as traffic management and forest protection, among others. Therefore, the market size of a WSN system would be large enough to provide a chance for the company to develop in the longer term.

(5) Will the future team be able to build competitive advantage for the company to compete in the industry in the longer term? i.e. what are the required capabilities to develop competitive advantage for longer-term development and will the team gain these required capabilities?

Company P's requirements implied that the competitive advantage of the company lay predominantly in its technology capability. David assessed the technology capability of existing competitors and concluded that this industry was in the emerging stage and no company had absolute technology advantage over others. As David knew where to source technology experts with strong R&D capability, there was a chance for the company to gain technology advantage in the longer term.

(6) Will the future team be able to manage the company in longer term?

David considered himself an entrepreneurial person and intended to invite a co-founder who had experience in managing engineering companies. Therefore, he was optimistic about this question.

The details of David's judgement of each question are presented in Table D-0, including evidence employed, underlying assumptions and answers with corresponding confidence levels. According to the judgements, David decided to establish Company D in the WNS market at t_0.

At this stage, although Company P provided clear requirements for its WNS system, David was not able to define the launch product because he was not as yet clear about the technology solution. As a result, he chose to follow an iterative trial process. Specifically, he started by developing a prototypical system and tested it with Company

P to gather customer feedback, which would be used as a basis for improvement. This development process would be repeated until Company P declared it was satisfied with the system.

According to the judgement of the fifth question, developing technology capability was of critical importance to company development in both the short and longer term. Therefore, the strategy for technology and market development was to focus on overcoming technology difficulties and then develop the market through its competitive products.

2) Implementation and results

After he decided to establish Company D, David started building his team according to the required capabilities identified at t_0. Three experienced engineers from research centres and large technology companies and one project manager who had an engineering and management background joined his team.

With the right people on board, the team started by overcoming the main challenge of current WSN systems: reducing the size of the battery while ensuring a well-functioning sensing and wireless communication at the same time. After 18-months of co-development, the hardware by Company D achieved its first prototype at the weight of 20kg (only 10% of their competitors' products) with a satisfactory performance in a lab environment. In parallel, the preliminary machine-learning algorithm for self-diagnosis was developed, waiting to be tested by real data in an operational environment.

David tested this prototypical system with Company P in an operational environment for three months to continuously improve the hardware and to train the machine-learning algorithm. At the end of this testing process, the system was developed to a satisfactory level. Up to the interview date, Company P had placed an order from Company D, indicting the company was going to break even.

3. Summary

At t_0, David made the market entry decision based on information provided by managers from Company P. He decided to follow an iterative process to define the launch product because he did not have a feasible technology solution at that moment. In this case, the customer had clear requirements for the system, such as it being easy to deploy, but they were not in themselves specific enough for defining the product. This indicates that understanding customer requirements is a necessary but not a sufficient condition for defining a product, as it also requires entrepreneurs to have clear technological solutions. With respect to the alignment of technology and market development in the early stage, David chose to focus on overcoming technology difficulties first and then developing the market once the product was well developed.

Table D-0 Business opportunity assessment at t_0

Question			Evidence Employed	Assumption	Judgement		
Will the company be able to develop in the short term?	Is there a market need for an intelligent monitoring system for maintaining power systems?		Company P has started trying an intelligent monitoring system on their power system; Company P has confirmed that they had need of an intelligent monitoring system.	Company P's purchase reflects its need for an intelligent monitoring system; The information managers provided can accurately reflect the needs of Company P.	Y		Y
	Will David be able to build a team capable of developing and selling the proposed product?	What are the required capabilities to develop and sell the proposed intelligent monitoring system?	Company P required the system to be reliable, easy to install, with a long battery life and capable of self-diagnosing; The potential customer values product performance and is not price sensitive; Product development requires the potential customer provide feedback when necessary throughout the product development process.	Sales mainly depend on the functionality and performance of the system.	The main required capabilities in the short term are leading technology capability and project management capability (to manage the cooperation with the potential customer); Marketing capability was considered less important in the short term.	Y	
		Will David be technologically able to develop the proposed WSN system?	David knows technology experts in the relevant area; Company P would like to provide support throughout the product development process.	David will build a capable team.	Y		
		Will David be able to manage a cooperative relationship with Company P?	During his internship at Company P, David has established a number of contacts there; Company P would like to provide support throughout the product development process.	Company P will provide support, as agreed.	Y		
	Will the company maintain healthy operations in the short term?		David planned to raise equity finance to ensure the short-term operation of the company.	David would be able to build a capable team; Investors would invest to his company.	Y		
Will the company be able to develop in the longer term?	Will the market for an intelligent monitoring system be large enough to be able to support the company to develop and grow in the longer term?		According to industry reports, there is a trend for the power industry to deploy intelligent monitoring systems, which will create a market worth hundreds of billions of dollars; Besides the power system, an intelligent monitoring system can be used in many other scenarios such as traffic management and forest protection.	There is a trend to use an intelligent monitoring system to replace human labour.	Y		Y
	Will the company gain competitive advantage to compete in the industry for longer-term development?	What are the required capabilities to build competitive advantage?	Company P requires the system to be reliable, easy to install, with a long battery life and capable of being self-diagnosing; The potential customer values product performance and is not price sensitive; The potential customer value product performance most; Product development requires the potential customer to provide feedback when necessary throughout the product development process.	The information managers provided accurately reflects Company P's requirements.	The main required capabilities in the longer term are leading technology capability and project management capability (to manage cooperation with the potential customer);		
		Will David be able to keep leading technology capability in the longer term?	David knows technology experts with strong R&D capabilities; Company P would like to provide support throughout the product development process.	David will build a capable team; Company P will provide support, as agreed.	Y	Y	
			David will apply a patent to protect IP as this method has been commonly adopted in the industry.	The method will be effective in IP protection.	Y		
		Will David be able to manage a cooperative relationship with Company P?	During his internship at Company P, David built some contacts there; David plans to invite a friend who has experience in project management.	David's friend will join his team and be capable in project management.	Y		
	Will David be able to manage the company in the longer term?		David considers himself an entrepreneurial person and he intends to invite a co-founder who has experience in managing engineering companies.	David has the potential to become a good entrepreneur; David will build a balanced team.	Y		

Company E

Company Codename	E
Year of Establishment	2015
Headquarters	US
Product	Self-driving robot for last mile delivery
Industry Maturity at t_0	Emerging
Problem to Solve	High costs for the last mile delivery
Core Technology	Self-driving technology
Interviewee	Co-founder

1. Background Information

Company E was established in 2015 by two PhD graduates in robotics from a world-leading university. They aimed to solve the problem of the high costs of last mile delivery (i.e. the costs of delivering orders from the local warehouse to receivers) by replacing human labour with self-driving robots. According to their estimations of the time, delivery costs were expected to fall by around 80% in the coming years. The industry of self-driving delivery robots was just emerging, with several companies developing similar products and exploring the market. Company E had passed a test with their delivery robot with a delivery company, which then became the company's first customer. At the interview date, the sales generated from this delivery company had seen Company E break even with its variable costs.

2. Company Development in the Early Stage

In the US, the high labour cost of last mile delivery lead to high delivery fees. In 2015, receivers needed to pay $6 - $12 for one order, which included $5 – 10 standard delivery fee plus $1 to $2 in tips to the deliverer. This high delivery fee restricts demand for delivery services and the further development of the delivery industry. Reducing delivery costs will make delivery services more affordable to more people and in turn boost the delivery industry.

Evan, a PhD graduate from a world-leading lab who was keen to apply his expertise in robotics to solve real world problems, came up with an idea to reduce the cost of last mile delivery by replacing human labour with self-driving robots. According to his estimation, delivery robots could reduce the delivery fee by 80% to $1-2 per order, with no tips needed. Therefore, Evan started to consider establishing a company making delivery robots for delivery companies.

1) Assessment and decisions made at t_0

The key questions Evan considered and judgement made for market entry decisions are:

(1) Will there be a market need for delivery robots in the short term?

The reduction of delivery fees would make delivery services more affordable to more people and in turn boost the delivery industry. In other words, both receivers and delivery companies will benefit from low delivery costs. Here, Evan realised that for the market need for a delivery robot to exist, the following conditions need to be satisfied: (a) receivers should accept delivery robots given the much lower delivery fees; (b) the local community should accept delivery robots moving around, and (c) future rules and regulations will allow delivery robots. At this stage, Evan did not have solid evidence showing these three assumptions were valid; therefore, he assumed there would be a market need but with a relatively low confidence level.

(2) Will the team be able to develop and sell the proposed delivery robots in the short term? i.e. what are the required capabilities to develop and sell the proposed product and will the team gain these required capabilities?

Evan expected that delivery companies' would require the robots to be able to significantly reduce delivery costs and offer a reliable delivery service. As it is automation that will reduce delivery costs and create value for delivery companies, delivery robots require strong self-driving technology capability. Given the strong research background of the two co-founders, Evan was confident that the team was technologically capable of developing reliable self-driving robots for local delivery. Once the delivery robots have been developed, the company would need to promote them to delivery companies, so marketing

capability was also required. Evan planned to join an incubator to use their platform for product marketing.

(3) Will the company maintain healthy operations in the short term?
The team planned to use their personal savings to test market need. Once market need was verified, they planned to apply for an incubator to gain support in early stage of business development and fund raising. Compared with projects in their target incubators, Evan was confident that they would be accepted if market was shown to exist.

(4) Will the market size for delivery robots be large enough to provide a chance for the company to develop in the longer term?
If delivery companies choose to use delivery robots, the market size will be in the billions according to the total number of deliveries in recent years in the US, which would be large enough to provide sufficient scope for companies in this industry to develop and grow in the long term.

(5) Will the team be able to build competitive advantage for the company to compete in the industry in the longer term? i.e. what are the required capabilities to develop competitive advantage for longer-term development and will the team gain these required capabilities?
Evan expected that customers would most value cost saving and reliability. As these two features are highly dependent on technology capability, it was identified as the most critical capability to build competitive advantage for the company in the longer term. Evan was confident about the team's technology capability in the longer term as the team members had strong R&D capability. In addition to technology capability, strong marketing capability was also required as this was an emerging industry with many potential competitors fighting for market share.

(6) Will the team be able to manage the company in the longer term?
Evan was a president in his student union and had long been keen on organising entrepreneurial activities at university. Although he did not have previous

experience in entrepreneurship, he was confident that his previous social experience was transferable to business management.

The details of Evan's judgement of each key question are presented in Table E-0, including evidence employed, underlying assumptions, and answers with corresponding confidence level. At t_0, Evan was not able to make a market entry decision as he knew that his judgement on market need was based on assumptions about receiver experience, social acceptance and regulations, and these assumptions need further testing. Evan believed that the most valid way to test these assumptions would be to send a robot to deliver orders and observe how receivers and people passing by responded to it. In order to test people's attitudes with minimal effort and cost, Evan decided to build a model robot fully controlled by remote operators with no automation function developed. The market entry decision would be conditional on the testing results, i.e. to enter the delivery robot market if the evidence revealed that receivers and the wider community viewed delivery robots positively.

At t_0, the team decided to follow an iterative process to define the launch product due to the lack of information on customer or user requirements. Therefore, they built a model robot according to their projections of user requirements and used it as a vehicle to gather user feedback and discover potential problems for further technology and product development.

As the team identified technology and marketing capability to be the most critical capability for short- and longer-term development, the strategy for technology and market development in the early stage was to concentrate on developing technology (if the market was entered), and once the core technology was sufficiently demonstrated the team would start developing the market by building a co-development relationship with large delivery companies to optimise its algorithm and secure potential customers.

2) Assessment and decisions made at t_1

In order to test the attitude of receivers and the local community to delivery robots, the team developed a model robot for trial deliveries at a local university. Cameras were installed on the model robot to observe people's responses. It was found that: (1) in

general, people passing by the model robot were curious about finding out what it was but were still friendly to it (people required the robot to move slowly and be designed as approachable); (2) university students found delivery robots interesting and left helpful feedback on how the product and service could be improved, for example, a real–time tracking function of their orders was required; and (3) some practical problems were revealed, such as, for example, when crossing the road the robot had to wait until there was someone to press the button at the traffic lights. The evidence gathered by the model robot indicated user and social acceptance and highlighted a number of challenges which required solutions.

This new evidence updated the team's judgements on the key questions (see Table E-1). Based on these updated judgements, the team decided to establish Company E and enter the market for delivery robots.

3) Implementation and results

Once the company had been established, the team focused on increasing automation by developing self-driving technology. In addition to core technology development, the team also optimised the product design and integrated required functions according to the receivers' feedback (such as real-time tracking). After three months, a prototype was developed and successfully tested with more than 50 deliveries at a local university over a total of more than 200 hours. The level of automation of this prototype had been significantly increased to enable a 60% reduction in delivery costs. Until then, this prototype had been sufficiently demonstrated that it was acceptable to receivers and the local community and was functional and user friendly.

Given the sufficiently demonstrated technology and social acceptance, Evan pitched his business plan to lease delivery robots to delivery companies and invited them to become co-developers to test the robots with real orders. One of the most famous US delivery companies showed great interest and agreed to test the robot with real orders. The testing process went well and enabled Company E to further refine its algorithm and eventually define their first product. The delivery companies were satisfied with Company E's delivery robots and decided to rent them for local delivery. Up to the

interview date, the revenue from leasing delivery robots to delivery companies had seen Company E break even with accumulated costs.

3. Summary

The existence of market need is a pre-requisite for any business opportunity, and therefore should be carefully verified. At t_0, Evan's answer to the question as to the market need for delivery robots was positive but at a relatively low confidence level because the answer was based on three assumptions that required further verification. Therefore, Evan was not able to make a market entry decision at t_0 until these assumptions had been sufficiently verified at t_1.

With respect to the process to define the launch product, as the specific requirements of potential users were not available at $t_{0,}$ the team decided to follow an iterative process, i.e. develop a model robot based on their projections of user/customer requirements first and then adjust the design based on receiver feedback. The launch product was defined when receivers felt sufficiently satisfied.

At t_0, the strategy for technology and market development in the early stage was to develop technology first to achieve a high level of automation and reliability, and once the technology had been developed and the product had been sufficiently demonstrated, the team would start to promote their delivery robots to develop the market and further refine the technology using more user data.

Table E-0 Business opportunity assessment at t_0

Question			Evidence Employed	Assumption	Judgement		
Will the company be able to develop in the short term?	Will there be a market need for delivery robots that can reduce delivery costs for delivery companies?		Delivery robots can reduce delivery costs by 60% to 80% for delivery companies.	Customers value cost reductions and would like to use delivery robots to reduce costs; *Delivery robots will be acceptable to receivers and the local community and be allowed by regulations.*	Y		Y
	Will Evan be able to develop and sell the proposed robots?	What are the required capabilities for developing and selling delivery robots?	Reliability and cost of delivery are two critical factors of delivery service; This is an emerging industry with many potential competitors fighting for market share.	Customers will require delivery robots to be reliable and economic.	The main required capabilities are strong technology capability and some marketing capability.	Y	
		Will the team be able to gain strong technology capability?	The two co-founders have strong research backgrounds in robotics.	The team's technology capability will remain.	Y		
		Will the team be able to promote their product to potential customers?	Evan planned to join an incubator to use their platform for product marketing.	*There is a market need;* The target incubator will accept the project.	Y		
	Will the company keep healthy operation in the short term?		The team planned to use their personal savings to develop a prototype and then apply for an incubator to help with early stage development and fund raising.	*There is a market need;* The target incubator will accept the project.	Y		
Will the company be able to develop in the longer term?	Will the market of delivery robots be big enough to be able to support the company to develop and grow in the longer term?		In 2015, there were 12.9 billion deliveries of food and packages.	The size of the delivery market reflects the long-term potential of the market size of delivery robots.	Y		Y
	Will the company have competitive advantage to compete in the industry for longer-term development?	What are the required capabilities to develop competitive advantage?	Reliability and cost are two critical factors of a delivery service; This is an emerging industry with many potential competitors fighting for market share.	In the longer term, sales depend on product competitiveness (functionality, reliability and efficiency) and marketing.	The main required capabilities are strong technology capability and marketing capability in the longer term.	Y	
		Will Evan be able to maintain leading technology capability in the longer term?	The team has strong R&D capabilities.	The team will retain leading R&D capability in the longer term.	Y		
			The team will keep the technology IP in house.	The method will be effective to protect software IP.	Y		
		Will the company be able to gain strong marketing capability in the longer term?	Evan planned to recruit an experience marketing person once the launch product was developed.	Evan will recruit an experienced marketing person when necessary.	Y		
	Will Evan be able to manage the company in the longer term?		Evan has shown leadership characteristics and has long been keen on entrepreneurial activities. He would like to devote himself to entrepreneurship.	Evan will be an effective entrepreneur.	Y		

Table E-1 Business opportunity assessment at t_1

Question			Evidence Employed	Assumption	Judgement		
Will the company be able to develop in the short term?	Will there be a market need for delivery robots that can reduce delivery costs for delivery companies?		Delivery robots can reduce delivery costs by 60% to 80% for delivery companies. Receivers at a local university and in the local community are friendly to delivery robots in general.	Customers value cost reductions and would like to use delivery robots to reduce costs; People's reactions recorded by the model robots can accurately reflect the attitudes of receivers and the local community.	Y		Y
	Will Evan be able to develop and sell the proposed robots?	What are the required capabilities for developing and selling delivery robots?	Receivers require the delivery service to be safe, punctual and tractable. Receivers and local community require the delivery robot to be well designed.	Feedbacks from the sample can fairly reflect customer requirement.	The main required capabilities are strong technology capability and marketing capability.	Y	
		Will the team be able to promote their product to potential customers?	The project was accepted by a top incubator in the US; The incubator provides a supportive service and platform for startups.	The incubator will help Company E promote its products.	Y		
	Will the company maintain healthy operations in the short term?		The project was accepted by a top incubator in US; The incubator provides seed investment and a platform for startups to raise finance.	The incubator will help Company E raise funding.	Y		
			]				

Company F

Company Codename	F
Year of Establishment	2014
Headquarters	US
Product	Smart parking software for parking operators and drivers
Industry Maturity at t_0	Mature in Europe but Emerging in US
Problem to Solve	Mismatch between demand and supply of parking space
Core Technology	Data binding, mathematical modeling, big data
Interviewee	Co-founder & CTO

1. Background Information

Company F was established in 2014 by two PhD graduates in data science from a world-leading university. The product at the interview date was management software for car parks. The software collects parking data from existing parking devices and analyses it for internal management purposes. The company's long-term goal was to build a platform on which car park operators would be able to provide online real-time parking information about availability and price, and drivers would be able to check and even reserve parking spaces in advance. At the interview date, the company had gone through the early stage.

2. Company Development in the Early Stage

The original business idea for building a parking platform for car parks and drivers arose when Frank experienced difficulty finding car parks in urban areas. He tried more than 50 parking apps but none of them could provide integrated and accurate real-time parking information. This was because the parking industry lacks a well-established data infrastructure. As a result, drivers are only able to check the availability of a car park when they actually drive there. Frank thought that if car park operators could upload their online real-time availability to a platform, then drivers would be able to

check and even reserve a parking space in advance in the same manner that people book hotels. If such a platform were built, flexible pricing in the parking industry would be possible. As flexible pricing could improve car parks' revenue by making the best use of their parking capacity, it was thought that car park owners would be willing to provide their data to help build such a platform.

However, Frank realised that building an integrated data infrastructure would take a long time, meaning that the car parks would not be expected to benefit in the short term from releasing their data for external use. This could lead to two potential problems. First, car parks might feel less motivated to cooperate; second, even though car parks would like to share their data, it would be difficult to charge them in the short term.

In order to surmount these two problems but gain data access to car parks to build a data infrastructure, Frank devised a two-step plan. First, he planned to develop management software for car parks for internal use, such as realising real time parking space management, building a database to enable data-driven decision-making such as pricing, and increasing automation to reduce operational costs. Second, after gaining access to a sufficient number of car parks, Frank would propose the platform plan to car parks and invite them to join to further boost their revenue through better matching the demand and the supply of parking spaces. Therefore, Frank considered becoming a car park management software provider first.

1) Assessment and decisions made at t_0

The key questions Frank considered and judgements he made for market entry decisions are:

(1) Will there be a market need for car park management software in the short term? Although car park management software already existed and was widely used in many EU and Asian car parks, in the US there were still a large number of car parks that had not realised automation. Frank planned to access data from car parks' existing facilities so that no commitment to extra hardware was required. Therefore, from the car parks' perspective, the management software would help reduce costs and improve efficiency at no extra cost or effort. Frank was thus confident that there would be a market need in the US.

(2) Will the team be able to develop and sell the required management software in the short term? i.e. what are the required capabilities to develop and sell the required management software and will the team gain these required capabilities?

As car park management software already existed, Frank assumed the existing management software on the market could provide a good reference for customer requirements regarding function, design and pricing. Accordingly, technology capability was required. Additionally, as the team needed to promote its software to car parks to obtain data access, marketing capabilities were also required. As a data scientist, Frank was confident that he was technologically capable of developing the required management software. With respect to marketing, Frank believed his research background in data science and the potential economic benefits from using management software would help him to promote the software.

(3) Will the company maintain healthy operations in the short term?

In the short term, the two co-founders would use their own savings and revenue to cover R&D costs and other expenditures. The team planned to apply to an incubator for financial and managerial support once they had secured their first customer.

(4) Will the market size of car park management software be large enough to provide a chance for the company to develop in the longer term?

Most car parks are rather traditional and highly reliant on human labour. If use the subscription fees in the EU market as a reference to estimate US market, the annual revenue of the US industry would be hundreds of billions of dollars. Therefore, Frank was confident that the market size of car park management software was large enough.

(5) Will the team be able to build competitive advantage for the company to compete in the industry in the longer term? i.e. what are the required capabilities to develop competitive advantage for longer-term development and will the team gain these required capabilities?

Customers are expected to value the net benefits gained by using the software. This required a strong data analysis capability to create value from existing data. In addition to strong technology capability, marketing capability was required in the longer term given the long-term platform plan. Therefore, gaining more market share would be critical to the company.

The two co-founders' strong R&D capability in data analysis was expected to remain in the longer term. With respect to marketing capability, Frank planned to build a marketing team in the longer term.

(6) Will the team be able to manage the company in the longer term?

Frank had been keen on organising entrepreneurial activities in university and had showed good leadership capabilities. Although he did not have previous experience in entrepreneurship, he was confident that he would be capable of learning from practice.

The details of Frank's judgement of each question are presented in Table F-0, including evidence employed, underlying assumptions and answers with corresponding confidence levels. At t_0, according to the judgements Frank decided to establish Company F to become a provider of car park management software. The launch product was defined directly at t_0, referring to the existing software on the market. As market development depended on both strong technology and marketing capability, the early-stage strategy for market and technology development was to develop technology to a satisfactory level and in parallel promote the software to gain enhanced market share.

2) Implementation and results

Frank pitched the proposed management software to several local car parks and one local airport agreed to provide him with data to develop the software for them.

The airport had six car parks, and each one had thousands of parking spaces. Before introducing the software, the airport had to send staff to count the available parking spaces twice per day in order to manage the parking system. It was costly, ineffective and inaccurate. According to the operational manager, reducing cost and improve operational efficiency was the top priority. Based on these requirements, Frank started

iteratively developing and testing the software with the airport. With the software, the frequency of human-based checking dropped to once a week during the testing period and was further reduced to once a month afterwards. The airport was satisfied with the significant cost reduction and operational efficiency gain enabled by the software.

The success of this project validated Frank's previous judgement on the market need for the management software for US car parks and marketing capability of the team, sufficiently demonstrated the team's technology capability, and proved the feasibility of the plan to obtain data access.

After successfully developing the software for the airport, Company F started securing more orders and more value-adding functions were built into the software, such as revenue prediction, flexible pricing and automatic financial statement reporting, among others. Company F continuously updated its software for existing customers and pitched repeatedly to potential customers with more developed software. Up to the interview date, Company F had gained more than 20 customers in six cities.

3. Summary

Management software for car parks is a mature product in the EU and Asia. However, in the US many car parks had not realised automation. According to existing market information available at t_0, Frank was confident that there would be a market need for management software for car parks in the US. Moreover, he defined the first launch product by using existing products as a reference. As gaining market share was considered of strategic importance for the company's long-term goal (establishing data infrastructure for the parking industry), the strategy for early-stage market and technology development was to develop technology to a satisfactory level and in parallel promote the software to gain more market share.

Table F-0 Business opportunity assessment at t_0

Question			Evidence Employed	Assumption	Judgement		
Will the company be able to develop in the short term?	Will there be a market need for management software that can reduce management costs and increase efficiency for US car parks?		The management software would help car parks reduce costs and improve efficiency with no extra commitment required.	Car parks would be willing to pay for cost reductions and efficiency improvements to gain the expected net benefits.	Y		Y
	Will Frank be capable of building a team that is able to develop and sell the proposed product?	What are the required capabilities for developing and selling management software for car parks?	Management software for car parks is a pre-existing product with product information and price available; The team needed to pitch their idea to car parks to obtain data access to develop software.	Operators of US car parks have similar requirements as EU and Asian car park operators; Sales depend on the net value created by the software and marketing.	The required capabilities are (1) technology capabilities in data access, data analysis and interface design, and (2) marketing capability; Cost control will not be a large concern for software development companies.	Y	
		Will the team be technologically capable of developing the proposed CNTs?	The two co-founders have strong technology capability in data analysis.	The team's technology capability will remain in the short term.	Y		
		Will the team have the required marketing capability?	Frank is good at communicating and building relationships.	The team's research background in data science and the potential economic benefits from using the management software would help to further market the software.	Y		
	Will the company maintain healthy operations in the short term?		The two co-founders would use their own savings and revenue to cover R&D costs and other expenditures; After securing their first customer, the team planned to apply for an incubator for training and fund raising purposes.	The team would realise sales revenues in the short term; The incubator will accept this project.	Y		
Will the company be able to develop in the longer term?	Will the market for management software for US car parks be large enough to support the company to develop and grow in the longer term?		In the US, most car parks are rather traditional and highly reliant on human labour; If using the price of such technology in the EU as a benchmark, the total annual revenue of US industry is in the billions of dollars.	Car parks would be willing to invest in cost-cutting technology and for efficiency improvements to gain the net benefits; The US and EU markets are comparable.	Y		Y
	Will the company gain competitive advantage to compete in the industry for longer-term development?	What are the required capabilities to build competitive advantage?	This is an emerging industry with many potential competitors fighting for market share.	Customers value the net benefits obtained from using the software.	The main required capabilities in the longer term are data analysis capability and marketing capabilities.		
		Will the team be able to maintain strong technology capability in the longer term?	The two co-founders have strong R&D capability in data analysis.	The two co-founders' strong R&D capability will remain in the longer term.	Y	Y	
			The IP will be kept in house.	The method will be effective in IP protection.	Y		
		Will the team be able to gain strong marketing capabilities in the longer term?	Frank planned to build a marketing team when necessary.	Frank will build a capable marketing team in the longer term if the business is validated.	Y		
	Will Frank be able to manage the company in the longer term?		Frank has shown leadership traits and is keen on entrepreneurial activities. He would like to devote himself to entrepreneurship.	Frank would be a potential entrepreneur.	Y		

Company G

Company Codename	G
Year of Establishment	2014
Headquarters	US
Product	Advanced Physics Simulation Engine for VR game companies
Industry Maturity at t_0	Emerging
Problem to Solve	Increase reality of the movement of virtual characters in VR games
Core Technology	Advanced physics simulation engine for animation
Interviewee	Co-founder – George and Grace

1. Background Information

Company G is a developer of an advanced physics simulation engine (hereafter referred to as a PE) for VR game developers. A PE is an algorithm used to simulate virtual characters' movements based on physical and biomechanical rules so that they are able to move in a realistic way. The company was established by George and Grace in 2014. George was a leading technology expert in PE development who had obvious technology advantage compared with other developers, and Grace was a veteran gamer and with a passion for starting a gaming business.

2. Company Development at the Early Stage

PE technology originated in a university research project in biomechanical artificial intelligence. In the last decade, this technology was introduced in the animation industry as a promising cutting-edge technology to enable high levels of reality.

The two main traditional technologies used in animation are keyframe and motion capturing technology, both of which allow characters to move in ways designed by

animators. As it is impossible for animators to design every possible movement, games developed using traditional technologies suffered a loss of reality and placed technical limits on the interaction between characters and game players. Aiming to replicate a deeper degree of character-player interaction, PE technology seeks to understand and model the physical and biomechanical rules of characters' movements, thereby allowing engineers to simulate characters in a highly realistic way.

George was a world-leading expert in PE industry with eight years of experience developing PE-driven games and has kept close cooperation with the best researchers in the field. His dream was always to establish his own PE game company and become a technology leader in the industry. Grace was a veteran gamer and had been constantly seeking opportunities to start a gaming business. Due to these similar interests and passions, George and Grace started seeking for opportunities to apply PE technology in the gaming industry.

2.1. PE-Driven Mobile Games

1) Assessment and decisions made at t_0

A PE is an algorithm that can be applied to different platforms, such as mobile phones and computers. Since 2013, the mobile game market has been booming at an annual growth rate of 30%, significantly higher than *PC-based* game market. As a growing industry, there were ample opportunities for start-up companies. Therefore, George began to consider becoming a PE-driven mobile game developer. The key questions he considered and judgements he made for the market entry decision are:

(1) Will there be a market need for PE-driven mobile games in the short term?

A PE allows characters to act in way that more realistically replicates human behaviour, enabling deep interaction between players and characters. Therefore, the team believed that mobile game players would value this high level of reality and was confident that there would be a market need for PE-driven mobile games.

(2) Will the team be able to develop and sell the proposed PE-driven mobile games in the short term? i.e. what are the required capabilities to develop and sell PE-driven mobile games and will the team have these required capabilities?

The team believed that mobile game players would value the high level of reality which PE technology allows. Therefore, they identified strong PE technology capability as the main required capability. As George was one of the best PE developers in industry, the team was confident that they would be capable of developing the proposed games.

(3) Will the company maintain healthy operations in the short term?

The team planned to raise external finance from venture investors. Given George's technology capabilities, they were confident they would secure investment for their business.

(4) Will the market size for PE-driven mobile games be large enough to provide a chance for the company to develop in the longer term?

According to market reports, since 2013 the mobile game market was booming at 30% annual growth rate and was expected to maintain this rate. The team believed that the growth of the mobile game market indicated a continuously large enough market potential for PE-driven mobile games.

(5) Will the team be able to build competitive advantage for the company to compete in the industry in the longer term? i.e. what are the required capabilities to develop competitive advantage for longer-term development and will the gain these required capabilities?

The team believed that mobile game players would value the high level of reality and the company's competitive advantage thus lies in technology advancement. Therefore, strong PE technology capability was identified as the main required capability. As George had a proven R&D capability, the team was confident that they would be able to build competitive advantage in the longer term.

(6) Will the team be able to manage the company in the longer term?

The team had balanced skills in technology and business and, more importantly, both founders had working experience in the game industry. Therefore, the team was confident that their understanding of the industry and the skills balance in the team would enable them to manage the business in the longer term.

The details of the team's judgement for each question are presented in Table F-0, including evidence employed, underlying assumptions and answers with corresponding confidence levels. According to the judgements, the team decided to enter the market for PE-driven mobile games. The launch product was defined to highlight the high level of reality enabled by PE technology without asking feedback from game players. The strategy for technology and market development at the early stage would be developing the technology and game internally and start marketing once the game had passed a beta test.

2) Implementation and results

Although George was the best PE developer in the industry, his technology was still in the early stage when the company was established. At that time, he only had an early version of PE that could support the simulation of bipedal characters. After sixmonths of development, George had successfully developed the algorithm for quadrupled characters and launched the game for beta testing with players.

However, the players' feedback was not as expected. First, the players thought the game was not fun to play – they noted it was more like a technology demo than a game. Second, although the players could feel that the game's characters were acting in a more realistic way, this feeling was not significant in a finger-controlled game on a mobile screen. Third, mobile game players value the speed of games, which requires that the memory is small. However as a complicated algorithm, PE-driven games occupy much more memory than traditional mobile games.

Based on this feedback, George and Grace realised their judgement on market need was inaccurate because they had not understood customer requirements well before

developing the product. The team should understand customer requirements first and then analyse whether PE technology could better satisfy them, rather than intuitively believe customers would value the better performance enabled by the technology. If the team had better understood customer requirements, they would have realised that (1) mobile game players do not actually value reality that much, and therefore PE-technology would not create added value, and (2) mobile game players like the game to be fun and well designed, which requires strong game development capability. However the team did not identify this capability as required and, as a result, they did not realised they were not able to develop mobile games.

The negative feedback for the beta test disproved the market need for PE-driven mobile games. On the mobile platform, traditional technologies such as keyframe are good enough to satisfy players' needs and PE technology was not seen to seen to add value by the players. Therefore, the team decided to terminate this project and start seeking other opportunities to apply PE technology.

2.2. PE Application on VR Platform

1) Assessment and decisions made at t_0'

After the failure in the mobile market, George and Grace started looking for new opportunities to apply their PE technology. In 2015, the VR game market began to emerge and attracted the team's attention. Deep interaction between players and characters was of critical importance to VR games, meaning characters are required to move in a realistic way. This indicated that on VR platforms PE would show a great advantage over traditional technologies. George and Grace realised that PE technology would be needed on VR platforms and that they could become VR game developers or technology providers to VR game companies. At this time, they were unsure as to exactly what business would be appropriate for them to start with. In other words, they did not know what product to develop or who would be their first target customer. Therefore, they decided to develop a technology demo to test market need and understand potential customers' requirements. The details of the team's judgement of each question are presented in Table G'-0, including evidence employed, underlying assumptions and answers with corresponding confidence levels.

2) Assessment and decisions made at t_1'

George integrated PE technology onto a VR platform and developed a virtual dog that people could touch and play with. When they presented this technology demo at trade shows, players, VR game developers and investors showed great interest in his technology. Several VR game companies approached Company G asking if they would like to develop PE technology for their games. This demonstrated the market need for PE on VR platforms and encouraged the company to start considering whether to become a technology solution provider to VR game companies. The key questions and judgements for market entry decision are as follows:

(1) Will there be a market need for PE technology development service in the short term?

At the trade shows, several VR game companies exhibited a strong willingness to outsource their PE development to Company G, which demonstrated the market need for PE technology development service.

(2) Will the team be able to develop and sell the required PE technology development service in the short term? i.e. what are the required capabilities to develop and sell the required PE technology development service and will the team have these required capabilities?

VR game companies value Company G's technology most and have specific requirements for performance. Given George's current technology and R&D capability, the team was confident that he would be technologically capable.

(3) Will the company maintain healthy operations in the short term?

The co-founders had raised $X (confidential information) from venture investors for early stage operations. Additionally, once Company G agreed to provide technology support to VR game companies, they were expected to start generating revenues soon, which would provide a considerable cash inflow to maintain healthy business operations.

(4) Will the market size for PE technology development services be large enough to provide a chance for the company to develop in the longer term?

VR games will be a trend for next generation entertainment. Industry reports have shown that there is an increasing number of VR game companies and the

VR game market is estimated to be worth billions of dollars in 2020. As a core technology of VR games, the team believed the market size for PE technology development services would be large enough.

(5) Will the team be able to build competitive advantage for the company to compete in the industry in the longer term? i.e. what are the required capabilities to develop competitive advantage for longer-term development and will the team gain these required capabilities?

As potential customers value Company G's technology advancement most, the team believed the competitive advantage of the company lay in its leading technology capability. Therefore, holding onto a leading position would be of critical importance to Company G. Given George's strong R&D capability, the team was confident its technology would retain its leading position in the longer term.

(6) Will the team be able to manage the company in the longer term?

The team had balanced skills in technology and business and, more importantly, both founders had working experience in the game industry. Therefore, the team was confident that their understanding of the industry and their skills balance would enable them to manage the business in the longer term.

The details of the team's judgement of each question are presented in Table G'-1, including evidence employed, underlying assumptions and answers with corresponding confidence levels. According to the judgements, the team decided to enter the VR market to become a PE technology service provider. The launch product would be defined on a case-by-case basis according to customer requirements. With respect to the early-stage technology-market strategy, Company G decided to fous on technology development to keep its industry leading position and leverage the market through its technology advancement.

3) Implementation and results

Up to the interview date, Company G had been labelled the most advanced PE developer in the industry. It had gone through the early stage and progressed to the growth stage.

3. Summary

When assessing the business opportunities offered by PE-driven mobile games, George and Grace were overconfident about their answers regarding market need and the required capabilities for developing the proposed product at t_0. As a result, the PE-driven mobile game that was developed over six months eventually failed in the market.

After experiencing this failure, the team started considering whether to apply PE technology to VR platforms. When this idea emerged, they were unsure about exactly what product they were going to develop or who their target customers would be. Unlike what had happened in the previous mobile game project, they decided to communicate with potential customers to understand market need and customer requirements before going ahead with product development. Based on feedback from potential customers, the team decided to become a PE technology supplier to provide technological support to VR game companies. As VR game companies had specific requirements, Company G would define and develop the product according to customer requirements. Given that VR companies most value Company G's leading technology capability, the early-stage strategy for technology and market development was to concentrate on technology development to keep its industry leading position and leverage the market through its technology advancement.

Table G-0 Business opportunity assessment at t_0

Question			Evidence Employed	Assumption	Judgement		
Will the company be able to develop in the short term?	Will there be a market need for PE-driven mobile games?		PE technology can improve the impression of reality of mobile games.	*Mobile game players will value the high degree of reality and would be willing to pay for it.*	Y		Y
	Will a team capable of developing and selling the proposed product be built?	What are the required capabilities for developing and selling PE-driven mobile games?	Mobile game players value the playing experience; PE technology can enable characters to achieve a higher level of reality.	*The high level of reality will significantly improve the playing experience.*	The main required capability is strong PE development capability in the short term.	Y	
		Will the team be technologically capable to develop the required PE-driven mobile games?	George has been working in the gaming industry for 8 years, focusing on PE development; George has already developed an early version PE for bipedal characters, which enjoyed a superior performance compared with competitors'.	George's leading technology capability will remain.	Y		
	Will the company maintain healthy operations in the short term?		George planned to raise equity finance to ensure the short-term operation of the company.	George would be able to build a capable team; Investors would invest to his company.	Y		
Will the company be able to develop in the longer term?	Will the market of PE-driven mobile games be big enough to be able to support the company to develop and grow in the longer term?		Since 2013, the mobile game market boomed at an annual growth rate of 30% and has hit annual sales in the tens billions of dollars.	*There will be a need for PE-driven mobile games.*	Y		Y
	Will the company gain competitive advantage to compete in the industry for longer-term development?	What are the required capabilities to build competitive advantage?	Mobile game players value the playing experience; PE technology can enable the characters to achieve a higher level of reality.	*The high level of reality will significantly improve the playing experience.*	The main required capability is strong PE development capability in the short term.	Y	
		Will the team be able to keep leading technology capability in the longer term?	George's technology advancement is about two years ahead of his competitors; George has strong expertise in PE development, and he knows experts in advanced physics simulation that might join his team.	George will keep technology advancement and strong R&D capability; PE experts will join his tem.	Y		
			The IP will be kept in house.	The method will be effective in IP protection.			
	Will the team be able to manage the company in the longer term?		George has been working in gaming industry as a software developer for more than 8 years, and he has been tracking PE technology and its applications; Grace had worked in a top consulting company for two years, and after which she joined the MBA programme at a leading Business School in the US.	The management team has balanced skills.	Y		

Table G'-0 Business opportunity assessment at t_0'

Question			Evidence Employed	Assumption	Judgement		
Will the company be able to develop in the short term?	Will there be a market need for PE-based applications on VR platforms?		PE technology can improve the degree of reality on VR platforms; Products on VR platforms require a high degree of reality.	*There are potential customers willing to pay for the high degree of reality enabled by their technology.*	Y		?
	Will a team capable of developing and selling the proposed product be built?	What are the required capabilities for developing and selling PE-driven mobile games?	Products on VR platform require a high degree of reality.	Other relevant information is not available yet.	The main required capability is leading PE development capability. Other required capabilities are unknown.	?	
		Will the team be technologically capable of developing the required PE?	The algorithm developed for mobile games can be applied to VR platforms, with minor adjustments; The technology demo has demonstrated the technology capability.	George's leading technology capability will remain.	Y		
	Will the company maintain healthy operations in the short term?		The co-founders had raised $X from venture investors for early stage operation.	Company G will get orders from VR game companies.	Y		
Will the company be able to develop in the longer term?	Will the market for PE technology on VR platforms be large enough to be able to support the company to develop and grow in the longer term?		A large number of existing and new companies have entered the VR industry; Venture capital chases VR projects.	*There will be a market need for PE technology on VR platforms;* The VR industry is emerging as increasing numbers of players enter; VR products need PE technology.	Y		?
	Will the company gain competitive advantage to compete in the industry for longer-term development?	What are the required capabilities to build competitive advantage?	VR game companies value Company G's technology advancement most and have specific requirements for technology performance.	The actual requirements will be the same as what VR companies have explained to Company G.	The main required capability is leading PE development capability. Other required capabilities are unknown.	?	
		Will the team be able to maintain leading technology capability in the longer term?	The algorithm developed by George can enable a better performance than other algorithms developed by competitors; George has strong expertise in PE development, and he knows experts in advanced physics simulation that might join his team.	George will keep technology advancement and strong R&D capability; PE experts will join his team.	Y		
			The IP will be kept in house.	The method will be effective in IP protection.	Y		
	Will the team be able to manage the company in the longer term?		George has been working in the gaming industry as a software developer for more than 8 years, and he has been tracking PE technology and its applications in the gaming industry; Grace had worked in a top consulting company for two years, and after which she joined the MBA programme at a leading Business School in the US.	The management team has balanced skills.	Y		

Table G'- 1 Business opportunity assessment at t_1'

Question			Evidence Employed	Assumption	Judgement		
Will the company be able to develop in the short term?	Will there be a market need for PE technology on VR platforms?		When they presented this technology in demos at trade shows, players, VR game developers and investors showed great interest and Company G was approached by several VR game companies asking for customised PE development.	VR game companies would like to outsource PE development to Company G.	Y		Y
	Will a team capable of developing and selling the proposed product be built?	What are the required capabilities for developing and selling PE-driven mobile games?	VR game companies value Company G's technology advancement most and have specific requirements on technology performance.	The actual requirement will be the same as what VR companies have explained to Company G.	The main required capability is leading PE development capability.	Y	
		Will the team be technologically capable of developing the required PE?	The algorithm developed for mobile games can be applied to VR platforms, with minor adjustments. The technology demos demonstrated the technology capability.	George's leading technology capability will remain.	Y		
	Will the company keep healthy operation in the short term?		The co-founders raised $X from venture investors for early stage operation; VR game companies will pay Company G a deposit for technology development.	Company G will get orders from VR game companies.	Y		
Will the company be able to develop in the longer term?	Will the market for PE technology on VR platforms be large enough to be able to support the company to develop and grow in the longer term?		A large number of existing and new companies have entered the VR industry; Venture capital chases VR projects.	The VR industry is emerging as increasing numbers of players enter; VR products need PE technology.	Y		Y
	Will the company gain competitive advantage to compete in the industry for longer-term development?	What are the required capabilities to build competitive advantage?	VR game companies value Company G's technology advancement most and have specific requirements on technology performance.	The actual requirement will be the same as what VR companies explained to Company G.	The main required capability is leading PE development capability.		
		Will the team be able to keep leading technology capability in the longer term?	The algorithm developed by George can enable a better performance than that of algorithms developed by competitors; George has strong expertise in PE development, and he knows experts in advanced physics simulation that might join his team.	George will keep technology advancement and strong R&D capability; PE experts will join his team.	Y	Y	
			The IP will be kept in house.	The method will be effective in IP protection.	Y		
	Will the team be able to manage the company in the longer term?		George has been working in the gaming industry as a software developer for more than 8 years, and he has been tracking PE technology and its applications in the gaming industry; Grace had worked in a top consulting company for two years, and after which she joined the MBA programme at a leading Business School in the US.	The management team has balanced skills.	Y		

Company H

Company Codename	H
Year of Establishment	2014
Headquarters	US
Product	Smart headset to keep drivers stay alert when driving
Industry Maturity at t_0	Emerging
Problem to Solve	Fatigue driving
Core Technology	Data collection and analysis technology of awareness monitoring
Interviewee	Henry (founder)

1. Background Information

Company H develops Bluetooth headsets to monitor drivers' awareness levels for safety purposes. When the headset senses the driver is drowsy, it releases a sound or vibration to stimulate the driver in order to alert him/her. The core technology is ane algorithm that was initially developed from fundamental research into awareness simulation to measure people's awareness levels. Company H was established in 2014 by a university graduate. At the interview date, Company H had already gone through the early stage and started to consider expanding the market by introducing new products.

2. Company Development at the Early Stage

The motivation to build Vigo can be traced back to Henry's final year project at university. In 2013, Henry was a final year undergraduate student in Mechanical

Engineering at a world-leading university in the US. Henry, an entrepreneurial person, wanted to develop something that could potentially be commercialised.

Henry saw many students experiencing drowsiness in lectures. He thought that if there was a wearable device that could monitor students' awareness levels and alert them when they felt sleepy, then there might be a demand for such a product. He asked his friends for feedback on this idea and received a positive response.

Given that existing research in awareness simulation had demonstrated that eye movements could effectively reflect people's awareness levels, Henry compared different technologies and designs with reference to his technology capability and budget. Eventually, he decided to make a pair of glasses with infrared sensors and accelerometers to track the movement of the eyelids and the head. He developed a simple algorithm to measure people's awareness levels. When a low level of awareness was detected, the glasses would give a vibrant stimulation.

When the glasses were developed, Henry brought them to a university innovation competition. Audiences liked the product and suggested many other potential application scenarios. For example, a driver said he needs to avoid falling asleep while driving, and a professor said he would like his students to wear the glasses. This positive feedback encouraged Henry to consider commercialising this product.

1) Assessment and decisions made at t_0

In order to assess the business opportunities of becoming a provider of awareness monitoring devices, Henry considered the following questions:

(1) Will there be a market need for awareness monitoring devices in the short term? On the one hand, the positive feedback from audiences indicated that there might be a market need. On the other hand, Henry also realised that this feedback might not adequately reflect demand in the wider market. Therefore, Henry had a positive answer to market need but with a relatively low confidence level.

(2) Will I be able to develop and sell the proposed awareness monitoring devices in the short term? i.e. what are the required capabilities to develop and sell proposed awareness monitoring devices and will the team gain these required capabilities?

Awareness monitoring devices are a new product that did not exist at the time. Therefore, Henry could only refer to smart wearable devices on the market to infer customer requirements. He expected that customers would require the awareness monitoring devices to be accurate, user friendly, well designed and affordable. This required a good algorithm, industrial design and effective cost control. In order to better train the algorithm, a large amount of user data is required, which means gaining more users would be of strategic importance in the short term. Therefore strong marketing capability was required. Henry planned to invite two friends, a CTO and an industrial designer with required capabilities, to become co-founders while he himself would take charge of marketing. He was confident about his marketing capabilities and believed the two friends would join the team. With respect to cost control, Henry planned to manufacture the hardware in China by joining an accelerator that bridges hardware start-ups with Chinese factories.

(3) Will the company maintain healthy operations in the short term?

Henry lacked money and experience in hardware development, so he planned to apply to one of the best US hardware accelerators to get his business off the ground. Henry thought if his project could be accepted, he would have sufficient money for short-term operations.

(4) Will the market size for awareness monitoring devices be large enough to provide a chance for the company to develop in the longer term?

Drivers would be one of the potential markets given the official statistics on the number of drivers. Therefore if the market need were validated, the market size would be large enough to provide a chance for the company to develop in the longer term.

(5) Will the team be able to build competitive advantage for the company to compete in the industry in the longer term? i.e. what are the required capabilities to develop competitive advantage for longer-term development and will the team gain these required capabilities?

Henry assumed customers would most value accuracy in the longer term. The degree of accuracy would depend on the algorithm, and the most effective way to improve the accuracy was to train the algorithm through real data from more drivers. In other words, the technology capability increases with the number of customers. Therefore, the two capabilities needed were identified as technology and marketing capability. Henry was confident that he would be able to build a capable marketing and technology team in the longer term to build competitive advantage.

(6) Will I be able to manage the company in longer term?

Henry was an entrepreneurial person who had successful entrepreneurial experience in running social media. He believed he would be able to manage this company in the longer term.

The details of the team's judgement of each question are presented in Table H-0, including evidence employed, underlying assumptions and answers with corresponding confidence levels. At t_0, as Henry was unsure about the market need, so he chose not to make a market entry decision at this stage but to further explore the market for awareness monitoring devices. At this time, Henry was also unsure about which potential market would be appropriate to target first and what the target customers would require. Therefore, Henry decided to follow an iterative process to define the launch product, i.e. use his smart glasses to test market need and customer requirements, and use the resulting market response as a basis for identifying the target market and defining the launch product. With respect to the early-stage technology-market strategy, as technology development was highly reliant on the number of users, Henry decided to launch the product once the technology had been developed to a sufficiently accurate level and then use first mover advantage to develop the market to gain more user data for technology development. The technology and market development would thus accelerate each other and therefore would be developed hand in hand.

2) Assessment and decisions made at t_1

Henry assumed a number of potential user groups, such as drivers, students, security guards, among others, would demand a wearable awareness monitoring device. In order to further test the need and understand the customer requirements of different potential market segments, Henry showed the awareness monitoring glasses to them for feedback and suggestions. According to people's responses, Henry found that drivers showed the highest amount of interest and willingness to buy. This finding further verified the market need and identified drivers as the target market. With this new evidence, Henry updated his previous judgements and decided to establish Company H to enter the market for wearable awareness monitoring devices. The updated factors are presented in Table H-1.

As drivers were identified as the preliminary target market, Henry decided to prioritise drivers' opinions and habits when defining the product, while keeping other potential user groups in mind.

3) Implementation and results

The two friends that Henry invited joined the team as co-founders. With the right people on board he submitted the business plan to his target accelerator and got accepted, as expected. The accelerator offered a package of seed investment plus a four-month training programme in the entrepreneurial city of Shenzhen, China, where large numbers of manufacturing factories are located. The accelerators brought them to the right place and provided guidance on how to select, approach, negotiate and build cooperation with local manufacturers.

In order to further understand drivers' requirements, Henry occasioned chats with professional drivers and even stayed with a truck driver for a whole day to observe his driving behaviour and habits. Henry realised that most drivers wore Bluetooth headphones to make phone calls. This phenomenon caused the change of product design from glasses to headphones with a calling function. With the new design, drivers would not need to change their habit of wearing headphones would be more likely to accept the product.

After iteration repeated 10 times and trial production, the launch product was improved in terms of the main functions, additional functions, and design. In other words, the core algorithm was further developed in order to improve the accuracy of the measuring awareness levels; the product was redesigned into a headphone version; and Bluetooth and a calling function were integrated into the headphones.

At this stage, although Company H had their first product ready, Henry decided not move to mass production because he thought the real market situation would be different from the testing environment. In order to avoid unnecessary waste, he decided to launch the product on a US crowd-funding platform for advance sales. The response from the real market would further test the need in different potential markets and, more importantly, would help to check if the driver market was the most promising market to start with.

Company H launched its project aiming to achieve $50,000 sales in 50 days. The campaign ended up with 635 backers pledging $57,365, which further verified the need for an awareness monitoring device and nudged the company into the mass production phase. Comments came from professional truck drivers, security guards, people who suffer from narcolepsy, and people who feel they could use the product to help them generally feel more alert more of the time. By analysing the backers' data and comments, Company H found that most bought the product to keep them alert at the wheel, and many of them were professional drivers, i.e. taxi and transport drivers. By carefully comparing different markets in terms of willingness to pay and market potential, Company H decided to launch its product targeting primarily the driver market. With real data from increasing number of drivers, Company H's core algorithm had been significantly improved.

In order to gain more market share, in addition to selling to individual drivers, Henry contacted several large transport companies and promoted the alerting headphones to them. One company, with more than 100,000 drivers, agreed to try Company H's product on one team. The transport company required Company H to develop a real-time dashboard for fleet managers to track drivers' awareness condition so that they can rearrange shifts and work schedules on time in order to reduce the chance of drowsiness-related accidents. The trial went well, and up to the interview data the

transport company had ordered 3000 units for their drivers. Moreover, Company H's technology had attracted some traditional car manufacturers who were considering integrating the awareness monitoring technology into their self-driving cars.

3. Summary

The wearable device for awareness monitoring was a new product that had not existed before. At t_0, Henry had limited evidence indicating there might be a market need for the proposed product. As this evidence was considered insufficiently solid, Henry decided not to rush to enter the market but instead test it first. Therefore, he showed the smart glasses version to potential users to ask whether they would be prepared to pay for it. Feedback indicated that the drivers had the highest degree of interest and willingness to buy, which verified the market need and encouraged Henry to enter this market.

With respect to the process of defining the launch product, at t_0 Henry was unsure who the first target customers would be and what they would like the product to be. Therefore, he decided to use his smart glasses to test the market response to identify the target market and then define the launch product through iterative prototyping and testing with target customers.

In terms of the early-stage technology-market strategy, in this case technology development highly relied on a large number of real users, which indicated that market development was of critical importance to product competitiveness. Therefore, Henry decided to launch the product once the technology was developed to a sufficiently accurate level and use first mover advantage to develop the market to gain more user data for improved technology development.

Table H-0 Business opportunity assessment at t_0

Question			Evidence Employed	Assumption	Judgement		
Will the company be able to develop in the short term?	Is there a market need for awareness monitoring glasses in the short term?		Audiences liked Henry's product and suggested many other potential users such as drivers, night-time security officers, and hypersomniacs.	*This feedback accurately reflects the real market response.*	Y		Y
	Will Henry be able to build a capable team capable of developing and selling the proposed product?	What are the required capabilities for developing and selling awareness monitoring wearable device?	Existing wearable devices are required to be functional, affordable, easy to use and stylish; The development of an algorithm required a large amount of user data, so gaining more users would be of strategic importance for technology improvement.	Potential customers will require the products to be functional, affordable, easy to use and stylish.	Required capabilities are sufficiently good technology capability, efficient cost control, good industry design and strong marketing capability.	Y	
		Will Henry build a team that is technologically capable to develop proposed awareness monitoring glasses?	Henry planned to invite a technology expert to become CTO and co-founder of the company.	The technology expert will join his team.	Y		
		Will Henry build a team with required capability in industrial design?	Henry planned to invite an experienced industrial designer to become CTO and co-founder of the company.	The industrial designer will join his team.	Y		
		Will the team realize effective cost control?	Henry plans to manufacture hardware in China by joining an accelerator that will bridge hardware startups with Chinese factories.	Henry's project will be accepted.	Y		
		Will the team have strong marketing capability?	Henry is good at marketing and communication.	Henry's marketing skills will remain.	Y		
	Will the company maintain healthy operations in the short term?		Henry planned to apply for one of the best US hardware accelerators to get his business off the ground.	*There will be a market need;* *Henry's project will be accepted.*	Y		
Will the company be able to develop in the longer term?	Will the market for awareness monitoring glasses be large enough to be able to support the company to develop and grow in the longer term?		Drivers would be one of the potential markets given the official statistics on the number of drivers (including those that drive for as their profession).	Drivers will need awareness monitoring glasses.	Y		Y
	Will the company gain competitive advantage to compete in the industry for longer-term development?	What are the required capabilities to build competitive advantage?	Accuracy depended on the algorithm. The most effective way to improve the accuracy was to train the algorithm with the real data of more drivers. In other words, the technology capability increases with the number of customers.	Customers would most value accuracy in the longer term.	The two main capabilities needed to build competitive advantage were identified as technology and marketing capability.	Y	
		Will the team be able to retain leading technology capability in the longer term?	Henry plans to build a strong technology team and cooperate with research institutes to develop technology in the longer term.	Henry will build a capable technology team and establish cooperation with research institutes.	Y		
			The IP will be kept in house.	The method will be effective in IP protection.	Y		
		Will the team retain strong marketing capability?	Henry plans to build a strong marketing team.	Henry will build a capable marketing team in the longer term.	Y		
	Will Henry be able to manage the company in the longer term?		Henry is an entrepreneurial person who has enjoyed successful entrepreneurial experience running social media.	Henry has the traits to become a potential entrepreneur and will be able to manage this company in the longer term.	Y		

Table H- 1 Business opportunity assessment at t_1

Question			Evidence Employed	Assumption	Judgement	
Will the company be able to develop in the short term?	Is there a market need for awareness monitoring glasses in the short term?		Henry showed the awareness monitoring glasses to potential users for feedback and suggestions. According to their responses, drivers showed the highest interest and willingness to buy.	This feedback can accurately reflect the real market response.	Y	Y
		What are the required capabilities for developing and selling an awareness monitoring wearable device?	Drivers required the awareness monitoring wearable device to be functional, affordable, easy to use and stylish.		Required capabilities are sufficiently good technology capability, efficient cost control, good industry design and strong marketing capability.	
	Will the company maintain healthy operations in the short term?		Henry planned to apply to one of the best US hardware accelerators to get his business off the ground.	Henry's project will be accepted.	Y	
			]			

Chapter Summary

This chapter has analysed how technology entrepreneurs make the three early stage decisions by analysing the early-stage development of eight technology companies. The individual analysis focuses on explaining (1) the questions considered and the underlying rationale entrepreneurs consider and follow for making the three decisions, and (2) how they judge these key questions and make the three focal decisions.

In the next chapter, the key questions for the three decisions will be summarised across the cases and the data in the business opportunity assessment tables will be further analysed to identify the key factors involved in making effective judgements.

Chapter 5 Cross-Case Analysis and Findings

Chapter Overview

The objective of this chapter is to answer the research questions with cross-case analyses. The main research question is: 'How may technology entrepreneurs conduct an effective assessment to decide (1) whether to pursue a business opportunity, (2) through which process to define the launch product, and (3) how to strategically align technology and market developments in the early stage of company development?' The four sub-questions are:

1. What are the key questions for market entry decisions and how can they be structured to develop a rationale that also helps to consider the other two decisions?
2. What are the key questions and rationale for deciding the process to define the launch product?
3. What are the key questions and rationale for deciding the strategic alignment of technology and market development in the early stage of company development?
4. What is the key to achieving effective judgements for the key questions and how could entrepreneurs be helped to conduct effective judgements in an entrepreneurial environment?

The first three sub-questions refer to identifying key decision-related questions and their underlying rationale, and the last one focuses on understanding the key to and the method for achieving effective judgements. Accordingly, this chapter is organised into three sections. Section 5.1 proposes the key decision-related questions and the underlying rationale for each of the three decisions. Section 5.2 analyses the key to achieving effective judgements, which is having an appropriate understanding of the reliability of the answers. Section 5.3 suggests a method to assist technology entrepreneurs obtain this understanding.

5.1. Key Decision-Related Questions and Underlying Rationale

This section proposes the key questions and underlying rationale for each of the three focal decisions. For each decision, the findings are presented in the form of a set of structured questions presented in Figure 16, Figure 17, and Figure 18.

5.1.1. Key Questions and Underlying Rationale for Market Entry Decisions

Through the iterative Grounded Theory method, a series of questions for market entry decisions has emerged. In Figure 16, the key questions are structured in a way that explains a rationale for market entry decisions but also helps entrepreneurs to consider the other two decisions. It is important to note that this research does not claim that this is the only or best rationale for entrepreneurs follow, but is one that serves the purpose of this research.

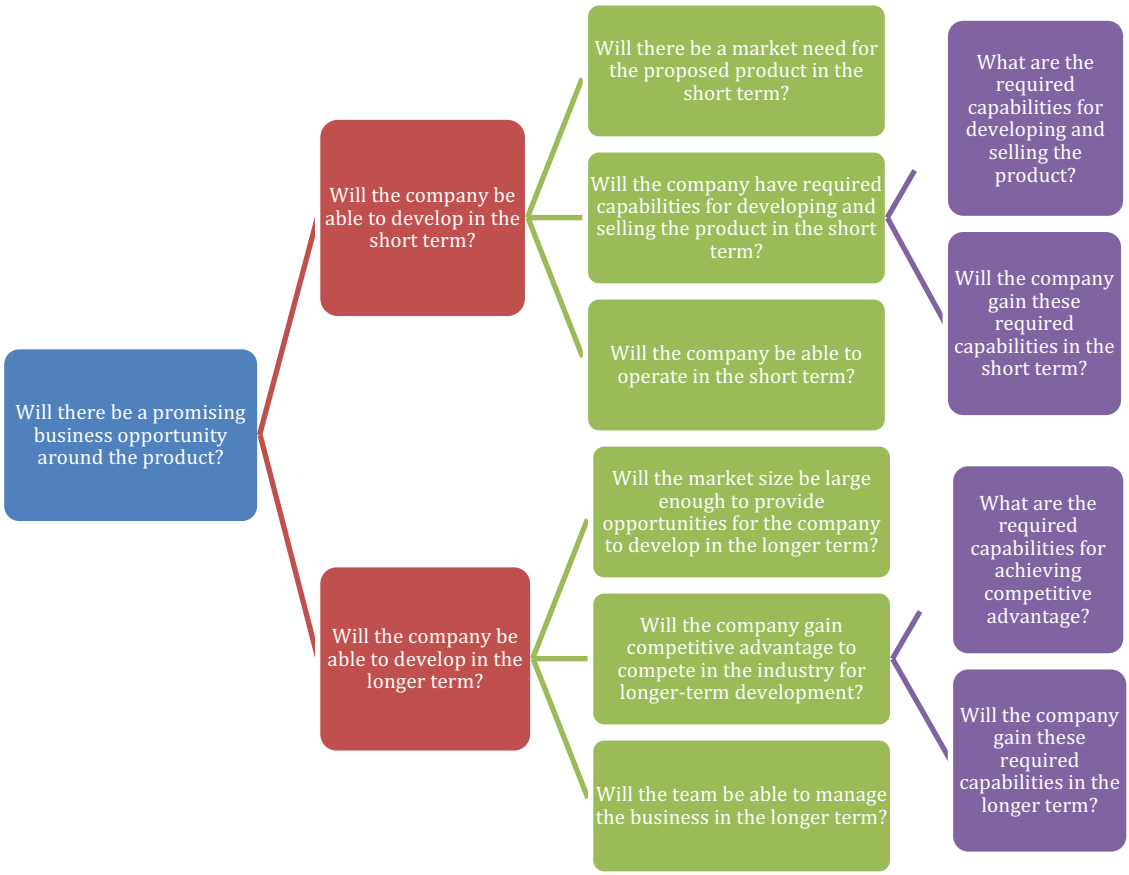


Figure 16 Key questions and underlying rationale of the business opportunity assessment for market entry decisions

Every interviewed entrepreneur explicitly or implicitly mentioned the six core questions in green when deciding whether to enter a market. The data from the cases show that entrepreneurs tend to enter a market when all these six questions are judged positive with a relatively high level of confidence. These six questions are not independent of one another; they are closely inter-related and should be considered jointly during the assessment. For a concise description, the six questions are labelled according to the key aspects of concern, namely market need, required capability in the short term, short-term operation, market size, required capabilities in the longer term, and long-term management. The six questions are discussed in related pairs below.

1. Market Need and Market Size

Entrepreneurs often consider market need and market size jointly as they are two key aspects underpinning market opportunity. Market need is concerned with whether there will be potential customers willing to pay for the proposed product in the short term. The existence of market need is the prerequisite for any business opportunity to exist. Therefore, it should be carefully verified before other aspects in the business opportunity assessment. Market size emphasises the total profit that the product or technology will generate at the industrial level, conditional upon verified market need. Sufficient market size is a prerequisite for companies to be able to develop in the longer term.

2. Required Capabilities in the Short- and Longer-Term

Assuming the market need is verified, companies are required to have certain capabilities to be able to (a) develop and sell profitable products for short-term development, and (b) build competitive advantage to compete in the industry for longer-term development. In order to judge whether companies will gain the required capabilities, entrepreneurs should first understand what capabilities are required. In other words, entrepreneurs need to make judgements on (1) the required capabilities for developing and selling products in the short term and building competitive advantage in the longer term, and (2) if the company will have these required capabilities.

3. Short-Term Operation and Long-Term Management

Short-term operation relates to immediate managerial considerations associated with healthy operations. It is important for companies at all stages, but especially for early stage companies with limited resources and managerial experience. Therefore entrepreneurs need to judge whether the company will be able to operate in the short term when assessing business opportunities in the early stage.

Good management is necessary for any company to develop in the longer term. Although for some technology ventures it can be difficult to judge teams' management capabilities in the early stage, considering this can help entrepreneurs to understand the potential strengths and weaknesses of their management team so they can take actions to make the most use of the strengths and/or remedy the weaknesses.

In summary, there are six key questions relating to market entry decisions:

1) Will there be a market need for the proposed product in the short term?
2) Will the company have the required capabilities for developing and selling the product in the short term?
    i. What are the required capabilities for developing and selling products in the short term?
    ii. Will the team gain the required capabilities in the short term?
3) Will the company be able to operate in the short term?
4) Will the market size be large enough to provide opportunities for the company to develop in the longer term?
5) Will the company gain competitive advantage to compete in the industry for longer-term development?
    i. What are the required capabilities for building competitive advantage in the longer term?
    ii. Will the team gain the required capabilities in the longer term?
6) Will the team be able to manage the business in the longer term?

According to the cases, entrepreneurs decided to enter certain markets when their answers to these questions were positive with a relatively high level of confidence. In cases B, D, F and G, the entrepreneurs decided to enter the market at t_0 as they were

confident that the answers to the above questions were positive. In contrast, in cases A, C, C', E, G' and H, the entrepreneurs either felt less confident about their positive answers or had no answers to certain questions, and therefore they decided to delay the decision until these questions were better understood. Table 27 shows the judgements the entrepreneurs made on the above questions and the resulting decisions at different times. Answers in red (green) cells indicate entrepreneurs had a high (low) confidence level.

Table 27 The judgements on the six questions and resulting decisions made at different time points

Case No.	Time	Question 1)	Question 2)	Question 3)	Question 4)	Question 5)	Question 6)	Resulting Decision
A	t_0	Y	Y	Y	Y	Y	Y	Seek financial support and enter the market if financial constraints can be removed.
	t_1	Y	Y	Y	Y	Y	Y	Enter the market.
B	t_0	Y	Y	Y	Y	Y	Y	Enter the market.
C	t_0	Y	Y	Y	?	Y	Y	Talk with potential customers to understand market size and enter the market if market size is deemed sufficiently large.
	t_1	Y	Y	Y	N	Y	Y	Do not enter the market.
C'	t_0	Y	Y	Y	Y	Y	Y	Test market need first and enter the market if there is a market need.
	t_1	Y	Y	Y	Y	Y	Y	Enter the market.
D	t_0	Y	Y	Y	Y	Y	Y	Enter the market.
E	t_0	Y	Y	Y	Y	Y	Y	Enter the market if market need is verified.
	t_1	Y	Y	Y	Y	Y	Y	Enter the market.
F	t_0	Y	Y	Y	Y	Y	Y	Enter the market.
G	t_0	Y	Y	Y	Y	Y	Y	Enter the market.
G'	t_0	Y	?	Y	Y	?	Y	Test market need first and enter the market if there is a market need.
	t_1	Y	Y	Y	Y	Y	Y	Enter the market.
H	t_0	Y	Y	Y	Y	Y	Y	Test market need first and enter the market if there is a market need.
	t_1	Y	Y	Y	Y	Y	Y	Enter the market.

5.1.2. Key Questions and Underlying Rationale for Deciding the Proceed to Defining the Launch Product

The cases have shown that entrepreneurs undergo different processes to define the launch product. By analysing and comparing the underlying rationales for choosing these processes, this research reveals that entrepreneurs need to be clear about three aspects before they define the launch product. They are (i) the first target customer, (ii)

customer requirements, and (iii) appropriate technological solutions to develop the proposed product. This research claims that it is the entrepreneurs' degree of understanding of these three aspects that determines the process they follow to define the launch product.

This research compared the rationales behind entrepreneurs' choices of different processes and devised five key questions to help entrepreneurs be clearer about the three aspects. The five key questions are:

(1) Does the team know what product to propose?
(2) Is the first target customer clearly identified?
(3) Are the customers' requirements clearly understood?
(4) Do the target customers have a clear understanding of their requirements of the product?
(5) Does the team know which technological solution is appropriate to develop the required product?

These five questions are structured to explain the rationale underlying the different processes (see Figure 17). By answering the questions, technology ventures are classified in six types in terms of the process they followed to define the launch product. This research proposes that technology entrepreneurs may align with a certain process type and refer to this process to define their launch product.

In summary, this research has found that the launch product may be appropriately defined when entrepreneurs have a clear understanding of the first target customer, customer requirements and a feasible technology solution. If entrepreneurs are not sure of any of these three questions, it is recommended that they ask the key questions in Figure 17 to consider the process for defining the launch product.

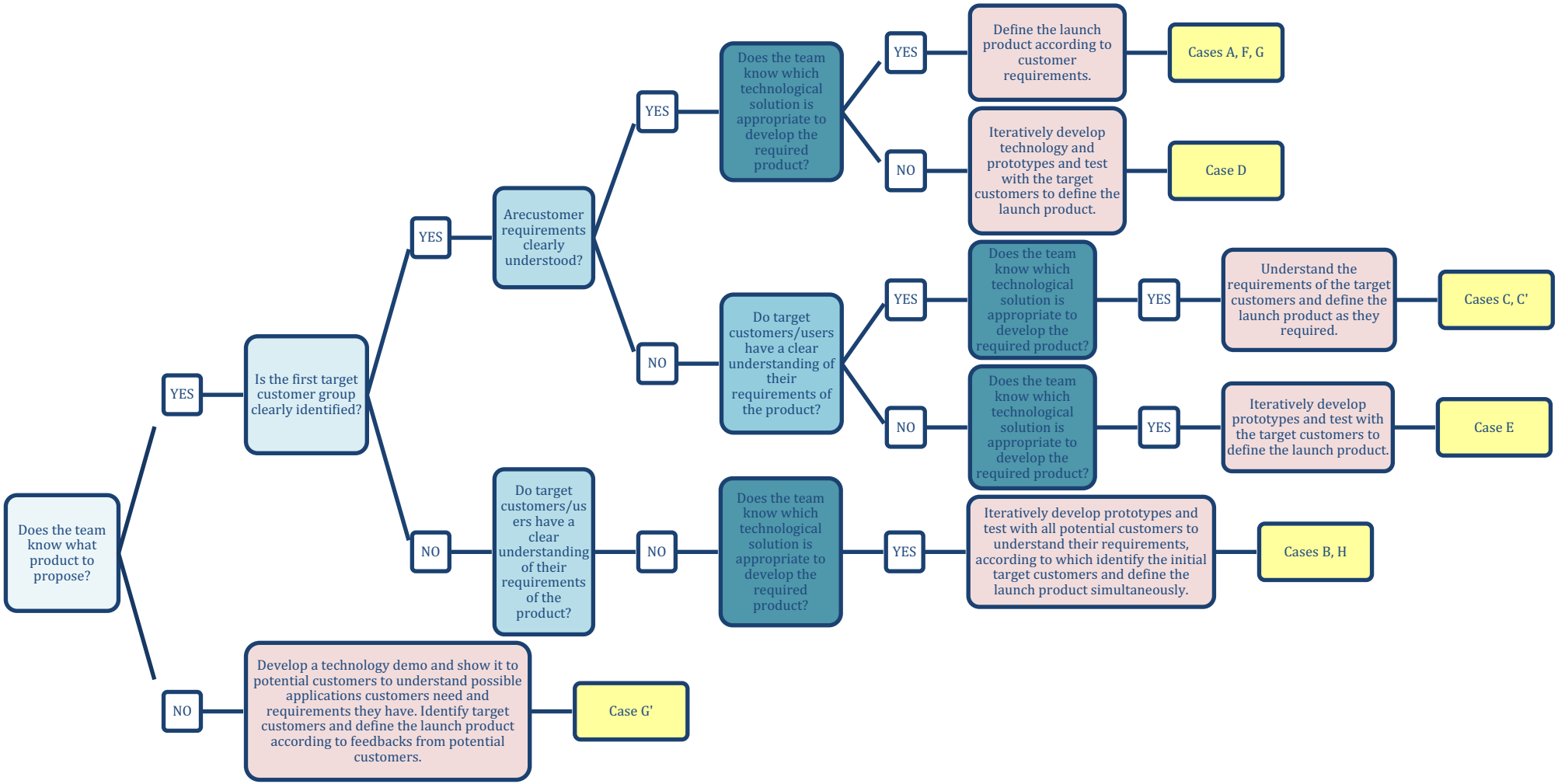


Figure 17 Key questions and underlying rationale for deciding the processes to define the launch product

5.1.3. Key Questions and Underlying Rationale for Aligning Technology and Market Development in the Early Stage

To build competitive advantage, entrepreneurs need to understand what the required capabilities are and how to acquire them. According to the cases in this study, technology ventures choose different strategies to align technology and market development in the early stage. For example, Company A chose to concentrate on technology development and leverage the market through its technology advancement; Company H chose to launch and market the product when the technology was just developed to a sufficient level and then further develop the technology through market advantage; and Company B chose to develop technology and market in parallel, simultaneously.

In this research, technology entrepreneurs were asked to explain the underlying rationale for choosing a certain strategy. The data shows that technology ventures choose different strategies because of two reasons. First, ventures face different opportunities and threats in the early stage and thus require different capabilities to exploit opportunities and neutralise threats. For example, marketing capabilities are important for selling the launch product in cases B and H while are considered less important in Case A. Second, the interaction between technology development and market development varies case by case, so the most effective way to achieve the required capabilities through technology and market development are different. For example, in Case A the market is expected to come to companies that have strong technology capabilities, and therefore market development mainly relies on technology capabilities. In case H, on the one hand, the core algorithm will improve with more user data, which indicates that technology development partially relies on market development; on the other hand, strong technology capabilities will help to develop the market. Therefore, in Case H, technology and market development accelerate each other. In Case B, market development relies on both marketing and product competitiveness, and therefore marketing and technology capability were developed simultaneously. Therefore, the key factors that determine the early-stage alignment of technology and market development are: (1) the required capabilities to exploit opportunity and neutralise threats; and (2) the interaction between technology and market development.

According to the cases, this research identifies four questions that reflect the two determinates. The four questions are:

(1) Does technology capability increase with more user data?
(2) Does gaining more user data require market development?
(3) Will individual customers benefit from a larger market share?
(4) Is marketing required for selling the launch product at the early stage?

According to the answers to these four questions, the cases are classified in five types in terms of the strategy they choose to align technology and market development at the early stage (see Figure 18). This research proposes that technology entrepreneurs may position themselves into a certain type and refer to the suggested strategy to align technology and market development in the early stage.

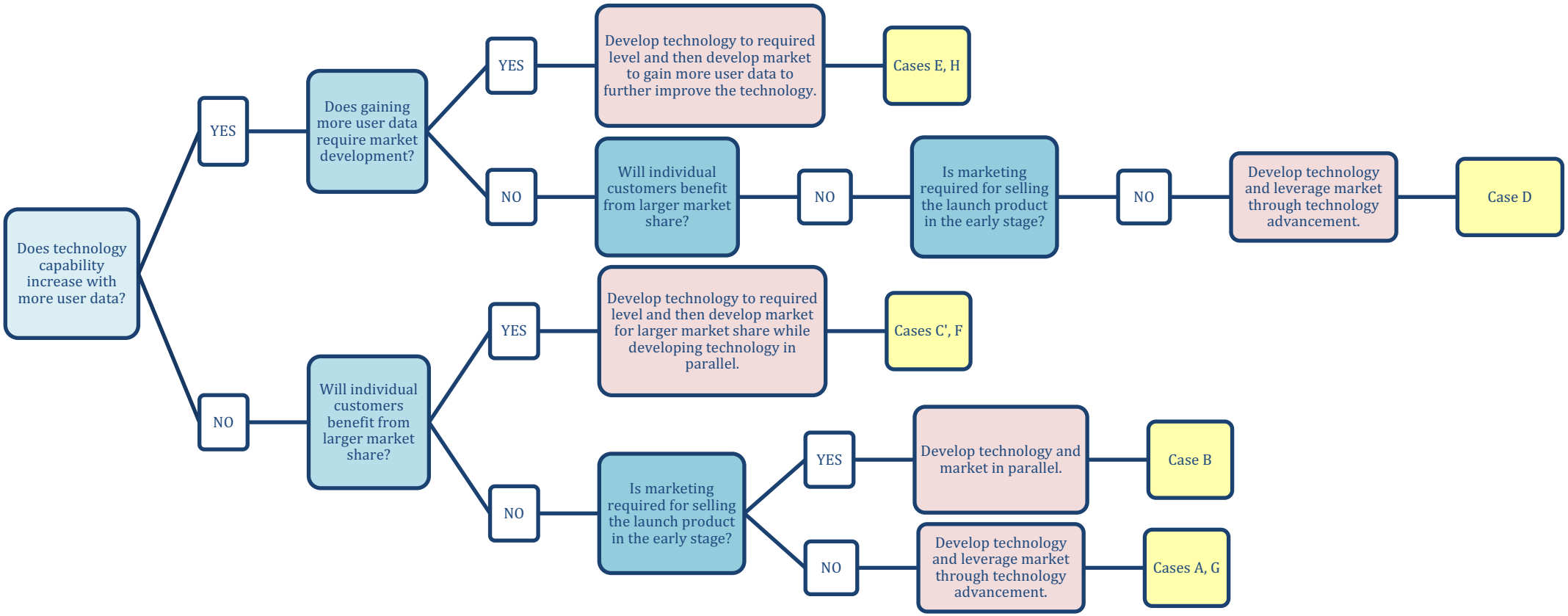


Figure 18 Key questions and underlying rationale of different strategies to align technology and market development

5.2. Key to Making Effective Judgements

By analysing the effective and ineffective judgements entrepreneurs made for the three decisions, it was found that:

A. Decisions are made based on both answers to key questions and the confidence levels entrepreneurs have in the answers.
B. The key for technology entrepreneurs to making effective judgements is to have an appropriate understanding of the reliability of the answers.
C. Inaccurate answers can lead to effective judgements as long as entrepreneurs are able to realise the potential *inaccuracy* of their answers.

The three main findings are explained as follows.

5.2.1. Finding A

The cases shows that decisions are made based on both answers and entrepreneurs' confidence levels in the answers. For example, when making market entry decisions, entrepreneurs take three types of decisions in general: (1) pursue the business opportunity, (2) do not pursue the business opportunity, and (3) delay the decision. As summarised in Table 27, entrepreneurs decided to pursue (or not pursue) a business opportunity when key questions were judged as positive (or negative) at a high confidence level, while in the cases where entrepreneurs had relatively low confidence levels in their answers to some key questions, they tended to delay decisions until they had gained more evidence to confidently answer the questions. Therefore, given that in this research judgements are defined as the basis for making decisions, a judgement to a question contains two elements: (1) answer, which is the answer to the question, and (2) the entrepreneur's confidence level in the answers, which reflects his or her understanding of the reliability of the answers. Figure 19 illustrates the two elements of a judgement.

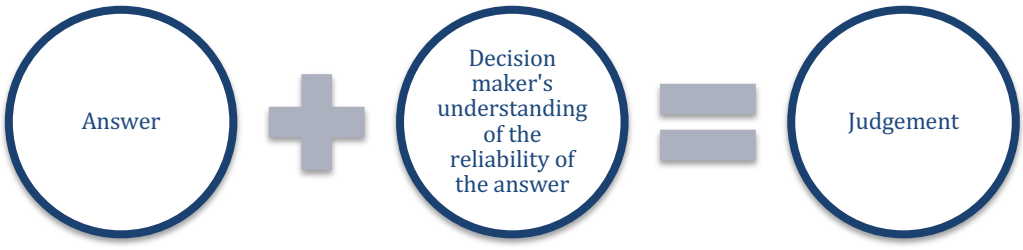


Figure 19 The two elements of a judgement

5.2.2. Finding B

Before explaining Finding B, it is necessary to recall the meaning of c_t and C_t as well as the presentation of judgements in the assessment tables in Chapter 4. c_t is the confidence level entrepreneurs had to certain answers at time t, and C_t is the confidence level they should have had at time t to certain answers, which is retrospectively evaluated by decision makers. In the assessment tables, judgements are presented in normal font when $c_t = C_t$; while when $c_t \neq C_t$, judgements are underlined. Additionally, effective judgements are given in black and ineffective judgements are highlighted in red.

By analysing the judgements in the assessment tables, all judgements in black are in normal font, and all judgements in red are underlined, i.e. all effective judgements are characterised by $c_t = C_t$, and all ineffective judgements are characterised by $c_t \neq C_t$. In other words:

All effective judgements satisfy $c_t = C_t$
All ineffective judgements have $c_t \neq C_t$

c_t reflects how confident the entrepreneur felt about his or her answer at time t. In other words, c_t is the reflection of one's understanding of the reliability of their answers at time t. C_T reflects how confident the entrepreneur should have felt about his or her answer at time t given the evidence employed, which is the appropriate understanding that entrepreneurs should have had about the reliability of their answers at time t.

Therefore, $c_t = C_t$ indicates that the entrepreneur had an appropriate understanding of the reliability of his or her answers at time t. This characterises the effective judgements and indicates that the key for entrepreneurs to achieve effective judgements is having an appropriate understanding of the reliability of their answers. In other words, if an entrepreneur does not have an appropriate understanding of the reliability of their answers, he or she is likely to make low quality decisions.

In the cases, most judgements are effective except certain judgements in Case G. Table 28 shows the judgements on business opportunity assessments in Case G.

Table 28 Judgements on business opportunity assessments in Case G at t_0

Question			Judgement		
Will the company be able to develop in the short term?	Will there be a market need for PE-driven mobile games?		Y		Y
	Will a team capable of developing and selling the proposed product be built?	What are the required capabilities for developing and selling PE-driven mobile games?	The main required capability is strong PE development capability in the short term.	Y	
		Will the team be technologically capable of developing the required PE-driven mobile games?	Y		
	Will the company maintain healthy operations in the short term?		Y		
Will the company be able to develop in the longer term?	Will the market for PE-driven mobile games be large enough to be able to support the company to develop and grow in the longer term?		Y		Y
	Will the company gain competitive advantage to compete in the industry for longer-term development?	What are the required capabilities to build competitive advantage?	The main required capability is strong PE development capability in the short term.	Y	
		Will the team be able to maintain leading technology capability in the longer term?	Y		
	Will the team be able to manage the company in the longer term?		Y		

In Case G, George and Grace were confident that there would be a market need for PE-based mobile games in the short term, i.e. $c_t = High$; while when retrospectively evaluating this answer, they agreed that they were overconfident about this answer. In other words, they should have had a low confidence level in their positive answer, i.e. $C_t = Low$. Therefore, in this case $c_t \neq C_t$ indicates an inappropriate understanding of the reliability of the answer on market need at t_0. Similarly, when George and Grace identified the required capabilities for becoming a mobile game developer, they were confident that the main required capability would be PE technology capability, i.e. $c_t = High$. However, when retrospectively evaluating this answer, they agreed that they should have been less confident with this answer, i.e. $C_t = Low$. Therefore, in this case $c_t \neq C_t$ indicates an inappropriate understanding of the reliability of their answer on the required capabilities. This inappropriate understanding of the reliability of the answers on market need and required capabilities resulted in a low quality decision – pursue the business opportunity and develop PE-based mobile games without any further market research. As a result, the PE-driven mobile game that was developed over six months with great effort eventually failed in the market place. This case supports Finding B, namely that the key to achieving effective judgement is having an appropriate understanding of the reliability of answers.

5.2.3. Finding C

From the cases, it was found that effective judgements do not require accurate answers. In other words, inaccurate answers do not preclude effective judgements as long as entrepreneurs are aware of the potential inaccuracy of these results. The assessments shown in Table C-0 and C'-0 are analysed as two examples to explain this finding.

According to Table C-0, when judging the market size for carbon nanotubes at t_0, Chris had no idea about the potential scale of the market. In other words, at that time his answer was a question mark. Obviously, this answer was not accurate. However, this judgement was evaluated as effective and the decision based on this inaccurate answer was evaluated as high quality. This is because Chris knew that he did not have valid data to make such a judgement, and therefore he decided to conduct further investigations and delay making the market entry decision until he had valid evidence on market size. As a result, he decided to talk with potential customers to estimate market size rather than rush into technology and product development. According to potential customers, the market size was estimated as limited, with high confidence levels. Therefore, Chris assessed the business opportunity as unattractive and decided not to pursue it. The judgements on market size at t_0 and t_1 are compared in Table 29.

Table 29 Judgements on business opportunity assessments in Case C at t_0

Question	Time	Answer	Level of Confidence
Will the market of the proposed CNTs be big enough to be able to support the company to develop and grow in the longer term?	t_0	Not able to judge	-
	t_1	The market size is too limited to support the company to develop and grow in the longer term.	High

In Table C'-0, Chris's judgements of required capabilities in both the short and longer terms were inaccurate. At t_0, Chris thought the required capabilities for developing and selling a standard CVD system were leading technology capability and good marketing capability, and the required capability for building competitive advantage was leading technology capability. However, with more evidence gathered at t_1, Chris updated his answers. The different judgements made at t_0 and t_1 are compared in Table 30.

Table 30 Judgements on business opportunity assessment in Case C' at t_0' and t_1'

Question	Time	Answer	Level of Confidence
What are the required capabilities for developing and selling a standard CVD system in the short term?	t_0'	Leading technology capability and good marketing capability	Low
	t_1'	Sufficiently good technology capability and good marketing capability	Low
What are the required capabilities to build competitive advantage in the longer term?	t_0'	Leading technology capability	High
	t_1'	Leading technology capability and strong capability in marketing.	High

The answer at t_0 was inaccurate as it was updated by new evidence. However, this inaccurate answer did enable a high-quality decision at t_0 because Chris realised his answer could potentially be inaccurate and he therefore decided to talk to potential customers to understand what they actually require and value first rather than rush into technology and product development based on this potentially inaccurate answer. This example shows that inaccurate answers can lead to high-quality decisions as long as entrepreneurs are able to perceive the potential inaccuracy.

In summary, this research claims that both accurate and inaccurate answers can enable high quality decisions as long as entrepreneurs have an appropriate understanding of the reliability of their answers. This research acknowledges the legitimacy of inaccurate answers in the context of technology entrepreneurship and highlights the importance of having an appropriate understanding of the reliability of answers.

5.3. Method for Making Effective Judgements

The previous section shows that the key for entrepreneurs to make effective judgements is having an appropriate understanding of the reliability of their answers. This section proposes a method to help entrepreneurs obtain such an understanding. Section 5.3.1 shows that the key to obtaining an appropriate understanding of the reliability of answers is having an appropriate understanding of the validity of their underlying assumptions. Accordingly, Section 5.3.2 suggests that the process of identifying and analysing assumptions underlying the evidence and answers can help entrepreneurs understand the validity of the assumptions and thus the reliability of their answers.

5.3.1. Key to Obtaining an Appropriate Understanding of the Reliability of Answers

Analysing the data in this study revealed that the key to obtaining an appropriate understanding of the reliability of answers is having an appropriate understanding of the validity of their underlying assumptions. By comparing the validity levels of assumptions and the confidence levels of answers in this research's cases, it was found that when entrepreneurs' confidence levels in their answers were consistent with the validity of their underlying assumptions, their understanding of the reliability of answers is appropriate; when this consistency does not hold, inappropriate understanding occurs.

Table 31 list a number of typical judgements on the key questions for market entry decisions as examples to explain this finding. The examples include effective and ineffective judgements with evidence employed, underlying assumptions and answers with corresponding confidence levels. Effective judgements are given in black and ineffective judgements in red; answers with high confidence level are in red cells and the less confident answers are in green cells; assumptions with high levels of validity are in normal font and less valid assumptions are in *italics*.

Table 31 Typical judgements of the key questions for market entry decisions

Table No.	Question	Evidence	Assumption	Judgement
A-0	Will there be a need for high quality megavolt MOVs in the short term?	The China Power System has announced a bid for megavolt MOVs in 6 months.	The bid will open as planned.	Y
B-0	Will there be a market need for ANC headphones with good quality and at an affordable price in the short term?	In an affordable ANC headphone market, customers pay low prices for low quality headphones.	Consumers are rational and will prefer high quality products at the same price	Y
C-0	Will there be a need for the proposed CNTs in the short term?	Higher quality field emissions can improve the performance of precision instruments.	*Potential customers value high quality field emissions and would be willing to buy CNTs for better performance.*	Y
C-1	Will there be a need for the proposed CNTs in the short term?	The potential customers are willing to buy CNTs in the short term.	Potential customers' feedback accurately reflects their need.	Y
C'-0	Will there be a market need for a standardised CVD system that can save time and effort for research institutes in the short term?	Buying a standardised CVD system from suppliers can save time and effort for research institutes; The research community would benefit from using a standardised system.	*Customers would be willing to buy a CVD system from Company C instead of building them in-house.*	Y
C'-1	Will there be a market need for a standardised	Many research institutes were interested in purchasing the	Potential customers' feedback accurately reflects their need.	Y

	CVD system that can save time and effort for research institutes in the short term?	standardised CVD system and two of them showed a great willingness to buy.		
D-0	Is there a market need for an intelligent monitoring system for maintaining the power system?	Company P has begun to try an intelligent monitoring system on their power system; Company P had confirmed that they required an intelligent monitoring system.	Company P's purchase reflects its need got an intelligent monitoring system; The information managers provided accurately reflects the needs of Company P.	Y
E-0	Will there be a market need for delivery robots that can reduce delivery costs for delivery companies?	Delivery robots can reduce delivery costs by 60% to 80% for delivery companies; A survey conducted with friends showed positive results on expected receiver experience, social acceptance and regulation trends.	Customers values cost reduction and would like to use delivery robots to reduce costs; *Delivery robots will be acceptable to receivers and the local community and would be allowed by regulations.*	Y
E-1	Will there be a market need for delivery robots that can reduce delivery costs for delivery companies?	Delivery robots can reduce delivery costs by 60% to 80% for delivery companies; Receivers at a local university and local community were friendly to delivery robots in general.	Customers value cost reduction and would be willing to use delivery robots to reduce costs; People's reactions recorded by the model robots accurately reflect the attitudes of receivers and the local community.	Y
F-0	Will there be a market need for management software that can reduce management costs and increase efficiency for US car parks?	The management software would help car parks to reduce costs and improve efficiency with no extra commitment required.	Car parks would be willing to pay for cost reduction and efficiency improvements to gain the net benefits.	Y
G-0	Will there be a market need for PE-driven mobile games?	PE technology can improve the degree of reality of mobile games.	*Mobile game players would value the high degree of reality and would be willing to pay for it.*	Y
G'-0	Will there be a market need for PE technology on VR platforms?	PE technology can improve the degree of reality on VR platforms. Products on VR platforms require a high degree of reality.	*There are potential customers willing to pay for high degree of reality enabled by their technology.*	Y
G'-1	Will there be a market need for PE technology on VR platforms?	When they presented this technology demo at trade shows, players, VR game developers and investors showed great interest in it. Company G was approached by several VR game companies asking for customised PE development.	VR game companies would like to outsource PE development to Company G.	Y
H-0	Is there a market need for awareness monitoring glasses in the short term?	When potential customers were shown the awareness monitoring glasses to potential customers for feedback and suggestions, drivers had the highest interest and willingness to buy.	*This feedback accurately reflects a real market response.*	Y
H-1	Is there a market need for awareness monitoring glasses in the short term?	A lot of positive feedback was received from the audience that suggested possible application scenarios. For example, a driver said he needs to avoid falling asleep while driving; a professor said he would like his students to wear the glasses.	These feedbacks accurately reflect a real market response.	Y

In cases A, D, B, and F, the entrepreneurs were able to confidently judge the market need for the proposed product at t_0. Adam and David were confident about the existence of market need at t_0 because it had already been confirmed by potential customers. Here, the underlying assumptions are 'the bid will open as planned' and 'the managers provided valid information', which are relatively solid. In Case B, Bob believed there would be a market need for good-quality affordable ANC headphones because the market for affordable ANC headphones already existed and the proposed product would be more competitive than the existing product. Therefore, his judgement on market need was based on the assumption that 'customers are rational and will prefer high quality products at the same price'. Similarly, in case F, Frank believed there would be a market need for management software for US car parks as long as the software could generate net benefits for car parks, a belief also based on the rational customer assumption. The above answers were made based on sufficient valid information and thus relatively solid assumptions; as a result, the entrepreneurs were confident about their answers. In the above cases, entrepreneurs had an appropriate understanding of the reliability of the answers because there was a consistency between the solid assumptions and the high levels of confidence in the answers.

In cases C, C', E, G' and H, the entrepreneurs were not able to confidently judge the market need for their proposed product at t_0 due to insufficient valid information. For instance, in Case C, the evidence employed at t_0 was the fact that 'a higher quality of field emissions can improve the performance of precision instruments'. To arrive at a positive answer for market need, it was assumed that 'potential customers value high quality field emissions and would be willing to buy CNTs with a better performance'. This assumption could potentially be invalid. Therefore, given the information availability at t_0, Chris assumed there would be a market need but also was aware of the potential inaccuracy of this answer. In this case, the entrepreneur's appropriate understanding was reflected in the consistency between the weak assumptions and low levels of confidence. This awareness of potential inaccuracy motivated Chris to gather more valid evidence to test the assumption for a more accurate answer. Therefore, Chris discussed his idea with potential customers and understood that they had a willingness to buy conditional upon certain requirements. Based on customer feedback gained at t_1, Chris was confident that there would be a market need. Comparing the underlying

assumptions at t_0 and t_1, the validity of assumptions increased with more valid evidence gained. Although the information availability was different at t_0 and t_1, Chris had an appropriate understanding of his answer as the level of confidence in the answers matched the level of validation of their underlying assumptions.

An example of inappropriate understanding can be found in Case G. At t_0, George and Grace were confident that there would be a market need for PE-drive mobile games because PE technology could improve the degree of reality for mobile games. Analysing this statement, the underlying assumption that links the evidence employed and the answer can be identified as 'mobile game players will value the high degree of reality and would be willing to pay for it'. At this stage, there was no direct evidence showing this assumption was valid. In other words, this assumption may be invalid. This potential invalidity embedded in the assumption could potentially lead to inaccurate answers. However, George and Grace did not realise the potential invalidity of the assumption and therefore overestimated the reliability of their answer. In this case, ignorance of the potential invalidity of the assumption led to an inappropriate understanding of the answer, and this overconfidence in turn led to an arbitrary and low-quality decision. This example supports the finding that the key to obtaining an appropriate understanding of the reliability of answers is having an appropriate understanding of the validity of the underlying assumptions.

5.3.2. Method for Obtaining an Appropriate Understanding of the Validity of Assumptions

This section proposes a method to help technology entrepreneurs obtain an appropriate understanding of the validity of the assumptions underlying a statement.

According to Toulmin (2003), assumptions are not always explicitly stated but are can also be implied. The ineffective case (Case G) shows that the entrepreneurs made poor decisions when they simply focused on the supporting evidence but ignored the underlying assumptions. Therefore, this research suggests that the process of making underlying assumptions explicit can help entrepreneurs think more clearly and effectively about the validity of their assumptions. Accordingly, a three-step method is

suggested below to help entrepreneurs gain an appropriate understanding of the validity of their assumptions:

1) Identify the answer and evidence employed in a statement;
2) Identify the underlying assumptions from the evidence and answer;
3) Evaluate whether the assumption is solid or needs to be further approved or tested.

For example, in Case E, the statement Evan made about market need was "there would be a market need for delivery robots (answer) because they can reduce delivery costs by 60% to 80% for delivery companies (evidence employed)". Evan realised that the reliability of his positive answer on market need depended on the validity of the following assumptions: (a) receivers will be prepared to accept the delivery robots given the much lower delivery fees they offer; (b) the local community will accept delivery robots moving around; and, (c) future rules and regulations will allow delivery robots. At t_0, Evan did not have valid evidence to support these three assumptions, and therefore he assumed there would be a market need but with a relatively low confidence level.

In summary, this research claims that (1) the key to obtaining an appropriate understanding of the reliability of answers is to have an appropriate understanding of the validity of their underlying assumptions, and (2) the process of making underlying assumptions explicit can help entrepreneurs understand the validity of their assumptions.

Chapter Summary

This chapter answers the research questions through cross-cases analysis to help technology entrepreneurs conduct effective assessment to decide (1) whether to pursue a business opportunity, (2) through which process to define the launch product, and (3) how to strategically align technology and market developments in the early stage of company development. In this chapter, key questions with their underlying rationales for the three focal decisions have been identified, the key to achieving effective judgements has been proposed, and a method to help entrepreneurs make conduct effective judgements has been suggested.

The findings and the proposed method have been developed into a tool to test with technology entrepreneurs and other stakeholders of technology entrepreneurship. The tool and validation are presented in Chapter 6.

Chapter 6 Tool and Verification

Chapter Overview

The main findings and proposed method in Chapter 5 are developed into a management tool to assist technology entrepreneurs to decide (1) whether to pursue a business opportunity, (2) through which process to define the launch product, and (3) how to strategically align technology and market developments in the early stage of company development. The tool, presented in Section 6.1, is used as a vehicle to test the findings and proposed method. The feedback from technology entrepreneurs and other stakeholders of technology entrepreneurship is analysed in Section 6.2.

6.1. A Tool to Help Technology Entrepreneurs Make the Three Decisions

According to Chapter 5, the three main findings from cross-case analysis are:

1) A set of structured questions for considering the three focal decisions;
2) The key to technology entrepreneurs making effective judgements is to have an appropriate understanding of the reliability of their answers;
3) The key to obtaining an appropriate understanding of the reliability of answers is to have an appropriate understanding of the validity of the underlying assumptions.

According to the second and third findings, this research proposes that the process of identifying and analysing the assumptions that link evidence and answer can assist entrepreneurs to understand the validity of the underlying assumptions and thus make effective judgements.

The findings and proposed method have been integrated into a management tool to guide technology entrepreneurs to make effective assessments to make the three decisions. The tool and guidance on its use are presented below.

A Tool to Help Technology Entrepreneurs Make Three Early-Stage Decisions

This tool is designed to guide technology entrepreneurs make effective assessments to decide: (1) whether to pursue a specific business opportunity; (2) the process to define the launch product; and, (3) how to strategically align technology and market development in the early stage for building competitive advantage in the longer term. For each decision, it is recommended that users follow the steps set out below.

Decision 1: Whether to pursue a business opportunity?

Step 1 Consider the questions listed in Table I and insert the answers to each question in the 'answer' column.

Step 2 Provide evidence that supports the answer. It is important to note that evidence should be factual.

Step 3 Identify the assumptions underlying the answer and evidence employed, and analyse the validity of the underlying assumptions.

Step 4 Measure the confidence level of each answer according to the validity of the identified assumptions.

For example, the answer to " Will there be a need for the proposed product in the short term" might be "Yes", and the evidence employed might be "The potential customer has announced a call for a bid in six months". The assumption underlying the evidence and answer is then "The bid will open as expected". If this assumption is considered valid, then the confidence level of the answer is evaluated as high.

Decision 2: Which process can define the launch product?

Step 1 Position the company's current situation by answering the questions in Figure I.

Step 2 Consider the corresponding suggestions proposed on the process to define the launch product.

Decision 3: How to strategically align technology and market development to build competitive advantage for the company?

Step 1 Position the company's current situation by answering the questions in Figure II.

Step 2 Consider the corresponding suggestions proposed for aligning technology and market development in the early stage.

Figure I Business opportunity assessment for market entry decisions

Question				Evidence	Assumption	Answer	Level of Confidence
Will the company be able to develop in the short term?	Q1: Will there be a need for the proposed product in the short term?						
	Q2: Will the company have the required capabilities for developing and selling the product in the short term?	What are the required capabilities for developing and selling the proposed product in the short term?				E.g. technology capability, capability in cost control, production capacity, capability in design, marketing capability.	
		Will the company gain the required capabilities in the short term?	Technology capability				
			Capability in cost control				
			Production capacity				
			Capability in design				
			Marketing capability				
			Other required capabilities				
	Q3: Will the company be able to operate in the short term?						
Will the company be able to develop in the longer term?	Q4: Will the market size be big enough to provide opportunities for the company to develop in the longer term?						
	Q5: Will the company gain competitive advantage to compete in the industry for longer-term development?	What are the required capabilities for building competitive advantage in the longer term?				E.g. technology capability, capability in cost control, production capacity, capability in design, marketing capability.	
		Will the company gain the required capabilities in the long term?	Technology capability				
			Cost control capability				
			Capability in design				
			Marketing capability				
			Other required capabilities				
	Q6: Will the team be able to manage the business in the longer term?						

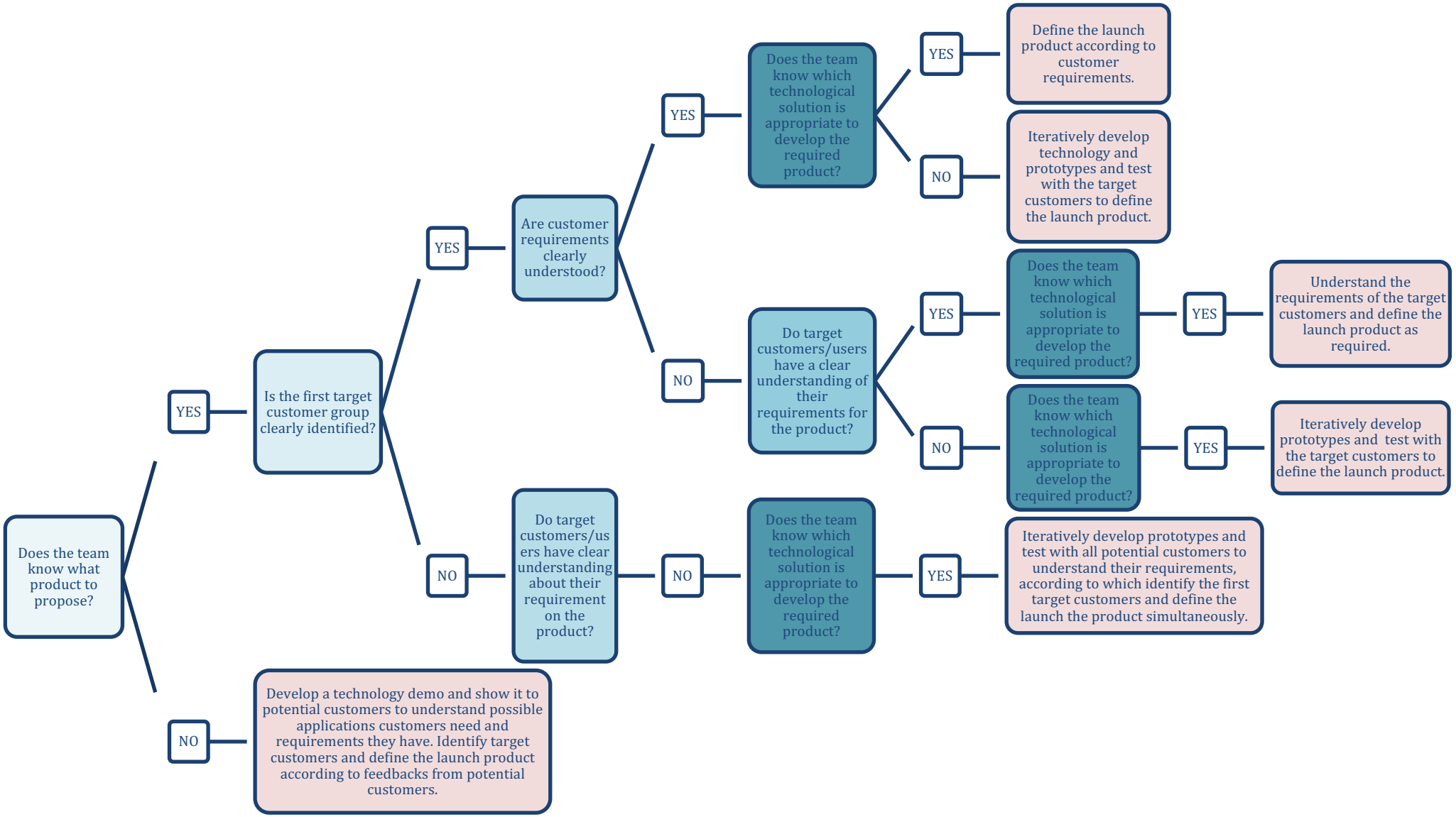


Figure II Map to help technology entrepreneurs choose the process to define the launch product

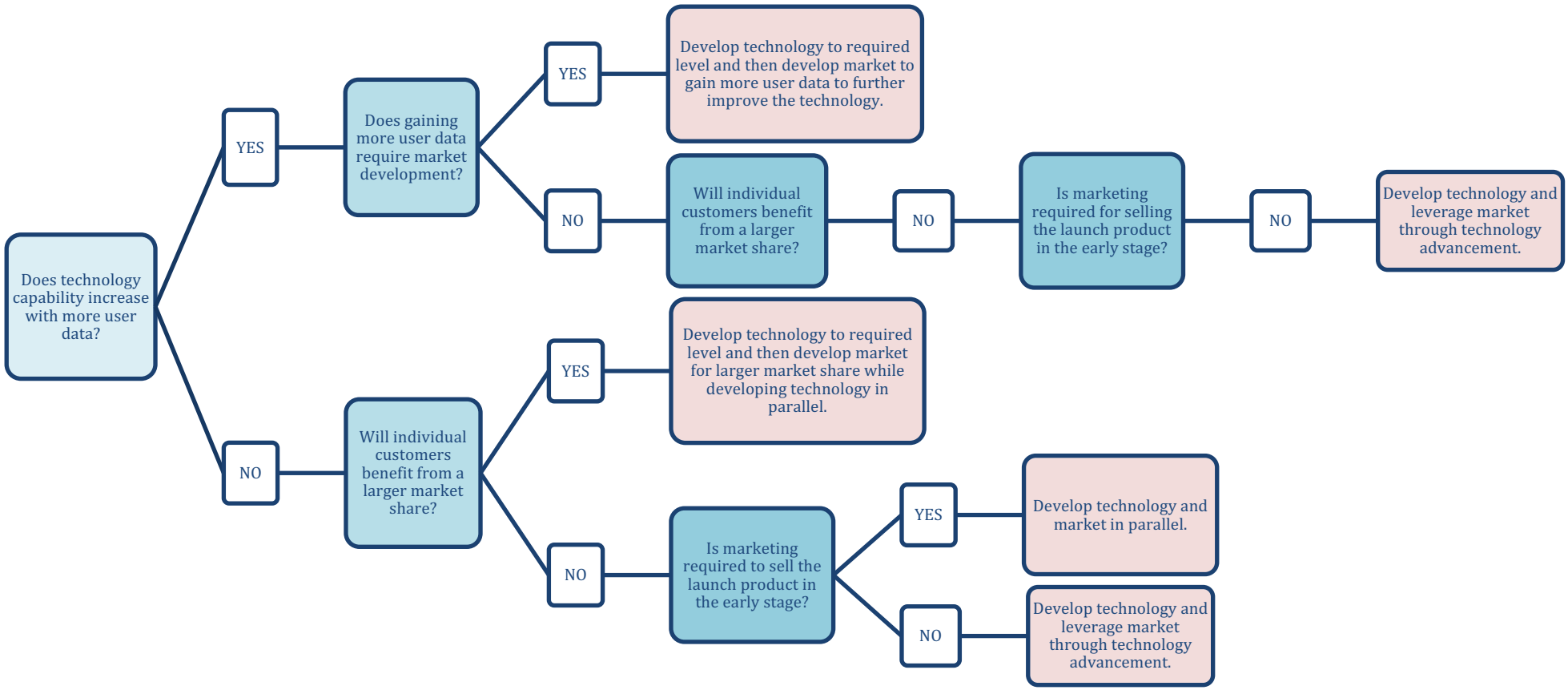


Figure III Map to help technology entrepreneurs to decide the strategic alignment of technology and market development in the early stage to build competitive advantage for the company in the longer term

6.2. Verification of the Findings and Proposed Method

To verify the findings and proposed method, the researcher tested the tool with five technology entrepreneurs and seven other stakeholders in technology entrepreneurship, namely, two venture capitalists, one incubator manager, one staff from a university technology transfer office, one mentor for technology entrepreneurs at an accelerator, and one researcher in entrepreneurship. It is important to note that, due to the time constraints of this research, the tool was not tested through actual usage but was rather reviewed and commented on. The interviewees are listed in Table 32.

Table 32 List of interviews conducted for testing the findings of the research

Interview Date	Occupation of Interviewee	Location
2017.09	Technology entrepreneurs in super conduction	CN
2018.02	Technology entrepreneurs in medical devices	UK
2018.04	Technology entrepreneur in machine learning	US
2018.06	Technology entrepreneurs in semi-conductor	UK
2018.06	Technology entrepreneur in optical devices	UK
2017.06	Business angel	UK
2017.08	Incubator managers	CN
2018.04	Investment director at a technology investment fund	CN
2018.04	Investment director at a technology investment fund	CN
2018.04	Staff member from a university technology transfer office	CN
2018.04	Mentor for technology entrepreneurs at an accelerator	CN
2018.06	Researchers in entrepreneurship	UK

The questions include four closed-ended and one open-ended question, as listed below. As the purpose of testing the tool is to test whether the main findings can help entrepreneurs make the three decisions, the questions therefore concern its utility and effectiveness. Other commonly used criteria for tool verification such as usability (ease of use) and feasibility were considered less relevant for the purposes of this study and were therefore excluded. The interviewees were asked to score the first four questions thus: 1 = strongly disagree, 2 = disagree, 3 = neither agree not disagree, 4 = agree, 5 = strongly agree.

1. Do you think this tool is helpful to assist technology entrepreneurs make the three decisions?
2. Do you think the key questions are sufficiently complete and the underpinning rationale is appropriate for making the three decisions?
3. Do you think having an appropriate understanding of the reliability of the answers is important for making high quality decisions?

4. Do you think the process of identifying assumptions from evidence and answers will help entrepreneurs achieve a better understanding of the accuracy of the answers?
5. Do you have any comments or suggestions on the tool?

The scores received from technology entrepreneurs and other stakeholders for the first four questions are shown in Table 33. The scores indicate that both technology entrepreneurs and other stakeholders had a positive opinion on the main findings and proposed method.

Table 33 Four close-ended questions and feedback from technology entrepreneurs and other stakeholders

Question	Feedback	
	Technology Entrepreneurs	Other Stakeholders
Do you think this tool is helpful to assist technology entrepreneurs make the three decisions?	4.8	4.8
Do you think the key questions are sufficiently complete and the underpinning rationale is appropriate for making the three decisions?	4.8	4.7
Do you think having an appropriate understanding of the accuracy of the answers is important for making high quality decisions?	4.9	4.9
Do you think the process of identifying assumptions from evidence and answers will help entrepreneurs achieve a better understanding of the accuracy of the answers?	4.9	4.8

According to the comments received, the three most valued features of the tool from the perspective of the technology entrepreneurs were identified as: (1) the well-structured key questions for considering the three decisions; (2) the emphasis on the importance of entrepreneurs' understanding of the reliability of their answers to decision quality; and, (3) the process of identifying assumptions that pushes decision makers to consider the validity of those assumptions. These are explained as follows.

The structured key questions for market entry decisions leaded the technology entrepreneurs to assess business opportunities through the perspectives of short-term and longer-term development. Short-term development is closely related to the launch product, and longer-term development depends on a company's competitive advantage. Therefore, by filling in the blanks in the table of business opportunity assessment from both short-term and longer-term perspectives, technology entrepreneurs not only make

market entry decisions but also naturally relate short-term considerations with the process of defining the launch product and longer-term considerations with regard to the strategic alignment of technology and market development. In other words, the questions and flow designed for business opportunity assessment are helpful for considering Decision 2 and Decision 3. This foreshadowing built in the framework of business opportunity assessment was appreciated by the technology entrepreneurs. With respect to the maps for Decision 2 and Decision 3, the technology entrepreneurs found that the key questions could effectively explain why entrepreneurs choose different processes to define the launch product and different strategies to align technology and market development in the early stage. The structure and perceived effectiveness of the approach were highly valued by the technology entrepreneurs.

In addition to the well-structured key questions, the technology entrepreneurs strongly agreed that decisions are made not only based on answers but also the confidence of their answers, which is a reflection of their understanding of the reliability of their answers. Given that this research defines high quality decisions as decisions that lead to low waste, the technology entrepreneurs agreed that having an appropriate understanding of the reliability of their answers is the key to making high quality decisions. They also acknowledged that when making decisions they tended to focus more on answers than on the level of confidence they have in their answers. Therefore, they believed this tool could help improve decision quality as it emphasises the importance of entrepreneurs' confidence in their answers to decision quality and encourages entrepreneurs to consider this factor.

To use the tool, entrepreneurs are required to identify the assumptions underlying the answers and the evidence employed. The technology entrepreneurs found this process helped them to understand the validity of their assumptions and consider the reliability of their answers, enabling them to identify less valid assumptions and the potential inaccuracy embedded in the answers. According to one technology entrepreneur, this process *"improves the decision-making process by forcing decision makers to think slowly".*

The feedback from the other stakeholders was consistent with that of the technology entrepreneurs. They evaluated this tool based on their experience working with

technology entrepreneurs. They strongly agreed that having an appropriate understanding of the answers is the key to making high quality decisions as they have seen many ventures fail due to overconfidence and arbitrary decisions.

Specifically, the technology investors mentioned that they would be likely to use Figure I as a template and ask entrepreneurs to submit their business proposals by filling it in. They believed that reading standardised tables would be more efficient than reading business plans. Also, the venture investors thought they might be able to understand entrepreneurs' personal characteristics better, such as risk preference and reasoning ability, by analysing how they make judgements. Incubator managers and the member of staff from a university technology transfer office suggested that this tool could be used for entrepreneur education as, on the one hand it was specific enough for the three important decisions, while on the other hand the principle and methods for making effective judgements could be applied to decision-making processes in general.

In summary, the technology entrepreneurs and the other stakeholder of technology entrepreneurship justified the main findings and the proposed method. The key questions for the three decisions are evaluated as sufficiently complete and sufficiently structured to provide effective guidance to technology entrepreneurs. It has also been confirmed that the principle for achieving effective judgements is having an appropriate understanding of the reliability of the answers, and this can be gained by identifying and analysing the underlying assumptions that link evidence with answer.

Chapter Summary

The main findings and proposed method proposed from cross-case analysis were developed into a management tool which was used as a vehicle to test the research findings. The tool was reviewed and commented on by technology entrepreneurs and other stakeholders in technology entrepreneurship and the main findings and proposed method were justified. The next chapter will discuss the research findings, contributions, and limitations of this research.

Chapter 7 Discussion

Chapter Overview

This chapter discusses the research findings, outlines the contributions of the research, identifies its limitations and suggests future possible research directions.

7.1. Discussion of Main Findings

This section discusses the findings, referring to previous literatures and the research gap identified in Chapter 2.

1. Key Questions and Rationale for Market Entry Decisions

Chapter 2.1.1 reviewed the existing literature and identified considerations (dimensions, factors, and questions) that are important for market entry decisions. The key questions proposed by this research are consistent with previous findings as entrepreneurs mentioned these considerations in answer those questions. Table 34 shows a number of examples of considerations to the key questions.

Table 34 Examples of considerations of the key questions

Key Questions	Examples of Relevant Considerations
Will there be a market need for the proposed product in the short term?	• Uniqueness of product • Market acceptance of product
Will the company have the required capabilities for developing and selling the product in the short term?	• Education background • Marketing skills • Relevant track record
Will the company be able to operate in the short term?	• Prior entrepreneurial and start-up experience • Financial skills
Will the market size be large enough to provide opportunities for the company to develop in the longer term?	• Market size • Growth potential of market • Profit margins
Will the company gain competitive advantage to compete in the industry for longer-term development?	• Patentability of technology • Challenges from competition • Protection from competitive entry
Will the team be able to manage the business in the longer term?	• Managerial experience in related industries • Degree of familiarity with target market • Capability of sustained intense effort • Market acceptance of the product

In the previous literature, most of the key factors in business opportunity assessment are developed from regression or investors' experiences, while few of them are developed from the entrepreneurs' perspective. Additionally, the existing literature does not suggest a rationale of business opportunity assessment for market entry

decisions that also helps to consider the other two decisions on first product definition and competitive advantage development.

This research identifies a set of key questions for business opportunity assessment using empirical evidence garnered from technology entrepreneurs. To relate business opportunity assessment with the other two decisions, this research structures the key questions from the short- and longer-term perspectives (see Figure 16). The first three short-term oriented questions relate to the launch product, and the last three longer-term oriented questions cover considerations of competitive advantage development. This foreshadowing, designed for business opportunity assessment, helps entrepreneurs consider the other two decisions.

2. Key Questions and Rationale for Choosing the Process to Define the Launch Product

The key questions and rationale proposed by this research adds understanding to what determines entrepreneurs' choices regarding the processes of defining the launch product. Few studies have investigated the determinants and underlying rationale of how entrepreneurs choose which process to follow to define the launch product. This research has reviewed the previous literature in new product development and proposes that the processes entrepreneurs follow is determined by the degree of clarity of entrepreneurs' understanding of their first target market, customer requirements and technology solutions. This proposition is then justified in this research using empirical evidence. More importantly, this study has devised five key questions, the answers to which classify technology ventures into six types in terms of the process they followed to define the launch product. It was found that technology entrepreneurs may position themselves in a certain category by answering the five questions and consider the suggested process to define the launch product. These five questions have been justified as effective and efficient to serve its purposes.

3. Key Questions and Rationale for Aligning Technology and Market Development in the early stage

The key questions and rationale proposed by this research adds understanding to the determinants of entrepreneurs' strategic choices on technology and market development in the early stage. Previous research has implied that entrepreneurs' strategic choices on early-stage technology and market development are determined by the required technology and market capabilities to exploit opportunities and neutralise competitive challenges. However, in previous studies, little has been researched on the interaction between technology and market development in the process of technology entrepreneurship. According to its empirical evidence, this research claims that in addition to the required technology and market capabilities, the interaction between technology and market development is another important determinant. Four questions and respective answers were developed which classify technology ventures into five types in terms of the strategic alignment of technology and market development in the early stage. This study proposes that technology entrepreneurs may position themselves in a certain category by answering the four questions and refer to the suggested strategy to align technology and market development in the early stage. These four questions have been justified as effective and efficient for serving its purposes.

4. Key to and Method for Making Effective Judgements

Previous studies have highlighted the importance of the accuracy of answers for making high quality decisions but they lack an explicated emphasis on another determinant, namely entrepreneurs' understanding of the reliability of their answers. This research, according to the empirical evidence garnered, proposes that the key for entrepreneurs to make effective judgements is having an appropriate understanding of the reliability of their answers to decision-related questions.

As explained in Chapter 2, previous studies have tended to focus on answers rather than entrepreneurs' understanding of the reliability of those answers. Researchers, such as Blank (2013) and Eric (2011) claim that making high quality decisions in the early stage is challenging because it is difficult for entrepreneurs to accurately judge decision-related questions under low levels of information availability and/or high levels of future uncertainty. The underlying assumption of this argument is that the reliability of

answers determines the quality of the resulting decision. However, from the perspective of this research, this assumption does not stand. Instead, this study posits that achieving high quality decisions in the early stage is challenging because it is difficult for entrepreneurs to perceive the potential *in*accuracy of their answers, and this overconfidence is more likely to occur under conditions when valid evidence is limited. This finding challenges our current understanding of the determinants of decision quality. The findings show that it is entrepreneurs' understanding of the reliability of their answers that determines decision quality, which is inconsistent with the conventional wisdom because the latter assumes that accurate answers to the main questions is the key to achieving high quality decisions.

Given that the key to making effective judgements is having an appropriate understanding of the reliability of the answers to key decision-related questions, this research claims that entrepreneurs may gain such an appropriate understanding by identifying and analysing the assumptions underpinning the answers and the evidence employed. This is because the process of making underlying assumptions explicit can help entrepreneurs consider more carefully the validity of the assumptions, which in turn determines the reliability of the corresponding answers.

7.2. Contributions

This research contributes to knowledge from both practical and theoretical perspectives. For practical contributions, this research develops a tool to help technology entrepreneurs make three early-stage decisions. This research adds understanding to practical problems in entrepreneurial decision-making that have not been properly explained in previous studies. Specifically, this research contributes to practice through:

1) Identifying and structuring the key questions to help technology entrepreneurs make market entry decisions;
2) Identifying and structuring the key questions to help technology entrepreneurs choose an appropriate process to define the launch product;
3) Identifying and structuring the key questions to help technology entrepreneurs align technology and market development at the early stage in order to build competitive advantages for the longer term;

4) Proposing a method to help technology entrepreneurs obtain effective judgements of decision-related questions.

According to Whetten's (1989) paper "What Constitutes A Theoretical Contribution", a contribution can be considered as a theoretical contribution if it identifies new factors/variables or relationships that affect the causality of conventional understanding of a phenomenon. According to this definition, this research claims two theoretical contributions. First, this research explicitly identified that the basis for decision-making (or judgement in this research) consists of two elements: entrepreneurs' answer to decision-related questions and their understanding of the reliability of their answer. This research concludes that the key for achieving effective judgements and high-quality decisions is entrepreneurs' understanding of the reliability of their answer to key decision-related questions, which changes the conventional understanding that assumes accurate answer is the key for achieving high quality decisions. Second, this research suggests that the process of identifying assumptions underlying corresponding evidence and answer can help entrepreneurs to think about the reliability of their answer and therefore improve decision quality. This relationship provides a theoretical explanation of how hypothesis-based thinking (such as lean startup theory) may improve decision quality.

7.3. Limitations and Possible Future Research Directions

This section discusses the limitations of this research and suggests possible future research directions.

First, this research is based on case studies with 17 technology-based companies. Although these companies cover different industries and are developing different technologies, this research does not claim that the findings are generalisable to all technology ventures. In contrast, the findings are considered sufficiently sound for the purposes of this research based on the current evidence, but are also open to further refinement if the research were to be extended by more empirical evidence. This research is more focused on providing insights into the field in order to encourage other researchers to conduct more studies or explore more cases to further validate its generalisability.

Second, due to time and data accessibility constraints, this research relies on retrospective data recalled by technology entrepreneurs. The underlying assumption of this research method is that the retrospective data is consistent with actual data. However, this assumption can be questioned. Therefore, future research could consider collecting real time data through different research methods, such as longitudinal case studies.

Third, in this research, there is only one case (Case G) that includes poor decisions. This might be attributable to one of two possible reasons: (1) the main source of the poor decisions was failed projects, but these cases are difficult to find and entrepreneurs tend to be less willing to share their unsuccessful experiences; or, (2) this research defines poor quality decisions as decisions that cause unnecessary resources to be devoted to valid or disproved business ideas while, when retrospectively evaluating decision quality, the entrepreneurs may have tended to believe the resources they deployed were necessary at that time. The determinants for assessment effectiveness and decision quality are better understood by comparing and contrasting good and poor practice; therefore, it would be worthwhile to collect more data on poor decisions and ineffective assessments in future research.

Fourth, to test the findings and the proposed method, the researcher explained the tool to technology entrepreneurs and other stakeholders in technology entrepreneurship and asked their opinions about it. In other words, the tool was not tested by actual use, and therefore testing and further development of the tool through application in real-world situations might provide a direction for future work, using an action research method.

Finally, although the focus of this research is assessment, which is the basis for making decisions, the case studies show that entrepreneurs who make high quality decisions tend to apply options thinking. For example, given a business opportunity assessed as possible but with a relatively low confidence level, some entrepreneurs might decide to give up, others might decide to invest, while yet others might choose to test the business opportunity and hold back on making the market entry decision until the uncertainty is reduced. Entrepreneurs using options thinking tend to consider the investment for testing the business opportunity as buying an option, which allows them to delay

making decisions until sufficient evidence has been gathered. The discussion of the effect of options thinking in entrepreneurial decision-making is beyond the scope of this research but this topic is definitely a factor that future research might consider investigating.

Chapter Summary

This chapter has discussed how the research gap identified in Chapter 2 has been filled by this research and how the research contributes to knowledge from both a practical and a theoretical perspective. The next chapter will briefly summarise the study overall from the background and motivation of this research, to its questions, its findings and its contributions.

Chapter 8 Conclusions

Technology entrepreneurship has played an increasingly important role in the development of society and the economy from the first industrial revolution of the 18th century up to the modern digital era. Emerging technology breakthroughs in a number of fields, including robotics, artificial intelligence, blockchain, nanotechnology, quantum computing, biotechnology, the Internet of Things, 3D printing and autonomous vehicles, are expected to have a major impact on society in the coming decades.

However, in the process of technology entrepreneurship, tremendous waste exists in terms of time, human capital, natural and financial resources as a result of poor quality decisions. For example, it happens often that technology entrepreneurs devote an enormous amount of time and effort to develop a product that goes on to be rejected by the market place. Given the fast changing and uncertain entrepreneurial environment associated with the era of Industry 4.0, it is even more important for technology entrepreneurs to understand the nature of the decisions they face and how confidence in the quality of their decision making can be built. The ultimate goal of this research is to reduce waste in technology entrepreneurship by helping technology entrepreneurs to make three key early-stage decisions, namely: (1) whether to pursue a business opportunity; (2) which process to follow to define the launch product to get the business off the ground in the short term, and (3) how to strategically align technology and market development at the early stage to build competitive advantage in the longer term.

Previous studies have shown that people make decisions based on assessment, which consists of their judgements of a series of questions that they consider relevant to the decision. This implies that decision quality depends on the questions they take into consideration and the corresponding judgements they make. Therefore, this research focuses on understanding:

1) The key questions and underlying rationale for the three focal decisions;
2) The method to make effective judgements for these key questions in an entrepreneurial environment.

Therefore, the main research question is defined as:

How may technology entrepreneurs conduct effective assessments to decide (1) whether to pursue a business opportunity, (2) through which process to define the launch product to get the business off the ground in the short term, and (3) how to strategically align technology and market developments in the early stage of company development to gain competitive advantage in the longer term?

The four sub-questions are:

1. What are the key questions for market entry decisions and how can they be structured to develop a rationale that also helps to consider the other two decisions?
2. What are the key questions and rationale for deciding the process to define the launch product?
3. What are key questions and rationale for deciding the strategic alignment of technology and market development in the early stage of company development?
4. What is the key to making effective judgements on the key questions and how might entrepreneurs be helped to make effective judgements under different levels of information availability and future uncertainty?

To address these questions, the researcher interviewed entrepreneurs from 17 technology-based companies, exploring how they made the three decisions. By analysing good and poor practices, this research identifies key questions and underlying rationales for the three focal decisions and proposes a method to help technology entrepreneurs make effective judgements.

In general, the answer to the main research question is:

Technology entrepreneurs may make effective assessments for the three focal decisions if they consider the suggested key questions and judge them following the proposed method.

The answers to the four sub-questions are:

1. The suggested rationale for considering market entry decisions is by considering the short- and longer-term perspectives. Accordingly, key questions are structured as in Figure 20. It is suggested that technology entrepreneurs consider these key questions carefully and make the final decision to pursue a business opportunity if all key questions are judged as positive with relatively high confidence levels.

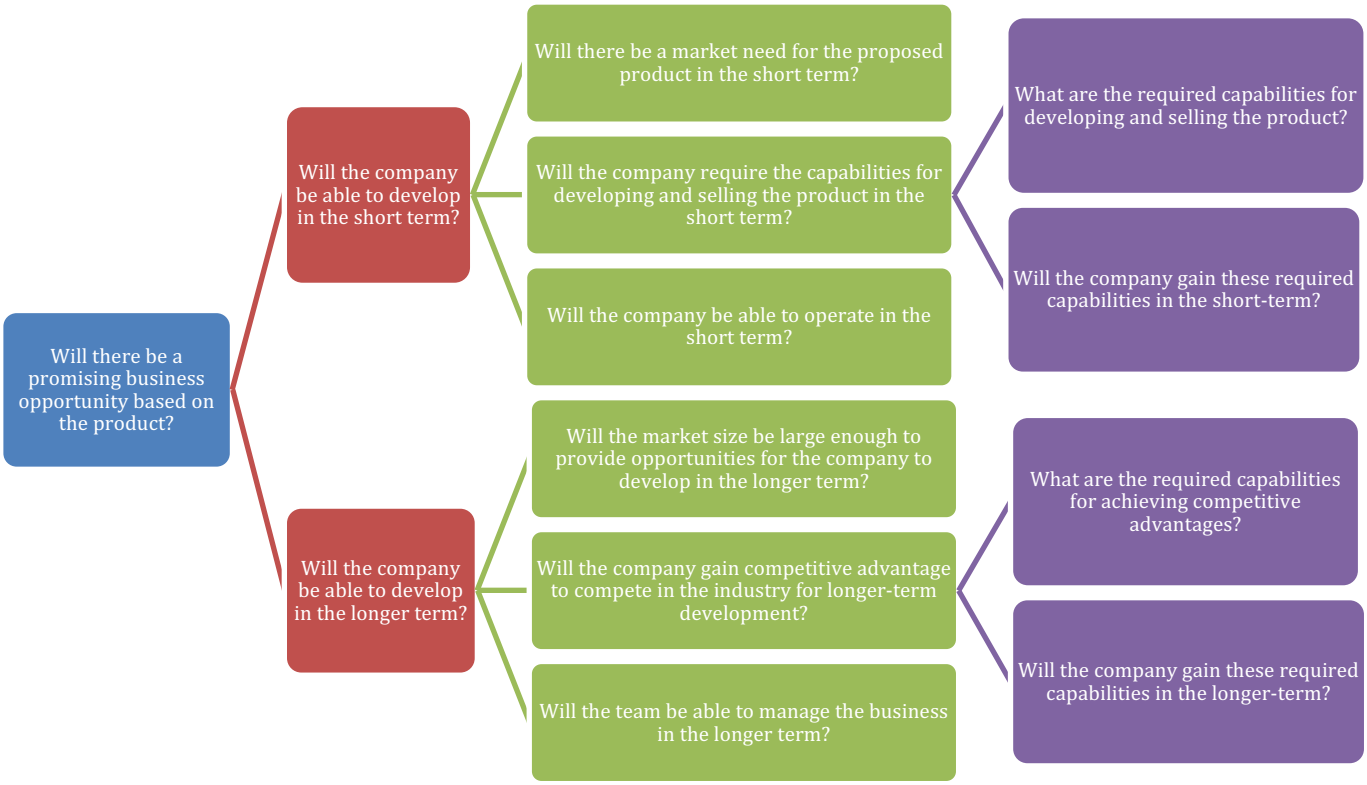


Figure 20 Suggested key questions and underlying rationales for market entry decisions

2. The five key questions for deciding the process to define the first product are:
   1) Does the team know what product to propose?
   2) Is the first target customer clearly identified?
   3) Are customer requirements clearly understood?
   4) Do the target customers have a clear understanding of their requirements of the product?
   5) Does the team know which technological solution is appropriate to develop the required product?

These five questions are structured to classify ventures into six types in terms of the processes followed to define the launch product (see Figure 21). This research proposes that technology entrepreneurs may position themselves in a certain type and refer to the suggested process to define the launch product.

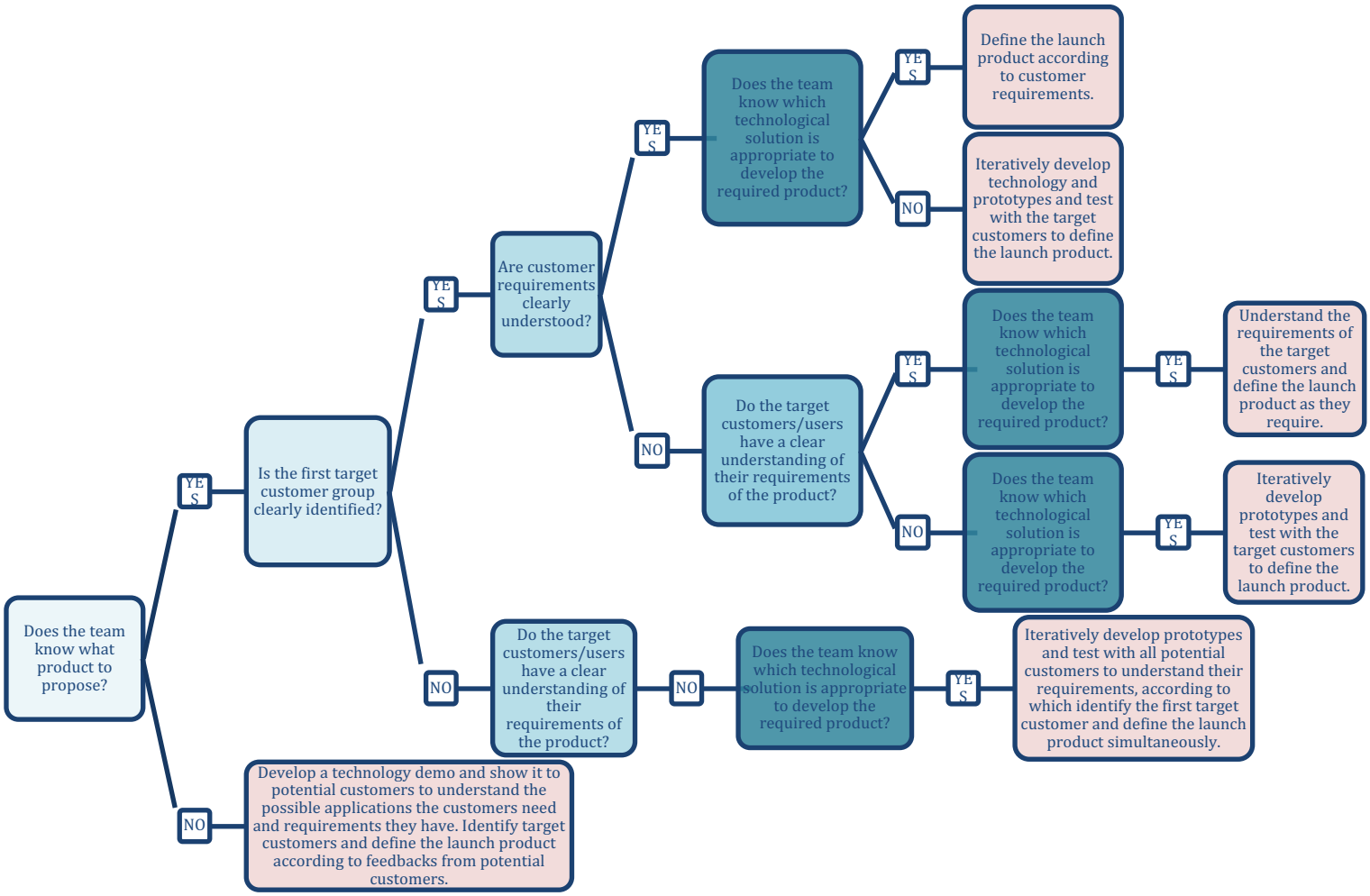


Figure 21 Suggested key questions and rationale for deciding the process to define the launch product

3. The four key questions corresponding to different strategies for aligning technology and market development are:
   1) Does the team know what product to propose?
   2) Are the first target customers clearly identified?
   3) Do target customers have a clear understanding of their requirements of the product?
   4) Does the team know which technological solution is appropriate to develop the required product?

These four questions are structured to classify ventures into five types in terms of the strategy they choose to align technology and market development in the early stage (see Figure 22). This research proposes that technology entrepreneurs may position themselves into a certain type and refer to the suggested strategy to align technology and market development in the early stage.

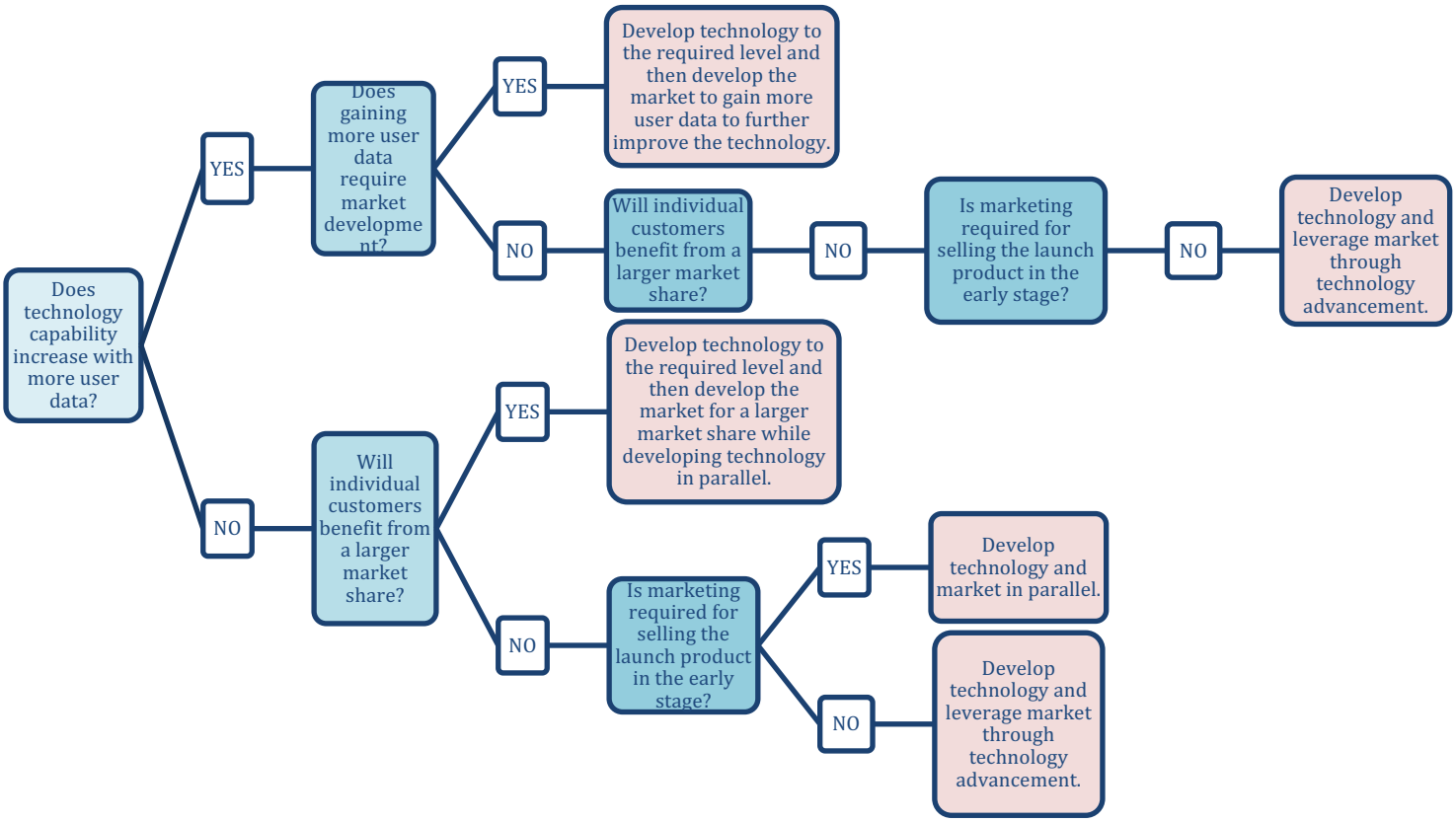


Figure 22 Suggested key questions and rationales for aligning technology and market development

4. The judgement of a question consists of two elements: answer, which is the answer to the question, and the decision-maker's level of confidence in that answer, which reflects his or her understanding of the accuracy of the answer. The key for technology entrepreneurs to make effective judgements is to have an appropriate understanding of the accuracy of their answers. Entrepreneurs can obtain this understanding by identifying and analysing the assumption underlying the answer and the evidence employed, as this process helps technology entrepreneurs carefully consider the validity of the assumption, which determines the accuracy of the answer based on it.

The findings have been developed into a tool (see Section 6.1 for detail) to test with technology entrepreneurs and other stakeholders of technology entrepreneurship, including venture capitalists, incubator managers, staff from the technology transfer offices of universities, mentors for technology entrepreneurs, and researchers in entrepreneurship. Their feedback verified the main research findings and indicated a number of possible implications of this research. Technology entrepreneurs claimed that the tool provides helpful guidance for making the three early-stage decisions. Additionally, they indicated that the proposed method of identifying assumptions underlying the evidence and answers can improve decision-making processes in general. The venture capitalists indicated that the template for business opportunity assessment (see Table I in Section 6.1) could improve communication between investors and technology entrepreneurs. The venture capitalists appreciated the suggested rationale for market entry decisions and a number of them indicated that they would be willing to use the flow diagrams to structure investment proposals or design early-stage due diligence. Incubator managers and mentors of technology entrepreneurs recognised the value of this research for entrepreneurial education. They would like to introduce the findings and the tool to their entrepreneur education programme to make this research more available to technology entrepreneurs.

This research contributes to existing knowledge from both the practical and theoretical perspectives. In terms of practice, a tool has been developed to help technology entrepreneurs conduct effective assessments for the three early-stage decisions. In terms of theory, this research challenges conventional understandings of 'what determines decision quality'. Previous studies in technology entrepreneurship have

tended to assume that an accurate answer to decision-related questions is the key to making high quality decisions. However, this research has found that some high quality decisions are based on inaccurate answers; high quality decisions do not depend principally on accurate answers, but rather require entrepreneurs' appropriate understanding of the accuracy of their answers. Moreover, this research suggests that the process of identifying the assumptions underlying the corresponding evidence and answers can help entrepreneurs to consider the reliability of their answers and therefore improve decision quality. This provides a theoretical explanation of how hypothesis-based thinking (such as lean startup theory) may improve decision quality.

References

Aaker, D. A. and Day, G. S. (1986) 'The perils of high-growth markets', *Strategic Management Journal*, vol. 7, no. 5, pp. 409–421.

Achtenhagen, L., Melin, L. and Naldi, L. (2013) 'Dynamics of business models - strategizing, critical capabilities and activities for sustained value creation', *Long Range Planning*, vol. 46, no. 6, pp. 427–442.

Andrews, K. (1987) *The Concept of Corporate Strategy*, 2nd ed. Homewood, Irwin.

Baden-Fuller, C. and Haefliger, S. (2013) 'Business Models and Technological Innovation', *Long Range Planning*, vol. 46, no. 6, pp. 419–426.

Bailetti, T. (2012) 'Technology Entreprenuership: Overview, Definition, and Distinctive Aspects', *Technology Innovation Management Review*, no. February, pp. 5–12.

Barney, J. (1991) 'Firm Resources and Sustained Competitive Advantage', *Journal of Management*, vol. 17, no. 1, pp. 99–120.

Barney, J. B. (1995) 'Looking inside for Competitive Advantage', *Academy of Management Executive*, vol. 9, no. 4, pp. 49–61.

Bell, C. G. and Mason, H. B. (1992) 'A method to diagnose high tech ventures', in *Technology Management : the New International Language*, US, IEEE, pp. 621–624.

Bell, C. G. and McNamara, J. E. (1991) *High Technology Ventures: The Guide to Entrepreneurial Success*, Reading, Addison-Wesley.

Black, F. and Scholes, M. (1973) 'The Pricing of Options and Corporate Liabilities', *The Journal of Political Economy*, vol. 81, no. 3.

Blank, S. (2013) 'Why the lean start-up changes everything', *Harvard Business Review*, vol. 91, no. 5.

Boudreau, K. J. (2017) 'A Short Guide to Strategy for Entrepreneurs', *Harvard Business Review*, no. October 2017, pp. 1–7

Bowman, E. H. and Moskowitz, G. T. (2009) 'Real Options Analysis and Strategic Decision Making', *Organization Science*, vol. 12, no. 6, pp. 772–777.

Briner, R. B., Denyer, D. and Rousseau, D. M. (2009) 'Evidence-Based Management: Concept Cleanup Time?', *Academy of Management Perspectives*, vol. 23, no. 4, pp. 19–32.

Bruderl, J., Preisendorfer, P. and Ziegler, R. (1992) 'Survival Chances of Newly

Founded Business Organizations', *American Sociological Review*, vol. 57, no. 2, p. 227.
Busenitz, L. W. and Barney, J. B. (1997) 'Differences between entrepreneurs and managers in large organizations: Biases and heuristics in strategic decision-making', *Journal of Business Venturing*, vol. 12, no. 1, pp. 9–30.
De Castro, J. O. and Chrisman, J. J. (1995) 'Order of market entry, competitive strategy, and financial performance', *Journal of Business Research*, vol. 33, no. 2, pp. 165–177.
Chandler, G. N. and Hanks, S. H. (1994) 'Market attractiveness, resource-based capabilities, venture strategies, and venture performance', *Journal of Business Venturing*, vol. 9, no. 4, pp. 331–349.
Charmaz, K. (1990) '"Discovering" chronic illness: Using grounded theory', *Social Science and Medicine*, vol. 30, no. 11, pp. 1161–1172.
Cooper, A. C. and Bruno, A. V. (1977) 'Success Among High-Technology Firms', *Business Horizons*, vol. 20, no. 2, pp. 16–22.
Cooper, G. R. (1990) 'Stage-Gate Systems: A New Tool for Managing New Products', *Business Horizons*, vol. 33, no. June, pp. 44–53.
Cooper, R. G. (1988) 'The new product process: A decision guide for management', *Journal of Marketing Management*, vol. 3, no. 3, pp. 238–255.
Cooper, R. G. (2000) 'Product Innovation and Technology Strategy', *Research Technology Management*, vol. 43, no. 1, p. 38.
Cooper, R. G. (2001) *Winning at new products: accelerating the process from idea to launch*, 2nd ed. New York, Basic Books.
Cooper, R. G. (2007) 'Managing Technology Development Projects', *IEEE Engineering Management Review*, vol. 35, no. 1, pp. 67–76.
Cooper, R. G. (2014) 'What's Next? After Stage-Gate', *Research-Technology Management*, vol. 57, no. 1, pp. 20–31.
Cooper, R. G., Edgett, S. J. and Kleinschmidt, E. J. (2001) *Portfolio Management for New Products*, 2nd ed. New York, Basic Books.
Corbin, J. M. and Strauss, A. (1990) 'Grounded theory research: Procedures, canons, and evaluative criteria', *Qualitative Sociology*, vol. 13, no. 1, pp. 3–21.
Creswell, J. W. (2002) *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*, 2nd (ed), New York, Sage Publications.
Crotty, M. (1998) *The foundations of social research: Meaning and perspective in the research process*, 1st ed. *booksgooglecom*, New York, Sage Publications.
Denzin, N. K. and Lincoln, Y. S. (2005) 'The discipline and practice of qualitative

research', in *The SAGE handbook of qualitative research*, pp. 1–32.

Dorf, R. C. and Byers, T. H. (2008) *Technology Ventures: From Idea to Enterprise*, 2nd ed. New York, McGraw-Hill.

Drejer, A. and Gudmundsson, A. (2000) 'Towards lean product development', *Technovation*, vol. 22, no. 12, pp. 733–745

Eisenhardt, K. M. (1989) 'Building Theories from Case Study Research.', *Academy of Management Review*, vol. 14, no. 4.

Eisenhardt, K. M. (1991) 'Better stories and better constructs: The case for rigor and comparative logic', *Academy of Management Review*, vol. 16, no. 3, pp. 620–627.

Eisenhardt, K. M. and Graebner, M. E. (2007) 'Theory building from cases: Opportunities and challenges', *Academy of Management Journal*, vol. 50, no. 1, pp. 25–32.

Eisenmann, T., Ries, E. and Dillard, S. (2011) 'Hypothesis-Driven Entrepreneurship : The Lean Startup', *Harvard Business School technical note 812-095*, vol. 44, no. December, pp. 1–23.

Ellis, G. (2016) 'Lean Product Development', in *Project Management in Product Development*, pp. 177–222.

Evans, J. D. and Johnson, R. O. (2013) 'Tools for Managing Early-Stage Business Model Innovation', *Research-Technology Management*, vol. 56, no. 5, pp. 52–56

Fischoff, B. and Beyth-Marom, R. (1983) 'Hypothesis testing from a Bayesian perspective', *Decision Research Eugene*, vol. 90, no. 3, pp. 239–260.

Forlani, D. and Mullins, J. W. (2000) 'Perceived risks and choices in entrepreneurs' new venture decisions', *Journal of Business Venturing*, vol. 15, no. 4, pp. 305–322.

Garcia, M. L. and Bray, O. H. (1997) *Fundamentals of technology roadmapping*, Albuquerque, Sandia National Laboratories.

Gassmann, O. and Frankenberger, K. (2015) *The Business Model Navigator: 55 Models That Will Revolutionise Your Business*, Edinburgh, Pearson Education Limited.

Geum, Y., Kim, J., Son, C. and Park, Y. (2013) 'Development of dual technology roadmap (TRM) for open innovation: Structure and typology', *Journal of Engineering and Technology Management - JET-M*, vol. 30, no. 3, pp. 309–325.

Glaser, B. G. (1978) *Theoretical sensitivity: Advances in the methodology of grounded theory*, 1st ed. Mill Valley, Sociology Press.

Glaser, B. G. (1992) *Basics of grounded theory analysis: Emergence vs Forcing*, 1st ed. Mill Valley, Sociology Press.

Glaser, B. G. and Strauss, A. L. (1967) *The Discovery of Grounded Theory: Strategies for Qualitative Research*, 2nd ed. Chicago, Aldine.

Grant, R. M. (1991) 'The Resource-Based Theory of Competitive Advantage: Implications for Strategy Formulation', *California Management Review*, vol. 33, no. 3, pp. 114–135.

Groenveld, P. (2007) 'Roadmapping integrates business and technology', *Research Technology Management*, vol. 50, no. 6, pp. 49–58.

Guba, E. G. (1990) 'The alternative paradigm dialog', 1st ed. in *The paradigm dialog*, London, Sage Publications, pp. 17–30.

Hastie, R. (2001) 'Problems for judgement and decision making', *Annual Review of Psychology*, vol. 52, no. 1, p. 653.

Hofer, C. W. and Sandberg, W. R. (1987) 'Improving New Venture Performance: Some Guidelines for Success', *American Journal of Small Business*, vol. 12, no. 1983, p. 11.

Hogarth, R. M. and Karelaia, N. (2012) 'Entrepreneurial Success and Failure: Confidence and Fallible Judgement', *Organization Science*, vol. 23, no. 6, pp. 1733–1747.

Hunt, F., Mitchell, R., Phaal, R. and Probert, D. (2004) 'Early valuation of technology: real options, hybrid models and beyond', *Journal of the Society of Instrument and Control Engineers*, vol. 43, no. 10, pp. 730–735.

Jensen, P., Hamon, E. and Olofsson, T. (2006) 'Product Development Through Lean', *Automotive Design Production*, vol. 118, pp. 465–474.

Kahneman, D. (2011) *Thinking, Fast and Slow*, 1st (ed), London, Penguin Group.

Karakaya, F. and Kobu, B. (1994) 'New product development process: An investigation of success and failure in high-technology and non-high-technology firms', *Journal of Business Venturing*, vol. 9, no. 1, pp. 49–66.

Karlström, D. and Runeson, P. (2005) 'Combining Agile methods with stage-gate project management', *IEEE Software*, vol. 22, no. 3, pp. 43–49.

Kirzner, I. M. (1997) 'Entrepreneurial Discovery and the Competitive Market Process : An Austrian Approach', *Journal of Economic Literature*, vol. XXXV, no. March, pp. 60–85.

Kodukula, P. and Papudesu, C. (2006) *Project Valuation Using Real Options: A Practitioner's Guide*, 3rd ed. Florida, J. Ross Publishing.

Lambkin, M. and Day, G. (1989) 'Evolutionary processes in competitive markets: Beyond the product life cycle', *Journal of Marketing*, vol. 53, no. 3, pp. 4–20.

Lawrence, E. R., Geppert, J. and Prakash, A. J. (2007) 'Asset pricing models: A comparison', *Applied Financial Economics*, vol. 17, no. 11, pp. 933–940.
Levers, M.-J. D. (2013) 'Philosophical paradigms, grounded theory, and perspectives on emergence', *SAGE Open*, vol. 3, no. 4, pp. 1–6.
Lieberman, M. B. and Montgomery, D. B. (1988) 'First-mover advantages', *Strategic Management Journal*, vol. 9, no. 1 S, pp. 41–58.
Luehrman, T. A. (1998) 'Investment Opportunities as Real Options: Getting Started on the Real Numbers', *Harvard Business Review*, vol. 76, no. 4, pp. 97–105.
Macmillan, I. C., Siegel, R. and Narasimha, P. N. S. (1985) 'Criteria used by venture capitalists to evaluate new venture proposals', *Journal of Business Venturing*, vol. 1, no. 1, pp. 119–128.
Mitchell, R., Phaal, R. and Athanassopoulou, N. (2014) 'Scoring Methods for Prioritizing and Selecting Innovation Projects', *Proceedings of the Portland International Conference on Management of Engineering and Technology*, pp. 27–31.
Moogk, D. R. (2012) 'Minimum Viable Product and the Importance of Experimentation in Technology Startups', *Technology Innovation Management Review*, vol. 2, no. 3, pp. 23–26.
Osterwalder, A. and Pigneur, Y. (2010) *Business Model Generation, A Handbook for Visionaries, Game Changers, and Challengers*, 1st ed, New Jersey, John Wiley & Sons.
Pastor, L. (2000) 'Portfolio Selection and Asset Pricing Models', *The Journal of Finance*, vol. 55, no. 1, pp. 179–224.
Perlitz, ManfredPeske, T. (1999) 'Real options valuation: The new frontier in R&D project evaluation?', *R&D Management*, vol. 29, no. 3, p. 255.
Pfeffer, J. (2010) 'Evidence-Based Management for Entrepreneurial Environments: Faster and Better Decisions with Less Risk', *SSRN Electronic Journal*, pp. 1–24.
Pfeffer, J. and Sutton, R. I. (2006) 'Evidence-Based Management', *Harvard Business Review*, vol. 84, no. 1, pp. 1–12.
Phaal, R. (2004) 'Technology roadmapping - A planning framework for evolution and revolution', *Technological Forecasting and Social Change*, vol. 71, no. 1–2, pp. 5–26.
Phaal, R., Kerr, C., Ilevbare, I., Farrukh, C. J. P., Routley, M. and Athanassopolou, N. (2015) 'Self-facilitating templates for technology and innovation strategy', *R&D Management Conference*, pp. 23–26.
Pielke, R. A. J., Sarewitz, D. and Radford, B. J. (2000) 'Decision Making and the Future of Nature: Understanding and Using Predictions', 1st ed. *Science, decision making, and*

the future of nature, Washington, Island Press, pp. 361–387.

Porter, M. E. (1985) *Competitive Advantage: Creating and Sustaining Superior Performance*, 1st ed. New York, Free Press.

Ralph, N., Birks, M. and Chapman, Y. (2015) 'The Methodological Dynamism of Grounded Theory', *International Journal of Qualitative Methods*, vol. 14, no. 4, pp. 1–6.

Reay, T., Berta, W. and Kohn, M. K. (2009) 'What's the Evidence on Evidence-Based Management?', *Academy of Management Perspectives*, vol. 23, no. 4, pp. 5–18.

Ries, E. (2011) *The Lean Startup*, 1st ed. London, Portfolio Penguin.

Roure, J. B. and Maidique, M. A. (1986) 'Linking prefunding factors and high-technology venture success: An exploratory study', *Journal of Business Venturing*, vol. 1, no. 3, pp. 295–306.

Roure, J. and Keeley, R. (1990) 'Predictors of Success in New Technology Based Ventures', *Journal of Business Venturing*, vol. 5, no. 4, pp. 201–220.

Rousseau, D. M. (2006) 'Is there such a thing as "evidence-based management"?', *Academy of Management Review*, vol. 31, no. 2, pp. 256–269.

Runge, W. (2014) *Technology Entrepreneurship A Treatise on Entrepreneurs and Entrepreneurship for and in Technology Ventures*, 1st ed. Karlsruhe, Karlsruhe Scientific Publishing.

Sackett, D. L., Rosenberg, W. M. C., Gray, J. a M., Haynes, R. B. and Richardson, W. S. (1996) 'Evidence based medicine: what it is and what it isn't', *British medical journal*, vol. 312, no. 7023, pp. 71–72.

Sandberg, W. R. and Hofer, C. W. (1987) 'Improving new venture performance: The role of strategy, industry structure, and the entrepreneur', *Journal of Business Venturing*, vol. 2, no. 1, pp. 5–28.

Schade, C. and Koellinger, P. (2007) 'Heuristics, biases, and the behavior of entrepreneurs', 1st ed. *in Entrepreneurship: The engine of growth*, London, Praegre, pp. 41–63.

Schmalensee, R. (1982) 'Product Differentiation Advantages of Pioneering Brands', *American Economic Review*, vol. 72. No. 3, pp. 349-365.

Schumpeter, J. (1934) *The Theory of Economic Development*, Cambridge, MA, Hardward University Press.

Shane, S. (2012) 'Delivering on the Promise of Entrepreneurship As a Field of Research', *Academy of Management Review*, vol. 37, no. 1, pp. 10–20.

Shane, S. and Venkataraman, S. (2000) 'The Promise of Entrepreneurship as a Field of Research', *The Academy of Management Review*, vol. 25, no. 1, pp. 217–226.

Shepherd, D. A. (1999) 'Venture Capitalists' Assessment of New Venture Survival', *Management Science*, vol. 45, no. 5, pp. 621–632.

Shepherd, D. A., Williams, T. A. and Patzelt, H. (2015) 'Thinking About Entrepreneurial Decision Making: Review and Research Agenda', *Journal of Management*, vol. 41, no. 1, pp. 11–46.

Siggelkow, N. (2007) 'Persuasion with case studies', *Academy of Management Journal*, vol. 50, no. 1, pp. 20–24.

Slater, S. F. (1993) 'Competing in high-velocity markets', *Industrial Marketing Management*, vol. 22, no. 4, pp. 255–263.

Stangler, D. (2017) 'Entrepreneurship at Home and Abroad', *The Washington Monthly*, vol. 49, no. 1/2, pp. 60–61.

Stanovich, K. E. and West, R. F. (2000) 'Individual differences in reasoning: Implicaitons for the rationality debate?', *Behavioral and Brain Sciences*, vol. 23, no. 5, pp. 645-65; discussion 665-726.

Stare, A. (2014) 'Agile Project Management in Product Development Projects', *Social and Behavioral Sciences*, vol. 119, pp. 295–304

Strauss, A. and Corbin, J. (1994) 'Grounded theory methodology', *Handbook of qualitative research*, New York, Sage Publications.

Stuart, R. and Abetti, P. A. (1987) 'Start-up ventures: Towards the prediction of initial success', *Journal of Business Venturing*, vol. 2, no. 3, pp. 215–230.

Suddaby, R. (2006) 'What grounded theory is not', *Academy of Management Journal*, vol. 49, no. 4, pp. 633–642.

Toulmin, S. E. (2003) *The uses of argument*, 1st ed. Cambrige, Cambridge University Press.

Tran, T. A. and Daim, T. (2008) 'A taxonomic review of methods and tools applied in technology assessment', *Technological Forecasting and Social Change*, vol. 75, no. 9, pp. 1396–1405.

Tyebjee, T. T. and Bruno, A. A. V (1984) 'A Model of Venture Capitalist Investment Activity', *Management Science*, vol. 30, no. 9, pp. 1051–1066.

Ven, A. H. Van de, Hudson, R. and Schoroeder, D. M. (1984) 'Designing new business start ups: Entrepreneurial, organizational, and ecological considerations.', *Journal of Management*, vol. 10, no. 1, pp. 87–107.

Venkataraman, S. (1997) ‘The Distinctive Domain of Entrepreneurship Research’, *Advances in Entrepreneurship, Firm Emergence and Growth*, vol. 3, no. October, pp. 119–138.

Whetten, D. a. (1989) ‘What Constitutes a Theoretical Contribution?’, *Academy of Management Review*, vol. 14, no. 4, pp. 490–495.

Williams, J. B. (1938) *The Theory of Investment Value*, 1st ed. Cambridge, Hardward University Press.

Willyard, C. H. and McClees, C. W. (1987) ‘Motorola’s technology roadmapping process’, *Research Technology Management*, vol. Seept.-Oct, pp. 13–19.

Yin, R. K. (1981) ‘The Case Study as a Serious Research Strategy’, *Science Communication*, vol. 3, no. 1, pp. 97–114.

Yin, R. K. (2013) *Case Study Research: Design and Methods*, 5th ed. New York, SAGE Publications.

York, J. L. and Danes, J. E. (2014) ‘Customer Ddevelopment, Innovation, and Decision-making Biases in the Lean Startup’, *Journal of Small Business Strategy*, vol. 24, no. 2, pp. 21–39.

Appendices

Appendix I A Glossary of Key Concepts and Terms

Concept/Term	Definition in This Research
Technology-based firms	Firms for which technology is of strategic importance throughout its development, requiring an emphasis on technology strategy and improvement of technology capability as the firm grows.
Technology ventures	Newly established technology-based firms
Technology entrepreneurs	Entrepreneurs in technology ventures
Early stage	The period from the time a business idea emerges to the point in time when the company's sales revenue breaks even its accumulated costs.
Waste	The difference between the minimal amount of resources entrepreneurs have to invest to validate or disprove a business idea and the actual amount of resources spent by entrepreneurs to validate or disprove the idea.
High quality decisions	Decisions that lead to low waste
Assessment	The base of decision-making, consists of decision-related questions
Effective assessment	Assessment that leads to high quality decisions
Key questions	Decision-related question that entrepreneurs consider important for certain decisions.
Effective judgements	Judgements that do not cause low quality decisions
Product defined	The design of the product is complete without further changes.
Market entry decision made	The entrepreneur evaluates the business opportunity as attractive and decides to develop a sustainable business around it.
t_0	The time a business idea emerges
R_0	The minimal amount of resources entrepreneurs have to invest to validate or disprove a business idea
R	The actual amount of resources spent by entrepreneurs to validate or disprove the idea
c_t	The level of confidence entrepreneurs had about the result of a question at the time of conducting the assessment
C_t	The level of confidence entrepreneurs should have about the result of a question at the time of conducting the assessment

Appendix II An illustration of Coding Process from Raw Interview data to Concepts

Extract from Interview Transcript	Concepts Identified for Framework Development
"In 2014, I did an internship at electricity dispatch department at Company P, an operator of the power system in China. The power system can get sick, so we need people to take care of them. With the expansion and upgrade of China's power system, the infrastructure system become very complicated, which makes human-based inspection very difficult and inefficient.	Evidence that indicates an emerging problem
The company realised this problem and had tried several intelligent monitor systems on their power system, but none of them was considered satisfactory – they were heavy and required frequent recharging. This was mainly because of the battery technology was still under development. I saw the problem during my internship and started thinking about if I would be able to provide a solution.	Evidence that indicates market need Evidence of the technology capability of competitors Question 1 identified: will I be able to provide a solution?
The Wireless sensor network (WSN) system is very complicated. You need a sensing system to collect data. For the sensing system, you need communication, computation and sensing components. These are all electronics. You need a very solid mechanical structure for the sensing system, and also you need reliable energy sources. You also need a good wireless communication method to send data back with low power consumption. Given all the data, you need a machine learning technology to analyse massive amount of data to tell you what type of fault it is and where it comes from.	The required technology capabilities for developing WSN system;
I study electronics and I knew good engineers in materials, electronics, mechanics and machine learning. I assessed the technology as difficult, but not unachievable. If I could build a team and spend one year or two years on the technology, I believed we could work it out.	Evidence employed for Question 1; Answer to Question 1
I did a survey with some managers at Company P, asking their requirement on intelligent monitoring system and willingness to buy. They said they require the system to be reliable under extreme weather conditions, compact and light, easy to deploy and maintain and of course intelligent to enable self-diagnostic. They emphasised that the system had to have relatively long battery life so that there was no need to change and recharge batteries frequently. They expressed that they were keen to find a reliable intelligent monitoring system and were not price sensitive as long as the system could meet their requirements. The managers also indicated that there would be a trend to replace human-based inspection with intelligent systems, as long as the technology got mature. The market of WSN system would be enormous.	Customer requirement on WSN Evidence that indicates market needs Evidence that indicates market potential
…"	…