THE UNIVERSITY OF HULL

Opening Up the Fuzzy Front-End Phase of Service Innovation

being a Thesis submitted for the Degree of

Doctor of Philosophy

in the University of Hull

by

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April 2015

Acknowledgement

First of all, I am heartily thankful to both of my supervisors, Prof Richard Vidgen and Dr Thanos Papadopoulos, whose guidance, support and encouragement have been invaluable. Working with them has been a great experience in my academic life and will benefit me forever.

My study was made possible by funding from the Ministry of Science and Technology of Thailand and King Mongkut's Institute of Technology Ladkrabang (KMITL). I would like to give my special thanks to Associate Professor Nopporn Chotikakamthorn for his support and guidance. Also, I am very much indebted to the staff of the Office of Educational Affairs, the Royal Thai Embassy for their support, advice and encouragement.

I am indebted to many of my colleagues who have directly or indirectly helped and supported me throughout the duration of my doctoral studies.

I owe my deepest gratitude to my family and friends who have been listening to me sharing happiness and sadness.

Last, but not the least, my special acknowledgement goes to my understanding wife, Dungduan Kasemsuk, who gave me the will power, inspiration, and unconditional loves; without her this journal would have not have been possible.

Abstract

The "fuzzy front-end" (FFE) of innovation begins when an opportunity is first considered worthy of further ideation, exploration, and assessment and ends when a firm decides to invest in or to terminate the idea (Khurana & Rosenthal, 1998). Since such an early phase is often characterised as being highly uncertain and unstructured, scholars have suggested that uncertainty must be reduced as much as possible during the FFE to achieve success in innovation (Frishammar et al., 2011; Moenaert et al., 1995; Verworn, 2009; Verworn et al., 2008). Although openness has been proposed as crucial to innovation success (Chesbrough, 2003; Chesbrough et al., 2006), little effort has been put into studying its role in reducing uncertainty in the FFE of service innovation. To address this gap, the current study aims to examine the effect of "openness competence" within the FFE – i.e., the ability of a FFE team to explore, gather and assimilate operant resources from external sources by means of external searches and inter-organisational partnerships – on the success of service innovation. It will also identify the key dimensions of openness competence.

This mixed methods study is comprised of two main phases. In the first phase, we interviewed 12 informants who participated in the FFE of 6 distinctive online service innovations. The data were analysed through a services-dominant (S-D) logic analytical lens. The case findings together with the extant literature were used to develop a formative second-order construct of openness competence, and to form a series of hypotheses concerning an "open service innovation" (OSI) model. In the second phase, a total of 122 valid survey responses were collected and analysed using a partial least square structural equation modelling (PLS-SEM) technique with the aim of validating the proposed OSI model.

The key findings of this study include the four dimensions of openness competence within the FFE, namely: searching capability, coordination capability, collective mind and absorptive capacity. A FFE team's IT capability was identified as an antecedent of openness competence. Further, we found that openness competence is positively associated with the amount of market and technical uncertainty being reduced during the FFE. Contrary to our expectations, the impact of openness competence on service innovation success is direct, rather than being mediated by the degree of uncertainty reduction. These findings offer several implications for research on open innovation and on the FFE. Additionally, by identifying the key dimensions of openness competence, the current study provides guidance to front-end managers as well as presenting new areas for future research.

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1. Introduction

1.1. Background of the Study – The FFE of Service Innovation

For the past few decades, particularly in western countries, the economic contributions from the service sector have surpassed those from the manufacturing sector. According to Ostrom et al. (2010), services generate more than 70% of the gross domestic product (GDP) of many of the world's most advanced economies. Similar trends have also been found in emerging Asian economies (Noland et al., 2012). In recent years, innovation in services has attracted much attention from academics and practitioners alike (Alam, 2006a). The literature on service innovation has highlighted the importance of the performance of activities in the early stages, or the "fuzzy front-end" (FFE), of innovation to service innovation success (Alam, 2006a; Magnusson, 2009).

In general, the FFE phase begins when an opportunity is first considered worthy of further ideation, exploration, and assessment and ends when a firm decides to invest in or to terminate the idea (Khurana & Rosenthal, 1998). The FFE of innovation is critical for two reasons. First, the success or failure of an innovation project often depends on a well-defined product/service concept, which is one of the main outcomes of the FFE phase (Khurana & Rosenthal, 1998; Verworn et al., 2008; Zhang & Doll, 2001). Second, FFE activities have the largest potential for improvements with the least amount effort, in comparison with activities in the later phases of innovation (Reid & De Brentani, 2004). In other words, the proficiency of the FFE phase contributes more to successful innovation than the proficiency of the project execution phase (Koen et al., 2001).

The FFE has traditionally been characterised as being unstructured, and often involves high levels of market and/or technological uncertainty (Khurana & Rosenthal, 1997; 1998). Scholars who have taken an information-processing view (Galbraith, 1974) argue that uncertainty must be reduced as much as possible in the FFE (Frishammar et al., 2011; Lievens & Moenaert, 2000; Moenaert et al., 1995; Verworn, 2009; Verworn et al., 2008). Therefore, one of the main issues for front-end managers may be whether their development team has the ability to systematically reduce front-end fuzziness, or whether they simply leave it to be managed by chance.

Successful front-end processes are those that have effective uncertainty reduction mechanisms in place (Frishammar et al., 2011). The literature has suggested two uncertainty reduction mechanisms: to acquire and assimilate information and knowledge from sources external to the firm's boundary (Muller & Zenker, 2001; Zahay et al., 2004), and to co-develop with customers and innovation partners (Alam, 2006a; Kim & Wilemon, 2002). The ability to integrate complementary resources and competences between organisations enhances competitive advantage through innovation (Lusch et al., 2007). This is consistent with the concept of "inbound open innovation", suggesting that firms can and should use external ideas (as well as internal ideas) to enhance their competitive advantage through innovation (Chesbrough et al., 2006). Open innovation proponents indicate that the exploration and acquisition of external knowledge, as well as cooperation with external partners allow firms to lower their R&D costs, increase their innovation productivity and newness, and reduce time to market (Chesbrough, 2003; Enkel et al., 2009; Huizingh, 2011).

1.2. Statement of the Problem

Although innovation in services has emerged as a strategic imperative for not only service but also manufacturing firms (Chesbrough, 2011), research on service innovation is relatively recent and under-represented in comparison to the literature on technological innovation within manufacturing (Drejer, 2004; Nijssen et al., 2006). In fact, until the early 1990s, innovation in the service sector was largely neglected (Pires et al., 2008).

Furthermore, although innovation in services has been regarded as important to economic growth in both advanced and emerging economies, service innovation in emerging Asian economies attracts considerably less attention from scholars (Thakur & Hale, 2013). According to a study by Uchupalanan (2000), the application of models and frameworks of service innovation formed in more economically developed countries is limited in less advanced economies.

Despite the growing body of service-related research, the majority of the literature on innovation in services to date has either reduced it to the adoption and use of information and communication technologies (ICTs) (Gallouj & Savona, 2009), or treated services as merely a special type of product (i.e., intangible, heterogeneous, inseparable and perishable products) (Drejer, 2004; Lovelock & Gummesson, 2004). However, these two approaches have been substantially criticised in the recent years (Gallouj & Savona, 2009; Lovelock & Gummesson, 2004). As the boundaries between goods and services become more blurred, an integrative approach has been suggested as being more promising in terms of theoretical advancement (Gallouj & Savona, 2009; Vargo & Lusch, 2004).

A review of the literature demonstrates the importance of the reduction of uncertainty in the early stages of the innovation process to innovation success (Frishammar et al., 2011; Lievens & Moenaert, 2000; Moenaert et al., 1995; Verworn, 2009; Verworn et al., 2008). However, the majority of prior attempts emphasises on the FFE phase of new product development (NPD) (e.g., de Brentani & Reid, 2012; Khurana & Rosenthal, 1997; 1998; Verworn, 2009; Verworn et al., 2008). Considerably fewer studies (e.g., Alam, 2006a; Magnusson, 2009; Ozer, 2007) have addressed the issue in a service context.

Even though proponents of open innovation have been promoting a more open approach to innovation (Chesbrough & Crowther, 2006; Chesbrough, 2003; Chesbrough et al., 2006; Laursen & Salter, 2006; Lichtenthaler, 2009b; Von Hippel & Von Krogh, 2006), there are several disadvantages of opening up the innovation process, such as a loss of knowledge, high coordination costs, (Enkel et al., 2009) and the disclosure of a corporate crown jewel (Rivette & Kline, 2000). Several empirical studies have even found negative impacts of openness on innovation performance (e.g., Knudsen & Mortensen, 2011; Mention, 2011). One explanation for the conflicting results could be that prior research has studied the innovation process as a whole instead of separating it into distinctive phases. The current study argues that the strategic use of openness in the FFE might have more impact than in the later stages of the innovation process.

To our knowledge, apart from a few exceptions (e.g., Alam, 2006a; Magnusson, 2009), empirical studies that have focused on opening up the FFE phase are yet limited. We are not aware of research that has taken a services-dominant (S-D) logic integrative approach to examine openness competence within the FFE, or that has considered the impact of openness on service innovation success through front-end uncertainty reduction. In addition, due to the lack of attention on service innovation in a less economically developed context, research that applies the current knowledge generated in more advanced countries to a developing country (e.g., Thailand) could prove to be a fruitful one. To address these gaps, the current study focuses on *'openness competence'* within the FFE – i.e., the ability of a front-end team to explore, gather and assimilate operant resources from external sources by means of external knowledge searches and inter-organisational partnerships – and argues that it is critical that participants in the FFE should possess openness competence within the FFE in order to successfully execute open innovation activities in the early stages of service innovation. The effective execution of openness activities can lead to successful uncertainty reduction during the FFE, which in turn influences the overall performance of the innovation process.

1.3. Research Objectives and Questions

The current research addresses openness in the FFE phase of service innovation. The main objectives of this study are twofold. The first objective is to identify and verify the key dimensions of openness competence within the FFE of service innovation. The second objective is to address the impact of openness competence on service innovation success through early uncertainty reduction. The research questions below reflect these two objectives:

RQ1: What are the key dimensions of openness competence within the FFE of service innovation?

RQ2: Does openness competence within the FFE contribute to service innovation success?

RQ3: If yes, does openness competence contribute to service innovation success through the degree of market and technical uncertainty reduction during the FFE phase?

1.4. Research Context

The data collection for this study was undertaken in Thailand. Thailand is an emerging economy and is considered the second largest economy in the Association of Southeast Asian Nations (ASEAN) (ADB, 2015). The services sector plays a substantial part in the Thai economy, accounting for nearly half (i.e., 48.1%) of its national gross domestic product (GDP) (BOT, 2014). In terms of employment, Thailand's service sector has been the primary source of new job creation in recent years. While the employment share of services has continuously increased from around 20% in 1980 to around 40% in 2010 (Park & Shin, 2012), the service sector's share of GDP however has not changed much and has even decreased recently (see Figure 1.1). This trend implies that there are still opportunities for further enhancements in the service sector, which should be exploited in order to move Thai economy forward. An investigation into how to improve the innovation process in Thai service firms could therefore make a significant contribution towards this matter.

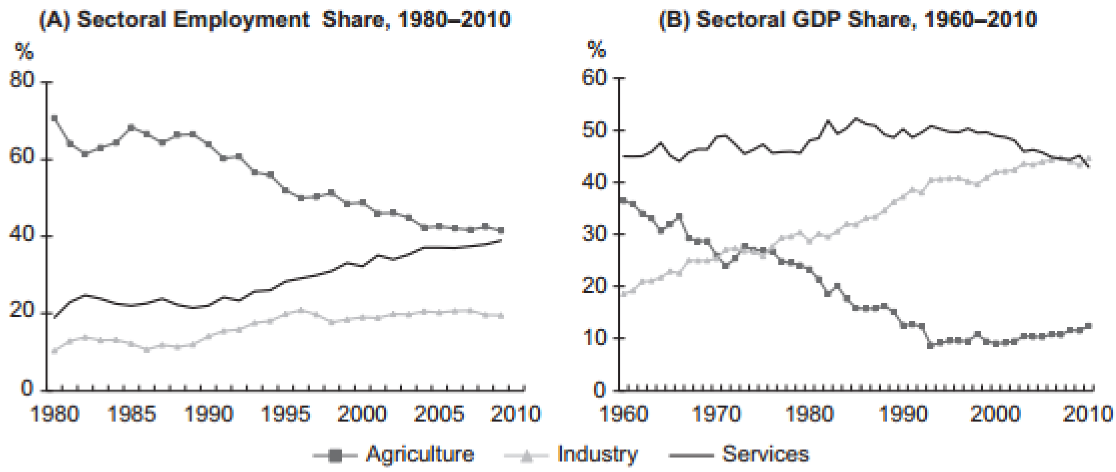

Figure 1.1: Employment and GDP shares of Thailand's service sector (source: Park and Shin (2012))

1.5. Overview of Methodology

In the present study, the researcher holds the philosophical worldview of pragmatism. This is because, rather than being concerned with choosing between qualitative and quantitative methods, pragmatism emphasises the practicality of the research findings and research problems, and the use of all tools available to inform the problem of interest (Creswell & Plano Clark, 2011). Consequently, we implemented a sequential exploratory design study with two main data collection and analysis phases. To address the first research question (RQ1), an inductive multiple case study was performed. The case study involved a total of 6 distinctive online service innovation projects aiming to market in Thailand. The intention was to unearth key dimensions of the FFE teams' openness competence and to explore how openness competence contributes to innovation success. In the second inductive phase, we conducted a confirmatory large-scale survey aiming to answer the other two research questions (RQ2 and RQ3). Self-administered questionnaires were used to gather the information from project managers in Thai IT service providers. A second-generation multivariate technique called "partial least square structural equation modelling" (PLS-SEM) (Hair et al., 2014) was used to analyse the survey data. The main reason for collecting qualitative data in the first phase was that, to our knowledge, there were no existing instruments measuring openness competence within the FFE.

1.6. Expected Contributions

This research project studies the FFE phase of IT-based service innovation projects in Thai firms with an expectation of making several contributions to the literature:

- Firstly, the current research aims to make a contribution to service innovation literature by applying theories and frameworks developed in more advanced economies to a less economically developed context – i.e., Thailand. More specifically, knowledge about any similarities and differences that might be discovered from this study could be beneficial to the current body of knowledge.
- Secondly, the answer to the first research question (RQ1) is expected to make a contribution to the literature on open innovation (Chesbrough, 2003; Chesbrough et al., 2006) by identifying the core components of openness competence within the FFE. We also intend to verify the emergent components with quantitative data in order to enhance the generalisability of the findings.
- Finally, answering both RQ2 and RQ3 could benefit the literature on the FFE of innovation since it emphasises the impact of openness competence in the FFE on innovation performance. Specifically, we try to explain how an innovation team might be able to effectively reduce front-end fuzziness, which in turn influences project

success, by simply being more open to the outside early in the process. In addition, as the context of this research is in Thailand – i.e., an Asian developing country –, if the anticipated outcomes were to be found, they would provide empirical support for open innovation proponents' claims of the universality of the concept.

In terms of managerial practices, we aim to make contributions in two main areas.

- Firstly, the findings of this study will be of interest to managers in service organisations who want to compete more effectively in the marketplace through innovation. The expected findings would encourage managers to reduce the uncertainties associated with front-end activities through openness. Managers are recommended to nurture a collaborative culture among stakeholders in the FFE phase and encourage their team to search widely and broadly for new ideas.
- Secondly, identifying the core dimensions of openness competence within the FFE is expected to have crucial practical implications. By focusing managerial attention on the proposed dimensions, the successful promotion of both openness to ideas, knowledge and expertise lying outside of the firm as well as organisational learning and knowledge sharing within the firm could be achieved.

1.7. Outline of the Thesis

Following this introductory chapter, the second chapter reviews the literature on related topics (i.e., service innovation, the FFE, IT/IS development, the information-processing theory and open innovation). Based upon prior works pertaining to the themes covered in this study, an initial conceptual model, which helped to frame the current study, is demonstrated.

The third chapter explains the philosophical worldview that was adopted. The reasoning behind the decision to adopt a mixed methods design is also provided. This is followed by a brief description of design decisions regarding the data collection and analysis of the two phases of the present study.

The fourth chapter involves interview data gathered from the multiple case study of Thai online service innovation projects. The within-case analysis of all cases is presented first, then the cross-case analysis. Next, we discuss the findings which results in a total of 7 propositions and an initial “open service innovation” (OSI) model. The propositions and the model were the foundation of the research hypotheses formed in the fifth chapter.

In addition to hypothesis formation, the fifth chapter provides the measurement instruments employed to collect data in the second quantitative phase. All of the instruments were gathered from prior works in the relevant fields. Then, the descriptive data concerning key characteristics of the respondents are presented. Finally, we present the PLS-SEM analysis that leads to hypothesis testing results.

The sixth chapter summarises the key findings. These are discussed and compared with existing knowledge on the relevant topics.

The seventh chapter concludes the whole thesis. We try to answer the research questions and integrate the research objectives. Additionally, contributions to research, and implications for managers are offered. Finally, suggestions on both the limitations and directions for future research are provided.

2. Literature Review

2.1. Introduction

The main purpose of this thesis is to understand openness competence within the FFE phase of service innovation projects and to examine its impact on overall project success. Since the FFE often involves high levels of uncertainty, we propose that openness should be used to mitigate front-end uncertainty which, in turn influences innovation performance. Therefore, the present research prominently rests upon the foundations of four broad areas of study – service innovation, the FFE of innovation, IS development process, an information-processing theory and open innovation. In this chapter, prior works that have been done in each area and other areas relating to them are reviewed.

This chapter is organised as follows. When one tries to makes sense of the nature of service innovation, one should firstly understand the definition of the term “innovation” as well as its three dimensions often discussed in the literature (i.e., stages of innovation, level of analysis, and innovation typology). Service innovation is then brought into the picture; and its three main research streams (i.e., assimilation, demarcation, and synthesis) are described. After that, the literature on the FFE phase of innovation is reviewed focusing on its main characteristics and the reasons why such the FFE is considered important for successful innovation. Since the focus of this study is on the FFE of IT-based service innovation, we therefore include the literature on IS/IT development process. The next section involves key ideas of the information-processing view that we use to explain the relationship between openness within the FFE and service innovation success. Finally, we present the concept of open innovation and provide evidence of how openness can help reduce uncertainty early in the innovation process.

2.2. What is Innovation?

The word "innovation" can simply be defined as "a new idea, method or device" or "the process of introducing something new" (Gopalakrishnan & Damanpour, 1994, p. 95). Innovation researchers have investigated it from two perspectives (Crossan & Apaydin, 2010): as an outcome (Daft, 1978; Damanpour et al., 1989; Ettlie & Reza, 1992) or as a process (Cooper, 1993; Rogers, 1995; Rothwell, 1994). Researchers who take the outcome view focus on identifying the antecedents and consequences of the adoption of innovations, while the other group attempts to understand the process of innovation, i.e., how and why innovations are generated, developed, implemented and terminated over time (Wolfe, 1994).

The current study focuses on how openness can improve the FFE of service innovation; thus embracing the process view of innovation. Some researchers (e.g., Alam & Perry, 2002; Cooper, 1993) argue that stages in the innovation process occur in a linear sequence, while others (e.g., Kline, 1985; Rothwell, 1994) view innovation as a complex and messy process. While complex and non-linear innovation processes are useful for explaining irregularities, linear models theoretically offer a normative framework for understanding the process of innovation (Gopalakrishnan & Damanpour, 1994). The latter is also useful for identifying similar types of innovation processes as well as for comparison across innovation situations (Gopalakrishnan & Damanpour, 1994).

Diverse and numerous definitions of the term "innovation" exist in literature from different disciplines; this may be due to the fact that no single discipline can capture all aspects of innovation (Fagerberg, 2005). In addition, the lack of a clear and common definition of innovation is considered problematic in innovation literature (Baregheh et al., 2009; Crossan & Apaydin, 2010). A discussion of the selection of a definition of innovation that fits the context of this study is therefore essential.

2.2.1. Definitions of innovation

Before discussing the definition of innovation, the distinction between "invention" and "innovation" should be made. According to Fagerberg (2005, p. 4), invention is the occurrence of an idea for a new product or service, which can emerge anywhere (e.g., in universities, public labs, etc.); while innovation is the first attempt to commercialise it, which occurs mostly in firms. Moreover, in many cases, there is a considerable time lag before an invention becomes an innovation. This is due to the different requirements of generating an idea and adopting the idea (Damanpour & Wischnevsky, 2006). In order to turn an invention into an innovation, appropriate knowledge, capabilities, skills, resources, and complementary technologies must be in place (Fagerberg, 2005). In addition, various aspects of the invention, such as its necessity and sufficiency, its intentionality, its beneficial nature, its successful implementation and its diffusion, should be considered when transforming it from invention to innovation (Crossan & Apaydin, 2010, p. 1155).

To demonstrate the diversity of the definitions of innovation, we would like to quote several examples that focus on different aspects of innovation. West and Farr (1989 via Anderson and West, 1998, p.239) define innovation as:

> "The intentional introduction and application within a role, group or organization of ideas, processes, products or procedures, new to the relevant unit of adoption, designed to significantly benefit role performance, the group, the organization or the wider society."

This definition emphasises the outcome or adoption view. Alternatively, by focusing on the process of developing and commercialising new products or services, innovation can be defined as:

> "An iterative process initiated by the perception of new market and/or new service opportunity for a technology-based invention which leads to development, production,

> and marketing tasks striving for commercial success of the invention (OECD, 1991 via Garcia and Calantone, 2002, p. 112)."

Similarly, Baregheh and colleagues (2009, p. 1334) define innovation as:

> "The multi-stage process whereby organizations transform ideas into new/improved products, service or processes, in order to advance, compete and differentiate themselves successfully in their marketplace."

The last example aims to capture all important aspects of innovation, stating that:

> "Innovation is production or adoption, assimilation, and exploitation of a value-added novelty in economic and social spheres; renewal and enlargement of products, services, and markets; development of new methods of production; and establishment of new management systems" (Crossan & Apaydin, 2010, p. 1155).

In the current study, the second definition (i.e., the OECD's definition) is recognised as most suitable for two reasons. Firstly, the OECD's definition of innovation not only incorporates a process view but also includes the perspective of idea generation. Secondly, it highlights the transformation of a technology-based invention or an idea into a commercial success. These two aspects of the definition suit the main idea of this study which is to achieve commercial success of IT-based service innovations by opening up the FFE phase.

2.2.2. Dimensions of innovation

When one tries to deeply understand innovation, questions arise regarding three dimensions of innovation (Gopalakrishnan & Damanpour, 1997). These three dimensions are: stages of the innovation process, levels of analysis and types of innovations. This is similar to a study conducted by Camisón-Zornoza et al. (2004), which proposed a four-dimensions framework. Its first three dimensions are exactly the same as Gopalakrishnan and Damanpour's (1997) work. However, the additional aspect mainly involves the adoption of innovation in organisations, thus not in the interest of the current study. The three dimensions framework proposed by Gopalakrishnan and Damanpour (1997) is described below.

Stages of innovation

Stages within the unitary sequence models of the innovation process are different depending on whether the researcher views the focal organisation as an originator or an adopter of innovation (Gopalakrishnan & Damanpour, 1997). Although numerous models of the innovation process have been proposed, scholars tend to conceptualise the innovation process in general terms, including both innovation generation and adoption in their model (e.g., Angle & Van de Ven, 2000; Rogers, 1995). However, the processes of innovation generation and innovation adoption differ considerably. Therefore, it is essential to discuss which of the two innovation process views is embraced by the current study.

The creation of an idea and its commercialisation together encompass the innovation-generating process (Damanpour & Wischnevsky, 2006). Generation process researchers conceive innovation as a process of initiating and developing new products or services in organisations (e.g., Cooper, 1993; Gallouj & Weinstein, 1997). According to Gopalakrishnan and Damanpour (1997), the process of innovation creation generally involves five stages: (1) idea generation, (2) project definition, (3) problem-solving, (4) design and development, and (5) commercialisation. Specifically, the first three stages of the innovation generation process are characterised by activities that lead to an invention through information about customers' needs (need-pull) and/or the presence of complementary technologies (technology-push) (Zmud, 1984). The last two stages emphasize the development and commercial exploitation of the product or process, after its economic feasibility has been established (Gopalakrishnan & Damanpour, 1997). In a more parsimonious way, Koen et al. (2001) divided the entire innovation process into three main stages, namely (1) front-end of innovation, (2) new product and process development, (3) and commercialisation. For a more practical model, Cooper's (2001) Stage-Gate system (designed for major product developments) consists of five main stages: (1) scoping, (2) building a business case, (3) development, (4) testing and validating, and (5) launch. The core elements of the Stage-Gate system are the stages, where "the project team undertakes the work, obtains the needed information, and does the subsequent data integration and analysis," and the gates, where "go/kill decisions are made" (Cooper, 2008, p. 214).

In general, the adoption of innovation aims to improve the organisation's effectiveness and competitiveness by introducing a new product, service or process to the adopting firm. This process generally causes organisational changes, for instance, in operators' skills, organisational structure or culture (Damanpour & Wischnevsky, 2006). The process of innovation adoption typically consists of two main phases: initiation and implementation (Damanpour & Wischnevsky, 2006). The initiation stage has three sub-stages: (1) awareness of an innovation, (2) formation of an attitude towards it, and (3) its evaluation from an organisational standpoint. The decision to adopt marks the beginning of the implementation stage, which includes two sub-stages: (4) trial implementation and (5) sustained implementation. Alternatively, by reviewing the literature on organisational innovation, Wolfe (1994, p. 411) proposed a general pattern of innovation adoption comprising of nine stages: a decision-making unit becomes (1) 'aware' of an innovation's existence, a problem or opportunity is then (2) 'matched' to the innovation, the innovation's costs and benefits are (3) 'appraised', sources of support and/or opposition attempt to (4) 'influence' the adoption process, a decision is made to (5) 'adopt (or reject)' the innovation, the innovation is (6) 'implemented', the innovation decision is reviewed and (7) ‘confirmed (or reversed)’, the innovation becomes accepted as (8) ‘routine’, and the innovation is (9) ‘infused’, i.e. is applied to its full potential. The final two stages of both models tend to be the most important ones, since their outcomes (i.e., the extent of the integration of the innovation into the organisation and its contribution to organisational behaviour and performance respectively) can influence the success of the overall adoption process (Gopalakrishnan & Damanpour, 1997).

In sum, the process of innovation in the literature can be classified into two categories: the innovation generation process and the innovation adoption process. The former consists of three main stages: front-end or predevelopment, development, and commercialisation, while the latter has two main phases: initiation and implementation.

Levels of analysis

In the fields of economics, organisational sociology and technology management, scholars have conceptually and empirically investigated innovation across four levels of analysis: industry, organisation, organisational subunit, and the innovation itself (Gopalakrishnan & Damanpour, 1997).

Researchers study innovation by using either inter-industry approaches or intra-industry approaches (Camisón-Zornoza et al., 2004; Gopalakrishnan & Damanpour, 1997). The former involves identifying factors that distinguish innovation development patterns and innovation magnitude across industries. These patterns and magnitude are dependent on both technological factors (e.g., technological appropriability and technological opportunity) and industry-related factors (e.g., industry expenditure on R&D and the stages of the industry life-cycle). The latter focuses on the relative differences in the timing of adoption of an innovation across organisations within an industry, as well as the innovation's implications for organisational performance (Gopalakrishnan & Damanpour, 1997).

At an organisational level, the literature in the field of organisational innovation generally takes either an outcome approach or a process approach (Gopalakrishnan & Damanpour, 1997). On the one hand, researchers taking the outcome view attempt to juxtapose innovative and non-innovative organisations regarding their contextual, structural and behavioural characteristics in order to explain organizational innovativeness (generally being operationalised based on the number of innovations adopted by an organisation) (Gopalakrishnan & Damanpour, 1997). Prior literature review works identified numerous determinants of organisational innovativeness, such as functional differentiation, formalization, centralization, managerial attitude, slack resources, external communications, internal communications (Damanpour, 1991), structural complexity, organisational size (Camisón-Zornoza et al., 2004; Damanpour, 1996) organisational structure, strategy, and organisational learning (Lam, 2005). However, this approach has been criticised for its ignorance of changes that might happen during the innovation process and its focus on adoption decisions, rather than implementation (Wolfe, 1994). On the other hand, studies taking the process view helped to discern the processes and stages central to the new product/service development process in organisations (Gopalakrishnan & Damanpour, 1997). Based on a recent review of the literature, Crossan and Apaydin (2010) identified five core business processes that support innovation in organisations. They are: (1) initiation and concept generation, (2) portfolio management, (3) development and implementation, (4) project management, and (5) marketing and commercialisation.

Two main research streams can be identified at an organisational subunit level of (Gopalakrishnan & Damanpour, 1997). The first group of studies seeks to discover factors affecting innovation within R&D units including intra-project and departmental communication (Thamhain & Wilemon, 1987), tenure of R&D groups (Katz & Allen, 1982) and diversity of R&D groups (Gordon et al., 1991); while the other group focuses on analysing the interactions between R&D and other departments, such as marketing and manufacturing (Ettlie & Reza, 1992; Moenaert et al., 1995). Specifically, the latter group seeks to identify factors that either facilitate or hinder cross-functional cooperation in innovation as well as successful innovation adoption. Those factors are, for example, the performance and cost effectiveness of the adopting innovation, compatibility with the requirements and skills, and user involvement in the development process (Leonard-Barton & Sinha, 1993). Further, concerning innovation creation, several factors, such as, project formalisation, project centralisation, and communication between R&D and marketing departments (Moenaert et al., 1995), have been found to be significant.

At an innovation level of analysis, innovation adoption studies, focusing on the innovation itself, concentrate on innovation characteristics, such as type, relative advantage, complexity and newness. These characteristics affect either the rate of diffusion of the innovation within an industry or the extent of its use within an organisation (Gopalakrishnan & Damanpour, 1997). They can be divided into two categories: primary and secondary (Gopalakrishnan & Damanpour, 1997). Primary characteristics, such as innovation type (e.g., product and process), do not vary regarding an organisation’s or an industry’s perceptions of them, while secondary characteristics, such as cost or relative advantage, do. In terms of innovation generation, the extant literature has similarly addressed the process of developing new products or services at micro levels (Menor et al., 2002), such as, the overall innovation portfolio (Gann & Salter, 2000), particular types of innovations (Lamastra, 2009), a given product line, or an individual innovation project (Cooper & Kleinschmidt, 1994; Ebner et al., 2009). Different types of innovations (i.e., products versus services) are often assumed to have different antecedents. For example, while formal strategies and structures are needed when producing new products, new service development (NSD) uses a short beta testing process and exploits general manager ideas as an alternative to a formal innovation process (Ettlie & Rosenthal, 2011).

Types of innovations

Reviews of prior studies that examine the determinants, processes, and consequences of innovation in organisations continually observe inconsistent results (Downs & Mohr, 1976; Wolfe, 1994). To address this problem, researchers have developed contingency theories of different innovation types (Damanpour & Wischnevsky, 2006). Nevertheless, there is a disagreement on whether the determinants, processes and consequences of different types of innovation (i.e., product versus process or incremental versus radical) differ. While some studies empirically reported significant differences between innovation types (Daft, 1978; Damanpour & Gopalakrishnan, 2001), the results of a meta-analysis study conducted by Damanpour (1991) showed that relationships between organisational factors and organisational innovativeness are not distinguished significantly by the types of innovation. Therefore, it might be fruitful to look into the contingency theory of innovation types. Two frequently employed typologies are discussed below.

The first typology is product versus process innovations. Product innovations are new products or services introduced to meet an external user or market need (Damanpour, 1991). Process innovations can be defined as new elements introduced into an organisation's production or service operations – input materials, task specifications, work and information flow mechanisms, and the equipment used to produce a product or render a service (Damanpour, 1991). While product innovations have a market focus and are primarily customer-driven, process innovations have an internal focus and aim to increase efficiency and effectiveness of the existing organisational processes in order to facilitate the production and delivery of goods or services to the customers (Damanpour &

Gopalakrishnan, 2001; Damanpour et al., 2009; Utterback & Abernathy, 1975). Meeus and Edquist (2006) categorised four main types of innovations: product innovations (Cooper & Kleinschmidt, 1994; Johne & Snelson, 1988), service innovations (Gallouj & Weinstein, 1997; Menor et al., 2002), technological process innovations (which are new ways of producing products or delivering services to the customer, or new elements added to the existing production lines or service operations) (Ettlie & Reza, 1992; Silvestro et al., 1992), and administrative process innovations (which are new management practices, processes, structures, or techniques that are intended to further organisational goals) (Birkinshaw et al., 2008).

The second typology of innovation is also well-known and widely used by scholars. It concerns the degree of newness or innovativeness of an innovation to the market, or of the technology being used. Scholars have identified that innovations with a higher degree of newness require unique front-end processes (Reid & De Brentani, 2004), more formal innovation management practices (Oke, 2007), and different organisational capabilities (Chang et al., 2012). Furthermore, product/service newness has also been linked to innovation success (Kleinschmidt & Cooper, 1991; Oke, 2007; Therrien et al., 2011). However, there is still inconsistency as to how the literature defines the concept of innovation newness, which has significantly hindered academic advancements in terms of choosing innovation processes that are suitable for innovations with different degrees of newness (Garcia & Calantone, 2002). Garcia and Calantone (2002) proposed an interesting classification criteria for innovation newness.

Garcia and Calantone's (2002) classification schema is based on a combination of two levels of analysis (macro/micro perspective) and two types of discontinuities (marketing/technological discontinuities) caused by the innovation. From a macro perspective, innovativeness is measured based on how an innovation is new to the world, the market, or an industry. On the other hand, when looking from a micro perspective, how new of an innovation to the firm or to the firm's customers must be concerned. A new product (service or process) may require a new marketplace, a new customer group, and/or new marketing capabilities of the firm (i.e., marketing discontinuities). In a similar vein, an innovation may require a paradigm shift in the state of the science, new R&D resources, and/or a new production process of the firm (i.e., technological discontinuities).

According to Garcia and Calantone (2002), "radical innovations" can be defined as innovations that incorporate a new technology, which results in a new market infrastructure. Moreover, the introduction of a radical innovation provokes discontinuities on both macro and micro levels. This is due to the assumption that radical innovations create a new demand previously unrecognized. This new demand then cultivates new industries, new competitors, new distribution channels and new marketing activities. "Incremental innovations" are those products (services or processes) that provide new features, benefits or improvements to the existing technology in the existing market (Garcia & Calantone, 2002). Specifically, on a firm level, an incremental innovation refines as well as enhances existing products, services, or production and delivery processes. However, on a macro level, incremental innovations result in neither technology nor market discontinuity. The majority of innovations lying between radical and incremental ones is the moderately innovative class of innovations called "really new innovations" (Garcia & Calantone, 2002). On a macro level, this type of innovation newness either causes technology or market discontinuity. On a micro level, marketing or technological discontinuity, or both of them, occurs in the innovating firm. For example, really new innovations could be a product line extension incorporating a new technology or a new service product using an existing technology that is familiar to the firm.

To put the three core dimensions of innovation into perspective, concerning the first dimension, the current study adopts the innovation generation process view due to its research objectives, which are concerned with improving the FFE phase of the creation process of new service offerings through openness. Furthermore, the level of analysis of the current study is at the project level. We intend to investigate the impact of a front-end team's ability to be more open (i.e., openness competence) on the degree of uncertainty reduction, which may in turn affect the overall success of the service innovation. Regarding innovation typology, the main interest of this research is in the development of new services, IT-based services in particular, rather than in the process of new product or process innovation. The next section therefore presents the current knowledge about innovation in services.

2.3. Innovation in Services

In earlier reviews (e.g., Drejer, 2004; Gallouj & Savona, 2009), scholars have identified three schools of thought being prominent in service innovation research – assimilation, demarcation, and synthesis. These schools are fundamentally different in their basic assumptions about innovation in services. The current study takes the synthesis approach in defining and studying innovation in services. The reasons behind this decision are provided at the end of Section 2.3.3. Before that, a review of the literature in each of the three research streams is presented, with a discussion of the strengths and weaknesses of each of them. This leads to the selection of the approach adopted in the current study.

2.3.1. Assimilation approach

An "assimilation" approach equates innovation in services to the adoption and use of technology (e.g., computers or ICTs) (Gallouj & Savona, 2009). Such an approach proposes that concepts and theories developed in studies on innovation in manufacturing can easily be applied in service contexts.

Barras's (1986) reverse product cycle (RPC) model, which is perceived by many researchers (Droege et al., 2009; Gallouj & Savona, 2009; Linton & Walsh, 2008) as marking the beginning of the service innovation research stream, complies with the main idea of this approach. Barras (1990, p. 215) argues that ICTs are the "enabling technology" being adopted by firms in service sectors, which accounts for their innovation capability (Gallouj & Savona, 2009). According to the RPC model, the types of innovations emphasised by service firms are: incremental process innovations to increase efficiency; radical process innovations to improve effectiveness; and radical product innovations to generate new services (Barras, 1986). Specifically, in the initial phase of the cycle, the focus is on the delivery of the service which can be improved through automation and business process reengineering with the adoption of the enabling technology (Linton & Walsh, 2008), thus incremental process innovations. Over time, a better understanding of the processes and technologies is collectively gained, therefore radical process innovations take place. In the third phase, new features are innovated for the existing service or new services, therefore the rate of service product innovations will be greater than the rate of service process innovations. Finally, as the end of a product's life cycle is approaching, the rates of both types of innovations reduce (Barras, 1986) (see Figure 2.1).

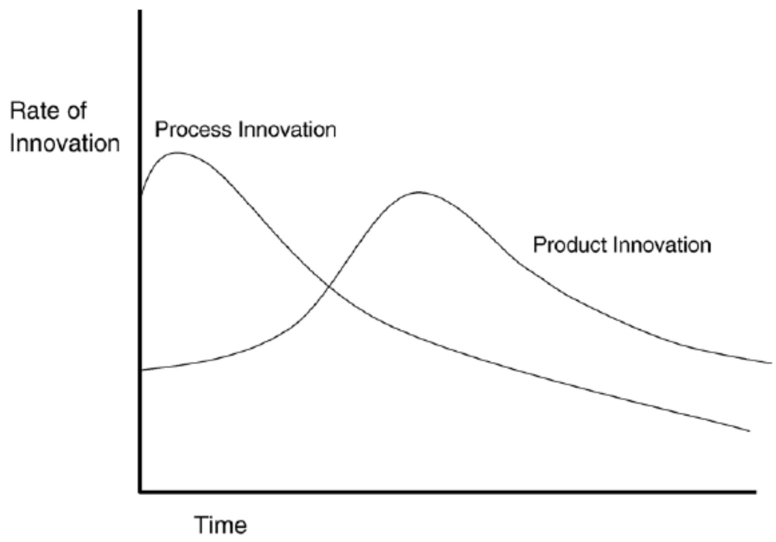

Figure 2.1: Barras's (1986) reverse product cycle model (source: Linton and Walsh, 2008).

Nevertheless, both the RPC model and the basic assumption of the assimilation approach have been heavily criticised for the reduction of service innovation to the adoption and use of ICTs (Droege et al., 2009; Gallouj & Savona, 2009). An overemphasis on technology-based innovations and the overestimation of technological dimensions have been reprimanded as showing ignorance of non-technological service innovations (Gallouj, 1998) and being too limited to describe the dynamic of innovation in services (Drejer, 2004). Therefore, as argued by Gallouj (1998), the RPC model should only be seen as the adoption and diffusion patterns of ICTs in financial services. Several buzzworthy questions remain unanswered (Gallouj & Savona, 2009, p. 158):

- Is the RPC model valid beyond ICT adoption?
- Is the RPC model valid beyond ICT adoption in other sectors, apart from financial services?
- Is the RPC model valid for innovation in the service functions internal to manufacturing firms?

Furthermore, research that takes this approach often suggests that the key drivers of product and service innovation are similar, with some differences between the two contexts regarding their relative importance. For example, based on a survey of 158 manufacturing and 117 service firms in Australia, Atuahene-Gima (1996) posited that both service and manufacturing firms focus on similar key drivers of innovation performance. However, the relative importance of those factors are different, for instance, in service firms, the firm's human resource strategy is the most crucial factor, while it ranks third in manufacturing contexts. Consistently, Sirilli and Evangelista (1998) compared a survey data of technological innovation in Italian service and manufacturing firms. They discovered that overall there are more similarities than differences between innovation in services and in manufacturing regarding some basic dimensions (e.g., innovation expenditure per employee, innovation sources, the objectives of their innovation strategies, etc.). Nevertheless, these findings of similarities between the two contexts should be interpreted with caution since they could be biased by the overemphasis on technology and underemphasis on non-technological aspects of service innovation of the assimilation approach (Drejer, 2004).

2.3.2. Demarcation approach

In contrast with the assimilation approach, a "demarcation" approach emphasises the distinctive characteristics of services (i.e., intangibility, heterogeneity, inseparability, perishability and or IHIP) (Zeithaml et al., 1985) which, in turn, make it difficult to apply knowledge from innovation in manufacturing to innovation in services (Droege et al., 2009). Specifically, the extant literature suggests that services are different from physical goods due to these four unique characteristics. First, "intangibility", according to Bateson (1979), is the critical property that differentiates goods from services. Intangibility is a bidimentional concept comprising of a physical dimension (reflecting the degree of materiality of products or services), and a mental dimension (concerning the degree of difficulty in defining, formulating, or understanding the nature of products or services) (Bielen and Sempels, 2003 via Lovelock and Gummesson, 2004). Second, "heterogeneity", where services provided by the same person may differ between customers or differ at different times. This causes a difficulty in producing uniform service outputs, especially in labour-intensive services (Lovelock & Gummesson, 2004, p. 27). The third unique characteristic is the "inseparability" of production and consumption, thus contact between provider and customer is unavoidable (Zeithaml et al., 1985). Finally, "perishability" – services cannot be saved stored, resold or return, hence services that are not consumed are lost (Zeithaml & Bitner, 2003).

Studies in this research stream usually attempt to develop a specific framework for NSD processes and to discover the specificities in service products and processes (Gallouj & Savona, 2009). From a review of literature in this stream, we discover that innovation in services is unique in at least three aspects: (1) patterns of innovation, (2) types of innovation and (3) the innovation process. These topics are discussed below.

Patterns of innovation in services

Using the demarcation approach, the service innovation literature has identified several patterns of innovation in service firms. Miozzo and Soete (2001) proposed three groups of innovative service companies: science-based, scale-intensive and supplier-dominated services. Science-based services (e.g., software, technical consultants and specialized business services) are regarded as pure producers of technology, while supplier-dominated services (e.g., retail, health care, restaurants and hotels) are considered pure technology users. Scale-intensive services (e.g., banks, insurance and telecommunications) are characterised by a combination of the two types. Similarly, de Jong and Vermeulen (2003) reviewed the service innovation literature and identified three particular groups of service firms, namely knowledge-intensive, product-intensive, and supplier-dominated services. In a different vein, Den Hertog (2000) conceptually proposed five innovation patterns in service firms. The five patterns are supplier-dominated innovation (e.g., microwave ovens in catering), innovation in services (e.g., introduction of a new shop formula), client-led innovation (e.g., green banking, door-to-door transport services), innovation through services (e.g., technical consultancies innovate for their client), paradigmatic innovation (e.g., the large-scale introduction of multi-functional smart cards). Each of the patterns involves a different mix of linkages between three types of actors: suppliers (equipment, capital, human resources, etc.), the innovating service firms, and customers or end users.

Taxonomies of service innovations

Service innovation researchers have proposed many classification schemes focusing on the peculiarities of service innovations (rather than just the product-process classification). They are summarised in Table 2.1. For example, Den Hertog (2000) proposed a four-dimensional model of service innovation representing four interrelated types of service innovations: (1) new service concept, (2) new client interface, (3) new service delivery system, and (4) technology options. However, in practice, a combination of the four dimensions may characterise a particular service innovation. To clarify, a radical new service will usually require a new service delivery system to be developed; employees to change their way of work (the client interface); a new IT system to be implemented; and a new service concept to be designed (Den Hertog, 2000). Consider the following example. A new CRM system, which is basically a technological innovation (i.e. dimension 4), may need a new re-designed process (dimension 1); a new way of customer interactions (dimension 2) and new employees' skill sets (dimension 3).

Different categories of product or service newness are potentially linked to different types of product/service innovation-related risks, development costs (Alam, 2006b) and innovation performance (Kleinschmidt & Cooper, 1991). Therefore, it may be crucial for managers to adjust their approach to service innovation depending on the degree of innovativeness of the new services that they are developing. Moreover, studies that do not address the different degrees of newness of innovations may be biased. Further, the predictive and external validity of the research findings of such studies may be limited, given the heterogeneous characteristic of most service offerings (Menor et al., 2002). For some empirical examples, Avlonitis et al. (2001) empirically constructed a typology consisting of six innovativeness types and suggested that that each type of new services requires different development practices and a different degree of formalization. Interestingly, the study unearths an inverted U-shaped relationship between the degree of innovativeness and the innovation's financial performance. Alam (2006b) empirically employed Avlonitis and colleagues' (2001) newness typology and discovered that a low cost and lower risky option for developing moderately innovative services (i.e. new to company services) is the most popular strategic choice of both US and Australian firms. In another study conducted by Oke (2007), which employed three broader types of service newness (i.e., radical innovations, innovations that are copied from competitors or me-too innovations, and incremental innovations), the results indicated that UK service companies focus their innovation activities more on incremental and me-too innovations than on radical innovations. More recently, Paswan et al. (2009) conceptually proposed a service innovation typology that embraces a S-D logic and is anchored by three contextual dimensions, namely environmental uncertainty, strategic orientation, and market orientation.

Table 2.1: Typologies of service innovations in the literature

Author	*Typology*	*Industry*	*Type of Study*
Gadrey et al. (1995)	• Innovation in service products • Architectural innovations • Modifications of the service products • Innovation in processes and organization	Insurance	Interview
	• Product innovation • Process innovation • Organisational innovation • Market innovation • Ad hoc innovation	Business consultancy services	
	• New product or service development • Improvement of products or services • Process innovation	Electronic information services	
Den Hertog (2000)	• New service concept • New client interface • New service delivery system • Technology options	-	Conceptual
Djellal and Gallouj (2001)	• Product/service innovation • Process innovation • (Internal) Organisational innovation • External relational innovation	Financial services, consultancy, operational services, and hotel/catering/retailing	Survey
Avlonitis et al. (2001)	• New to market services • New to company services • New delivery processes • Service modifications • Service line extensions • Service repositionings	Financial services	Survey
Drejer (2004)	• Ad hoc innovation • External relationship innovation • Formalisation innovation • Expertise-field innovation	-	Conceptual
Oke (2007)	• Radical innovation • Me-too innovation • Incremental innovation	Financial and insurance, retail, transport, and telecommunications	Survey and interview
Sundbo et al. (2007)	• Product innovation • Process innovation • Organisational innovation • Market innovation • Technological innovation • Widened service	Tourism	Survey and interview

Paswan et al. (2009)	• Incremental service innovation with a focus on creation and/or delivery efficiencies through high firm control and low customer involvement • Radical service innovation with a focus on creation and/or delivery efficiencies through high firm control and low customer involvement • Incremental service innovation with a focus on creation and/or delivery efficiencies through high firm control and increased customer involvement • Radical service innovation with a focus on creation and/or delivery efficiencies through high firm control and high customer involvement • Incremental service innovation with a focus on differentiation through high firm control and low customer involvement • Radical service innovation with a focus on differentiation through high firm control and low customer involvement • Incremental service innovation with a focus on differentiation through high firm control and increased customer involvement • Radical service innovation with a focus on differentiation through high firm control and high customer involvement	-	Conceptual
Nam and Lee (2010)	• Conventional innovation • Collaboration-based innovation • Customer-oriented innovation • Service dominant innovation	-	Conceptual
Wu et al. (2013)	• Management innovation • Service innovation • Technical innovation • Collaborative innovation	Chinese public sector	Case study

Innovation process in services

When compared to the manufacturing context, relatively little scientific knowledge about the innovation process in service firms has been acquired (Droege et al., 2009; Ettlie & Rosenthal, 2011). The nature of innovation in service firms is generally less formalized than most other critical functions of organizations (Ettlie & Rosenthal, 2011). Moreover, relative to manufacturing, service firms lack formal structures to elicit ideas for new services, and to select and develop the ideas (de Jong & Vermeulen, 2003).

According to de Jong and Vermeulen (2003), to become successful, service firms must keep their development process from being ad hoc. Researchers empirically studied the innovation process in service firms and reported interesting results (summarised in Table 2.2) Based on a series of interviews in ten financial service firms, Sundbo (1997) identified four main phases of innovation in service firms: idea generating, transformation into an innovation project, development, and implementation. Avlonitis et al. (2001) adopted a NSD model that includes five main stages (see Table 2.2) and discovered that the type of new services and the degree of innovativeness characterise the innovation process and its structuring. These models, however, seem to be similar to those suggested by product innovation studies (presented in Section 2.2.2 – stages of innovation).

Focusing more on the uniqueness of services, Alam and Perry (2002) proposed an expanded model of ten service development stages (see Table 2.2) and suggested that management of financial service firms seemed to pay more attention to the idea generation and screening stages than the other stages. Based on this ten-stage model, Alam (2006b) studied service innovation processes in US and Australian firms and reported that firms that developed more innovative services focused heavily on the stages of idea generation, idea screening, formation of cross-functional team and personnel training, while firms that developed moderately innovative services put more emphasis on the business analysis and commercialisation stages. Furthermore, due to the importance of human and organisational factors in the service innovation process, Oke (2007) argued that the Goffin and Pfeiffer's (1999) pentathlon framework should be adopted to study the process of innovation in service firms since the framework addresses both soft organisational and process issues. The researcher empirically discovered that, in service firms, the development process of radical innovations is likely to be more formal than me-too and incremental innovations. Song et al. (2009) developed a staged service innovation model consisting of five main stages (i.e., idea screening, business and market opportunity analysis, service design, service testing, and service launch) and an additional pre-launch service quality training. The researchers suggested that proficiency of four of the five main stages and the integration of the pre-launch training stage are significantly related to service innovation performance. In a more recent study, Zomerdijk and Voss (2011) conducted a case study of 17 companies including both innovating experiential service providers, and design agencies and consultancies. They found that the NSD process in experiential services are both systematic and flexible and that the process can benefit from learning from the customers as well as from firms in other industries.

Table 2.2: innovation process framework used in service innovation literature

Author	*Innovation process*	*Industry*	*Type of Study*
Sundbo (1997)	• Idea generating • Transformation into an innovation project • Development • Implementation	Financial services	Case study
Avlonitis et al. (2001)	• Idea generation and screening • Business analysis and marketing strategy • Technical development • Testing • Commercialisation/launching	Financial services	Survey
Alam and Perry (2002)	• Strategic planning • Idea generation • Idea screening • Business analysis • Formation of cross-functional team • Service design • Personnel training • Service testing • Test marketing	Financial services	Case study

	• Commercialisation		
Hansen and Birkinshaw (2007)	• Idea generation ○ In-house idea generation ○ Cross-pollination ○ External sourcing • Conversion ○ Selection ○ Development • Diffusion ○ Spread of the idea	-	Conceptual
Oke (2007)	• Innovation strategy • Creativity and ideas management • Selection and portfolio management • Implementation management • Human resource management	Financial and insurance, retail, transport, and telecommunications	Survey
Song et al. (2009)	• Idea screening • Business and marketing opportunity analysis • Service design • Service testing • Pre-launch service quality training • Service launch	Professional, scientific, technical services, financial services, information, hotels, and administrative and support	Survey
Zomerdijk and Voss (2011)	• Immersion • Investigation • Ideas • Implications • Implementation • Impact	Experiential service providers, and design agencies and consultancies	Case study

The differentiation approach taken by research in the demarcation stream is however not without criticisms. The IHIP concept, in particular, has been heavily criticised by Lovelock and Gummesson (2004) for its claim of universal generalisability to all services. To support their argument, Lovelock and Gummesson (2004) gave some examples of exceptions when applying the IHIP characteristics to four major types of services – i.e., Table 2.3. In addition to the generalisability issue, the demarcation approach has also been criticised for its focus on studying the peculiarities of service innovation, rather than directly comparing and contrasting innovation in services with innovation in manufacturing (Drejer, 2004). The danger of such a view "lies in inferring that particular features are unique for services, although they might actually be just as characteristic of manufacturing, despite having been ignored in traditional analyses limited by the product/process dichotomy” (Drejer, 2004, p. 554).

Table 2.3: Application of the "IHIP" concept to different types of services (source: Lovelock and Gummesson, 2004, p. 31)

IHIP Characteristic	***Service Category Involving***			
	Physical Acts to Customers' Bodies (e.g., passenger transport, health care, lodging, beauty salons)	Physical Acts to Owned Objects (e.g., freight transport, repair/ maintenance, warehousing, laundry and cleaning)	Nonphysical Acts to Customers' Minds (e.g., entertainment, news, education, consulting)	Processing of Information (e.g., Internet banking, insurance, accounting, research)
Intangibility	Misleading – performance is ephemeral, but experience may be highly tangible and even result in physical change	Misleading – performance is ephemeral but may physically transform possession in tangible ways	Yes	Yes
Heterogeneity	Yes – often hard to standardise because of direct labour and customer involvement	Numerous exceptions – can often be standardised	Numerous exceptions – can often be standardised	Numerous exceptions – can often be standardised
Inseparability	Yes	No – customer usually absent during production	Only when performance is delivered "live", e.g., live concerts	Many exceptions – customers often absent during production
Perishability	Yes	Yes	Numerous exceptions – performance can often be stored in electronic or printed form	Numerous exceptions – performance can often be stored in electronic or printed form

Interestingly, several patterns, taxonomies and innovation models proposed by service scholars seem to be similar to those advanced by studies in manufacturing contexts. To give an example, de Jong and Marsili (2006) empirically posited that the taxonomy of innovative small firms in manufacturing and services sectors are similar which includes four categories: science-based, specialised suppliers, supplier-dominated and resource-intensive. In a demarcation-oriented study, Djellal and Gallouj (2001) analysed the data collected from a postal survey of innovation in services carried out in France. In the survey, the definition of innovation in services goes beyond the product-process framework. It includes two additional types of innovation, namely organisational innovation and external relational innovation. The results of the survey suggest the importance of clients, the multiplicity of possible actors involved in innovation, and the pre-eminence of interactive models of innovation over traditional linear models. In the context of product innovation, the importance of clients or users has consistently been pointed out by Von Hippel (2005, p. 1):

> "User-centered innovation processes offer great advantages over the manufacturer-centric innovation development systems that have been the mainstay of commerce for hundreds of years. Users that innovate can develop exactly what they want, rather than relying on manufacturers to act as their (often very imperfect) agents."

The concept of open innovation (explained in detail in Section 2.8), that suggests the importance of external multi-actor involvement, has also stemmed from innovation practices in manufacturing firms (Chesbrough, 2003; Chesbrough et al., 2006). Based on a survey of 605 SMEs in the Netherlands, van de Vrande et al. (2009) found no major differences between open innovation practices in manufacturing and in service industries. Finally, regarding the innovation process, interactive processes are not only pre-imminent in service firms; looping, iterations, and back-and-forth also characterises the Stage-Gate model – one of the most popular models used in manufacturing firms (Cooper, 2008). Accordingly, we argue that innovation in services or manufacturing seems to be indistinguishable in various aspects, such as the importance of users and multiple-actor involvement and the non-linearity of the innovation process.

Moreover, many innovation drivers pointed out by demarcation studies seem to be as significant in services as in manufacturing contexts. For example, regarding the use of IT in the NSD process, it has been found that social connectivity of human entities in service systems is more important to value co-creation than the presence of supportive ICTs (Breidbach et al., 2013). Similarly, in product innovation contexts, Ettlie and Pavlou (2006) also suggested an indirect impact of supportive IT on innovation success through inter-firm NPD partnership dynamic capabilities.

The criticisms of the demarcation approach as well as the resembling findings of prior works on innovation in services and products presented above seem to suggest the need for a more convergent approach to research that applies to innovation in both product and service contexts.

2.3.3. Synthesis approach

The limitations of both assimilation and demarcation approaches have led to calls for the development of a new paradigm or theoretical foundation that applies to innovation in all sectors (Drejer, 2004). As a response, a third approach, which is "integrative" or "synthesising", has been proposed. Researchers following this approach believe that the boundaries between goods and services have become more blurred than ever before (Gallouj & Savona, 2009). This is due to the increasing significance of the intangible aspects of physical products as well as the exponential simplicity and cost-effectiveness of the standardisation of services enabled by today's advanced technology (Gallouj & Savona, 2009). Accordingly, synthesis-oriented studies have attempted to develop a common conceptual framework that can account for a more general view of innovation and is applicable to both goods and services.

To give some examples of studies in this stream, Gallouj and Weinstein (1997) adopted a characteristic-based approach and conceptually established six types of product (either a good or service) innovation: radical, improvement, incremental, ad hoc, recombination, and formalisation innovation. Gallouj and Weinstein (1997, p. 547) defined innovation as "any change affecting one or more terms of one or more vectors of characteristics (of whatever kind – technical, service, or competence)." Some empirical studies, such as de Vries (2006) and Windrum and García-Goñi (2008), have employed Gallouj and Weinstein's (1997) framework to investigate innovation in services. Alternatively, Vargo and Lusch (2004, 2008) have proposed a relatively new conceptual lens through which allow us to view service provision, rather than goods, as the fundamental unit of economic exchange. They called this new concept as "service-dominant" (S-D) logic. Instead of focusing on product-service dichotomies, firms should compete through service innovation by viewing themselves and the market through the S-D logic (Lusch et al., 2007).

Several synthesis studies have empirically and conceptually applied the S-D logic (e.g., Lusch et al., 2007; Maglio & Spohrer, 2008; Melton & Hartline, 2013; Michel et al., 2008a; Michel et al., 2008b; Ordanini & Parasuraman, 2011). The overarching idea of the S-D logic is that service, being defined as the application of operant resources (knowledge and skills), is the basis of all economic exchange – i.e., "service is exchanged for service" (Vargo & Lusch, 2008, p. 7). It highlights the importance of operant resources (resources that are capable of acting on other resources) over operand resources (resources on which an operation or act is performed to produce an effect) as the fundamental source of competitive advantage in both service and manufacturing contexts

(Vargo & Lusch, 2008; Vargo & Lusch, 2004). The distinctions between goods- and service-dominant views (differentiated by the role of operand and operant resources) are presented in Table 2.4. Based on an idea of value co-creation, the S-D logic suggests service is:

> "The interwoven fabric of individuals and organizations, brought together into networks and societies, specializing in and exchanging the application of their competences for the applied competences they need for their own well-being" (Lusch et al., 2007, p. 5).

Thus, the S-D logic defines service as "the application of specialised competences (knowledge and skills) through deeds, processes, and performances for the benefit of another entity and the entity itself" (Vargo & Lusch, 2004, p. 2). Such a definition is consistent with various theories frequently applied in innovation literature such as resource-based view (Barney, 1991), core competency theory (Prahalad & Hamel, 1990), customer-active paradigm (Von Hippel, 1978), and open innovation (Chesbrough, 2003).

Table 2.4: Differences between the logic of goods and service-dominant views suggested by operand and operant resources (source: Vargo and Lusch, 2004, p. 7)

	Good-Dominant (G-D) Logic	***Service-Dominant (S-D) Logic***
Primary unit of exchange	People exchange for goods. These goods serve primarily as *operand resources*.	People exchange to acquire the benefits of specialized competences (knowledge and skills), or services. Knowledge and skills are *operant resources.*
Role of goods	Goods are *operand resources* and end products. Marketers take matter and change its form, place, time and possession.	Goods are transmitters of *operant resources* (embedded knowledge); they are intermediate "products" that are used by other operant resources (customers) as appliances in value-creation processes.
Role of customer	The customer is the recipient of goods. Marketers do things to customers; they segment them, penetrate them, distribute to them,	The customer is a coproducer of service. Marketing is a process of doing things in interaction with the customer. The customer is

	and promote to them. The customer is an *operand resource*.	primarily an *operant resource*, only functioning occasionally as an operand resource.
Determination and meaning of value	Value is determined by the producer. It is embedded in the *operand resource (goods)* and is defined in terms of "exchange-value"	Value is perceived and determined by the consumer on the basis of "value in user." Value results from the beneficial application of *operant resources* sometimes transmitted through *operand resources*. Firms can only make value propositions.
Firm-customer interaction	The customer is an *operand resource*. Customers are acted on to create transactions with resources.	The customer is primarily an *operant resource*. Customers are active participants in relational exchanges and coproduction.
Source of economic growth	Wealth is obtained from surplus tangible resources and goods. Wealth consists of owing, controlling, and producing *operand resources*.	Wealth is obtained through the application and exchange of specialized knowledge and skills. It represents the right to the future use of *operant resources*.

The foundation ideas of the emerging S-D logic include six differences in the arrangement of operand and operant resources and 10 foundational premises (FPs) (Vargo & Lusch, 2008; Vargo & Lusch, 2004). The former are presented in Table 2.4 and the latter are displayed in Table 2.5 below.

Table 2.5: S-D logic's ten FPs (source: Vargo and Lusch, 2008, p. 7)

FPs	***Foundational Premise***	***Comment/Explanation***
FP1	Service is the fundamental basis of exchange.	The application of operant resources (knowledge and skills), "service," as defined in S-D logic, is the basis of all exchange. Service is exchanged for service.
FP2	Indirect exchange masks the fundamental basis of exchange.	Because service is provided through complex combinations of goods, money, and institutions, the service basis of exchange is not always apparent.
FP3	Goods are distribution mechanism of service provision.	Goods (both durable and non-durable) derive their value through use- the service they provide.
FP4	Operant resources are the fundamental source of competitive advantage.	The comparative ability to cause desired change drives competition.

FP5	All economies are service economies.	Service (singular) is only now becoming more apparent with increased specialization and outsourcing.
FP6	The customer is always a co-creator of value.	Implies value creation is interactional.
FP7	The enterprise cannot deliver value, but only offer value propositions.	Enterprises can offer their applied resources for value creation and collaboratively (interactively) create value following acceptance of value propositions, but cannot create and/or deliver value independently.
FP8	A service-centered view is inherently customer oriented and relational.	Because service is defined in terms of customer-determined benefit and co-created it is inherently customer oriented and relational.
FP9	All social and economic actors are resource integrators.	Implies the context of value creation in networks of networks (resource integrators)
FP10	Value is always uniquely and phenomenologically determined by the beneficiary.	Value is idiosyncratic, experiential, contextual, and meaning laden.

The current study takes an S-D logic-based synthesis approach because of its intention to come up with a generic model for a more open front-end of service innovation. The S-D perspective seems particularly suitable for the current research because it moves away from the distinction between products and services. The S-D logic premises that all economies are service economies; and goods are only a distribution mechanism for services (Vargo & Lusch, 2008). This view equips us with a new way of thinking about innovation by shifting the focus from trying to create and/or deliver new products/services, to finding new ways of co-solving customer problems (Michel et al., 2008b). Furthermore, the traditional good-dominant logic paradigm falls short in explaining new forms of service innovation made possible by new technologies, such as cheap memories, high-speed internet, and powerful smartphones (Michel et al., 2008b). Finally, the S-D logic is "philosophically grounded in a commitment to collaborative processes with customers, partners, and employees; […] recognizes the firm and its exchange partners who are engaged in the co-creation of value through reciprocal service provision" (Lusch et al., 2007, p. 5), which has often been identified as being important in the service innovation literature (e.g., Djellal & Gallouj, 2001; Maglio & Spohrer, 2008; Ye et al., 2011).

We argue that firms might be able to develop new service offerings more successfully, which, according to the S-D logic, is the fundamental basis of exchange (Vargo & Lusch, 2004), if they gather and apply operant resources (knowledge and skills) from a broad range of external sources. Therefore, we apply the S-D logic's 10 FPs as an analytical lens through which we look at openness competence within the FFE of service innovation. With S-D logic principles in mind, the term "service innovation" can be defined as "a value proposition or an offering not previously available to the firm's customers that requires either the network of innovating organisations or the customers or both to renew, create, integrate and transform their collection of competences" (adapted from Lusch et al., 2007, p. 5).

Since we aim to study the impact of openness competence within the FFE on the success of service innovation projects, in the next section, we present a review of how success has been measured in previous studies of innovation in both products and services.

2.4. Service Innovation Success

Innovation success is multifaceted and is difficult to measure precisely (Griffin & Page, 1996; Menor & Roth, 2007; Menor et al., 2002). The literature seems to suggest that success at different levels of analysis requires different performance measures. For example, at an industry level, Hipp and Grupp (2005) proposed the use of trademarks as an empirical measure of innovations in the service sector. At a firm level, a firm's innovation performance is often measured in terms of the overall market performance relative to established goals, service quality (Roth & William, 1995), the number of new products/services (Froehle et al., 2000), share of new services in sales (Leiponen, 2005), the number of patent applications, the number of industry standards (Chen et al., 2011), profitability (Koufteros et al., 2005), and the speed of new product/service development (Chen et al., 2011; Froehle et al., 2000). Concerning the impact of service innovations at the firm level, Aas and Pedersen (2010) systematically reviewed the literature and identified five categories of firm-level effects: (1) business process effects, (2) capability effects, (3) relationship effects, (4) financial performance effects, and (5) competitiveness effects. In addition, scholars have also measured innovation success at a business unit level. At this level, two main success criteria are often measured – i.e., efficiency of the development process and effectiveness of the outcomes of the process (Ettlie & Pavlou, 2006; Fey & Birkinshaw, 2005; Pavlou & El Sawy, 2006; Ray et al., 2005). For instance, Pavlou and El Sawy (2006) evaluated NPD work unit performance based on (1) NPD process efficiency, (2) product effectiveness, (3) perceived competitive advantage in NPD, and (4) accounting ratios (return on sales, return on assets, and sale growth). In service innovation contexts, Ray et al. (2005) measured customer service process performance in terms of productivity (e.g., the level of throughput and cycle time) and the quality of the customer service process.

Since the aim of this study is to investigate the FFE phase of service innovation projects, success at the project level is emphasised. Scholars have suggested different approaches to measure innovation success at the project level. These include, inter alia, asking managers about their perception of whether the innovation project achieves the initial commercial success objectives (i.e., sales, market share, ROI and profit margin objectives) and project efficiency (i.e., development time and costs) (e.g., Knudsen & Mortensen, 2011; Melton & Hartline, 2010; Moenaert et al., 1995; Verworn, 2009; Verworn et al., 2008). Others have used more complex measures. For example, Griffin and Page (1996) adopted a project-level success measurement assessing three dimensions: (1) customer-based success, (2) financial success, and (3) technical performance success. They surveyed 80 product development practitioners using these measures to find an appropriate set of measures for assessing project-level success for projects with different degrees of innovativeness. Their findings were that, for most levels of project newness, the informants identified project profitability as an appropriate indicator of financial success. Further, the competitive advantage provided by the innovation project is the most useful indicator of technical performance success. Finally, customer-based success is best measured in terms of customer satisfaction and customer acceptance. Alternatively, Tatikonda and Montoya-Weiss (2001) measured product innovation success from an operational and marketing perspectives. They suggested that operational outcomes can be assessed considering product quality, unit cost, and time-to-market, while market outcomes of a product innovation project can be measured in terms of customer satisfaction and relative sales.

In services, Menor et al. (2002, p. 141) argued that service innovation performance is multidimensional and involves both operational effectiveness and market competitiveness. The former involves cost, effectiveness and speed, whereas the latter includes financial, competitiveness and quality measures. For hi-tech service innovations, Van Riel et al. (2004, p. 353) employed and statistically verified three success factors: (1) short term success (representing the most salient aspects of innovation success), (2) long-term success (factors associated with sustained competitive advantage) and (3) indirect success (preconditions for future success). Internal effects of service innovation have also been addressed. In addition to financial and technical success, Lievens and Moenaert (2000) argued that the learning effects of service innovation should also be assessed. This is because project members gain knowledge and learn new skills as they exchange information during the innovation process (p. 59). Table 2.6 provides some examples of project-level innovation success measures used in the literature.

Since the context of this study is IT-based service innovation projects, we also reviewed the IS and project management literature. From the review, scholars have viewed the concept of IS project success from two distinct perspectives: IS adoption and IS development. While the former focuses on quality of the system being adopted, user acceptance and impact on the adopting organisation, the latter concerns efficiency and effectiveness of the IS development process. This is consistent with the outcome and the process views found in the innovation literature discussed in Section 2.2.

Scholars taking the adoption perspective have proposed several success models. One of the most widely cited IS success models was posited by DeLone and McLean (1992). The D&M model was later updated based on a review of relevant empirical and conceptual works that were published during the 1992-2003 period (DeLone & McLean, 2003). The model illustrates the multidimensional and interdependent nature of IS success. The seven components of the D&M IS success model are: (1) information quality, (2) system quality, (3) service quality, (4) intention to use, (5) use, (6) user satisfaction, and (7) net benefits. The D&M model was later examined in several meta-analysis studies (Petter et al., 2008; Sabherwal et al., 2006), which have validated a substantial part of the model. Alternatively, Grover et al. (1996) argue that IS success measures are contingent upon the context. By addressing the three evaluation contexts of evaluation criteria, unit of analysis, and evaluation type, the researchers produced six classes of IS effectiveness measures. In a similar way, Seddon et al. (1999) proposed a two-dimensional matrix containing a collection of success measures that can be selected based on the type of IS and the stakeholders for whom the IS is being evaluated.

With respect to success in IS development, de Wit (1988) proposed that project success must be evaluated with regard to the project objectives. However, objectives vary by the stakeholders involved, type of project, throughout the project life cycle and the management hierarchy (de Wit, 1988). He also argues that there is a distinction between "project success" and "success of the project management effort", which is often restricted to on time, within budget, and to specification. Consistently, Wateridge (1998) extended the widely adopted criteria of IS/IT project success (i.e., time, cost and specification) by adding several project success measures concerning benefits, quality, profitability of the outcomes of the project, and stakeholder satisfaction. Thomas and Fernández (2008) studied success measurement of IT projects in 36 Australian companies and suggested that firms who have an agreement among stakeholders on the definition of success at the start of the project – and effectively measure it – have a higher change of achieving success. Refer to Table 2.7 for a summary of IT/IS project success measures.

From the review, we found that both the innovation and IT/IS management literature views project success from two distinct perspectives, namely an outcome view (i.e., innovation or IT/IS adoption success) and a process view (i.e., innovation or IT/IS project development success). The current study takes the process view because it focuses mainly on the FFE of the development process of IT-based service innovations. Prior works that take the process view have consistently suggested that success at the project level is twofold, namely efficiency of the development process, financial or short-term success (e.g., sales, ROI, development time and costs, etc.) and effectiveness of the outcomes, non-financial or long-term success (customer satisfaction, market share, competitive advantage, etc.). Accordingly, this study measures success of IT-based service innovation projects concerning these two dimensions.

Table 2.6: Measures of innovation success at a project level of analysis used in the literature

Author(s)	***Success measures***	***Industry***	***Type of Study***
de Brentani (1991)	Sales performance • Exceed market share objective • Exceed sales/customer use level objectives • Exceed sales/customer use growth objectives • High relative sales/customer use level • High overall profitability • Positive impact on corporate image/reputation Competitive performance • Buyer perceives superior service "outcome" • Buyer perceives superior service "experience" • Unique benefits: perceived as superior to competitors • Give firm important competitive advantage Cost performance • Substantially lower costs for the firm • Perform below expected cost • Achieve important cost efficiencies for firm Other booster • Enhance sales/client use of firm's other products/services • Enhance profitability of firm's other products/services	Financial services, management services, transportation and communication	Survey and interview
Moenaert et al. (1995)	The extent to which the project achieves the initial commercial objectives and expectations perceived by the respondents The degree of commercial success of the project perceived by the respondents	Manufacturing (e.g., electronics, chemical, textile, etc.)	Survey
Atuahene-Gima (1996)	Financial performance • Market share objectives • Sales objectives • Growth objectives • Profit objectives Non-financial performance • Provide opportunities for cost efficiency • Give proprietary advantage to the firm • Enhance sales of other products/services • Open up new markets	Manufacturing (chemical, food and beverage, electronics, metal products, etc.); and services (banking and trust, insurance, computer software, etc.)	Survey

	• Improve sales and profitability of other products/services to the firm		
Griffin and Page (1996)	Customer-based success • Customer satisfaction • Customer acceptance • Market share goals • Revenue goals • Revenue growth goals • Unit volume goals Financial success • Meet profit goals • Meet margin goals • IRR or ROI • Break-even time Technical performance success • Competitive advantage • Meet performance specs • Speed to market • Development cost • Meet quality specs • Launch on time • Innovativeness	Manufacturing	Survey
Lievens and Moenaert (2000)	Financial performance • Achieve the initial commercial objectives and expectations • Exceed market share objectives • Exceed sales growth objectives • Overall profitability Technological performance perceived by the respondents The achievement of learning effects	Banks and saving institutions	Survey
Avlonitis et al. (2001)	Financial performance • Profitability • Sales • Market share • Exceed profit objectives • Exceed sale objectives • Exceed market share objectives Non-financial performance • The company's perceived image • Improve the loyalty of the existing customers • Enhanced the profitability of other products • Attract new customers • Give an important competitive advantage	Financial services	Survey
Tatikonda and Montoya-	Operational Outcomes • Product quality	Manufacturing	Survey

Weiss (2001)	• Unit cost • Time-to-market Market Outcomes • Customer satisfaction • Relative sales		
Menor et al. (2002)	NSD Outcomes Financial measures • Achieving higher overall profitability • Substantially lowering costs for the firm • Performing below expected costs • Achieving important cost efficiencies for the firm Competitiveness measures • Exceeding market share objectives • Exceeding sales/customer use level objectives • Exceeding sales/customer growth objectives • Achieving high relative market share • Having a strong positive impact on company image/reputation • Giving the company important competitive advantage • Enhanced sales/customer use of other products or services Quality measures • Resulting in service “outcome” superior to competitors • Resulting in service “experience” superior to competitors • Having unique benefits perceived as superior to competitors • Great reliability • More user friendly NSD Process Criterion cost • Average development cost per service product • Development cost of individual service product • Percentage of turnover spent on developing new services, products and processes Effectiveness • How many new services developed annually • Percentage new services that are successful Speed • Concept to service launch time • Concept to prototype time • Prototype to launch time	-	Literature review

	• Time to adopt new concept from outside the firm		
Hull (2004)	Time and cost • Shorter time taken from concept to test market for new service products • Shorter time taken from test market to full-scale delivery of new service products • Reduced cost of service product development • Reduced cost of service product delivery Product innovation • New features • Upgraded features	Banking, insurance, consulting services, health care, retail, education, distribution, etc.	Survey
Verworn et al. (2008)	Efficiency • Personal resources are sufficient • On budget Effectiveness • Meet profitability objectives • Meet sales objectives • Meet market share objectives • Competitive advantage • Customer satisfaction	Manufacturing	Survey
Verworn (2009)	Efficiency • Milestones achieved • Personnel targets achieved • Cost targets achieved Overall satisfaction • Satisfaction within team • Satisfaction with process • Satisfaction with results	Electronics, measuring instruments	Interview
Melton and Hartline (2010)	Sales performance • Exceed sales objectives • Exceed market share objectives • Exceed profit margin objectives • Exceed usage objectives • Exceed ROI objectives Project efficiency • Less than expected development costs • Less than planned concept to launch time • Performance of the innovation below expected cost	Education, health care, and financial services	Survey
Knudsen and Mortensen (2011)	Quality and timing • Product quality is clearly better than other alternatives on the market • Product was introduced on the market at the planned time Time to market (speed)	Electronics, Furniture, Machines and equipment, chemical, metal products, etc.	Survey

	• Slower than the norm in the industry • Slower than the project team's expectation • Slower than a typical NPD project in the firm Cost • Have higher cost compared to the norm in the industry • Have higher cost than our expectation • Have higher cost than a typical NPD project in the firm		

Table 2.7: Measures of IT/IS success proposed in prior works

Author(s)	*Success measures*	*Industry*	*Type of Study*
de Wit (1988)	Project functionality • Financially • Technically • Or otherwise Project management • Budget • Schedule • Technical specification Contractor's commercial performances • Short term • Long term	-	Concep-tual
Grover et al. (1996)	• Infusion measures • Market measures • Economic measures • Usage measures • Perceptual measures • Productivity measures	-	Literature review
Wateridge (1998)	• It is profitable for the sponsor/owner and contractors • It achieves its business purpose in three ways (strategically, tactically and operationally) • It meets its defined objectives • It meets quality thresholds • It is produced to specifications, within budget and on time • All parties (users, sponsors, the project team) are happy during the project and with the outcome of the project	IT consultants	Survey
DeLone and McLean (2003)	• Information quality • System quality • Service quality • Intention to use • Use	-	Literature review

	• User satisfaction • Net benefits		
Thomas and Fernández (2008)	• On-time • On-budget • Sponsor satisfaction • Steering group satisfaction • Project team satisfaction • Customer/user satisfaction • System implementation • Meet requirements • System quality • System use • Business continuity • Meet business objectives Delivery benefits	Finance and insurance, mining, electricity, gas and water supply	Survey

Since the main focus of the current study is on the early phase of the innovation process, an overview of current knowledge about the FFE phase is described next.

2.5. The FFE of Innovation

To be successful in service innovation, firms should use a systemic process for developing new services (de Jong & Vermeulen, 2003). Several models have been proposed in the existing literature as described in Section 2.3.2 – innovation process in services. Inspired by Koen et al. (2001), we assert that, typically, the innovation process has three main phases: FFE or predevelopment, development, and commercialisation. The FFE is considered to be the first stage of the innovation process. The FFE begins when an opportunity is first considered worthy of further ideation, exploration, and assessment. It ends when a firm decides to invest in or to terminate the idea (Khurana & Rosenthal, 1998). The FFE is often characterised as involving low levels of formalisation and high levels of uncertainty (Alam, 2006a; Verworn, 2009; Verworn et al., 2008; Zhang & Doll, 2001), thus it is often called the “fuzzy front-end” (FFE) – a term first coined by Smith and Reinertsen (1991).

To better understand the FFE, we present the knowledge produced by previous works concerning key activities in the FFE, antecedents of the FFE, and outcomes of the

FFE, respectively in the next three sub-sections. In the fourth sub-section, we discuss the importance of the FFE and the reasons why we decided to focus on openness in the FFE rather than in the whole innovation process.

2.5.1. Front-end activities

The literature on innovation management offers several frameworks emphasising the stages/processes/activities that occur in the early phase of innovation. For example, Khurana and Rosenthal's (1997, 1998) framework consists of four activities: (1) opportunity identification, (2) opportunity assessment and (3) product definition, and (4) project planning. Koen et al. (2001) suggested that the front end of innovation involves five elements: (1) opportunity identification, (2) opportunity analysis, (3) idea genesis, (4) idea selection, and (5) concept and technology development. Enkel et al. (2005) proposed a five-phase model structured in cycle consisting of: (1) knowledge generation, (2) idea generation, (3) opportunity identification, (4) prototype development, and (5) concept definition phases. In a more recent study, Akbar and Tzokas (2013) empirically proposed a front-end knowledge conceptualisation framework being comprised of five stages: (1) knowledge generation, (2) knowledge evaluation, (3) knowledge expansion, (4) knowledge refinement, and (5) knowledge crystallisation. By looking at the variety of front-end activities presented here, we are able to identify the main purposes of the FFE. The goals of such an early phase seem to be to come up with a lot of interesting ideas, to be able to select the right idea, and to know as much as possible about the idea. We argue that the chance that these goals will be achieved is likely to increase if the FFE team open up to external ideas and knowledge or co-develop with others outside of the firm.

2.5.2. Antecedents of the FFE

Scholars have identified various factors that influences the outcomes of the FFE. Some of those factors are intensity of planning (Verworn, 2009; Verworn et al., 2008), innovation attributes (de Brentani & Reid, 2012), interdisciplinary FFE team (Moenaert et al., 1995; Verworn, 2009), decision-maker characteristics (de Brentani & Reid, 2012), heavyweight project manager (Kim & Wilemon, 2002; Zhang & Doll, 2001), clear team vision (Zhang & Doll, 2001), potential absorptive capacity (Fosfuri & Tribó, 2008; Jansen et al., 2005), use of IT (Gordon et al., 2008; Kim & Wilemon, 2002; Montoya-Weiss & O'Driscoll, 2000), management control (Poskela & Martinsuo, 2009), innovative communication (Blazevic & Lievens, 2004; Schulze & Hoegl, 2008), customer involvement (Alam, 2006a; Magnusson, 2009; Zhang & Doll, 2001), supplier involvement (Khurana & Rosenthal, 1997; Zhang & Doll, 2001), market orientation (Langerak et al., 2004), and diverse information sourcing (Leiponen, 2005). In sum, scholars have identified success factors associated with elements located both inside and outside the four walls of the innovating firms. The current study highlights the significance of the latter group by focusing on the openness competence within the FFE. We argue that a FFE team with a high level of openness competence is likely to produce higher quality outcomes of the FFE.

2.5.3. Outcomes of the FFE

Kim and Wilemon (2002) proposed that the FFE phase can play a significant role in shaping subsequent phases in three aspects. The first aspect involves project selection and product definition, which produce two key deliverables: the selection of the right project and a well-defined product concept. A well-defined product concept allows a more precise estimation of development time, costs, required technical expertise, market potential and positioning, risk, and organizational fit (Cooper, 1993). The second dimension concerns the speed of the FFE process. The most important cost of the FFE may be the cost of delay, due to short product life cycle and intensified competition. This is particularly important in service innovation contexts as increasingly short product life cycles are one of the main challenges to innovation in services (Menor et al., 2002).

Therefore, the development of robust product/service concepts and project plans that enables a faster and more effective implementation and commercialisation of the new concepts might be necessary. Finally, the people dimension involves the relationships between the FFE team members, senior management, other functions, and external partners. Activities relating to this dimension, such as the effectiveness of transferring FFE learning to the development teams, can influence the performance of the development phase (Kim & Wilemon, 2002). Several empirical studies have measured FFE performance concerning these three outcome aspects. For example, Ho and Tsai (2011) measured FFE performance in terms of efficiency (i.e., speed and costs) and effectiveness (i.e., whether the project plan is explicit and stable, and whether the product concept is clear and in line with customer needs) of the front-end process. Verworn (2009) used deviations from specifications derived from the FFE phase in the following project execution phase and communication during the project execution phase to measure the performance of activities taking place in the FFE phase.

In a different way, the potential of ideas generated during the FFE phase has been used to evaluate front-end performance. Scholars measured FFE performance in terms of competitive potential and future business potential of the product concept generated during the FFE phase (Martinsuo & Poskela, 2011; Poskela & Martinsuo, 2009). Markham (2013) assessed the success of the FFE phase based on the percentage of ideas that moved into the development phase and on the respondent's perception of the potential value of the new ideas from the FFE. In addition, the degree of market and technical uncertainty that had been reduced during the FFE phase was also used to indicate the FFE performance (Lievens & Moenaert, 2000; Moenaert et al., 1995; Verworn et al., 2008).

2.5.4. Why the FFE is important?

The front-end of innovation is particularly important to success because it is characterised as being highly uncertain and is the most information intensive phase (Alam, 2006a; Moenaert et al., 1995; Verworn, 2009; Verworn et al., 2008; Zhang & Doll, 2001). Nevertheless, activities in the FFE phase have the highest potential for improvements with the greatest time saving and the least expense, in comparison with activities in the other phases. This is because the cost of generating several potential ideas is considerably lower than the cost of implementing any one idea (Reid & De Brentani, 2004). Furthermore, scholars often conceptually and empirically suggest that the success or failure of an innovation project depends on the proficiency of front-end activities (e.g., Kim & Wilemon, 2002; Langerak et al., 2004; Zhang & Doll, 2001). A well-defined product/service concept (which is one of the main outcomes of the FFE phase) is particularly important (Khurana & Rosenthal, 1998; Verworn et al., 2008; Zhang & Doll, 2001). When designing a new service or redesigning an existing one, managers and designers alike have to make decisions on what components (i.e., processes, people skills, and materials) are needed and how to integrate them (Goldstein et al., 2002). In other words, a service concept specifying both what and how must be defined in order to concretise the service innovation. However, since services are intangible, heterogeneous, and delivered over time and space, bias (i.e., oversimplification and incompleteness in conceptualising new service offerings) is often present in both the specification and the interpretation of the service concept (Bitner et al., 2008).

Langerak et al. (2004) discovered positive relationships between proficiency in FFE activities and new product performance based on data collected from a survey of 126 firms in the Netherlands. Furthermore, in a study of 497 new NPD projects in Japanese manufacturing firms, Verworn et al. (2008) suggested that intensive planning activities and a reduction of market and technical uncertainty during the FFE have a positive impact on NPD effectiveness at a project level (which is defined as the extent to which an innovation fulfils the company's objectives regarding profit targets, customer satisfaction and competitive advantage). More recently, Markham (2013) empirically unearthed positive and independent impacts of front-end performance on overall success, time to market, market penetration and financial performance, even after controlling for the use of formal implementation processes, innovation strategy and champions.

Nevertheless, it must be noted that the other phases of the innovation process (i.e., development and commercialisation) are also significant to the project success. Some scholars argue that in order to transform a potential idea into a successful innovation, the process of idea conversion or transformation is crucial (e.g., Hansen & Birkinshaw, 2007; Love et al., 2011). Hansen and Birkinshaw (2007, p. 126) strongly claimed that "a company's capacity to innovate is only as good as the weakest link in its innovation value chain (IVC)". The IVC model includes three main stages: idea generation, idea conversion and idea diffusion (Hansen & Birkinshaw, 2007). The causal links between the elements of IVC were empirically tested by Love et al. (2011) based on the survey data of 1,151 UK business service firms. In a similar vein, in a study of 2,464 innovative Spanish firms, Fosfuri and Tribó (2008) found that R&D cooperation, external knowledge acquisition and experience with knowledge searches are key antecedents of a firm's potential absorptive capacity (PAC) (which is defined as the ability to map from external useful knowledge flows to internally available information) and thus proposed that PAC is a source of competitive advantage in innovative firms. Although no empirical test had been done, they theoretically suggested that a firm's realised absorptive capacity (RAC) (which is defined as the ability to exploit the external knowledge once it has been brought within the boundaries of the organization) is a mediator of the relationship between PAC and innovation performance.

The current study however focuses solely on the FFE phase due to two main reasons. Firstly, as we discussed earlier in this sub-section, the FFE phase is crucially important to innovation success. Secondly, we believe that an external openness strategy is most useful when being applied to the FFE of innovation. By being more open to the outside, a development team might be able to gather relevant information and knowledge to reduce risks and uncertainties associated with the FFE. More complete knowledge about customers, the market situation and technology help improve project planning and reduce deviation from specifications (Verworn, 2009). Moreover, during the FFE, high levels of fuzziness can damage shared team purpose, strategic fit of the innovation, and clarity of project targets (Zhang & Doll, 2001). These could cause problems in the development phase, including conflicts among parties involved as well as disputes over a project's legitimacy (Kim & Wilemon, 2002). Moenaert and colleagues (1995, p. 249) consistently suggested that the majority of information acquisition and uncertainty reduction takes place in the FFE, whereas the later stages are mainly concerned with the implementation of the agenda developed during the FFE phase.

Since the context of this study is the FFE of IT-based service innovation, the IS literature was included in the review. The current knowledge of IS development process focusing on the early stages in particular is presented next.

2.6. The FFE of IT/IS Development

One of the most well-known IT/IS development process models is the "information systems development life cycle" (SDLC) or the "waterfall model" (Avison & Fitzgerald, 2006). Although many variants of the SDLC exist, it has six basic stages: (1) feasibility study, (2) systems investigation, (3) systems analysis, (4) systems design, (5) implementation, and (6) review and maintenance (Avison & Fitzgerald, 2006). The feasibility study is a preliminary investigation of the existing system for problems, constraints, requirements and possible alternative solutions. Generally, at the end of this stage, the system analyst generates a formal report that is presented to management who will then decide whether to proceed or not. After the project has been given approval, the systems investigation begins. It involves a thorough investigation of the information found in the previous stage. The systems analysis stage tries to understand all aspects of the current systems and indicates how things could be improved – i.e., requirements of the new system. Next, the systems design involves the design of both the computer and manual parts of the new system. Following these designs the new system is then implemented and tested. The final stage of the SDLC takes place once the system is operational. Staff will be assigned for maintenance. A review and evaluation of the system is performed to ensure that it fulfils the requirements set out in the earlier stages, and the development is within budget and timeline (Avison & Fitzgerald, 2006).

When looking at the key activities of the FFE of innovation presented in Section 2.5.1, one might observe several similarities between those front-end activities and activities in the first four stages of the SDLC. To illustrate the point, key deliverables of those four stages of the SDLC are essentially a list of system specifications or requirements, a design of both new computer systems and new business processes, and a project plan (Avison & Fitzgerald, 2006). Similarly, the aim of the idea generation, evaluation, and uncertainty reduction activities in the FFE of innovation is also to generate ideas for a new service/produce as well as its specifications, while the other front-end activities (i.e., concept development and project planning) produce a prototype, a detailed design and an execution plan. In addition, one of the major problems of the traditional waterfall model is that requirements are difficult for users to articulate or define at the early stages of the SDLC (Avison & Fitzgerald, 2006). Users often realise what they really want or do not want at the end of a long development process, probably late in the implementation phase or during user testing. Making major amendments to the system at this time may be very costly. An increasingly popular development approach called "agile" has been proposed as a solution to the requirement problem (Highsmith & Cockburn, 2001). The agile approach adopts an evolutionary approach, which is characterised by an ongoing and iterative nature, together with prototyping and a philosophy that embraces changes. Interactions, frequent delivery of working software, customer collaboration and responding to changes are crucial in agile development (Avison & Fitzgerald, 2006).

Success of an IT/IS development process often relies on the effectiveness of requirements gathering (Hofmann & Lehner, 2001; Verner et al., 2005). Getting the requirements right is probably the most difficult part of a development project (Hofmann & Lehner, 2001). Moreover, since the current study explores the impact of openness competence on front-end uncertainty reduction in generating specifications for IT-based service innovations, a review of prior works on how system requirements are generated in IT/IS development projects may provide valuable insight into the FFE of IT-based service innovation. Therefore, a review of the literature on IS design and requirements engineering is presented in the following sub-sections.

2.6.1. What is requirement engineering and why it is important?

Requirement engineering (RE) is the first activity of the IS development process (Kauppinen et al., 2004). It involves both a process of requirements specification by gathering the needs of all stakeholders of an IS project (e.g., customers, users, senior management, project managers, developers) and a process of systematically refining and analysing those specifications (Hofmann & Lehner, 2001, p. 59). RE includes four key activities, namely elicitation, modelling, validation, and verification (Hofmann & Lehner, 2001). Typically, it starts by the process of eliciting requirements from various sources, such as experts, documents, users, the current system, etc. These requirements are then modelled to provide an alternative solution. The gradual normalisation of the model lead to a candidate specification, which then is validated and verified by feedback from the stakeholders (Hofmann & Lehner, 2001).

RE is the most critical and complex phase of the development of socio-technical systems (Juristo et al., 2002; Pandey et al., 2010). Scholars have identified deficiencies in requirements as the most important cause of software project failure (Hofmann & Lehner, 2001) and suggested that gathering good requirements and effectively managing those requirements impact project success (Verner et al., 2005). Moreover, RE is critical because errors in such an early stage can lead to problems later in the stages of system design and implementation (Kauppinen et al., 2004). According to Davis (1993), detecting and repairing errors later in the maintenance phase may cost 200 times more than detecting and repairing them in the RE phase. Furthermore, more than half of the development costs of complex IS is attributable to decisions made in the requirements specification and design phase (Walz et al., 1993).

2.6.2. Factors affecting the success of requirements engineering

Prior to the discussion about the current knowledge on critical success factors of RE, an understanding of how RE success is defined in the literature should first be obtained. According to El Emam and Madhavji (1995), RE success is multidimensional. Its three components are (1) cost effectiveness of the RE process focusing on resources used during the RE phase, (2) quality of RE products assessing the quality of documents, architectural design, and cost/benefit analysis, and (3) quality of RE service concerning user satisfaction with the service provided by the RE team. To achieve successful RE outcomes, scholars have suggested several critical success factors. Firstly, a team with superior application domain knowledge is crucial to RE success (Curtis et al., 1988; Hofmann & Lehner, 2001; Walz et al., 1993). It is also found that smaller group of analysts with tighter and less interrupted collaboration would produce a more complete specification and workable design (Curtis et al., 1988; Daley, 1978). Thirdly, based on survey and interview data of software projects' stakeholders, Hofmann and Lehner (2001) discovered that successful RE teams tend to involve customers/users and establish good relationships with all stakeholders. This is because organisational boundaries impede communication between the team and external stakeholders which results in disrupted acquisition, sharing and integration of knowledge (Curtis et al., 1988; Walz et al., 1993). The fourth factor is slack resources as Hofmann and Lehner (2001) found that successful projects allocate significantly more resources and efforts to RE, than projects with average performance. Finally, since RE is a complex process that involves gathering product specifications from a vast number of viewpoints, roles, responsibilities and objectives (Pandey et al., 2010, p. 287), a systematic approach and well-defined process is therefore necessary (Hofmann & Lehner, 2001; Kauppinen et al., 2004).

Based on the discussion in the previous and the current sections, we argue that the main objectives of the FFE of both the innovation and the IT/IS development processes are to gather as much information as possible about the innovation or the IT/IS under development in order to allow preplanning and decision making in advance to the actual execution. Since previous studies have suggested the importance of gathering ideas, information and knowledge from all stakeholders to FFE performance, we propose that the ability of a FFE team to open up the front-end process (i.e., openness competence within the FFE) is related to the team's ability to effectively reduce front-end uncertainty. FFE outcomes with less uncertainty in turn are more likely to lead to project success. To support these propositions, in the following sections, we review the literature on information-processing and open innovation. In addition, we discuss why openness competence within the FFE is crucial to front-end uncertainty reduction and innovation success.

2.7. An Information-Processing Theory

The "information-processing theory" proposes that there is a positive relationship between the degree of uncertainty and the amount of information processing required (Galbraith, 1974). Specifically, the greater the uncertainty of a task, the greater the amount of information is required by decision makers in order to achieve a given level of performance. Galbraith (1974) explained the rationale behind this relationship as follow:

> "If the task is well understood prior to performing it, much of the activity can be pre-planned. If it is not understood, then during the actual task execution more knowledge is acquired which leads to changes in resource allocations, schedules, and priorities. All these changes require information processing during task performance. […] The basic effect of uncertainty is to limit the ability of the organization to preplan or to make decisions about activities in advance of their execution." (p. 28)

Accordingly, we argue that, to avoid deviations from the pre-planned specifications in subsequent phases, an innovation team should try to enhance its ability to pre-plan and to make decisions by reducing uncertainty as much as possible during the FFE.

According to Galbraith (1974), to cope with the amount of task uncertainty, firms should improve their information processing capacity by adopting three mechanisms. First, for routine predictable tasks, the use of rules and programs allows the operators to execute a pre-defined set of actions which is appropriate to the situation he/she is facing. Second, for tasks with greater uncertainty where, in some situations, there are no rules to be applied, the hierarchy is used on an exception basis. Third, instead of specifying rules and programs, organisations should set goals or targets to be achieved. Employees then select the behaviours or actions that lead to achieving those goals and targets. However, if the project does not achieve the goals and targets as planned, the hierarchy is again employed.

Nevertheless, for tasks like introducing new products or services, venturing into new markets, or incorporating new technologies, a vast amount of information may often be required. This leads to more exceptions, more information processing, and an overloaded hierarchy (Galbraith, 1974, p. 29). The organisational mechanisms suggested above might not be sufficient. To tackle the problem, firms can proceed in either of two general ways. They can either try to reduce the amount of information required to be processed, or to increase the firm's information-processing capacity (Galbraith, 1974; Tushman & Nadler, 1978).

There are two ways to reduce the need for information processing (Galbraith, 1974). The first is the creation of slack resources. As the task uncertainty soars, one response strategy is to increase the planning goals or targets, e.g., deadline extensions, a loose budget, or buffer inventories. The other is to create self-contained tasks. This strategy shifts the authority structure from one based on input, resources and skills to one based on output or geographical factors. For example, instead of functionalities, subunits can be created around product lines, projects, target client groups, or geographical areas. To improve information processing capacity, Galbraith (1974) suggested two general strategies. First, firms can improve its decision makers' information processing capacity by investing in vertical IS. Second, lateral relationships should be established in order to relieve the information processing burden of a small number of decision makers to others sharing the problem.

We argue that managers' attention will be more fruitful when focusing on improving the front-end teams' information processing capacity, in lieu of focusing on reducing information-processing requirements. It may not be practical to employ the slack resources strategy in the current market situation of the service industry because it is characterised by hyper-competition, exceptional turbulence and short product life cycles

(Van Riel et al., 2004). Furthermore, as strongly claimed by Chesbrough (2003) "Not all smart people work for us" (p. xxvi), a group of people from different functionalities of the firm might not possess sufficient knowledge, competencies or skills to develop radical new products or services. Accordingly, the use of lateral relationships or external openness to improve the FFE team's information-processing capability, which is likely to be less costly than investing in new IS, is proposed to contribute more efficiently and effectively to the outcomes of the FFE and, ultimately, to innovation success.

2.7.1. A link between front-end uncertainty reduction and innovation success

Based on the literature on the front-end of innovation, drivers of uncertainty include the involvement of multiple actors, technology and market newness (Frishammar et al., 2011; Verworn et al., 2008). According to Zhang and Doll (2001), fuzziness related to the front-end of innovation involves customers, technology and competition. They also hypothetically suggested that there are negative effects of high levels of front-end fuzziness on shared team purpose, strategic fit of project targets, and clarity of project targets. In addition, Chang et al. (2007) conceptually proposed three main sources of front-end fuzziness, namely (1) front-end environment, (2) front-end means and (3) front-end goals. The front-end environment concerns general environment and task environment. While the former includes those non-specific factors affecting all innovators (e.g., socio-cultural, demographic factors, natural environment and resources, etc.), the latter involves more direct sources of fuzziness including departments, consumers, competitors, suppliers, and innovation partners. The front-end means refer to key activities in the FFE. Two categories of front-end activities were identified: strategic-level (e.g., innovation portfolio management, project planning, the linkages between innovation strategy and business plan, etc.) and operating-level activities (e.g., opportunity identification, idea evaluation, concept development, etc.). The final source is the front-end goals, which can be classified into intermediate goals (e.g., timeline and budget, strategic fit, innovativeness, etc.) and final goals (new product/service concepts, business/project plans, risk reduction, etc.). Vague or highly abstract goals could cause front-end fuzziness (Chang et al., 2007). By gathering relevant knowledge and information externally and exploiting innovation partnerships, the present study argues that the negative effects of the three sources of front-end fuzziness can be mitigated.

FFE scholars taking the information-processing view often suggest that, by reducing uncertainty as much as possible during the FFE phase, the overall performance of an innovation project can be improved (Frishammar et al., 2011; Moenaert et al., 1995; Verworn, 2009; Verworn et al., 2008). Verworn et al. (2008) empirically identified positive relationships between the degree of market and technical uncertainty reduction during the FFE and overall project success. Furthermore, Moenaert et al. (1995) observed a significant difference between successful and unsuccessful innovation projects regarding the amount of uncertainty reduced during the FFE. They found that on average innovation uncertainty, which concerns the FFE team members' knowledge of user needs, marketing and R&D resources requirements, technology used, and technological strategy of the competition, had been reduced during the FFE in successful innovation projects as much as it had been during the whole cycle in unsuccessful ones. Frishammar et al. (2011) studied the FFE phase of product and process innovation in metal and mineral firms and discovered that, in successful projects, uncertainty differed significantly between the first and the last sub-phase of the FFE. However, no significant difference was found for unsuccessful projects. In high-technology service industries, innovation success has been found to be related positively and directly with the systematic reduction of decision-making uncertainty (Van Riel et al., 2004).

Uncertainties inherent in the front-end of innovation mainly involve market and technology (Verworn, 2009; Verworn et al., 2008; Zhang & Doll, 2001). The former includes uncertainty over customers' needs, competitors, pricing and market situations; the latter concerns knowledge gaps in technology specification, technical requirements (e.g., timeline, resources, skills, etc.), and potential technical problems that might arise during the development (Verworn et al., 2008, p. 4). As posited by Calantone et al. (1996), a higher proficiency in marketing reduction initiations (e.g., market assessment studies, product testing, etc.) and in technical reduction activities (e.g., technical assessments, product designs, etc.) results in greater innovation success. In this study, we argue that for tasks involving a high level of market and technical uncertainty, such as the development of a new product or service, it is important that the development team increases their information-processing capacity by reaching out for information, knowledge, or expertise from outside of the firm. Front-end managers should therefore focus on reducing both the market and technical uncertainty systematically and effectively through openness. Such a view coincides with the concept of openness in the open innovation literature.

In the following sections, the key principles of open innovation are delineated, as well as a review of the extant literature on open innovation. After that, a discussion of how openness is crucial to uncertainty reduction in the early phase of innovation is presented.

2.8. Open Innovation

During the post war (WWII) period, R&D functions in firms were in the age of deep vertical integration, because there were few capable external alternatives (Chesbrough, 2003). This internally-focused way of innovation management is virtue, since it is easy to capture value from one's R&D when one controls the entire value chain, thanks to one's dominant position in the market (Chesbrough, 2003). Chesbrough (2003) called this paradigm as "closed innovation". In this view, successful innovation requires firms to generate and develop ideas internally, nurture them in one of their business units, and commercialise them through their sale and distribution channels (Chesbrough et al., 2006). However, Chesbrough (2003) argues that the closed innovation paradigm has recently been challenged by four erosion factors: (1) the increasing availability and mobility of skilled workers; (2) the emergence of a venture capital market; (3) the availability of external paths to market for ideas sitting on the shelf; and (4) the increasing capability of external suppliers. The landscape of knowledge has shifted away from central R&D facilities towards the outside world as a result of these erosion factors. A closed innovation approach is now likely to overlook business opportunities in the large pool of knowledge lying outside of the firm's boundaries. Moreover, these erosion factors also make it very difficult for firms to prevent internally generated knowledge from leaking out when entrepreneurial employees leave the company and start their own business with the help of venture capitals (Chesbrough et al., 2006).

To address the weaknesses of the closed innovation paradigm, Chesbrough (2003) proposed a new innovation paradigm called "open innovation" by drawing from an earlier body of academic scholarship concerning spillovers generated by internal R&D (Chesbrough & Rosenbloom, 2002), absorptive capacity (Cohen & Levinthal, 1990), democratising innovation (Von Hippel, 2005), use of alliances (Baum et al., 2000; Gerlach, 1992), construction of networks (Gomes-Casseres, 1996) and the rise of intermediate markets (Arora et al., 2002). He argues that valuable ideas can come from inside or outside of the company's boundary and can go to market from inside or outside of the firm. In addition, the role of business models is highlight, in enabling the utilisation of both external and internal ideas to create value and the delineation of internal mechanisms to capture some portion of that value (Chesbrough, 2003, p. xxiv). Figure 2.2 illustrates the process of open innovation.

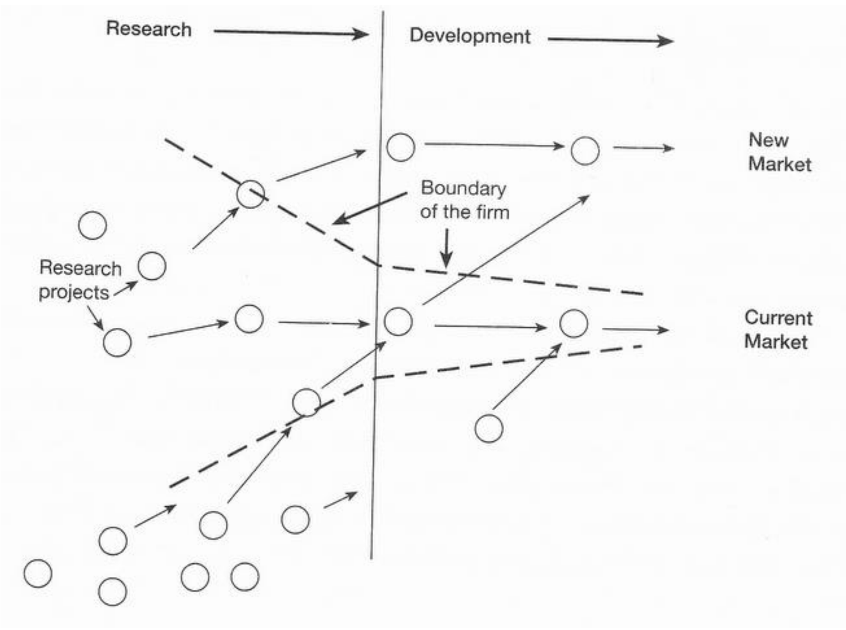

Figure 2.2: Open Innovation paradigm for managing industrial R&D (source: Chesbrough, 2003)

As shown in Figure 2.2, ideas can originate from either inside or outside the firm's research process. However, some of those ideas may leak out through the permeable boundary of the firm, either in the research phase or later in the development phase. Leakage mechanisms are, for instance, start-up companies, out-licensing and departing employees (Chesbrough, 2003). To sum up, the important assumptions of open innovation are: good R&D practices must include accessing and integrating external knowledge; firms can and should manage their intellectual property to advance their own business model as well as commercialise their intellectual property to profit from their rivals' use; and start-up companies can be exploited as additional commercialisation channels or experimental marketing fields.

There are several motives for firms to move from closed to open innovation. Exploration and acquisition of external knowledge, or cooperation with external partners enables firms to lower their R&D cost, increase innovation productivity and reduce time to market, while out-licensing or venturing can be an additional way to make profit from novel ideas (Chesbrough, 2003). In an interview-based study of 12 early adopters of open innovation, Chesbrough and Crowther (2006) found that the search for growth, in revenues and in new products is the most common reason behind the adoption of the concept. Furthermore, innovative firms may practise open innovation in order to gather new ideas, knowledge or complementary resources, to spread risks, or to build an innovation network (Hoffmann & Schlosser, 2001; Mohr & Spekman, 1994). In terms of outbound open innovation, Lichtenthaler and Ernst (2007) empirically identified numerous drivers, such as attempting to entry into foreign markets through licensing, setting an industry standard, guaranteeing freedom to operate, gaining access to other firms' knowledge, guaranteeing the firms' technological leadership, enhancing the firm's reputation, or strengthening its inter-organisational networks.

Nevertheless, companies investing in open innovation activities also face several risks and barriers (Enkel et al., 2009). Those risks are loss of knowledge, high coordination cost, loss of control, high complexity (Enkel et al., 2009), attention problems (Laursen & Salter, 2006), and disclosure of a corporate crown jewel (Rivette & Kline, 2000). The impediments that hinder innovative firms from fully profiting from their open innovation campaign are: the not-invented-here (NIH) syndrome and a lack of internal commitment (Chesbrough & Crowther, 2006), difficulty in finding the right partners (Miotti & Sachwald, 2003), insufficient time and financial resources (Enkel et al., 2009), organisational change issues (Chiaroni et al., 2010), and finding the right balance between exploration and exploitation (Jansen et al., 2006; March, 1991) because there is a curvilinear relationship between searching deeply and widely, and innovation performance (Laursen & Salter, 2006).

Next, reflecting on the multidimensional nature of open innovation, several definitions viewed from different perspectives are presented. Over the past decade, innovation researchers have extensively investigated into the open innovation phenomena and, as a consequence, proposed a variety of analytical frameworks. These frameworks could be very useful to both theory development and practical implementation of open innovation. The final sub-section reviews those open innovation frameworks and discusses the framework that frames the current study.

2.8.1. Definitions of open innovation

Scholars have used different definitions of open innovation in their studies. One of the most often used is: “the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively” (Chesbrough et al., 2006, p. 1). Two main concepts can be identified at the heart of this definition: inbound open innovation and outbound open innovation (Chesbrough & Crowther, 2006). The former involves the practice of leveraging others’ discoveries and knowledge based on the argument that firms need not and should not rely exclusively on their internal R&D. The latter suggests that companies should look for external organisations with business models that are better suited to their new ideas or inventions (Chesbrough & Crowther, 2006).

From a process perspective, open innovation can be defined as an innovation approach that “systematically [relies] on a firm’s dynamic capabilities of internally and externally carrying out the major technology management tasks, i.e., technology acquisition and technology exploitation, along the innovation process” (Lichtenthaler, 2008, p. 148). In addition, concerning a firm’s external search strategy, Laursen and Salter (2006) define openness as “the number of different sources of external knowledge that each firm draws upon in its innovative activities” (p. 1204). On the other hand, emphasising on the free revealing of ideas or outbound open innovation, Von Hippel and Von Krogh (2006) argue that “a central tenant of open innovation is free revealing of the detailed workings of novel products and services, so that others may use them, learn from them, and perhaps improve them as well" (p. 295). Although the diversity of definitions of open innovation seems to depict its richness and multi-dimensional nature, such a conceptual ambiguity, however, inhibits the ability to build a coherent body of knowledge about open innovation (Dahlander & Gann, 2010).

2.8.2. Classification frameworks of open innovation practices

In addition to Chesbrough and Crowther's (2006) inbound versus outbound open innovation classification scheme mentioned above, a broad variety of perspectives have been adopted to frame open innovation practices in organisations. Openness has been recognised by researchers as a continuum with varying degree of openness, rather than a binary classification of open versus closed (Chesbrough, 2003; Dahlander & Gann, 2010). From a firm's innovation process perspective, Enkel et al. (2009) argued that there are three core open innovation processes: (1) outside-in, (2) inside-out and (3) coupled processes. The outside-in process involves integrating knowledge from external sources, such as customers, suppliers, competitors, universities and research institutes, into the company's knowledge base in order to increase innovativeness and reduce time to market. The inside-out process refers to earning profits by bringing ideas or innovations to market through external channels, such as venturing[1], out-licensing[2] and spin-offs[3]. The coupled process encourages co-creation with complementary partners through alliances, cooperation, and joint ventures. This process combines the outside-in process with the

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[1] A practice where a large firm financially invests and takes an equity stake in, or offer a strategic alliance or support to, an innovative or specialist (often smaller) firm (Chesbrough, 2003).
[2] A practice where a firm commercialises its inventions or intellectual properties (IP) through selling or licensing their inventions or IP to another firm (Chesbrough, 2003).
[3] A practice involving the creation of an independent company through the sale or distribution of new shares of an existing business or division of a parent company. Businesses wishing to streamline their operations often sell less productive or unrelated subsidiary businesses as spinoffs (Investopedia.com, 2015).

inside-out process (Enkel et al., 2009). Additionally, by applying the dimensions of inbound versus outbound open innovation and pecuniary versus non-pecuniary interactions, Dahlander and Gann (2010) proposed two forms of inbound open innovation – (1) acquiring and (2) sourcing; and two outbound forms – (3) selling and (4) revealing. Open innovation practices can also be grouped by embracing both process and outcome views of innovation activities in organisations. Huizingh (2011) suggested that both the process and the outcome of innovation can be closed or open, which results in four types of innovation, namely (1) closed innovation (closed process and closed outcome), (2) private open innovation (open process but closed outcome), (3) public innovation (closed process and open outcome), and open source innovation (open process and open outcome). Finally, Lichtenthaler and Lichtenthaler (2009) amalgamated the literature on knowledge management, absorptive capacity, and dynamic capabilities; and came up with a capability-based framework for open innovation, which concerns knowledge exploration, retention and exploitation. As a result, six knowledge capacities (defined as a firm's capabilities of managing internal and external knowledge in open innovation processes) were identified – i.e., inventive, absorptive, transformative, connective, innovative, and desorptive capacity.

The main construct of interest in this study – i.e., openness competence within the FFE – is defined based on the outside-in and the coupled processes proposed by Enkel et al. (2009). We propose that openness competence is crucial to the overall success of a service innovation project as it helps mitigate uncertainties related to the FFE phase. The next section discusses how the term "openness competence" is defined in this research study. Also, it presents prior works that suggest the impact of openness competence on innovation performance; and its role in the FFE of innovation.

2.9. Openness Competence

The literature on dynamic capabilities suggests that a source of sustain competitive advantage for organisations operating in high-velocity markets is “the firm's ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments” (Eisenhardt & Martin, 2000, p. 516; Teece et al., 1997). According to Teece (2007, p. 1322), to identify and shape opportunities, firms must “constantly scan, search, and explore across technologies and markets, both ‘local’ and ‘distant’.” Moreover, links with potential collaborators, such as customers, suppliers, universities, must be established for firms to tap into innovations emerging outside (Teece, 2007). Sensing capability is one of the essential dynamic capabilities needed for service innovation (Kindström et al., 2013). Kindström et al. (2013, p. 1066-1067) proposed that firms seeking to increase the service content of their business portfolios and those looking to develop new services should employ sensing activities in four main areas:

- *Customer-linked service sensing* which focuses on building up deep customer knowledge, including organising feedback loops and creating organisational roles, systems and processes that continuously capture and relay customer demands;
- *Service system sensing* which involves building up an understanding of the entire service system, including links to partners and suppliers and creating an innovation network;
- *Internal service sensing* which emphasises building up internal sensing: e.g., opportunities related to the integration of products and services and the detection of decentralised initiative, as well as having a structured service development process to facilitate internal sensing; and
- *Technology exploitation* which includes scanning and exploring sources outside the service system, primarily related to merging new-to-industry technologies.

In a similar way but in a different context, Robertson et al. (2012, p. 827) argued that, to achieve incremental process innovation, firms need to possess an accessive capacity which refers to “capabilities that promote finding, assimilating and recognising the importance of knowledge … [as well as] the importance of taking the initiative in establishing contacts with other organisations to gather external information or knowledge.”

The discussion above is consistent with the concept of inbound open innovation. A firm’s abilities to effectively execute external searches and innovative coordination can have an impact on the success of innovation in services (Chesbrough, 2011). This is in line with Lichtenthaler and Lichtenthaler’s (2009) capability-based framework for open innovation. Their framework suggests that a firm’s abilities to explore external knowledge and to retain knowledge in inter-firm relationships are crucial for managing external knowledge in the open innovation process. Similarly, Enkel et al. (2009) proposed an open innovation archetypes framework consisting of three core processes: (1) the outside-in process, (2) the inside-out process and (3) the coupled process. While the inside-out process concerns earning profits from the ideas generated from the front-end process, the outside-in and coupled processes are relevant to idea generation activities in the FFE phase. Thus, the current study highlights these two processes.

The “outside-in process” involves “enriching the company’s own knowledge base through the integration of suppliers, customers, and external knowledge sourcing” (Enkel et al., 2009, p. 312). The implications of such activities have been identified in the literature. Scholars have suggested a positive relationship between a firm’s external knowledge search and its innovation performance (Chang et al., 2012; Chiang & Hung, 2010; Laursen & Salter, 2006; Leiponen, 2005).

The “coupled process” refers to “co-creation with (mainly) complementary partners through alliances, cooperation, and joint ventures during which give and take are crucial for success” (Enkel et al., 2009, p. 313). Inter-organisational partnerships allow firms to gain access to and draw from diverse knowledge, resources and capabilities to generate innovative new products or services (Eisingerich et al., 2009). In addition, alliance networks may also be necessary in situations where economies of scale could not be achieved by a sole firm and/or diverse skills, technologies and competencies are required (Chesbrough, 2011; Zeng et al., 2010). Scholars have long encouraged firms to co-create value with external partners, such as customers (Alam, 2006a; Oliveira & von Hippel, 2011), competitors (Mention, 2011), business partners (Ordanini & Parasuraman, 2011), suppliers (Den Hertog, 2000; Hsieh & Tidd, 2012), intermediaries (Howells, 2006; Zeng et al., 2010), and universities and research organisations (Fey & Birkinshaw, 2005; Segarra-Blasco & Arauzo-Carod, 2008).

Since activities in the FFE primarily involve exploring new opportunities, concretising ideas and assessing them (Khurana & Rosenthal, 1998), the current study emphasises the inbound activities of open innovation. Specifically, regarding Enkel and colleagues’ (2009) open innovation archetypes framework, the concept of openness employed in the present study is essentially framed by the outside-in and coupled processes that, we believe, helps to reduce uncertainty related to the FFE of service innovation projects which in turn leads to service innovation success. Firms that build capabilities to widely explore external sources of ideas (Chen et al., 2011; Laursen & Salter, 2006), to absorb external knowledge (Caloghirou et al., 2004; Cohen & Levinthal, 1990), and to cooperate with external partners (Ettlie & Pavlou, 2006; Zeng et al., 2010) have been reported as better performers, both in terms of innovativeness and sales of innovations, compared to their relatively closed counterparts.

The researcher defines *'openness'* within the FFE phase as a concept involving both the outside-in and coupled processes. As the S-D logic's FP4 indicates, "operant resources are the fundamental source of competitive advantage" (Vargo & Lusch, 2008, p. 7). We therefore define '*openness competence*' within the FFE as "the ability of a front-end team to explore, gather and assimilate operant resources from external sources by means of the outside-in and the coupled processes." Such competence may be important for a team adopting a more open approach to the front-end of innovation.

2.9.1. Openness competence and innovation success

Several empirical research studies have suggested a positive relationship between inbound openness and innovation performance. For example, Hsieh and Tidd (2012) found that a more closed approach to service innovation tends to reduce the development time, while a more open approach produces a greater variety of innovations and higher levels of innovation novelty. In terms of external knowledge searches, greater search depth and breadth enhance innovation performance (Chen et al., 2011; Chiang & Hung, 2010). For innovation partnerships, Ordanini and Parasuraman (2011) reported that a development team's ability to collaborate with customers and business partners contributes to innovation volume and newness of the innovations, respectively. Zeng et al. (2010) discovered a positive relationship between inter-firm cooperation and the innovation performance of SMEs.

Nevertheless, others have reported contradictory results. Knudsen and Mortensen (2011) surveyed 110 Danish firms and discovered interesting findings. The study found that firms employing single-firm innovation strategies overpowered their more open counterparts who employ collaborative strategies with regard to innovation performance. In addition, their findings suggest that higher openness in innovation leads to worst timing to market, slower development, and higher development costs. In a similar way, according to Laursen and Salter's (2006) study, there is a curvilinear (an inverted U-shape) relationship between searching deeply and widely, and innovation performance. Therefore, the right balance between exploration and exploitation needs to be achieved in order to be successful in innovation, as March (1991, p. 71) described:

> "Adaptive systems that engage in exploration to the exclusion of exploitation are likely to find that they suffer the costs of experimentation without gaining many of its benefits. They exhibit too many undeveloped new ideas and too little distinctive competence. Conversely, systems that engage in exploitation to the exclusion of exploration are likely to find themselves trapped in suboptimal stable equilibria."

One possible explanation for these conflicting findings may be that openness has been studied at a higher level of analysis (e.g., at the firm or the innovation project levels). Examining openness at different phases of the innovation process could yield more consistent results. We argue that, unlike in the later stages, a more open approach might fare better in the early stages of the innovation process. Activities in the information-intensive FFE phase are likely to lend themselves better to greater external openness, which sometimes incurs higher costs and is time-consuming (Knudsen & Mortensen, 2011). The next section therefore reviews prior works on openness in the FFE phase.

2.9.2. Openness competence within the FFE

While the entire process of new product or service development could benefit from being more open, we argue that openness may be most useful in the FFE where the majority of information acquisition and uncertainty reduction takes place (Moenaert et al., 1995). Openness to new ideas, inputs and sources of inspiration external to the firm's boundary is considered crucial for innovation projects, especially in their early stages (Fagerberg, 2005). In the service sector in particular, since formal R&D plays a much less important role than it does in manufacturing, service firms' innovation capacities strongly depend on access to external information sources (Muller & Zenker, 2001).

According to Luoma et al. (2008), although resources used in the FFE are accounted for only 10% of the total cost of new product or service development, 70% of the total costs are committed at this phase. Therefore, gathering and assimilating as much knowledge and information as possible regarding market situation, technical feasibility, financial feasibility, etc. may be crucially important for activities in the FFE. de Brentani and Reid (2012, p. 76) conceptually studied the FFE of radical innovations and argued that the use of webs of external relationships allows the FFE team to draw on new and different areas of knowledge and product application situations rather than focusing on current uses and markets. They also proposed that, during the FFE phase of radical innovation projects, longer search times, more processing time and additional information might be necessary in order to improve the quality of information and decision making (de Brentani & Reid, 2012, p. 77). Even though this may translate into the slower speed of FFE information movement. Love et al. (2011) empirically highlighted the importance of external openness in the initial, exploratory phase of the innovation process, while internal openness (e.g. team working) is suggested as the more prominent mode of innovation in the later stages. These findings indicate a need for front-end people to expose themselves to the outside world more in order to achieve a higher level of front-end performance.

Prior studies have proposed several benefits for a FFE team that possesses the ability to open up effectively during the FFE phase. Firstly, the FFE of innovation has traditionally been characterised by a low level of formalisation (Khurana & Rosenthal, 1997; 1998) and often involves high levels of market and technical uncertainty (Verworn, 2009; Verworn et al., 2008). To reduce front-end uncertainty, various sources of knowledge and information lying outside the innovating firm's boundaries have been suggested by the literature. Alam (2006a) conducted a qualitative study involving 26 financial firms and reported that the early involvement of customers in the FFE phase of service innovation makes the FFE much less fuzzy. Similarly, demand uncertainties in the FFE of new online service development can be mitigated by analysing data collected from observing customers' actual behaviours (Ozer, 2007). Cooperation with external entities, such as suppliers, intermediaries, government agencies and competitors, can also help reduce the level of front-end fuzziness (Kim & Wilemon, 2002). Based on a case study of two innovation projects in a high-tech company, Stevens (2014) indicated that, to reduce uncertainty, the front-end team should use the customer's knowledge as a basis for decision-making. The use of personal networks is also crucial in the FFE phase due to the limited amount of time and resources available in such an early period (Stevens, 2014). The use of both internal and external networks by boundary-spanning individuals in the FFE of discontinuous innovation induces higher quality information flow into the innovating firm (de Brentani & Reid, 2012).

Secondly, external knowledge searching and inter-organisational partnerships provide information and knowledge that help to inspire creative solutions and identify problems early. Chesbrough and Crowther (2006) discovered that early adopters of open innovation used these practices to address possibly the most important issues of the FFE phase, i.e., how to avoid over-funding incremental projects and how to adequately fund higher potential, longer term ideas. In an experiment by Magnusson (2009), early involvement of lead users was found to facilitate the production of ideas that challenged the prevailing dominant logic of the innovating firms. Consistently, Björk and Magnusson (2009) empirically suggested that individuals with more network connectivity are likely to provide a higher proportion of high-quality ideas in the idea generation phase.

Finally, the risk of cooperation failures in innovation can be reduced through previous experiences in partnership (Lhuillery & Pfister, 2009). Therefore, early involvement of innovation partners might help strengthen the partnerships before venturing into the development phase, thus reduce the risk of cooperation failure. Similarly, a study by Verworn (2009) highlighted the importance of reducing market and technical uncertainty early in the FFE phase, since both were found to help improve both intra- and inter-communication between the participants later in the development phase.

As presented in this section, although scholars have recommended external knowledge searching and the establishment of external partnerships early in the innovation process, empirical studies that investigate openness competence within the FFE are yet limited. To address this issue, we have established a conceptual framework based on the information-processing and open innovation theories. The framework is illustrated and explained in the next section.

2.10. A Conceptual Framework

From the review of previous research presented in this chapter, we have been able to construct an initial conceptual framework (Figure 2.3) that was used to frame our entire investigation. The framework was formed with a purpose to provide answers to the three research questions mentioned in Chapter 1:

RQ1: What are the key dimensions of openness competence within the FFE of service innovation?

RQ2: Does openness competence within the FFE contribute to service innovation success?

RQ3: If yes, does openness competence contribute to service innovation success through the degree of market and technical uncertainty reduction during the FFE phase?

With regard to RQ1, we argue that openness competence is multidimensional in nature. However, from the literature review, prior knowledge of openness competence within the FFE of service innovation is limited. Concerning the key construct of the model, we intend to unearth the key dimensions of openness competence within the FFE through an S-D logic analytical lens.

As discussed in Section 2.9.1, previous findings on the effect of openness on innovation success are inconclusive. This study is an attempt to provide a possible explanation for these conflicting results by providing answers to RQ2 and RQ3. The conceptual framework was founded upon two areas of the literature. Firstly, the information-processing literature suggests the extent to which a FFE team (or an information processing team) can reduce uncertainty (e.g., by closing any information gaps between the team and the customers, competitors, technology, etc.) during the FFE phase (where uncertainty is high) influences the success of the service innovation process (i.e., a process of uncertainty reduction). Secondly, based on the open innovation theory, the model proposes that openness competence can be linked to market and technical uncertainty reduction during the FFE.

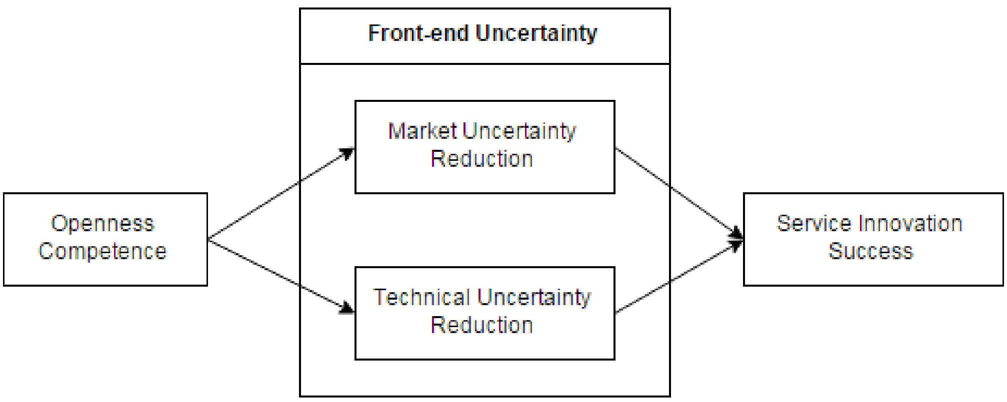

Figure 2.3: A conceptual framework of this study

2.11. Summary of the Chapter

In this chapter, we reviewed the literature in the fields of service innovation, the FFE of innovation, the information-processing theory and open innovation. The extant literature reveals the prominent influence of service innovation on the competitive advantage of firms competing in modern economies. There are three main streams of research on service innovation, namely assimilation, demarcation, and synthesis. The current study takes a synthesis approach and looks at openness competence within the FFE through an S-D logic analytical lenses. Although the FFE has been suggested as a significant phase in the innovation process, little effort has been made to investigate the role of openness in reducing the uncertainty related to such an early phase. Building on the literature on information-processing theory and open innovation, we created an initial theoretical framework (shown in the previous section). The next chapter describes and verifies the philosophical worldview and methodologies adopted by the researcher. The current study adopts a mixed methods design that includes an exploratory case study and a confirmatory survey of IT-based service innovations in Thailand. A detailed description of the design of the two phases is provided in next chapter.

3. Research Design

3.1. Introduction

According to Creswell (2009, p. 5), the term "research design" refers to "the plan or proposal to conduct research, involve[ing] the intersection of philosophy, strategies of inquiry, and specific methods." The research design of the current study is a sequential mixed methods design with an exploratory nature. Therefore, it consists of two distinct phases: qualitative followed by quantitative (Creswell & Plano Clark, 2011). We first performed a theory-building case study. The case data helped us to identify the key dimensions of openness competence and to develop hypotheses, which, in the second phase, were tested with data from a large-scale survey of project managers who participated in the FFE phase of IT-based service innovation projects.

There are several reasons why a mixed methods design is an appropriate approach for solving the research questions under study. Firstly, mixed methods research enables the researcher to answer questions that cannot be answered by qualitative or quantitative methods alone (Creswell & Plano Clark, 2011). In other words, both exploratory and confirmatory research questions can be addressed simultaneously (Teddlie & Tashakkori, 2009, p. 33). This allows us to explore openness within the FFE and its impact on service innovation success through front-end uncertainty reduction as well as to verify the findings discovered from the exploration. Secondly, the combination of qualitative and quantitative methods offsets the weaknesses associated with purely qualitative or quantitative research (Bryman, 2006; Creswell & Plano Clark, 2011). Finally, mixed methods research provides stronger inferences (Teddlie & Tashakkori, 2009). Rather than choosing between qualitative and quantitative data collection method, we argue that using in-depth interviews in conjunction with questionnaires can provide a greater depth and breadth of understanding of the poorly understood phenomenon of the FFE of service innovation. First, we conducted an inductive multiple case study to build a theory regarding the key dimensions of openness competence within the FFE and to initially confirm its contribution on success through front-end uncertainty reduction. Then, a deductive quantitative study was carried out to statistically verify the emergent dimensions and the proposed relationship between openness competence and service innovation success.

Framed by a “framework for design” proposed by Creswell (2009) (Figure 3.1), this chapter starts with a discussion on the general view of the world and the nature of research that a research study holds, i.e., its philosophical worldview. Then, the strategies of inquiry considered suitable for answering the present study’s research questions are explained. Thirdly, the details of the data collection and analysis methods is delineated. Finally, we provide a summary of the chapter.

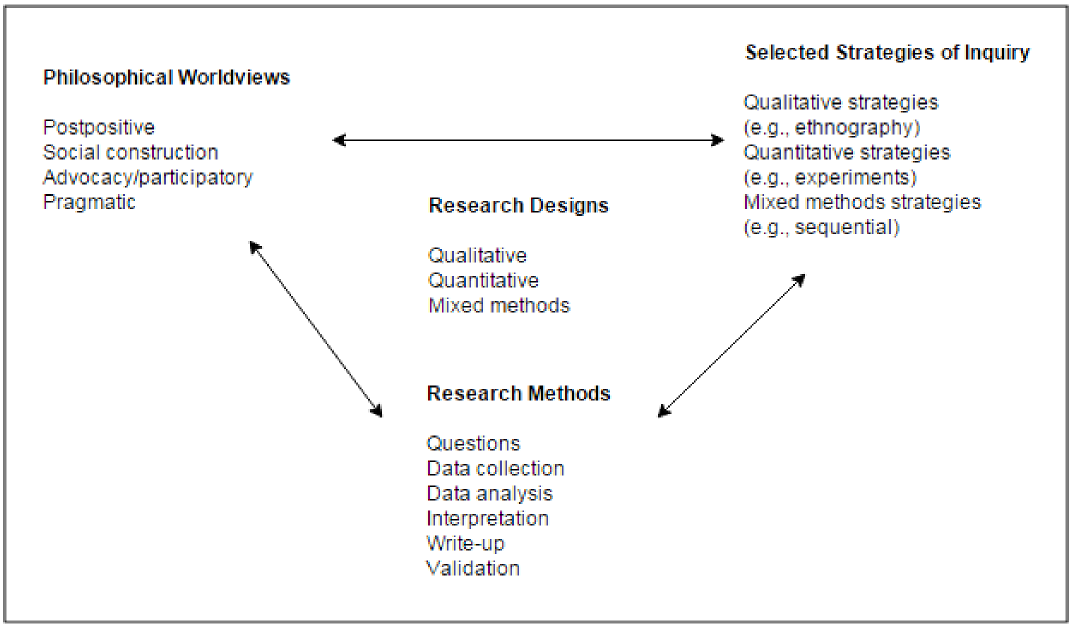

Figure 3.1: A “Framework for Design” – the interconnection of worldviews, strategies of inquiry, and research methods (source: Creswell, 2009, p. 5)

3.2. Philosophical Worldviews or Paradigms

“Both qualitative and quantitative methods may be used appropriately with any research paradigm. Questions of method are secondary of paradigm, which we define as the basic belief system or world view that guides the investigation, not only in choices of method but in ontologically and epistemologically fundamental ways" (Guba & Lincoln, 1994, p. 105).

Following this statement, the current section critically discusses on the philosophical assumptions that guide our choice of methodology. The term "worldviews" or "paradigms" refers to "systems of beliefs and practices that influence how researchers select both the questions they study and methods that they use to study them" (Morgan, 2007, p. 49). In social and behavioural sciences, there are three methodological communities of researchers Teddlie and Tashakkori (2009, p. 4):

- Quantitatively oriented researchers – who primarily work within the "postpositivist/positivist" paradigm,
- Qualitatively oriented researchers – who subscribe to a paradigm known as "constructivism" and its variants, and
- Mixed methodologies – those who are philosophically oriented to the "pragmatism" or "transformative perspective" paradigm.

Historically, quantitative approaches dominated social science research from the late 19th century up until the mid-20th century. Interest in qualitative research increased during the latter half of the 20th century, which inevitably led to the paradigms debate (Creswell, 2009; Teddlie & Tashakkori, 2009). The beginning of mixed methods research dated back to the late 1980s (Creswell, 2009). The use of triangulation strategies eventually led to the continued emergence of mixed methods research. In addition, the "incompatibility thesis" had been criticised by the scholars during the 1970-1990 era (Teddlie & Tashakkori, 2009, p. 75). These led to the institutionalisation of mixed methods as a third methodological orientation (Teddlie & Tashakkori, 2009).

In this section, the ongoing debate on the two competing paradigms of positivism and constructivism is firstly demonstrated. Then, the researcher explains and justifies the current study's worldview of pragmatism which is generally positioned in the middle between the two polar approaches.

3.2.1. The paradigms debate - positivism versus constructivism

The "quantitative approach" dominated social science research methodology up until the late 1970s, when "qualitative research" began to gain attention (Creswell, 2009; Morgan, 2007). Advocates of qualitative research often claimed that various issues associated with quantitative research could possibly be solved by taking qualitative approaches. The prominent work of Lincoln and Guba (1985) proposed a system for comparing different paradigms in social science through the concepts of: ontology, epistemology, and methodology. The main assumption of the paradigm debate is that radically different beliefs concerning the nature of reality and knowledge, held in different paradigms (e.g., positivism versus constructivism), make it impossible to translate or reinterpret research between the paradigms (Morgan, 2007). A brief review of the ongoing paradigms debate between "positivism" and "constructivism" (or "interpretivism") is given below.

In terms of ontology, positivist researchers hold an objective view of reality; hence they believe that "there are objective facts about the world that do not depend on interpretation or even the presence of any person" (Nonaka & Peltokorpi, 2006, p. 75). Regardless of observers, the world can be conceived though causal relations between entities; and there is such thing as universal knowledge (Nonaka & Peltokorpi, 2006). The role of researchers is therefore to "discover the objective physical and social reality" (Orlikowski & Baroudi, 1991, p. 9). In contrast, constructivism/interpretivism asserts a subjective view of the world and argues that there is no reality independent of human perception (Lee & Lings, 2008). Further, constructivists assume that "the social world (that is, social relations, organizations, division of labor) is not 'given'. Rather the social world is produced and reinforced by humans through their action and interaction" (Orlikowski & Baroudi, 1991, p. 14). Therefore, unlike positivists, interpretive researchers believe that social reality cannot be discovered, but can only be interpreted (Orlikowski & Baroudi, 1991).

Epistemologically, positivists believe that "human experience of the world reflects an objective, independent reality and that this reality provides the foundation for human knowledge" (Weber, 2004, p. vi). Therefore, valid knowledge can only be obtained through observation and measurement (Holden & Lynch, 2004). To support such belief, researchers need to build a set of constructs and hypotheses based on existing theories, and develop a set of instruments to measure them (Orlikowski & Baroudi, 1991). These hypotheses will then be statistically tested and either confirmed or rejected, leading to a new cycle of theory development and testing (Saunders et al., 2009). Note that the objective view of positivists has been heavily criticised for their disregard of many subjective decisions being made by the researchers themselves during the course of their study (Johnson & Onwuegbuzie, 2004). A few examples of subjectivism in quantitative research include deciding what to study, identifying the target constructs, developing instruments to measure those constructs, choosing alpha levels, etc. In contrast, constructivism suggests that social phenomena cannot be captured in a deductively constructed model and by statistically testable hypotheses (Orlikowski & Baroudi, 1991). Constructivists believe that knowledge "is built through social construction of the world" (Weber, 2004, p. vi) and "cannot be discovered, as it is subjectively acquired – everything is relative" (Holden & Lynch, 2004, p. 400). Therefore, when investigating social phenomena, researchers need to get inside the world of those generating it and interpret it through the researchers' set of meanings (Holden & Lynch, 2004). Specifically, constructivists focus on making sense of social phenomena through their stream of consciousness and their interaction with social actors (Saunders et al., 2009). Instead of going to the field with a well-defined set of constructs built on a priori theory, interpretative researchers try to derive their constructs from the field by conducting in-depth investigation into and expose themselves to the social phenomenon of interest (Orlikowski & Baroudi, 1991).

The positivist paradigm has several strengths as well as weaknesses. The first strength is that its assumptions support causality and law-like generalisations (Saunders et al., 2009). In general, such law-like generalisations are possible only when the constructs of interest are operationalised and reduced to the simplest possible elements (Holden & Lynch, 2004). Secondly, positivism's adherence to a highly structured methodology facilitates replication, which essentially increases the external validity of the results (Saunders et al., 2009). In comparison, replicability is much more challenging in interpretive studies because of the less well-defined nature of their research methods and the subjective nature of their interpretation (Weber, 2004). In terms of weaknesses, positivist studies tend to disregard the historical and contextual conditions of the phenomena of interest; they mainly emphasise the status quo (Orlikowski & Baroudi, 1991). This disregard may lead to an incomplete picture of the phenomena. Additionally, positivism believes in a hypothesis-deductive approach to research (Orlikowski & Baroudi, 1991). Unlike the inductive approach of constructivism, such a deductive procedure is not likely to lend itself to the discovery of new emerging themes or theories. Finally, as the constructs of interest are usually operationalised and reduced to the simplest elements, the knowledge produced may be too abstract and general to be directly applied to specific situations, contexts, and individuals (Johnson & Onwuegbuzie, 2004).

The main strength of constructivist inquiry is that an interpretative perspective enables researchers to capture the complexity and dynamics of social phenomena that are both time and context dependent (Orlikowski & Baroudi, 1991). In addition, an inductive approach allows fresh themes, categories or theories to emerged from empirical evidences (Holden & Lynch, 2004). Finally, although positivism focuses on causal relationships, it tends to lack the ability to explain why those relationships happen in the first place (Saunders et al., 2009). By focusing on sense making and interactions in a particular setting, interpretative researchers may be able to understand what is happening. However, in addition to the issues of replicability, there are several additional flaws in the philosophical assumptions of constructivism. Firstly, many positivists heavily criticise constructivism for its concepts of relativism and incommensurability (Holden & Lynch, 2004). Extreme subjectivists argue that "there are many equal versions of reality; each version of reality is personal and community-specific" (Holden & Lynch, 2004, p. 405). Therefore, each version of reality is incommensurable. This belief conflicts with the concept of scientific progress. The second limitation is that constructivist research fails to explain "the unintended consequences of human action", which refers to the actions that cannot be explained by the intentions of the actor (Orlikowski & Baroudi, 1991).

The paradigms debate is the foundation of the "incompatibility thesis", stating that "it was inappropriate to mix QUAL [qualitative] and QUAN [quantitative] methods due to fundamental differences in underlying paradigms [i.e., constructivism versus positivism]" (Teddlie & Tashakkori, 2009, p. 73). However, according to Teddlie and Tashakkori (2009), the paradigms debate was resolved for many researchers with the emergence of the "compatibility thesis" proposed by Howe (1988). Instead of the two polar opposites, Teddlie and Tashakkori (2009) proposed a QUAL-MM-QUAN continuum as portrayed in Figure 3.2. Zone A consists of totally qualitative (QUAL) research, whereas zone E includes only quantitative (QUAN) oriented studies. Zone B and D consist of mixed methods (MM) research that focuses primarily on the qualitative and quantitative components, respectively. Finally, zone C represents mixed methods research that weights its qualitative and quantitative elements equally. Along this continuum, Teddlie and Tashakkori (2009) positioned five distinct paradigms that are associated with the three research communities, i.e., qualitative, mixed methods, and quantitative. Their comprehensive summarisation of the important philosophical assumptions and beliefs of each of the five paradigms related to the three research communities is displayed in Table 3.1. Since this is a mixed methods study, a brief description of the researcher's pragmatic worldview as well as the reasons why such a worldview is appropriate to this study's research questions are explained next.

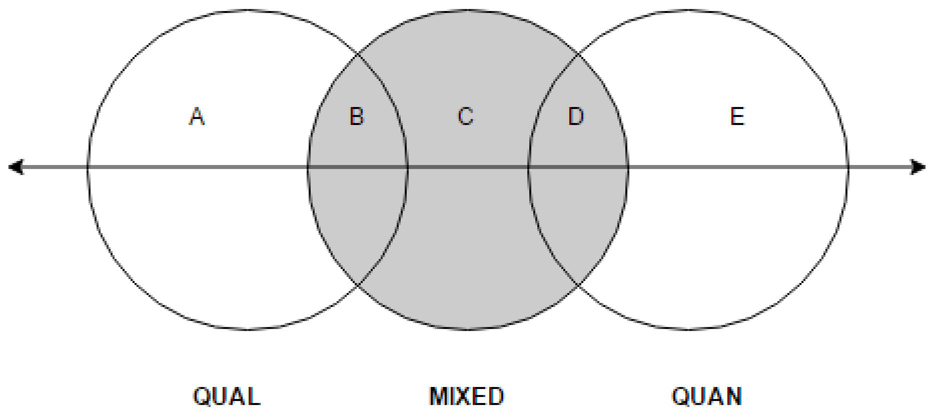

Figure 3.2: The QUAN-MM-QUAL Continuum (source: Teddlie & Tashakkori, 2009, p. 28)

Table 3.1: Paradigm contrast table comparing five paradigms (source: Teddlie & Tashakkori, 2009, p. 88)

Dimension of Contrast	***Constructivism***	***Transformative***	***Pragmatism***	***Postpositivism***	***Positivism***
Methods	Qualitative	Both qualitative and quantitative; community of practitioners involved in methods decisions	Both qualitative and quantitative; researchers answer questions using best methods	Primarily quantitative	Quantitative
Logic	Inductive	Both inductive and hypothetico-deductive	Both inductive and hypothetico-deductive	Hypothetico-deductive	Hypothetico-deductive (originally inductive)
Epistemology (researcher/participant relationship)	Subjective point of view; reality co-constructed with participants	Both objective and interaction with participants valued by researchers	Both objective and subjective points of view, depending on stage of research cycle	Modified dualism	Objective point of view (dualism)
Axiology (role of values)	Value-bound inquiry	All aspects of research guided by social injustice	Values important in interpreting results	Values in inquiry, but their influence may be controlled	Value-free inquiry
Ontology (the nature of reality)	Ontological relativism – multiple, constructed realities	Diverse viewpoints regarding social realities; explanations that promote justice	Diverse viewpoints regarding social realities; best explanations within personal value systems	Critical realism (external reality that is understood imperfectly and probabilistically)	Naïve realism (an objective, external reality that can be comprehended)
Possibility of causal linkages	Impossible to distinguish causes from effects; credibility of descriptions important	Causal relations that should be understood within the framework of social justice	Causal relations, but they are transitory and hard to identify; both internal validity and credibility important	Causes identifiable in a probabilistic sense that changes over time; internal validity important	Real causes temporally precedent to or simultaneous with effects
Possibility of generalisation	Only ideographic statements possible; transferability issues important	Ideographic statements emphasised; results linked to issues of social inequality and justice	Ideographic statements emphasised; both external validity and transferability issues important	Modified nomothetic position; external validity important	Nomothetic statements possible

3.2.2. The pragmatic approach to social science research

Proponents of mixed methods suggest a shift from the top-down approach of ontological comparisons to a more pragmatic approach (e.g., Bergman, 2008; Morgan, 2007). Morgan (2007) explained that the top-down approach imposes constraints on any of a researcher's subsequent epistemological assumptions. These assumptions about the nature of knowledge in turn restrict the range of methodological choices. Bergman (2008, p. 16) argued that:

> "The decision on whether the researcher deals (or, better, wants to deal) with one single reality, a constructed reality, multiple realities, multiple constructed realities, a co-constructed reality between the researcher and the researched, or no reality at all is unrelated to whether patterns in the data are detected via statistical analysis or otherwise."

In addition, the claim that knowledge produced by research in different paradigms is "incompatible" creates major communication barriers and does not allow researchers to combine or even compare results from studies taking different ontological beliefs (Morgan, 2007). Specifically, rather than debating over which of the paradigms is better and dismissing the others' work, research communities as a whole would be better off if, for example, researchers in the qualitative camp pay more attention to exploring and/or explaining the range of phenomena that researchers in the quantitative camp have sought to define and test, and vice versa. Therefore, a pragmatic approach could be a viable alternative on this issue (Morgan, 2007).

The researcher believes that a pragmatic approach emphasises actual behaviour ("line of action"), the beliefs that stand behind those behaviours ("warrant assertions"), and the consequences that are likely to follow from different behaviours ("work ability") (Morgan, 2007, p. 67) could be an interesting alternative. Rather than focusing on methods, pragmatism highlights the consequences of research, the research problems, and the use of all tools available to inform the problem of interest (Creswell & Plano Clark, 2011).

According to Cherryholmes (1992), Creswell (2009), Johnson and Onwuegbuzie (2004), and Morgan (2007), the key features of pragmatism are:

- Truth is what works at the time. Truth is not based in a duality between reality independent of the mind or within the mind (Creswell, 2009). Pragmatism views current truth, meaning, and knowledge as tentative and as changing over time (Johnson & Onwuegbuzie, 2004).
- Knowledge is viewed as being both constructed and based on the reality of the world (Johnson & Onwuegbuzie, 2004). Pragmatists believe that asking questions about reality and the law of nature must be stopped (Cherryholmes, 1992).
- Theories are viewed instrumentally (the workability of a theory depends on its predictability and applicability) (Johnson & Onwuegbuzie, 2004).
- Pragmatism rejects the traditional dualism of subjective and objective. (Johnson & Onwuegbuzie, 2004). Pragmatists employ an intersubjective approach to the relationship between the researcher and the research process (Morgan, 2007).
- Pragmatism's logic of inquiry is abduction, involving working back and forth between induction and deduction (Morgan, 2007).
- Pragmatists are free to choose the methods, procedures, and techniques that best match their research problems and objectives (Creswell, 2009).

Pragmatism therefore allows the use of, different assumptions, different research methodologies, and both qualitative and quantitative data collection and analysis (Creswell, 2009). It offers an immediate middle ground philosophically and methodologically (Johnson & Onwuegbuzie, 2004).

On the one hand, the nature of RQ1 ("What are the key dimensions of openness competence within the FFE of service innovation?") is exploratory, since, to our knowledge, the core components of openness competence have yet to be suggested by the literature. On the other hand, the other two questions (RQ2: "does openness competence within the FFE contribute to service innovation success?" and RQ 3: "if yes, does openness competence contribute to service innovation success through the degree of market and technical uncertainty reduction during the FFE phase?") are rather confirmatory. Therefore, for the current study, we hold the worldview of pragmatism, which allows us to tackle research questions with radically different natures without any methodological limitations. Furthermore, we believe that knowledge generated from qualitative and quantitative approaches complements each other, which could result in more practical answers to the research questions.

3.3. Strategies of Inquiry or Research Methodologies

"Strategies of inquiry" or "research methodologies" refer to "types of qualitative, quantitative, and mixed methods designs or models that provide specific direction for procedures in a research design" (Creswell, 2009, p. 11). Some examples of research methodologies are displayed in Table 3.2.

Table 3.2: Strategies of inquiry (compiled from Creswell, 2009; Creswell and Plano Clark, 2011; Saunders et al., 2009)

Strategies Associated With Quantitative Approach	***Strategies Associated With Qualitative Approach***	***Strategies Associated With Mixed Methods Approach***
• Experiment • Survey	• Narrative research • Phenomenology • Ethnography • Grounded theory • Case study • Action research	• Sequential • Embedded • Transformative • Multiphase

When selecting a research strategy, six conditions should be considered. According to Yin (2009, p. 8), three criteria – (1) the type of research question, (2) the extent of control over behavioural variables, affecting internal validity and (3) the degree of focus on contemporary events – should be taken into account when one makes a research strategy choice. Further, Scandura and Williams (2000, p. 1250) suggest a trade-off between three additional important dimensions – (4) generalisability, relating to the issue of external validity; (5) precision in measurement, affecting construct validity; and (6) realism of context. With regard to these six dimensions, Table 3.3 compares and contrasts the four predominant research strategies.

Table 3.3: Differences between research strategies (compiled from Scandura and Williams, 2000; Yin, 2009; Saunders et al., 2009).

	Experiment	*Survey*	*Case Study*	*Action Research*
The type of research question	Why, how?	What, how, who, where?	Why, how?	How?
Control of behavioural variables	High	Low	Low	Moderate
Focuses on contemporary events?	Yes	Yes	Yes	Yes
Generalisability	Low	High	Low	Low
Precision of measurement	High	Low	Low	Moderate
Realism of context	Low	Low	High	Moderate

A theory-building case study is considered as an appropriate strategy for the first phase of this study for several reasons. Firstly, such an inductive approach lends support to this study's attempt to answer the first research question (RQ1), which focuses on identifying key dimensions of openness competence within the FFE and explaining why those dimensions are important. Secondly, given the emerging trend of open service innovation (Chesbrough, 2011), the amount of prior research on openness in the FFE phase of service innovation is very limited. Therefore, a case study is a suitable method to identify patterns and new perspectives about the phenomena (Eisenhardt, 1989). Thirdly, the researcher proposes that the front-end of service innovation is typically fuzzy, unstructured, and requires multi-party involvement. Therefore, a case study strategy is particularly suited to such a poorly understood social phenomenon (Yin, 2009). Nevertheless, theories emerging from case studies has usually been challenged on their generalisability (Eisenhardt & Graebner, 2007). Furthermore, the control over behavioural variables and the precision of measurement are considered problematic in case study research (Table 3.3). To counter these drawbacks, an additional data collection and analysis phase was introduced. A survey strategy was employed in the later phase of the study to improve generalisability as well as for triangulation purposes.

In the second phase, the survey strategy was chosen for the following reasons. Firstly, survey is considered as an appropriate strategy to verify the core components of openness competence discovered from the case data. Furthermore, survey data can be statistically analysed to confirm the initial framework proposed in Chapter 2 (Figure 2.3), thus answering RQ2 and RQ3. Secondly, given that one of the main aims of the second phase is to generalise the initial findings, the survey strategy is therefore preferable to other strategies. Survey is a more economical way to collect data from large samples (Saunders et al., 2009) which leads to higher levels of generalisability (Scandura and Williams, 2000). Figure 3.3 presents an overview of the design of the current study.

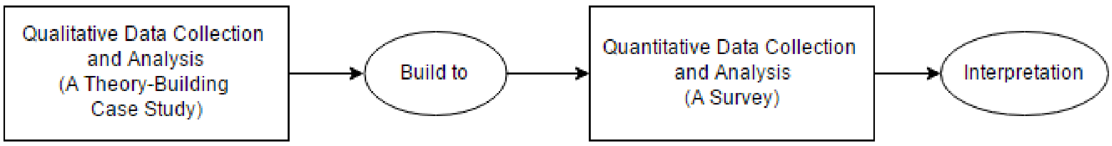

Figure 3.3: The sequential exploratory mixed methods design (adapted from Creswell and Plano Clark, 2011)

The next section describes, in detail, the final component of Creswell's (2009) framework for research design – "research methods".

3.4. Research Methods

The third major component of the framework of design (Figure 3.1) concerns the specific methods of data collection and analysis (Creswell, 2009). This mixed methods sequential exploratory study consists of two main phases: an exploratory phase employing a case study strategy, and a confirmatory phase involving a large-scale survey. In this design, the researcher first collected and analysed the qualitative data collected by interviewing key participants in the FFE phase of 6 online service innovation projects. The results obtained in the first phase were used to operationalise the openness competence construct and to build 11 research hypotheses. These hypotheses were then statistically tested by analysing the data gathered from a survey of project managers in Thai IT service provider firms.

This section starts by explaining how the case study was conducted and how the interview data were analysed. Next, the sampling method, survey administration procedure, and data analysis techniques adopted in the second quantitative phase are described exhaustively.

3.4.1. The first qualitative phase

The main objectives of the first phase of this research are twofold: to preliminarily assess and develop the initial conceptual framework (Figure 2.3) and to identify key dimensions of the openness competence construct. To fulfil these objectives we conducted an inductive multiple case study of online service innovations in an emerging economy context, i.e., Thailand. In this section, the design of the data collection process and the data analysis procedure is delineated. The details of the execution can be found in Chapter 4.

Sample and data collection

The case selection strategy of "purposeful theoretical sampling" is particularly appropriate for inductive theory development (Eisenhardt, 1989; Eisenhardt & Graebner, 2007; Yin, 2009). The particular approach that we took was "polar types, in which a researcher samples extreme (e.g., very high and very low performing) cases in order to more easily observe contrasting patterns in the data" (Eisenhardt & Graebner, 2007, p. 27). The unit of analysis is online service innovation projects targeting two types of project: projects with an "open" FFE and projects with a "closed" FFE. Projects with an open FFE are those that search for ideas and knowledge from a wide variety of sources and extensively co-develop with external partners, while projects with a closed FFE search more narrowly and have very few innovation ties, if any, with other organisations.

The choice of the online service industry was influenced by a desire to investigate service firms experiencing hyper-competition and exceptional turbulence in their marketplaces (Van Riel et al., 2004). Moreover, online services have increasingly played a significant role in the global economy due to the availability of low-cost ubiquitous computing and high-speed connections. However, increasingly short product life cycles are one of the main challenges that online service firms face. Therefore, a faster and more effective way to innovate is required (Van Riel et al., 2004). These characteristics make online services an interesting context for research that focuses on how openness affects innovation success.

Despite the increasingly important role of the service sector in emerging Asian economies (Noland et al., 2012), relatively little attention has been given to research on service innovation in less advanced Asian economies (Thakur & Hale, 2013). The applicability of models and frameworks of service innovation developed in more economically-developed countries to the context of developing countries, such as

Thailand, was found to be limited (Uchupalanan, 2000). Moreover, according to a report by TNSO (2013), online services play an increasingly significant role in the Thai economy. For example, the value of the sales of e-commerce businesses in Thailand increased from 427,460 million THB (~7,890 million GBP) in 2008 to 608,587 million THB (~11,240 million GBP) in 2011. Nevertheless, Thailand's index level of service innovation capability (1.84) is still far behind its product innovation capability (2.29) (Wonglimpiyarat, 2010). Thus, a study of how to improve innovation in the Thai service sector should prove fruitful.

In terms of case selection, following Yin (2009), we carried out several preliminary interviews to screen for possible candidates. A set of screening criteria was used for the selection process. The criteria were: (1) the projects are an online service innovation, (2) the projects fit into the open versus closed categories, and (3) the FFE phase was completed. Initially, we contacted 9 firms developing 11 online service innovations and asked to speak with the person who had participated in the FFE phase of their most recent online service innovation project. The respondents were asked to describe the project, the key activities in the FFE, and any external sources and partners involved in the FFE. Data collected from the 11 projects were preliminarily analysed and then the 'polar' projects were selected, i.e., the 3 projects that were most clearly open and the 3 projects that were most clearly closed (screening criterion 2). For the selected projects, additional interviews were conducted with the informants who participated in the initial screening interviews. We asked the informants to refer us to their colleagues who had also participated in the FFE of their service innovation project. The main data collection method was semi-structured in-depth interviews.

To fulfil the first objective – i.e., to assess and develop the initial conceptual framework (Figure 2.3), our line of questioning focused on how openness competence of an innovation team affects market and technical uncertainty reduction in the FFE and whether FFE outcomes (i.e., produce designs, project plans, etc.) with less uncertainty lead to success of service innovation projects. For the second objective – i.e., to identify key dimensions of openness competence within the FFE – we asked the interviewees of the more open cases about what capabilities or operant resources are crucial for a more open approach to the FFE. Also, the reasons why teams in the more closed cases did not open up their front-end process were explored.

Data analysis

The data analysis process followed recommendations delineated in Eisenhardt (1989) and Miles et al. (2013). We first undertook a within-case analysis and then searched for cross-case patterns. The data analysis procedures were performed with the help of QSR International's (2012) NVivo 10 software. The software enabled the researcher to identify, search, retrieve, group, and regroup meaningful data chunks. Categories and codes could also be easily applied, changed and removed from the data chunks. Focusing on identifying key dimensions of openness competence within the FFE, a within-case analysis was conducted with the aim of identifying emergent constructs. Furthermore, a case-oriented strategy was used for the cross-case analysis (Miles et al., 2013). Case data were compared and contrasted across cases in the same group and across groups (i.e., open FFE versus closed FFE) in order to provide support for the emergent key components of openness competence. In addition, to confirm the relationships proposed in the initial conceptual framework (Figure 2.3), we made comparisons between the two types of projects that share patterns (i.e., open and closed FFEs classified by the number of external sources and partners of innovation used in the FFE phase).

To ensure internal validity, a multiple data collection approach was taken to achieve triangulation. In addition to the interview data, the data set also included a follow-up survey, field notes, websites, online articles, and statistics available on the Internet, Apple's App Store and Android's Play Store. Furthermore, the transcriptions of the interviews were sent back to the interviewees for verification. With an attempt to enhance external validity of the case findings, rich, thick, detailed descriptions of the data collection and analysis processes and the findings are provided in Chapter 4. This may allow anyone to repeat the procedures or the findings to be compared with similar studies.

3.4.2. The second quantitative phase

To verify the key dimensions of openness competence within the FFE and the research propositions suggested from the case study's findings, a large-scale survey concerning openness in the FFE phase of service innovation was carried out in Thai IT service provider firms. The second quantitative phase started with a further review of the literature with the aim of forming the current study's research hypotheses and gathering relevant measurement scales used in prior studies. The next step was to come up with an appropriate sampling frame and method. Subsequently, a self-administered survey was conducted. The collected data were then analysed using PLS-SEM (Hair et al., 2014).

Sample and data collection

The main data collection tool was a questionnaire. For the measurement scales of the main constructs, whenever possible, we relied on existing operationalisation in the literature for two reasons. First, questionnaires developed by novice researchers are unlikely to have the same level of reliability and validity as those that have been rigorously tested (Marshall, 2005). Second, using validated scales also allows researchers to save time and resources and to compare their findings with other studies (Boynton & Greenhalgh, 2004).

Prior to the survey, we performed an initial validation of the measurement scales. The initial validation of the measurement scales was conducted by interviewing 5 front-end managers. These interviews were conducted in April 2014. The interviewees were shown the measurement items and were asked to comment on the appropriateness of those items. This step provided the researcher some idea about the face validity of the instrument, that involves whether the questions appeared to measure the target variables (Creswell, 2014). In addition, it also helped the researcher to improve the content validity of the survey instrument (e.g., structure, suitability, jargon terms, translation issues, etc.). As a result, several modifications were made to the initial questionnaire. For example, one of the significant issues was the ambiguity of the term “front-end phase”. The researcher therefore replaced it with the term “predevelopment phase” which has also been used by the scholars (e.g., Atuahene-Gima, 1995; Cooper, 1988; Langerak et al., 2004). This term received more positive feedback from the interviewees in comparison to the previous term. The final version of the questionnaire is displayed in Appendix B.

The sampling frame of this study was a list of Thai IT service provider firms from the Department of Business Development’s business data warehouse (http://datawarehouse.dbd.go.th). The database contains a list of firms that registered with Thailand’s Ministry of Commerce up to the fiscal year 2013. To clarify, it is mandatory for firms operating in Thailand to register with Thailand’s Ministry of Commerce. Thus, the sampling frame could be considered exhaustive. The database was filtered by three criteria: (1) the firm’s business description (i.e., target businesses were “software package providers”, “website design and networking services” and “software consultancies”), (2) the firm’s assets are more than 2,000,000 Baht (~40,000 GBP) and (3) the firm’s headquarters are in Bangkok. As a result, a list of 598 companies was obtained.

With respect to sample sizes, according to Hair et al. (2014), G*Power software (Faul et al., 2007; Faul et al., 2009) can be used to compute minimum sample size requirements. G*Power analysis for a model with maximum predictors of 7 suggests a required sample size of 103 (Effect size f^2 = 0.15, significance level of 0.05, and a statistical power of 0.80). A similar study that focused on innovation at a project level (e.g., Van Riel et al., 2004) obtained a reasonable response rate of 16.7%. This response rate was used to calculate the number of responses that we anticipated to receive. Since we planned to send 3 copies of the questionnaire to each of the sample firms, we randomly selected a total of 200 firms from the list (i.e., (16.7 * (200 * 3)) / 100 = 100.2).

To gain access, Human Resource (HR) managers from the selected firms were contacted by phone to ask for their participation. Those HR managers who were willing to participate were requested to act as a gatekeeper, being responsible for the distribution and collection of the questionnaires. The number of copies of the questionnaire that were sent ranged from 1 to 5 depending on the number of project managers in the firm. The gatekeeper suggested the number of questionnaires. Both paper and online questionnaires were delivered to the gatekeepers. Two weeks afterwards, the researcher contacted the gatekeepers to ask for the return of completed questionnaires and to remind them about the importance of the study and their contributions. Two more reminder calls, one week apart, were made to those who had not yet returned the questionnaires.

Data analysis

The researcher performed data analysis procedures using SmartPLS software version 3.1.3 (Ringle et al., 2014). The particular method employed was a second-generation multivariate technique – i.e., PLS-SEM. Such a method is increasingly used as a key multivariate analysis method in various research disciplines such as strategic management (Hair et al., 2012b), international marketing (Henseler et al., 2009), marketing (Hair et al., 2012a), management information systems (Ringle et al., 2012), and operations management (Peng & Lai, 2012).

In social science research, there are two main approaches to estimating the causal relationships in a structural equation model, namely PLS-SEM and "covariance-based structural equation modelling" (CB-SEM) (Hair et al., 2014). Wold's (1974; 1982) and Lohmöller's (1989) PLS-SEM is a causal modelling approach focusing on maximising the explained variance of the dependent latent variables (Hair et al., 2011). In contrast, CB-SEM focuses primarily on minimising the difference between the theoretical covariance matrix and the estimated covariance matrix, without being concerned about explained variance (Hair et al., 2011). The reasons why the current study prefers PLS-SEM over CB-SEM are provided in Section 5.4, Chapter 5.

3.5. Summary of the Chapter

This chapter outlined the research design that was adopted. The researcher's philosophical worldview is pragmatism, thus incorporating both qualitative and quantitative methods. The current research is a mixed methods study with an explanatory sequential design consisting of two main phases. The first phase is a multiple case study in the Thai online service industry. The interview data collected in the first phase were analysed qualitatively. The emergent constructs and relationships were later tested by a large-scale survey in the second data collection phase. Self-administered questionnaires were employed as the main data collection tool. The target respondents were project managers in IT service provider firms in Thailand. The survey responses were quantitatively analysed using the PLS-SEM technique. The findings of the first and the second phases are presented in the next two chapters, respectively.

4. Findings – A Multiple Case Study of Online Service Innovations

4.1. Introduction

This chapter presents the findings of the theory-building case study. We conducted the case study on the FFE phase of online service innovation with two purposes in mind. The first was to uncover the key components of openness competence. The other was to provide an initial confirmation of the applicability of the conceptual framework displayed in Chapter 2 (Figure 2.3) to service innovation in a developing economy. We included 6 online service innovation projects from 5 IT service providers in Thailand. The main data collection method was in-depth interviews as we hoped that qualitative data might be able to provide us with rich and deep understanding of a complex phenomenon such as the FFE of service innovation.

The present chapter starts by describing how the case data were collected and analysed. It then presents the within-case analysis of each of the 6 service innovation projects. Based on a cross-case analysis, we identify the key dimensions of openness competence within the FFE as well as provide empirical support for the proposed conceptual framework. In the final section, the case study findings are discussed with the literature and, as a result, 7 propositions are proposed.

4.2. The Case Study

4.2.1. Data collection

In terms of data collection, semi-structured in-depth interviews were performed. In 5 of the 6 cases, the informants came from different organisational levels, including executives, project managers and senior developers, whereas access was more limited in the other case. As suggested by Ettlie and Pavlou (2006), access negotiation for radical innovation studies might take as long as one year. This claim was proven to hold true for this study as it took almost two months just to gain access to the 9 firms in order to conduct the 11 screening interviews. As a result, at the end of the data collection period (i.e., from May to September 2013), we were able to interview a total of 12 informants.

At the beginning of each interview the researcher explained the key terms addressed in the questions (e.g., front-end phase, service innovation, uncertainty, etc.). Each interviewee was asked the same set of questions focusing on the background of the project, the role and importance of the project to the organisation, the interviewee's role in the FFE, key activities of the FFE phase, project performance assessment, how/whether they opened up their front-end process, and any uncertainty associated with the FFE phase. However, the order of the questions varied depending on the flow of the discussion. Further, we avoided using academic language and encouraged the informants to express their thoughts in their own words. The nature of the interviewing was open, which allowed new ideas to be brought up. Whenever interesting ideas came up, they were further explored by improvised questions. The length of each interview was between one and one and a half hours. The interviews were audio-recorded and transcribed verbatim in Thai. After the analysis, relevant quotes were translated into English.

In addition to interview questions about how the informants evaluated the success of their project, a follow-up survey was conducted by asking the project manager in each case about whether the innovation project of interest achieved their initial success objectives (Appendix A). The survey results were used to triangulate the informants' comments on project success.

4.2.2. Data analysis

The data analysis was undertaken first within each case and then across all cases. The within-case analysis was conducted in a two-cycle fashion as suggested by Saldaña (2009). In the first cycle, the interview transcripts were read carefully, analytic memos were written, and codes were applied to the data chunks. As displayed in Table 4.1, based on code typologies suggested in Saldaña (2009), structural, descriptive, in vivo and process codes were used and 86 first-order codes were derived. Clustering was undertaken, based on the four a priori constructs in Figure 2.3, resulting in 21 second-order codes. In the second cycle, by applying a pattern coding technique, the second-order codes were grouped into more meaningful and parsimonious constructs. This process laid the groundwork for the cross-case analysis (Miles et al., 2013). In the cross-case analysis, we compared and contrasted the projects with open FFE projects and their closed counterparts. Consequently, several interesting patterns emerged. A pattern-matching analytic technique was used because such a technique "compares an empirically based pattern with a predicted one (Yin, 2009, p. 136)". In this case, the emergent patterns were compared with the initial conceptual framework (Figure 2.3). In addition, to make sure that the propositions fit with the case data, we also iteratively compared both the emergent constructs and their inter-relationships with evidence from each case (Eisenhardt, 1989).

Table 4.1: Data coding

Priori Constructs	***No. of First-Order Codes***	***No. of Second-Order Codes***	***Emergent Constructs***
Openness Competence	50	11	• Searching capability • Coordination capability • Mutual interest and understandings • Prior related knowledge • IT Capability
Market Uncertainty	10	3	• Customer uncertainty • Competitor uncertainty • Marketing strategy
Technical Uncertainty	11	2	• Project management uncertainty • Technological uncertainty
Service Innovation Success	15	5	• Financial-based success • Customer-based success

4.3. The Cases

The 6 online service innovation projects and the 5 firms from which the former were drawn are shown in Table 4.2. The name of the projects and the firms are fictitious in order to preserve the anonymity of the participants. The informants were those who participated in the FFE of the projects. The development time of the cases ranged from 3 to 24 months. The online service innovations of interest are in the form of either mobile or web applications or both. The first three cases (Case no. 1 - 3) were classified as being more "open", while the other three (Case no. 4 - 6) were classified as being more "closed". The former are those that search for ideas and knowledge from a wide variety of sources and extensively co-develop with external partners, while the latter are those who search more narrowly and have very few innovation ties, if any, with other organisations. In this section, the within-case analysis of each case is described in detail.

Table 4.2: Summary of the cases studied in the first phase

Case	***Name (Developing Firm – Firm Size)***	***Development Time (Year the Project Started)***	***Informants (Years of Exp.)***
Case 1 (Open FFE)	SmartEdu (Firm A - medium)	7 months (2012)	- Project manager (2) - Senior developer (4)
Case 2 (Open FFE)	AppCreator (Firm A - medium)	6 months (2012)	- Project manager (4) - Business development manager (4)
Case 3 (Open FFE)	MobileShopApp (Firm B - small)	3 months (2012)	- Senior designer (3) - Marketing director and co-founder (4) - Chief technology officer (CTO) and co-founder (5)
Case 4 (Closed FFE)	OnlineShopCreator (Firm C - small)	24 months (2009)	- Chief executive officer (CEO) (4) - Managing director (4)
Case 5 (Closed FFE)	PriceCompare (Firm D - small)	12 months (2009)	- System architect and co-founder (7)
Case 6 (Closed FFE)	OnlineStockTrade (Firm E - medium)	3-4 months (2012)	- Project manager (4) - Senior marketing executive (2)

4.3.1. Case 1 – SmartEdu

Founded in 2012, SmartEdu is an e-learning system incorporating a web and a tablet application. The system provides an online classroom exercise service involving three types of users, namely teachers, students, and parents. The system can be explained as a simple process initiated by the teachers. Teachers create exercises or exam papers on the SmartEdu's website. Students complete the exercises and get the results instantly on their tablet. Finally, on the tablet, parents can monitor their child's scores and progress as well as feedbacks from the teachers.

The SmartEdu system is the first to provide online classroom exercise services in Thailand. Although there are several similar systems in other countries, one of its unique functionalities is that, in addition to the ability to provide the correct answers and results for an exercise instantly, it is able to give detailed explanations as to why those answers are correct. Moreover, in cases where a teacher wants to modify a question in an exercise, he/she can do it anytime, even in class, on the website and the question will be updated promptly on students' tablets.

The firm who developed this project (Firm A) focuses on providing innovative services incorporating online and wireless communication technologies. The firm provides services, such as portal sites, online social media campaigns, custom-made websites, innovative mobile applications, and games. Their target customers are both private and public organisations.

In terms of inspiration, the firm looked into the government's two important educational campaigns and came up with the ideas that gave birth to this particular project. The first campaign is "Smart Thailand", which encourages the use of technologies to support several important strategic areas including education. The second campaign called "One Table Per Child" (OTPC). Early in 2013, the government took an important first step by providing tablets to all first level primary school students in Thailand. The next phase of this campaign will be to give all first level secondary school students a tablet as well. This particular service innovation project aimed to support this phase by providing an online classroom exercise platform. In addition, according to the informants, the company planned to build many new educational services on this platform.

The FFE phase

The key activities in the FFE phase of SmartEdu included opportunity identification, idea generation, idea evaluation, feasibility analysis, concept development, project planning, and piloting. Initially, the firm wanted to venture into education business. They saw an opportunity to do so with an E-learning system that supported the government's OTPC campaign. The development team searched the Internet, studied the competitors, and attended educational seminars and events in order to gather information and ideas for the new service. Two of the team members used to work as teachers. Their past experience was beneficial to the project with respect to the knowledge about the basic requirements of one of the system's key users – i.e., teachers.

> "[When considering which ideas gathered from both local and foreign competitors' products are interesting,] I used my past experience [the interviewee used to work as a teacher in a secondary school] when I taught in the classroom to think about what teachers really want based on my direct experience." (Project Manager – Case No. 1: SmartEdu)

In addition, the team built a workable prototype that was later piloted in a classroom. More specifically, the team collaborated with a pilot school and a government agency who provided tablets that were used in the pilot. During the pilot, they intended to observe the behaviour of both teachers and students in order to improve the system and to uncover any hidden requirements.

> “We interviewed the student, parents, and teachers who piloted the system. […] We observed the classroom when the teachers and students used the application. We observed the students’ actions. For example, the application provides four ways of answering a question, i.e., multi-choice, yes/no, short text and long text. We wanted to know how the students answered the questions and their typing habits in order to make modifications, such as what changes should be made to the UI [user interface].” (Project Manager – Case No. 1: SmartEdu)

The external sources and partners involved in the FFE phase of the project are summarised in Table 4.3. Additional relevant quotes are displayed in Appendix C.

Uncertainties within the FFE phase

While some uncertainties reported by the informants were uncontrollable, the majority of them seemed to be manageable. For the former, one of the informants worried that radical changes in the government’s policy would render the product outdated or diminish its attractiveness.

> “Right now, Thailand is preparing to participate in the AEC [Asean Economic Community]. In the current situation, there are 8 subject areas in total. Initially, we planned to build one app for each subject area. However, the recent news say that the subject areas may be reduced to only 6. Which will be included to those 6 subject areas? We cannot precisely predict.” (Project Manager – Case No. 1: SmartEdu)

The latter however included uncertainty about user acceptance, product specifications, potential technical problems and the timeline. Accordingly, several measures were used to reduce those controllable uncertainties. They are external knowledge searching, piloting with prospective users, and attending educational seminars and events.

> “As mentioned earlier, we wanted to focus on education. We investigated in more detail about the OTPC (On Tablet Per Child) campaign. Is this really practical? How can the tablets be used, etc.? Then, we analysed the information. Additionally, we studied our competitors. And, if there were any seminars and events about education, we went.” (Project Manager – Case No. 1: SmartEdu)

Personnel who had past experience in education and who had a relevant technical background were recruited.

> “Also, [we concerned about] the screen resolution problem [different models of Android devices have different screen resolutions], which is a general problem. Our development team had a lot of experience from previous projects. They knew how the screen should be placed to support all devices. Moreover, early in the development process, we tested with various models.” (Senior Developer – Case No. 1: SmartEdu)

More quotes regarding front-end uncertainties can be found in Appendix D.

The outcomes

Both the informants were very satisfied with the feedback from the management and teachers of the pilot school as described by the project manager:

> “When we were trying to pilot our system. […] The teachers of the pilot school that we contacted seemed to be happy and very co-operative. Initially, we wanted to pilot in only 2 subject areas. It turned out that more teachers than we expected were interested and wanted to try [using the system]. Consequently, we piloted in 4 subject areas.” (Project Manager – Case No. 1: SmartEdu)

Nevertheless, since the project was still in the middle of the piloting process when the interviews took place, it was not possible to obtain objective performance measures (e.g., sales, downloads, etc.). Therefore, the only success measure that was used by the interviewees was the positive feedback from those who participated in the pilot sessions.

4.3.2. Case 2 – AppCreator

Started in 2012, AppCreator is a web application that empowers ordinary users to create their own mobile applications on the major mobile platforms (i.e., iOS and Android). This service innovation's distinctive functionality is the "loyalty programme management", since it evolved from a previous project developing an application that focused on storing loyalty cards on smartphones or, in other words, on using a smartphone as a virtual wallet. Since mobile devices play an increasingly important role in today's lifestyle, the informants suggested that loyalty programme in mobile devices could be a perfect replacement for traditional loyalty cards.

> "When businesses or shops want to implement a loyalty programme, club card or discount voucher, they usually use paper or plastic cards. If you are a regular at 10 shops, you will end up with 10 – 20 cards in your wallet. Some women have to have a purse of cards, right? But if you are a man, you might just throw them away. So, we thought: why does it have to be this way? Mobiles – iPhones or BBs – and the Internet have increasingly been playing an important role in our lives. We thought a 'mobile app can handle this!', so this project emerged." (Business Development Manager – Case No. 2: AppCreator)

The interviewees also highlighted that this particular service innovation is their flagship service and is expected to provide a sustainable revenue stream. They commented that this mobile app creator platform will eventually replace their current made-to-order services.

> "Before AppCreator, we were looking for a product that could become our flagship and allows us to have a sustainable business. Instead of selling project after project,

[we wanted] a product that sells itself via an online market. As a result, AppCreator emerged from the idea that we wanted to have a sustainable revenue stream." (Project Manager – Case No. 2: AppCreator)

AppCreator was developed by the same company (Firm A) that developed the SmartEdu project. The target customers of AppCreator are individuals and small shops who want to have their very own mobile application. In addition, the firm also provides a tailor-made service targeting large organisations that want to add very specific features to their mobile application. Nevertheless, the tailor-made applications are built on the same platform used by typical customers. Such a concept considerably reduces the costs and time needed to develop a made-to-order mobile application.

In terms of innovativeness, AppCreator was the first to provide mobile app creator services in Thailand. The service provides a distinctive functionality – i.e., "loyalty programme management". The team also incorporated cutting-edge technology into the innovation. The system's redemption mechanic uses QR code technology. The implementation of NFC technology is in the near future. An interesting technique that combines website elements – WebView – with native app elements was also adopted. They called it a "hybrid application". This allows the app created by the customers to be more flexible since its design and features can be changed anytime without publishing a new version of the app on a publication platform.

"A 'hybrid application' is an application characterised by a mixture of a website or 'WebView' and a native application. Essentially, it [a hybrid application] has the flexibility and customisability of a website and the responsiveness of a native app. […] We saw some [similar products] use the technology [the hybrid application]. However, the majority of similar products on the market are actually mobile site builders. They created a mobile site and a mobile application that can only show the mobile site in the middle. […] It might have the flexibility of a website, and it might not need to be re-published [to the mobile application marketplaces] but it is very slow and laggy." (Project Manager – Case No. 2: AppCreator)

The FFE phase

There were seven key activities in the FFE of the project: opportunity identification, idea generation, idea evaluation, idea screening, feasibility analysis, concept development and project planning. As mentioned earlier, this new service evolved from a previous project involving a loyalty card storage application. The team decided to make fundamental changes that resulted in the emergence of AppCreator because of comments from prospective customers that they received when they attended events trying to promote the previous project.

"When we participated at 'CommunicAsia' in Singapore last year [2012], we received customer comments saying that 'This loyalty programme application is what I wanted, this is the right feature but I want to have it with my shop's name'[…] It [AppCreator] transformed to becoming an application creator specialised in the loyalty programme feature." (Business Development Manager – Case No. 2: AppCreator)

The most interesting features of the FFE phase of this particular project were, firstly, their extensive market research, as mentioned by one of the interviewees:

"We also did things like marketing research which involves asking the target group, i.e., females aged 18-25. They are carrying a card holder bag for their cards [e.g., loyalty cards or paper voucher] and they all have an iPhone. […] The other groups of users are businesses or merchants. They use the system to create a mobile application or create a loyalty programme on mobile. […] The small and medium –sized business owners, e.g., coffee shops, restaurants or tailor shops whom our team members know in person. We interviewed and asked them to fill in a questionnaire.” (Business Development Manager – Case No. 2: AppCreator)

Secondly, they developed a workable prototype which was used to pilot with small businesses in order to gain important information about prospective customers’ opinions, attitudes and requirements, the marketability of the new service, and an appropriate pricing strategy.

Interviewee: “We talked to stationary shop owners, cloth shop owners, restaurant owners, cake shop owners, car showroom owners and resort owners. We asked them ‘do they want an app?’ They said they wanted to have an app. We also asked them about what the acceptable price range is and what kind of features that they want to have on their app […]”

Interviewer: “Could you give me some examples of the ideas that you got from them and eventually applied to the product?”

Interviewee: “They wanted to be able to sell through the application created from our system. They wanted the application to make money for them. For example, the cloth shop suggested that the customer should be able to create purchase orders on the app. We took that comment and came up with a requirement to have the m-commerce plugin attached to the app created from our system. We also topped up that idea by planning to allow the shops to create products on our system that will be published on their mobile account. At the same time, the data will be synced to the inventory [data] of their cashier [point of sale system].” (Project Manager – Case No. 2: AppCreator)

The external sources exploited in the FFE phase of this project are summarised in Table 4.3. Quotes that are relevant to activities in the FFE are shown in Appendix C.

Uncertainties within the FFE

Since the service concept of this project was quite new to the Thai market, the informants seemed to be concerned with the uncertainty associated with the market more than the technical side of the project. During the FFE, the team tried primarily to address uncertainties about customers and to find the right marketing strategy. In terms of customer uncertainty, the team tried to reduce this using a variety of methods, such as customer involvement, market research and piloting. For the latter, they consulted a professor in marketing and studied similar products marketing in other countries.

> "We consulted a marketing professor from Chula [a university in Thailand]. Actually, he did not involve in the idea generation stage. We went to him for his advice after we finished thinking. He gave us his opinions concerning the feasibility of this project based on his experience. He also gave advice on what should be included in order to meet customer needs." (Business Development Manager – Case No. 2: AppCreator)

The informants also mentioned their concerns about whether the concept was technologically viable. The team attempted to mitigate this uncertainty by studying the technology that foreign products were using as well as encouraging the developers to search for information and to thoroughly analyse the technical feasibility of the concept.

> "[We were concerned about] the technological viability of the development of this product. If the senior engineer who took responsibility for researching the issue suggested that it was not possible to develop such a product, the project would have been terminated. This was the main risk." (Project Manager – Case No. 2: AppCreator)

Additional quotes regarding the uncertainties associated with the FFE of this project can be found in Appendix D.

The Outcomes

When the interviews took place, the project was still in the initial stages of the commercialisation phase. Any advertising campaign had yet to materialise. Therefore, when being asked about project success, the informants commented that it was too soon to talk about measuring success. However, they provided two reasons why they thought that the results of the project met their expectations. Firstly, the positive feedback that they had received from prospective customers when they participated in technology exhibitions to promote the new service. Secondly, in addition to the provision of an application creation service direct to customers, they did come up with a business model called 'reseller model'.

> "For the reseller model, we can assess the result [of the new service concept]. The resellers bought our product because they liked the concept. […] We actually are in the process of signing a contract with TELE Corp (one of top telecommunication service providers in Thailand) to become our reseller. […] Therefore, if you ask me, I think this project is a success." (Project Manager – Case No. 2: AppCreator)

The main principle of this business model is that the firm sells a bulk of credits (i.e., each credit can be used to create one application) to an organisation that, for example, may want to provide an application creation service to its existing customers as a bundle with its other services.

In sum, concerning the outcomes of the project, at the time of the interviews, the service innovation had received a lot of positive feedback from prospective customers. The firm had also sold several semi-custom-made projects where organisational customers had commissioned them to create a mobile application for them on the AppCreator platform. In addition, as mentioned in the quote above, the team were in the process of signing a contract involving a large amount of credits. Nevertheless, the sales targets regarding individuals or small businesses who subscribe to the service and create their very own mobile application by themselves have not yet been met. One of the informants (the project manager) argued that, after they officially launch their marketing campaigns, the figures should start to pick up.

4.3.3. Case 3 – MobileShopApp

MobileShopApp is a mobile shopping application that allows buyers and sellers to meet. In only 3 quick steps, sellers can start selling their items. When a seller want to sell a product, he/she starts with taking some photos of the product. The second step is to apply some tags to help buyers find it when they search. The final step is to post the product's photos and details – e.g., a short description, the price, and the preferred payment methods. The whole process can take less than one minute. Buyers can casually scroll through the virtually endless list of merchandise on their smartphone. When a buyer find the product that he/she wants to buy, he/she can also have a private conversation with the seller through MobileShopApp's messaging system to find out more about the product, which allows the buyer to make a more informed decision. However, the application does not provide any tools that facilitate online trading – e.g., online payment systems, tracking systems, etc. It only provides the private messaging system that allows sellers and buyers to negotiate prices and discuss how and where the exchange will take place.

The MobileShopApp application is the first in Thailand that provides this kind of services. The application differs from its competitors because its focus is entirely on m-commerce. Most competitors focus primarily on e-commerce, although some of them provide m-commerce as a supplementary service.

> "Following a consumer-to-consumer (C2C) model, [MobileShopApp] works like Alibaba's Taobao does in China, but this start-up is very much a mobile-first type of company." (Wee, 2013)

The company (Firm B) is a start-up company who has only one product, the MobileShopApp application. The company was originally a team of seven people, entered this particular service concept in a start-up competition and were runner-ups. As a consequence, the team had the opportunity to attend a 100-day seed accelerator programme in Singapore organised by an intermediary firm. The aim of the programme was to help start-up firms successfully develop their product concept by providing training sessions and mentors to guide them. At the end of the programme, the participating teams had to pitch their product concept and a workable prototype to a group of investors. In the case of MobileShopApp, the product attracted considerable interest from investors and, as a result, received an investment fund of more than 500,000 USD.

The main idea is to make the process of selling and buying goods online as hassle-free as possible. One of the informants commented that, from a seller's perspective, it is easier and cheaper to open an online shop on a website or a mobile app than to open a physical shop at a prime shopping location in Bangkok. However, one of the problems of e-commerce is that adding new products to an e-commerce website (Amazon for example) sometimes takes a lot of effort. Therefore, this app gives sellers the ability to list a new item so that buyers can see it in less than one minute.

> "Nowadays, I think online shopping becomes more and more main stream. If you have one million, will you open a shop at Chatuchak weekend market? That money may not be enough. Selling on the Internet first can reduce the risk right?" (Senior Designer – Case No. 3: MobileShopApp)

The FFE phase

The informants reported that their FFE phase involved idea generation, idea evaluation, feasibility analysis and prototyping. They stressed the importance of having a prototype (which could be as simple as a series of screenshots) as early as possible in the FFE process and testing it with users. They suggested that this was a vital tool for mitigating risks and uncertainty related to users.

> "At the very beginning, we just developed a series of screenshots. We then put them on our website where people can register for updates. With this, we can prove that there was a need for this kind of service, that we could build traction. After we knew that this concept was ok, we then developed a prototype, which was used to test with users again. […] Risks and uncertainty were gradually reduced at each step." (Marketing Director and Co-Founder – Case No. 3: MobileShopApp)

In addition to opening up to the users, the team also searched the Internet, studied similar foreign products and consulted with mentors. The latter were particularly important to the development of the service concept. The mentors were ex-start-ups who had created successful products before, and thus had a lot of experience and expertise in their respective fields.

> "A mentor advised me that I should design the marketplace screen with 3 pictures per row not 4. I was choosing between 3 or 4 pictures per row. He strongly suggested that I should do 3 columns. He told me that he did 3 columns and his transaction figures went up. Since then I have never changed the three-column design." (Senior Designer – Case No. 3: MobileShopApp)

The external sources used in the FFE phase of this project are summarised in Table 4.3. Relevant quotes are displayed in Appendix C.

Uncertainties within the FFE

The interviewees highlighted the need to attract as many people as possible to use their mobile shopping platform, thus focusing on reducing the uncertainty related to the market. Users and mentors were heavily involved during the FFE process. More specifically, users were the main source of ideas for new features and were used to identify potential problems, while mentors were consulted regarding marketing strategy (e.g., promotional channels and methods, and ways to attract more users).

> "The most important concern was whether the problem that the product is trying to solve really exists. Even though we asked the users – 7 out of 10 users said yes, I was still worried that the product may only serve [the needs of] a small group of people which may not be enough to build a business on. […] [To mitigate the risk,] We conducted a survey and uploaded a series of screenshots to a mock website saying a new mobile application was about to launch. We asked those who were interested in the product to register." (CTO and Co-Founder – Case No. 3: MobileShopApp)

> "The main concern was that the service may not be able to build traction. We were worried that the number of people who register may not reach the target. This was the most important factor affecting the attractiveness of our application. Attractive to investors and others. Also, if we publish the app to the app stores and nobody downloads, it would be a failure. […] We depended on the mentors' guidance. They guided us on promotional channels, ways to attract users, PR methods." (Marketing Director and Co-Founder – Case No. 3: MobileShopApp)

With regard to the technical side of the project, the technologies incorporated in the application were not very new since most of the application's main features (e.g., taking pictures, sending messages, etc.) have long been incorporated in other products.

> "[Technologically,] Our product was not that innovative, not that new. At that time, some of the functionalities had been proved by others already. The uniqueness of MobileShopApp was essentially its ability to bring sellers and buyers together. The other functions were similar to others [similar applications]; and thus had been proved

> by the others. For example, taking photos by mobile, the design of the feed page, etc."
> (Senior Designer – Case No. 3: MobileShopApp)

Technical concerns raised in the FFE phase were therefore mainly related to resources and timeline. Interestingly, instead of setting the priority of each task themselves, they reached out to suggestions from users.

> "There was also uncertainty regarding resources and timing. Some of the ideas were not possible to implement without prerequisite features. For example, based on the users who told us that they wanted a credit card payment system we wanted to implement a payment system. However, after some research, we found that it was a requirement that merchants had to provide us with some kind of identification. Trust and security issues were the main concern. Consequently, we concluded that this feature was not viable since too many prerequisite features were required. Let's assume that there were 5 prerequisite functions. In this case, we asked the users – 'which of the five is the most important?' We then prioritised the tasks accordingly."
> (CTO and Co-Founder – Case No. 3: MobileShopApp)

Nevertheless, a lack of attention to the technological aspects of the project could be the cause of a performance problem (i.e., delay due to high traffic) that occurred soon after the service was launched.

Quotes that are relevant to both market and technical uncertainty during the FFE phase of this case can be found in Appendix D.

The Outcomes

With respect to the FFE, the participants were very satisfied with its outcomes because the service concept that they had developed attracted investment funding. The funding allowed them to found the firm and further develop the innovation. To clarify, as mentioned earlier, this team of seven people submitted their initial product concept to a start-up competition in Thailand and the team were runner-ups. Consequently, they participated in a boot camp in Singapore organised by an intermediary firm. At the end of the boot camp, they pitched their idea and attracted an investment fund of more than 500,000 USD from two venture capital firms.

> "We think the project is a success since we were able to found our start-up firm. […] Like most start-ups, we started with no money. If you have an idea but no money, you will not have a product. Our early success as a start-up is due to the fact that we had the idea, we had the product, and we were able to raise an investment fund. This money allowed us to run our company and to learn more about our product for a couple of years." (Marketing Director and Co-Founder – Case No. 3: MobileShopApp)

In terms of overall project success, the informants highlighted the importance of attracting as many users as possible to use the application. Therefore, downloads were used as the key performance indicator in the initial stages of commercialisation. One of the interviewees also commented that an ideal measure would be the conversion rate (i.e., number of paying customers / number of visitors) which might be collected in later major updates of the application. At the time of the interviews, there were more than 70,000 downloads and 800 new items were being listed by the sellers every day. According to the product's website, the firm claimed to have more than 5,000 merchants listing their products on the application. However, in terms of financial success, at the time of the interviews, the team were still trying to find an appropriate business model. They had yet to generate any revenue from the application. However, the informants argued that their main priority was to attract as many sellers and buyers as possible, and further suggested that, when they have sizeable traction, a way to make money will appear.

4.3.4. Case 4 – OnlineShopCreator

This project involves a web application that allows people to create their own e-commerce website without having any computer programming knowledge. The website provides website creation tools with drag and drop features, shopping cart, online payment, and shop administration systems. Even though the concept of website creator was not new, some of the functionalities provided by the website were highly advanced and new to the Thai market at the time that the project began in 2009. Some examples are its high levels of customisability and its mixable website templates.

Founded in 2009, Firm C is a small start-up firm focusing on providing web-based online services. OnlineShopCreator was the firm's first project, which took almost 2 years to develop. At the time when the team started this project, there were only two big players in the market and they thought that their competitors' systems were out-dated. The firm wanted to be the third player. In addition, this service was a platform for the development of other services that they planned to implement later (e.g., website design services and an online marketplace like Amazon.com). At the moment, the firm has a total of 8 online service products, for instance, an online marketplace website, a photo storage and sharing site, a blog site, etc. These new services were developed around the firms' main service – i.e., OnlineShopCreator – as valuable supplements.

The FFE phase

The FFE phase of the OnlineShopCreator project involved three main activities: opportunity identification, idea generation and concept development. The FFE phase was very short and the team did not pay much attention to evaluating their ideas.

> "Actually, we did not spend much time [on the FFE phase]. Because we are developers we just roughly visualised the product concept. […] The idea generation phase was

very short. We started developing some of the parts and then went back to discuss how we can improve the product." (CEO – Case No. 4: OnlineShopCreator)

During the FFE phase, the team searched the Internet in order to study their direct competitors and similar products in foreign markets. This helped the team to generate ideas for the new service.

"In the front-end phase, I did not come up with many features myself. Many ideas actually came from similar foreign products. They were way more advanced than us." (Managing Director – Case No. 4: OnlineShopCreator)

However, the decision about which ideas are important seemed to be based solely on past experience because the CEO of the firm used to run an e-commerce website before. This leaded to the negligence of an important source of ideas – i.e., the customers. The CEO explained why he did not involve the customers:

"It [this type of services] was not something new. We knew what we needed to know by studying the competitors. I did not think that customers would be able to provide more advanced requirements. We had to think by ourselves. […] This is because customers usually become attached to the concepts of the old systems [their competitors' systems]." (CEO – Case No. 4: OnlineShopCreator)

The external knowledge sources used in the FFE of this project are summarised in Table 4.3. Relevant quotes can also be found in Appendix C.

Uncertainties within the FFE

With regard to market uncertainty, they attended training sessions provided by a government agency in order to improve their knowledge about the non-technical side of the project. However, this was the only thing that had been done to address the issue. One of the interviewees commented that:

> "We were not concerned about traction. We were quite confident that the product was good and people will like it. If things were not as we expected, we would just have to find another way to make it work. We were not really worried during the idea generation phase." (Managing Director – Case No. 4: OnlineShopCreator)

The development team's overconfidence in their knowledge about customers' needs seemed to backfire when the service innovation was first introduced because it struggled to make money.

> "One of the problems [that might happen after launch] was that the initial growth of the user base might struggle because we were new to the market. We countered the problem by not charging for the basic package."

To reduce technical uncertainty, competitors' technical mistakes (i.e., a competitor's servers were overloaded and went down) were studied and the team came up with several preventive measures, as reported by one of the interviewees:

> "Because we saw how the competitor's servers went down, we put in preventive measures at the very beginning of the development process. The main problem of this particular competitor was that their servers went down quite often and for a long period of time which put off the customers. The cause [of the problem] was that they only had one set of servers to serve several hundred thousand stores [customers' online stores]. So, the failures were unavoidable. We therefore split up our system into many sub-systems […] to mitigate the risks." (CEO – Case No. 4: OnlineShopCreator)

More quotes that are relevant to uncertainty reduction within the FFE of this project are provided in Appendix D.

The outcomes

With regard to the outcomes of the project, the informants mentioned four main success measures: traction, market share, transaction volume through the system, and profitability. At the time of the interviews, there were more than 100,000 shops in the system. In terms of market share, the firm is now number 3 in the market. Thirdly, transactions through the system were worth more than 8 million GBP in 2012. However, the firm only started making a profit from the new service just a few months before the interviews. The informants commented that the system was only able to generate around 400 - 600 GBP in the first month after it launched.

The informants also commented on the unusually long, two-year development process, which cost them both time and money. This was a huge deviation from their initial two-month plan. The CEO commented on what caused the delay:

> "Each sub-system actually took 3 – 5 months. This was because we were not satisfied with the outcomes. Both the UI and the development teams would not allow an unfinished product to be seen by customers. So, from the beginning to the launch, we had to redo it again and again 3 – 4 times [until everybody was happy with the product]." (CEO – Case No. 4: OnlineShopCreator)

It seemed to us that one of the reasons behind the huge delay could be the short FFE phase and the lack of openness to external sources of ideas and knowledge.

To conclude, although the figures of traction, market share and transaction volume may look satisfactory, the same cannot be said for the profitability figures and the unusually long development time of the new service. We argue that if the team were to spend more time in the FFE phase and had opened it up, and to pay more attention to reducing uncertainty related to the customers and market situations, these negative outcomes could be mitigated.

4.3.5. Case 5 – PriceCompare

PriceCompare is a price comparison website that compares the prices of merchandises being sold on Thai e-commerce websites. The website is the number one price comparison website in Thailand. At the time when this project started, there were no other price comparison websites and online shopping in Thailand was still in its infancy. Due to its first-mover advantage, the website now has the largest variety of merchandise as well as the largest user base. The company who developed PriceCompare (Firm D) is a small start-up firm. The project was started in late 2009 by a team of three software engineers. The firm's core business is price comparison services for merchandise selling on the Internet. Therefore, it focuses primarily on improving the quality of its service and expanding its market. In 2013, the firm expanded their market from Thailand to Indonesia.

In terms of technology, the informant commented that his main goal was to use technology to reduce human intervention as much as possible. The method was to use an engine crawler or "spider" to crawl and gather information from merchant's websites. The team also developed an algorithm to analyse text on those websites, and detect and gather key information, such as product name, product description, price, etc. However, the process is not entirely automatic. Humans are still needed for the validation of the collected information.

The main objective of the PriceCompare website is to attract as much traction as possible and to help e-commerce websites sell more. The business model of the website is that merchants have to pay in order to list their products on the website. In return, the merchants obtain traffic through the PriceCompare website. This model was inspired by Google AdWords – i.e., a website owner has to outbid his/her competitors in order to have his/her website listed at the top of Google's search page.

The FFE phase

The FFE phase of the project included four main activities: opportunity identification, idea generation, idea evaluation and project planning. The FFE team searched for ideas and knowledge from two sources, namely similar products and the Internet. The informant mentioned the main external source that was used during the idea generation:

> "We studied [similar] websites operating in other countries. What information does it provide? What features does it have? […] We tried to gather the good parts of each websites and chose the parts that we thought may work with Thai people." (System Architect and Co-Founder – Case No. 5: PriceCompare)

The informant also suggested that due to a lack of skills regarding the UI design of websites in the development team, they had to commission an external expert in website design to co-develop the UI of the website with them.

> "We knew that we were unskilful in some areas, so we hired an expert from the outside. We hired a website designer to design the user interface. However, we controlled the main concept and features." (System Architect and Co-Founder – Case No. 5: PriceCompare)

The external sources used in the FFE of the project are summed up in Table 4.3. Relevant quotes can be found in Appendix C.

Uncertainties within the FFE

The front-end process of this project is informal and unstructured because the three co-founders of the company only developed this project when they were free from their full-time jobs. Therefore, they did not pay much attention to uncertainty reduction during such an early phase, as the informant commented:

> "At that time [i.e., the FFE phase], we were all working part-time on this project. We just wanted to break even and the website can continue running by its own money. […] We were not really worried about anything. If it did not work and we had to shut it down, it was fine." (System Architect and Co-Founder – Case No. 5: PriceCompare)

The FFE team were only concerned about the uncertainty associated with competition and business model. For the former, the team did a SWOT analysis in order to understand the competition. Also, they did some research on the Internet in order to try to reduce the business model uncertainty during the front-end.

> "We were concerned about how to make money. The initial business model was to generate revenue from advertising so we did some research about it." (System Architect and Co-Founder – Case No. 5: PriceCompare)

However, the initial business model did not work very well. So, they kept searching for the right business model. Finally, in 2012, they found the best fit – i.e., the current business model of receiving payment from the merchants.

Quotes that are relevant to uncertainties considered during the FFE of this project can be found in Appendix D.

The outcomes

After the project was launched, the informant reported that they faced both technical and market problems:

> "There were a lot of problems [after the launch]. We thought that the traffic would come. However, the reality was very few people visited our website. […] Problems kept coming actually. Sometimes, we added new features and no one even used those features; or we could not make as much money as we thought we should have, so we

added more features which slowed down the website. We had to keep fixing the problems." (System Architect and Co-Founder – Case No. 5: PriceCompare)

Due to the technical problems and lack of traffic coming through the site, the team decided to rebrand and redesign the whole website with respect to the experience of running the website in the first year and feedback from the users. The website was relaunched in 2010 and this time the performance of the project was improved. The informant mentioned about two key performance measures – unique IP address and profitability. For the former, at the time of the interview, the website was visited by more than 100,000 unique IP addresses every day. Nevertheless, in terms of profitability, the website has been online in 2009 and relaunched in 2010 but it just started making profit in early 2013 after the business model was changed.

4.3.6. Case 6 – OnlineStockTrade

OnlineStockTrade is a mobile application for Android devices that supplies stock market information and allows users to trade stock anywhere, anytime on their mobile. Firm E who developed OnlineStockTrade is a subsidiary of the Stock Exchange of Thailand. The company's core business involves operating Thailand's stock trading system and providing channels for investors to complete stock trade transactions and obtain stock details and information. The firm developed this project with the aim of providing a new channel for investors who use Android devices to access stock information and trade in the stock exchange market of Thailand. This was because of the increasing market share of Android devices in the Thai smartphone market. Prior to this project, the firm has already been providing online stock trading services through various channels, e.g., the Internet, PDAs, Symbian phones, iPhones and iPads, etc.

In terms of competition, at the time that the firm started the project, there were only two players in the Thai market that provided this kind of services for Android users.

The firm was a bigger player in terms of market share but was new to Android market. While the service concept was identical – i.e., online stock trading, the difference between the two of them lies within the technologies that they adopted. Unlike the competitor who developed a native Android application, the particular technique that the OnlineStockTrade team adopted is called 'web embedded in app'. To explain, there are two main parts of the application: a website and a native mobile app. However, the latter is essentially a small web browser that shows only one website – the former. The former, which is obviously the more important part, displays the information and interacts with users and the company's core stock trading services.

Regarding the business model, since the application is free to download and use for stock traders (i.e., the end-users), revenue is generated from brokerage firms with which those traders have an account (i.e., the firm's target customers). The firm charges a fee for every transaction that was made through their application.

The FFE phase

The FFE phase of this project consisted of idea generation, idea evaluation and concept development. The team studied similar products from other countries and their competitor's product to help them make decisions and come up with new features. To unearth any potential issues, the Internet and users' comments on the competitor's product were also taken into account. In addition, since the development team lack the skills and experience required to develop an Android application, the members were sent to attend training courses outside of the firm. Experts (i.e., friends with some experience of the technology that was used in this project) were also consulted.

> "We sent our people to training focused on Android app development, however, not related to 'web embedded in app'. Therefore, we had to search for more information from the Internet – finding out about components that can be used to help us code

> easier, faster and tidier. Moreover, we asked experts outside of the firm for their opinions and advice, actually, from my friends who develop Android apps." (Project Manager – Case No. 6: OnlineStockTrade)

However, the team did not involve customers (i.e., brokerage firms) early in the innovation process. Rather, customers were invited to participate later in the testing phase. The senior marketing executive provided the reasons:

> "If we were to ask for their [the customers] comments in the early stages, the development process would have been more difficult. Because it would be chaotic if someone were to direct us 'you should put this button here', 'labels should be named like this or that' or 'I want this colour not that one'. Moreover, since this product belongs to our company, […] we should have the control of how the design or usability should be so that the final product will have the scent of our company or have our signature on it." (Senior Marketing Executive – Case No. 6: OnlineStockTrade)

The external sources used in the FFE of the new service are summarised in Table 4.3. Additional relevant quotes can be found in Appendix C.

Uncertainties within the FFE

Regarding market uncertainty, the informants identified concerns about user satisfaction and revenues. Since the FFE team anticipated that the revenue generated by the new channel might be considerably lower than their other channels, they did not seem to care much about providing a good user experience. Initially, they were considering two development options, namely to develop the service innovation as a native Android application which is more costly or to adopt the "web embedded in app" technology, which is considerably cheaper and less time-consuming. The team ultimately decided to go with the cheaper option as they were much more worried about cost than providing a good quality service.

> “The most important concern was the cost of maintaining several versions of the application [because Android devices vary in terms of screen size]. From what I knew, there were five different screen ratios. If we were to develop a native Android application and wanted it to look great on all devices, we would have five different versions of the app. This was the main reason why we decided not to do it.” (Senior Marketing Executive – Case No. 6: OnlineStockTrade)

On the contrary, the team were much more worried about their lack of knowledge and experience of the technology being employed, as the project manager commented:

> “The first concern was the lack of knowledge of Android app development and also ‘web embedded in app’. We really did not know what the results would be – a success or a failure. All we could do was learn from similar products. […] We also tried to study and understand the technology as much as possible.” (Project Manager – Case No. 6: OnlineStockTrade)

The team members were sent to several training sessions. Experts and the Internet were consulted about any potential technical issues. Quotes that are relevant to front-end uncertainty can be found in Appendix D.

The outcomes

Two measures of success were mentioned by the informants, namely the volume of transactions going through the system and development costs. They commented that, while the low development time and costs were satisfactory, the more important success measure – trade volume – did not meet their expectations.

> “The performance of this project was ok to a certain level, not very successful though. If we compare with the iOS versions, in terms of trade volume, there was some growth … from 1% of the iOS’s trade volume to around 10% in the past 6 to 7 months.

However, since the development costs were quite low when compared to development costs of the iOS versions." (Senior Marketing Executive – Case No. 6: OnlineStockTrade)

In addition, according to the Google Play Store (accessed on 19th January 2014), there have been more than 100,000 downloads. Although this number was high, the application has received quite a low rating (2.7 stars from 860 users), which reflects the users' dissatisfaction regarding the quality of the service that they received. Some of the comments from the Google Play Store were, for example, "Why this update want to know my (fine GPS) location? :(-- The program took too long to retrieve data." and "Need to improve much more. The interface isn't appealing, looks kinda awful. Needs to match or outdo iOS version.")

However, since then, the number of Android users in Thailand has significantly increased. The firm is now considering redeveloping the application entirely as a native Android application, which theoretically should provide a better response time and user experience. The new application may, consequently, achieve a higher level of user satisfaction as well as an increased market share. In our opinion, the FFE team may be overconfident in their knowledge of the market which, leads to inaccurate forecasts of the smartphone market. If they had paid more attention to the marketing side of the project, they might have decided to go with the more expensive option, thus avoiding having to redo the whole thing. Considering the fact that the firm is thinking about redeveloping the application, the project could be seen as a failure.

4.4. Cross-Case Analysis Results

The cases were categorised into two groups (i.e., open FFE and closed FFE[4]) based on the patterns found from an analysis of the individual cases. In terms of the key dimensions of openness competence, we focused on sharing characteristics and similarities of the more open cases. Contrasting evidence found in the closed group was also included to strengthen the internal validity of the findings. For the relationships proposed in the initial conceptual framework (Figure 2.3), we developed several complementary word tables containing the data from the individual cases with regard to openness, uncertainties within the FFE and overall project success. The contents in these tables were analysed in order to probe whether cases in the different groups share similar patterns.

4.4.1. Openness competence

Throughout all cases, the informants mentioned various activities that were employed to promote openness during the FFE phase. Those activities can be grouped into four categories: external searches, inter-firm partnerships, prior related knowledge, and use of IT.

External search

In all cases, searching for knowledge and ideas from external sources was used to some extent. The innovation sources that were used are reported in Table 4.3. The more open cases sourced ideas and knowledge more widely than their closed counterparts. The former also engaged more actively in external knowledge searching activities, as the project manager of SmartEdu described:

[4] For the definitions of the two categories – “open FFE” and “closed FFE” – please refer to Section 3.4.1, Chapter 3

> "Wherever there were events or conferences for teachers involving the use of ICT in education, we would definitely participate. We wanted to listen to the senior officers [in the Ministry of Education] for their vision about the direction of Thai education. They often mentioned about what [kind of services] they want to see in the Thai education system, which no one was providing. In addition, in this kind of event, we also met other firms who were developing educational applications as well as government agencies, such as SIPA [Software Industry Promotion Agency]. This allowed us to know what kind of applications that others were doing." (Project Manager – Case No. 1: SmartEdu)

On the other hand, in the closed cases, the FFE teams tended to be more inward-looking. The senior marketing executive in Case 6 explained why they did not involve customers in the front-end phase of the project:

> "If we were to ask for their [the customers] comments in the early stages, the development process would have been more difficult. Because it would be chaotic if someone were to direct us 'you should put this button here', 'labels should be named like this or that' or 'I want this colour not that one'. Moreover, since this product belongs to our company, […] we should have the control of how the design or usability should be so that the final product will have the scent of our company or have our signature on it." (Senior Marketing Executive – Case No. 6: OnlineStockTrade)

Furthermore, the interviewer also found that firms whose top management are open-minded and outward-looking are likely to encourage the FFE team to "get out of the building" rather than "stay in their comfort zone", as suggested by an informant:

> "Actually, initially most of our team prefer working in their comfort zone. However, our visionary CEO told us that he adheres to the principle that you have to get out of the building in order to ask others for ideas or attend seminars. […] Finally, we tried

to find the time to go out." (Marketing Director and Co-Founder – Case No. 3: MobileShopApp)

Table 4.3: Activities and structural factors promoting openness in the FFE phase

Activities/Structural Factors	***Open FFE***			***Closed FFE***		
	Case 1	***Case 2***	***Case 3***	***Case 4***	***Case 5***	***Case 6***
External search						
Events and seminars	•		•			
Academics	•	•				
Similar and/or competitors' products	•	•	•	•	•	•
The internet	•	•	•	•	•	•
Customers		•				
End-users	•	•	•		•	
Government agencies				•		
Inter-firm partnerships						
Pilot organisations	•	•				
Government agencies	•					
Intermediaries			•			
Consultants					•	
Suppliers		•				
Customer involvement	•	•	•			
The presence of a workable prototype for early testing or piloting	•	•	•			
Prior related knowledge						
Team with knowledge about the market	•			•		•
Team with knowledge about the technology	•	•	•	•	•	
Use of IT						
Knowledge management and sharing systems			•	•		
Collaborative work systems	•		•		•	•
Project management systems	•	•	•	•		•

'•' represents that innovation source, partner, activity, team or IT in the leftmost column was involved during the FFE phase.

Inter-firm partnerships

The closed cases involved fewer or no external partners in the FFE phase when compared with the open cases (Table 4.3). In the open cases, the respondents reported that they had put in a lot of effort to ensure smooth communication and collaboration with their partners by, for instance, having a dedicated contact person, constantly updating the partners on the project's progress, and trying to learn the partners' needs, as the project manager of Case 2 suggests:

> "We assigned one marketing staff to support [the partner and pilot organisations]. […] This one person – his job was to closely take care of the partners who co-developed their (mobile) application with us. What are their needs? Does our system capabilities match their needs?" (Project Manager – Case No. 2: AppCreator)

In addition, the informants reported that when all parties have a mutual interest in achieving the project goals and understand their roles and the roles of others, they are likely to contribute more and try to interrelate their actions with others. This is important for strengthening working relationships not only with external partners but also within the team:

> "The benefit of us joining the boot camp in Singapore was that all parties [intermediaries, investors and mentors] thought that this project was their work as well. Since they thought that our project was their work, they were willing to help, no holding back." (Senior Designer – Case No. 3: MobileAppShop)

> "In this project, all team members placed the utmost importance on common interests. They were ready to work hard so that the whole project could go smoothly. This may be due to our working relationships, which are family-like. We always help each other. I never assign work to my staff without explaining the rationale behind it. This is

because if they know what the work is for and how it affects the others, they will perform their best." (Project Manager – Case No. 2: AppCreator)

However, in one of the closed cases (Case No. 4: OnlineShopCreator), one of the interviewees commented that, during the FFE of the project, roles and responsibilities of some of the team members overlapped.

"Each of the team members was responsible for multiple tasks which sometimes overlapped. Some similar tasks were taken care of by two people with overlapping responsibilities instead of one." (Managing Director – Case No. 2: OnlineShopCreator)

Prior related knowledge

In all cases, the informants suggested that, by having past experience and prior related knowledge, they could acquire new knowledge more easily and in a less time-consuming way, as pointed out by the senior designer of MobileShopApp:

"Actually, my background was not as a graphic designer. I was a furniture designer before. […] Since I have an undergrad degree in product design, it was like I had the foundation knowledge of design. I just had to do some additional study in the Internet on the basic rules of [mobile] application or website design." (Senior Designer – Case No. 3: MobileShopApp)

One of the informants stressed the importance of past experience when acquiring new knowledge. While past experience enables learning at a sophisticated level, only basic knowledge could be obtained in the situation when past experience is lacking:

"We had a problem with the [mobile] application part which we had never implemented before. Basically, we can develop it. We can make it work. However, we did not know how to make it work well because we did not have any background in it before." (Project Manager – Case No. 6: OnlineStockTrade)

In a similar way, limited prior related knowledge hinders smooth communication among the parties involved in the co-creation process:

> "Since our partners were not in the IT business, they sometimes did not know what they really wanted. So, our marketing team had to interpret their requirements, their problems. Occasionally, this led to confusion or missing the main points." (Project Manager – Case 2: AppCreator)

Interestingly, in two of the closed cases (Cases 4 and 5), the participants articulated that the presence of members with related knowledge reduces the need for external knowledge:

> "I did not ask for ideas or help from others outside because I used to develop e-commerce websites and have also been involved in almost every stage of the e-commerce process. […] Therefore, I think I know what a [e-commerce] website wants. […] I and another in the team [who also has related knowledge about e-commerce] understood the user's perspective to some extent, so we hardly asked for comments from the outside." (CEO – Case No. 4: OnlineShopCreator)

Use of IT

In all cases, generic IT tools were used to facilitate external searches, communication, and collaborative working (Table 4.4). For knowledge management, IT systems such as Wikis, content management systems, and Facebook group pages were used to store and share ideas and knowledge gathered from outside of the firm. Tools such as email, VoIP and instant messaging software facilitated communication among the team members. In addition, a variety of software, ranging from sophisticated project management software to shared spreadsheets, was used to manage and facilitate coordination among different functions in the firm:

> “When we started the company, we only knew how to develop products, so we tried to set up an initiation encouraging the staff to search for interesting topics and share them in weekly meetings. […] We recorded the ideas on a web board [hosted locally]. […] We did that for a few months and then quit because we had other things that required attention. We kind of forgot and we did not see the significance of it.” (CEO – Case No. 4: OnlineShopCreator)

However, for external partners, the most frequently used communication channels were face-to-face meetings, telephone and emails. Unsurprisingly, the informants consistently highlighted the importance of physical presence:

> “[When testing the prototype with users] the interviewer had to observe the users’ face at all times. Must read what they [the users] anticipate when pressing a button. When they say something likes ‘it is ok’, it is usually negative when ‘it is ok’ comes up. If it is really ok, they will not say. They will just continue.” (Senior Designer – Case No. 3: MobileShopApp)

Table 4.3 summarises the external sources and partnerships, activities and structural factors associated with openness during the FFE that were mentioned by the interviewees. The data shown in the table are consistent with the preliminary classification of the “polar” cases into “open” FFE and “closed” FFE from the initial screening interviews. Comparing and contrasting these two categories helped the researcher to identify interesting patterns in the data presented in the following sections.

Table 4.4: Generic IT tools being used in the FFE phase

	Knowledge Management and Sharing Systems	*Collaborative Work Systems*	*Project Management Systems*
Case 1 (Open)	-	"When I wanted to have a meeting, I used Google Calendar. It allowed me to just send the others an invitation asking for their participation. If they click 'yes', then it is a confirmation. On the other hand, if I am the one being invited, it will notify me like 10 minutes before the meeting. This helped me a lot." "Since the company has already had a policy about using Gmail in place, we use G-Talk to communicate. Therefore, we can use the log and history features. We can keep record of our discussion, contact number, etc."	"We used a share document (shared in Google Spreadsheets). We share the broad timeline to all members, so all can see it. However, the engineer timeline (the more detailed one) was shared only among the engineers." "After a meeting with the marketing team, I usually listed the requirements in a Google share document. The one that is similar to Excel. It contained the estimated man-day of each feature in terms of development time."
Case 2 (Open)	-	-	Project management supported by IT (Google Spreadsheets). IT was used in sharing the requirements, project planning and tracking project status – if someone change the status of a task in the shared document the other will be able to see. "Google Doc was used by the marketing team to record and share the project timeline, feature lists, bug tests and reports. We used the spreadsheet in Google Docs. It was convenient since everyone can edit the worksheet in real-time."

Case 3 (Open)	"For knowledge sharing, we shared interesting articles in our Facebook group and blogs. We also had a shared folder dedicated to e-books. In cases of idea sharing, when somebody came up with an idea, the idea would be stored in Trello [a web-based collaborative project management application]. Then, people who should be involved were assigned to work on that idea."	"Facebook group, messengers and Skype were used for communication among the team members."	"[During the front-end phase,] We used [Google] calendar to schedule meetings. […] We also used a [Google] spreadsheet to create a task list and priorities. Trello was used in the production phase for assigning tasks to the team members. For strategic tasks, we mainly used spreadsheets and documents."
Case 4 (Closed)	"We recorded interesting ideas on a web board [hosted locally]. […] We did that for a few months and then quit because we had other things that required attention. We kind of forgot and we did not see the significance of it." "We have our own Wiki. Anyone who found interesting knowledge related to the project shared their discovery in here."	-	"We used to use Redmine [htttp://www.redmine.org] for a period of time. But we stopped using it because it is too complicated. […] Too many variables to be specified. […] Finally, nobody was using it."
Case 5 (Closed)	-	"We met on a weekly basis via Skype. We discussed the project and kept track of the progress. […] We also used MSN Messenger and recorded minutes of meetings which were shared by email."	-
Case 6 (Closed)	-	"Instead of forwarding email back and forth which causes confusion, centralising the task status, issues and contents of each team members into this system [SharePoint] is better."	"The requirements were listed in SharePoint. Every team member sees the requirements and is able to track the progress of each task. I used it to support project management, i.e. status tracking. … We can also post messages in the system and track the status of each task."

4.4.2. Openness and front-end uncertainty reduction

The cross-case analysis suggests that one of the main objectives of opening up the front-end is to reduce uncertainty. As suggested in prior studies, two main types of uncertainty related to the FFE can be identified from the case data, namely, market and technical uncertainties. For the former, the participants reported their concerns about risks and uncertainties related to competitors, customers' needs, pricing strategy, usability, and traction.

> "There were risks about what the customers [who shop in the merchants' website] would think about the features. Will they like it? Will they have any bad feelings, if we come up with a feature that the merchants [who use the website creator and hosting services provided by the firm] like, but the customers hate. We had to balance their needs." (CEO – Case No. 4: OnlineShopCreator)

Regarding technical uncertainty, the informants mentioned several issues, such as, compatibility, maintenance, development timeline, and technology adoption:

> "When a new technology comes to the market, we have to trade-off either being a first mover or playing it safe. If we are fast to react but the technology never reaches the mainstream, we may risk wasting both time and money." (Business Development Manager – Case No. 2: AppCreator)

The data suggest that, in the open cases, a more external approach was adopted in order to reduce both market and technical uncertainties. On the other hand, the informants from the closed cases were not concerned much about uncertainty during the front-end process, and thus put less effort into coping with uncertainty (Table 4.6). With regard to uncertainty related to the market and customers, the open cases stressed the importance of conducting market research and having customer involvement during the FFE:

> "Most importantly, we must understand the customers. To understand the customers, we conducted market research by asking target groups, business customers, and end-users. This helped us to know the needs of each type of customer. […] This also helped reduce uncertainties related to customers, in the case of selling the product to business customers in particular." (Business Development Manager – Case No. 2: AppCreator)

> "Whenever the mentors suggested new ideas to us, we always tested those ideas with the users [a group of 5 to 10 users] to see whether they should be included in the product or not." (CTO – Case No. 3: MobileShopApp)

For technical uncertainty reduction, searching in the Internet and studying competitors were used during the FFE phase. Moreover, uncertainty can also be reduced by collaborating with external partners such as suppliers, pilot organisations, and intermediaries:

> "That [consulting with mentors] is very important, because mentors can give us what they learned when they were working on their project like us now. […] For example, when I was deciding whether to go with 3 or 4 rows of pictures in the feed page, they told us with confidence that we must have only 3 rows. They told us that when they used 3 rows their transactions went up significantly." (Senior Designer – Case No. 3: MobileShopApp)

In sum, while the open cases reached out to the outside world in order to improve their ability to reduce market and technical uncertainties during the FFE phase, their closed counterparts did not perceive the need to open up and did not focus on early uncertainty reduction.

Table 4.5: Project success/failure

	Project Success/Failure	*Survey Rating***
Case 1 (Open)	**(+) Positive feedback from prospective customers:** "When we were trying to pilot our system. […] The teachers of the pilot school that we contacted seem to be happy and very co-operative. Initially, we wanted to pilot in only 2 subject areas. It turned out that more teachers than we expected were interested and wanted to try as well. Consequently, we piloted in 4 subject areas."	**6.5**
Case 2 (Open)	**(+) Positive feedback from prospective customers:** "Since we launched, we have participated in 3-4 exhibitions. In every exhibition, we had received a lot of interests from prospective customers. Some contacted us and are now in the negotiation process." **(+) Custom-made Sales:** Several mobile application development projects have been sold to organisational customers. The applications were built with the AppCreator system which significantly reduced development time and costs. **(+) Reseller model:** The firm was in the process of signing a contract with a large communication firm to sell a bulk of credits for using the application creator service.	**5.33**
Case 3 (Open)	**(+) Traction:** More than 70,000 downloads (25-30% are active users) and 800 new items are listed by merchants every day. **(+) The ability to attract investment funds:** The firm received funding of more than 500,000 USD from two venture capital firms to support the development of the service innovation. **(-) Profitability:** The application has yet to make money because the firm has yet to find an appropriate business model.	**5.83**
Case 4 (Closed)	**(+) Traction:** More than 100,000 shops in the firm's system. **(+) Market share:** "In terms of customer base, we are number three in the market. Currently, the big three are market.com, shop.com and us. In the past, who was the number three was not very clear." **(+) Transaction value:** Transactions running on the site are worth more than 8 million GBP in 2012. **(-) Profitability:** "The income target that we thought we would achieve was quite high. However, when we launched the first service, we got only 20,000 – 30,000 Baht (~ 400 – 600 GBP) in that month" (i.e., they just started making a profit in March 2013). **(-) Development time:** almost 2 years.	**4.83**

Case 5 (Closed)	**(+) Traction:** More than 100,000 unique IP addresses per day. **(+) Market share:** Number one price comparison website in Thailand. **(-) Profitability:** The website has been online since 2010 but it only started making profit in 2013. **(-) Failure of the initial launch:** When the website was first launched in 2009, it suffered from many technical problems and was not able to build traction. The website was therefore relaunched in 2010 with a new design based on what the team had learned from the first website.	**2.17**
Case 6 (Closed)	**(+) Traction*:** More than 100,000 downloads **(-) Negative users' feedback*:** Average rating of 2.7 stars from 860 users. Some of the comments from the Google Play Store were, for example, "Why this update want to know my (fine GPS) location? :(-- The program took too long to retrieve data." and "Need to improve much more. The interface isn't appealing, looks kinda awful. Needs to match or outdo iOS version.") **(-) The plan to revamp the application:** The firm is now considering redeveloping the application entirely as a native Android application which theoretically should improve the performance and user experience.	**4.83**

* The information was gathered from the Google Play Store (access on 19th January 2014).

** The informants' perceptions of the project's success from the questionnaire in Appendix A (mean value of the responses, i.e., min = 1 and max = 7).

4.4.3. Front-end uncertainty reduction and service innovation success

When asked about project success, the informants reported various success measures they had used, such as customer feedback, sales, profitability, number of downloads, transaction volume, website stats, etc. Table 4.5 displays a summary of the outcomes of the service innovation projects and the follow-up survey's results (Appendix A). Table 4.6 shows links between openness, early uncertainty reduction and service innovation success. The information in both tables suggests that, unlike the closed cases, the open cases put a considerable amount of effort into reducing uncertainty early in the process and, as a result, they seemed to be more successful. Note that the success ratings in Table 4.6 are based on the synthesis of the interview data and the survey results in Table 4.5.

Early reduction of market uncertainty is likely to result in a more robust service concept. For example, in Case No. 3, the team had an opportunity to attend a 100-day seed accelerator programme organised by an intermediary firm. At the end of the programme, the team pitched their product to a group of investors. Finally, they got an investment fund of more than 500,000 USD. The front-end process of this project was described by the marketing director and co-founder:

> "At the beginning, we hardly did anything, we just designed screenshots and put them on a website for people who were interested in using our service to register. This let us know that the concept was needed and traction can be built. We then brought the concept forward and developed a prototype to test with the users. […] Risks and uncertainties were gradually reduced in each step." (Marketing Director and Co-Founder – Case No. 3: MobileShopApp)

Table 4.6: The impact of openness on front-end uncertainty reduction and service innovation success

	Openness Activities	***Related Uncertainty***	***Success Rating****
Case 1 ***(Open)***	They actively participated in seminars and events related to education and technology. Similar domestic and foreign products were studied.	Market and competition uncertainty (e.g., education policy, competitors, etc.)	☆☆☆☆
	Education professionals were consulted They collaborated with a school in piloting the prototype.	User uncertainty (functionality and usability)	
	People with a previous background in education were recruited for concept development and IU design in the front-end phase. People who had experience of developing Android applications were also recruited.	Technical uncertainty (product specification and product design)	
Case 2 ***(Open)***	Since the product concept was very new in Thailand, they did a lot of market research and studied similar foreign products. A marketing professor was also consulted regarding the marketing strategy of the new service.	Competitor and market uncertainty (e.g., marketing strategy, pricing, etc.)	☆☆☆☆
	They involved prospective customers (pilot shops) early to test the prototype.	User uncertainty (functionality and usability)	
	People with the strongest technical background in the firm were teamed up to study the technological feasibility of the new service concept.	Technical uncertainty (project timeline and technical specification)	
Case 3 ***(Open)***	The informants stressed the importance of having the simplest version of the new service concept (a workable prototype) and customer involvement. A first iteration of the product with only core functions. Minimum effort and time was used to learn about the customers and the market.	Market and user uncertainty (target group, functionality and usability)	☆☆☆ ☆☆

	The opportunity to participate in the 100-day boot camp and co-develop with an intermediary was pointed out as very important. A number of mentors were consulted regarding technological, design and methodological issues.	Technical uncertainty (development framework, technology and design)	
Case 4 ***(Closed)***	The informants suggested that asking users was time-wasting. So, they made all decisions concerning the website's functionalities by themselves because some in the team had had experience developing and running e-commerce websites before.	-	☆☆☆
	The team studied technical mistakes made by the competitors. This resulted in several preventive measures.	Technical uncertainty (technical specification, maintenance plans)	
Case 5 ***(Closed)***	Competitor's products were studied; and friends were consulted regarding usability issues. Also, a consultant was hired to design the website.	User uncertainty (usability)	☆
	They were not concerned much about technical uncertainty during the front-end phase since they were confident in their technical knowledge.	-	
Case 6 ***(Closed)***	The informants said that very little was done to reduce market uncertainty since the main objective was to provide another channel to the existing stock trading services with minimum effort.	-	☆☆
	Lack of experience in mobile application development was mentioned as a main issue. Therefore, they tried to improve that by sending the developers to training, searching the internet and consulting experts.	Technical uncertainty (technology issues)	

*The ratings were given by the researcher (ranging from 1 star to 5 stars). They are based on a compilation of the information in Table 4.5.

Early reduction of technological uncertainty was also found to be crucial in narrowing technology-related knowledge gaps. One informant described how studying mistakes made by competitors was helpful:

> "Because we saw how the competitor's servers went down, we put preventive measures at the very beginning of the development process. The main problem of this particular competitor was that their servers went down quite often and for a long period of time which put off the customers. The cause [of the problem] was that they only had one set of servers to serve several hundred thousand stores [merchants' online stores]. So, the failures were unavoidable. We therefore split up our system into many sub-systems […] to mitigate the risks." (CEO – Case Mo. 4: OnlineShopCreator)

In contrast, a lack of uncertainty reduction activities in the FFE phase can lead to considerable hardship in the following phases. For example, in Case No. 5, there were several market-related and technical issues in the commercialisation phase:

> "There were a lot of problems [after the launch]. We thought that the traffic would come. However, the reality was very few people visit our website. […] Problems kept coming actually. Sometimes, we added new features and no one even used those features; or we could not make as much money as we thought we should have, so we added more features which slowed down the website. We had to keep fixing the problems." (System Architect and Co-Founder – Case No. 5: PriceCompare)

To sum up, the findings suggest that external searches, inter-firm partnerships, prior related knowledge and use of IT are key drivers of openness in the FFE phase of online service innovation projects. Moreover, it is also found that being more open early in the innovation process can lead to positive outcomes later, as it helps reduce innovation uncertainty. In the next section, we discuss the findings with the literature and introduce 7 research propositions concerning openness in the FFE of service innovation.

4.5. Discussion on the Findings

In this section, we look at the findings of the case study through the S-D logic analytical lens, and compare and contrast these findings with the extant literature. As a result, we propose a total of 7 research propositions. The current section starts with the 5 core dimensions of openness competence, namely searching capability, coordination capability, collective mind, absorptive capacity, and IT capability. Each dimension is discussed individually with regard to its impact on openness competence. Next, the role of openness competence within the FFE of service innovation as a tool that helps reduce front-end uncertainty is explained. Finally, an OSI model incorporating the research propositions is presented.

4.5.1. The five dimensions of openness competence in the FFE

As the S-D logic's FP4 indicates, "operant resources are the fundamental source of competitive advantage" (Vargo & Lusch, 2008, p. 7), The current study therefore focuses on openness competence – i.e., the ability of an innovation team to gather and apply operant resources from external sources and co-develop with other organisations possessing complementary operant resources –, which may be important for a team adopting a more open approach to the FFE phase. By looking at the interview data through the analytical lens of S-D logic, we were able to identify 5 core dimensions of openness competence: searching capability, coordination capability, collective mind, absorptive capacity, and IT capability. In the case study, the more open cases, which are likely to possess relatively high levels of these capabilities, were found to put more effort into reducing uncertainties related to activities in the FFE phase.

Searching capability

The first dimension concerns the development team's ability to search knowledge and sources of innovation (i.e., operant resources) with external and wider orientation, which is labelled as '*searching capability*'. The findings of the case study suggest that a front-end team with open-minded and outward-looking characteristics is likely to actively engage more widely and frequently in external knowledge searching, which leads to more successful outcomes (Chang et al., 2012; Chiang & Hung, 2010). The case data also suggest that top management's commitment to openness nurtures the team's searching capability, since such support is essential in creating an organisational setting that facilitates and encourages learning behaviours (Blazevic & Lievens, 2004). Scholars have suggested the important role of gathering knowledge from outside sources (e.g., suppliers, intermediaries, competitors, customers, etc.) plays in reducing the fuzziness of the front end phase (Alam, 2006a; Kim & Wilemon, 2002; Zhang & Doll, 2001). Thus, the first proposition is:

Proposition 1: Openness competence within the FFE phase incorporates searching capability, which can be nurtured by top management's commitment to openness.

Coordination capability

Vargo and Lusch's (2008, p. 7) FP6 (i.e., "the customer is always a co-creator of value") and FP9 (i.e., "All social and economic actors are resource integrators") suggest the significant role of customer and innovation networks in NSD. The current and the next dimensions of openness competence are proposed to be the fundamentals of customer integration and inter-firm partnerships. Scholars have identified the importance of communication in stimulating creative thinking and idea generation in the early stages of service innovation (Blazevic & Lievens, 2004), as well as highlighting the role of innovation networks (de Vries, 2006), personal networks (Stevens, 2014), and a firm's ability to co-create with other organisations (Chen et al., 2009a; Ettlie & Pavlou, 2006) as essential for innovation success. As suggested by the case data and the literature, we propose that, for innovation partnerships to be successful, effort and resources should be made available to ensure smooth communication and coordination among internal team members as well as between the team and its external partners.

Proposition 2: Openness competence within the FFE phase incorporates a coordination capability, which requires the innovating firms to commit effort and resources to allow seamless collaboration.

Collective mind

Whereas the good-dominant logic considers the customer and the firm separately in value creation, FP8 of the S-D logic emphasises a service-centred view arguing that "value creation is an interactive process and, thus, the firm and customer must be considered in a relational context" and further that "value […] is inherently customer oriented" (Vargo & Lusch, 2008, p. 8). Therefore, the third dimension concerns a FFE team's ability to be customer-oriented and relational. This study however interprets the term "customer" as not only the end customers who actually pay for the service, but all partners who derive a benefit from the value created by new service provisions. Therefore, to be successful in innovation, instead of focusing on benefiting only oneself, one should rather create value that benefits all parties involved.

From our case study, the informants in the more open cases suggested the importance of mutual interests in achieving project goals and of good understanding in the roles of oneself and the roles of others, which leads to high levels of contribution and harmonious work flows. High levels of commitment lead to better performance (Eisingerich et al., 2009) and partnership success (Mohr & Spekman, 1994). This is consistent with the concept of *'collective mind'* which is conceptualised as "a pattern of heedful interrelations of actions in a social system" (Weick & Roberts, 1993, p. 357). According to Weick and Roberts (1993, p.357), members of a system with a high level of collective mind "construct their actions (contributions), understanding that the system consists of connected actions by themselves and others (representation), and interrelate their actions within the system (subordination)". Therefore, we postulate that, to successfully co-develop with innovation partners, the presence of strong collective mind is necessary.

Proposition 3: If the participants share mutual interests and understandings, openness competence within the FFE phase is likely to be improved since the participants are willing to contribute more and interrelate their actions with others better.

Absorptive capacity

FP1 and FP4 of the S-D logic argue that the application of operant resources (knowledge and skills) is the fundamental basis of exchange and the source of competitive advantage (Vargo & Lusch, 2008). Consistently, the case study data indicated that the possession of sufficient prior related knowledge (a type of operant resources) by all participants improves external search activities, as well as collaboration and communication among the parties involved. The fourth dimension therefore captures the vital role of operant resources possessed by the development team. Prior related knowledge is often suggested as an antecedent of innovation performance by the literature on *'absorptive capacity'* (Caloghirou et al., 2004; Chen et al., 2009b; Fosfuri & Tribó, 2008; Zahra & George, 2002). According to a seminal study conducted by Cohen and Levinthal (1990, p. 128) absorptive capacity can be defined as "the ability of a firm to recognise the value of new, external information, assimilate it and apply it to commercial ends." Prior related knowledge enhances learning, problem-solving skills and creativity (Cohen & Levinthal, 1990). Furthermore, it allows the team to comprehend the external environment of important trends and know-how (Lusch et al., 2007). Accordingly, we propose that:

Proposition 4a: Openness competence within the FFE phase is likely to be improved when the participants possess prior related knowledge, which allows effective knowledge searches and coordination with external partners.

Interestingly, we discovered that, in the closed cases (see Table 4.6), the participants did not actively engage in external knowledge sourcing and inter-firm partnerships because they were confident in their knowledge of the market and the technology. One of the explanations may be that, since the service concepts of the closed cases were not very new, the degree of uncertainty may not be as high as the cases in the other group, and thus a team with strong related knowledge may be sufficient. A similar relationship between innovation novelty and intensity of knowledge sharing and communication has also been found by Hsieh and Tidd (2012).

Proposition 4b: In projects with low to moderate innovativeness, a high level of prior related knowledge could be used to substitute external knowledge sourcing and innovation partnerships.

IT capability

According to the interview data, the use of IT does not directly influence the quality of the new service concepts created in the FFE phase. Throughout all cases, IT (e.g., ICTs, knowledge management software, and project management software) was used to facilitate the FFE team in opening up the front-end process (Table 4.4). The literature propounds the benefit of the use of IT in the FFE of innovation (Gordon et al., 2008; Kim and Wilemon, 2002). Furthermore, it is suggested that ICTs, such as computers, internet, communication devices, etc., help enable the exchange of distributed sources of information and support the shift towards more open and collaborative innovation practices (Dodgson et al., 2006). For some empirical examples, non-routine technology was found to predict task performance in high information-processing tasks (e.g., the FFE of innovation) (Keller, 1994). Moreover, based on an experimental study by Schmidt et al. (2001), geographically and temporally dispersed decision-making teams supported by ICTs make more effective go/no-go decisions than both face-to-face decision making teams and individuals. Therefore, the fifth proposition:

Proposition 5: A high level of IT capability enables systematic and effective external knowledge searches, collection and sharing, as well as enabling collaboration among the parties involved, thereby facilitating a more open approach to innovation.

4.5.2. The indirect effect of openness competence within the FFE on service innovation success through front-end uncertainty reduction

By comparing and contrasting the cases in the two categories (i.e., open vs. closed), we were able to identify an interesting pattern. Unlike the closed front-ends, more effort had been made to manage uncertainty in the open FFE cases due to their positive attitude towards early uncertainty reduction, which leads to successful innovation outcomes (Table 4.6). The results are consistent with scholars taking the information-processing view (e.g., Frishammar et al., 2011; Lievens & Moenaert, 2000; Moenaert et al., 1995; Verworn, 2009; Verworn et al., 2008). Specifically, the findings suggest a link between early uncertainty reduction and innovation success. This highlights the significance of increasing firms' information-processing capacity when executing highly uncertain tasks, such as the FFE phase of service innovation. An explanation for this may be that the more open teams tried to increase their information-processing capacity by exploring and assimilating information and knowledge externally (Chang et al., 2012; Chiang & Hung, 2010; Laursen & Salter, 2006), and through sharing the information-processing burden by co-developing with external partners (Ettlie & Pavlou, 2006).

Furthermore, the S-D logic's FP4 indicates that "operant resources are the fundamental source of competitive advantage" (Vargo & Lusch, 2008, p. 7). In line with this argument, the literature on dynamic capabilities and open innovation also lends support to openness competence (i.e., an operant resource that is supposedly important to the FFE process of service innovation) as one of the key antecedents of innovation success (please refer to Section 2.9, Chapter 2). Therefore, this study proposes that a high level of the FFE team's openness competence leads to better outcomes of front-end uncertainty reduction activities. By virtue of the less fuzzy front-end, a successful service innovation can be created.

Proposition 6: A front-end team with a high level of openness is likely to engage in uncertainty reduction activities that involve information gathering and cooperation with others. As a result, the team is likely to effectively reduce front-end uncertainty which in turn leads to successful innovation outcomes.

It should be noted that we do not claim to have discovered the relationship between front-end uncertainty reduction and innovation success since scholars taking the information-processing view has long suggested such a link (Frishammar et al., 2011; Moenaert et al., 1995; Verworn, 2009; Verworn et al., 2008). This study is rather an attempt to conceptualise the openness competence construct as well as to explain how openness competence within the FFE phase enhances service innovation success through early uncertainty reduction.

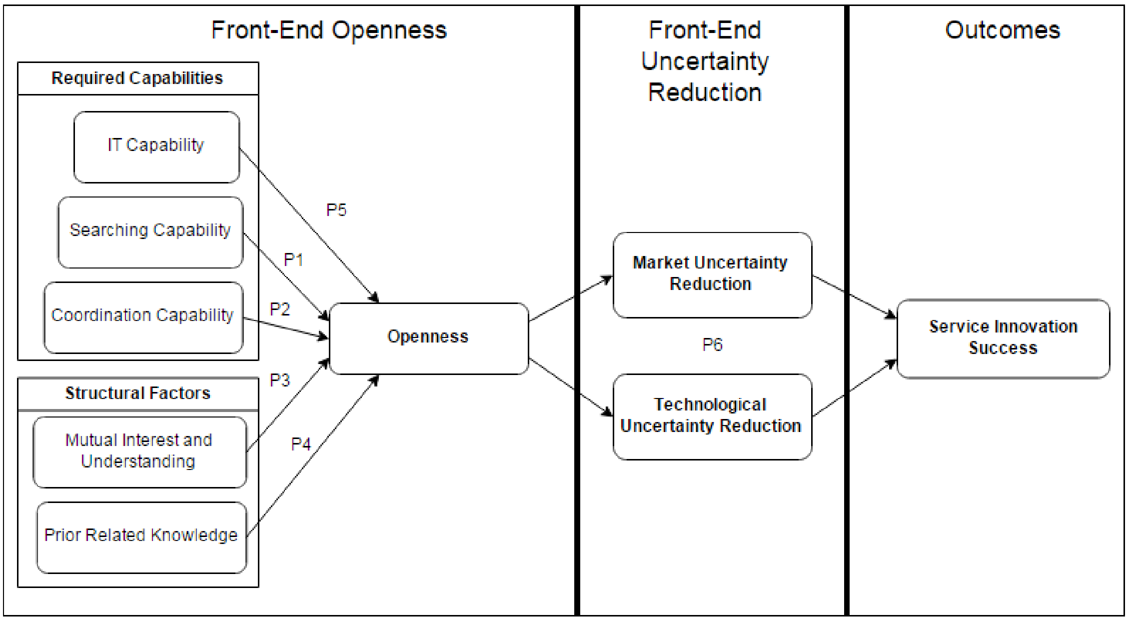

Figure 4.1: An initial OSI model

Figure 4.1 visualises the proposed research propositions in a "boxes and arrows" fashion. The researcher has named the resultant model – an "open service innovation" (OSI) model. The OSI model suggests how a firm can nurture openness competence in the FFE of service innovation by developing its 5 core dimensions, as well as the importance of openness competence as a tool that can be used to mitigate uncertainties early in the innovation process.

4.6. Summary of the Chapter

This chapter reported the findings of a case study of six online service innovation projects. Both within- and cross-case analysis results were presented. By synthesising the case data and the extant literature, we were able to identify 5 key dimensions of openness competence within the FFE. They are: searching capability, coordination capability, collective mind, absorptive capacity, and IT capability. In addition, the cross-case analysis also helped confirm the relationships suggested in our initial conceptual model (Figure 2.3). Based on these findings, we proposed an OSI model incorporating 7 research propositions. These propositions helped the researcher operationalise the openness competence construct, and establish this study's research hypotheses as well. The details of how the qualitative findings benefit the second part of this study are described in the next section. In addition, the next section demonstrates how the measurement scales were developed and how the survey was executed as well as providing an analysis of the results of the survey data.

5. Findings – A Survey of the FFE of IT-Based Service Innovation

5.1. Introduction

In the second phase, a large-scale survey was conducted in Thai IT service provider firms. The main purpose of this phase was to statistically verify the initial OSI model (Figure 4.1) proposed in the previous chapter. To move from a conceptual model to a model that can be tested with empirical quantitative data, we further reviewed the literature relevant to the key constructs of the proposed OSI model. We were able to establish a more quantitatively testable version of the model (Figure 5.1) which was founded upon the evidence from the case study and the additional literature review process.

The current chapter starts with the updated OSI model (Figure 5.1) and the formation of the research hypotheses that are incorporated in the model. Next, the operationalisation of the key constructs and their measurement scales are described. Finally, details of the data analysis procedures are presented as well as descriptive and inferential statistical results.

5.2. Hypothesis Formation

In this section, the researcher further reviews the relevant literature and discusses it with the findings obtained from the case study. The aim is to establish a model and research hypotheses that can be tested with survey data. The formation of an updated OSI model and a total of 11 research hypotheses incorporated in the model is discussed below.

5.2.1 An updated OSI model

The conceptual model shown in Figure 5.1 was founded upon the current knowledge in the literature as well as the research propositions provided in Section 4.5, Chapter 4. Essentially, the model in Figure 5.1 is an update of the OSI model (Figure 4.1) presented at the end of the previous chapter. The right side of the model in Figure 5.1 is inspired by the evidence found in the findings of the case study (i.e., Proposition 6). It concerns the contribution of openness competence to service innovation success through market and technical uncertainty reduction during the FFE. The more successful cases were more open and used openness to help reduce front-end uncertainties, whereas the less successful cases were less open and were not as concerned about early uncertainty reduction. This is consistent with the initial theoretical framework proposed in Section 2.10, Chapter 2 (Figure 2.3), which was founded upon the information-processing and open innovation theories. The left side of the updated model in Figure 5.1 features the key dimensions of openness competence within the FFE. These dimensions emerged from the analysis of the case data (Proposition 1 to Proposition 4). While 4 of the 5 key dimensions are hypothesised as first-order constructs that form openness competence, the other (i.e., IT capability) was rather considered as an antecedent (Proposition 5). The reasons behind this decision are described in detail in Section 5.2.5.

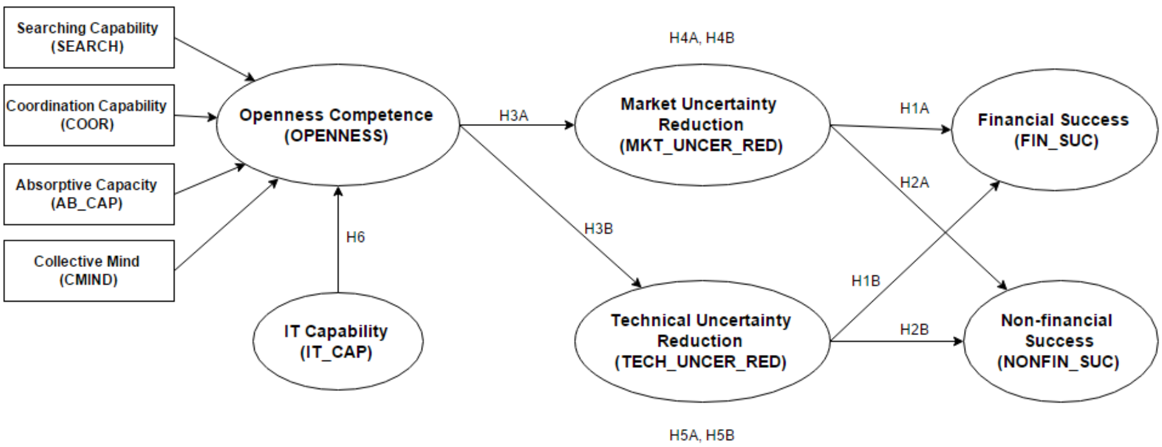

Figure 5.1: An updated OSI model

The updated OSI model in Figure 5.1 suggests how a firm can nurture openness competence within the FFE by encouraging front-end team members to develop the 4 key dimensions as well as their IT capability. Further, it highlights the important role of openness in service innovation success, as a tool that can be used to diminish front-end uncertainties. By statistically estimating paths in the model, this study aims to provide answers to the research questions. For RQ1 ("what are the key dimensions of openness competence within the FFE of service innovation?"), the openness competence construct was conceptualised as a second-order latent construct formed by the four key dimensions (i.e., searching capability, coordination capability, collective mind, and absorptive capacity) and was statically evaluated with the survey data. To answer RQ2 ("does openness competence within the FFE contribute to service innovation success?") and RQ3 ("if yes, does openness competence contribute to service innovation success through the degree of market and technical uncertainty reduction during the FFE phase?"), the proposed mediating effects of market and technical uncertainty reduction on the relationships between openness competence and the two service innovation success measures were assessed using PLS-SEM techniques.

Based upon the current knowledge in the literature and the case study's results, we propose 11 research hypotheses in the following sub-sections. The proposed research hypotheses are the foundations of the updated OSI model in Figure 5.1.

5.2.2 Uncertainty reduction and service innovation success

The analysis of the case study suggests a significant contribution of early uncertainty reduction to the overall project success. This is consistent with the information processing theory (Galbraith, 1974) and scholars who have studied the FFE from the information-processing perspective (Chang et al., 2007; Frishammar et al., 2011; Lievens & Moenaert, 2000; Moenaert et al., 1995; Verworn, 2009; Verworn et al., 2008; Zhang & Doll, 2001) (please refer to Section 2.7.1 for a detailed discussion on the literature listed here). Consistent with prior studies, we were able to identify two main types of front-end uncertainty from the case data, namely market and technical uncertainty. The effective reduction of these two types of uncertainty has been identified as one of the important antecedents of innovation success in previous studies (Moenaert et al., 1995; Perkins & Rao, 1990; Verworn, 2009; Verworn et al., 2008). Four hypotheses are proposed, suggesting the effects of market and technical uncertainty reduction during the FFE on the success of service innovation projects.

Hypothesis 1A (H1A): The degree of **market uncertainty reduction** during the FFE positively influences the **financial success** of service innovation projects.

Hypothesis 1B (H1B): The degree of **technical uncertainty reduction** during the FFE positively influences the **financial success** of service innovation projects.

Hypothesis 2A (H2A): The degree of **market uncertainty reduction** during the FFE positively influences the **non-financial success** of service innovation projects.

Hypothesis 2B (H2B): The degree of **technical uncertainty reduction** during the FFE positively influences the **non-financial success** of service innovation projects.

5.2.3 Openness competence

By looking at the case data through the analytical lens of S-D logic, we were able to identify four core dimensions of openness competence, namely searching capability, coordination capability, collective mind, and absorptive capacity. To clarify, the reasons why IT capability was hypothesised as an antecedent, rather than a fifth dimension of openness competence, are provided later in Section 5.2.5. In the second phase of this study, openness competence was conceptualised as a second-order latent construct formed by a set of four first-order factors – i.e., a formative hierarchical model. This depicts the multidimensional nature of openness competence within the FFE of service innovation. In this section, we review relevant previous research and discuss how each of the proposed key dimensions could contribute to service innovation success.

Searching capability

The first dimension is associated with Enkel et al.'s (2009) outside-in process. The findings of the case study suggest that a front-end team with open-minded and outward-looking characteristics is likely to actively engage in external knowledge searching more widely and frequently. The current study defines '*searching* capability' as "the development team's ability to search for knowledge and sources of innovation (i.e., operant resources) with external and wider orientation".

Scholars have suggested the importance of knowledge gathering from outside sources (e.g., suppliers, intermediaries, competitors, customers, etc.) in reducing the fuzziness of the front-end phase (Alam, 2006a; Kim & Wilemon, 2002; Zhang & Doll, 2001). Furthermore, the ability to search for external knowledge and ideas has also been identified as a key factor for success in innovation. For example, from a survey of 112 Taiwanese top manufacturing firms, Chang et al. (2012) unearthed the positive impact of openness capability on radical innovation performance. Similarly, Chiang and Hung (2010) posited that acquiring knowledge from a broad range of external channels can improve radically new product performance. In service innovation contexts, Lee et al. (2010) conducted a large scale survey in Korea and found that the effective and broad use of external information is associated with the number of service innovations. Chen et al. (2011) also empirically proposed a positive relationship between innovation performance and the diversity of knowledge sources in firms using a "doing, using and interacting" (DUI) mode of innovation favoured in service firms (Jensen et al., 2007). Moreover, external knowledge obtained from customers and competitors was found to be related to profitability and the sales of service innovations (Leiponen, 2005).

Nevertheless, based on data from a UK innovation survey, Laursen and Salter (2006) found that a firm's innovation performance is a curvilinear (inverted U-shape) function of "the number of different search channels that a firm draws upon in its innovative activities (p. 135)." One possible explanation for these conflicting findings is that these research studies did not investigate the FFE phase and the development phase separately. Since the FFE phase is different from the execution phase in many dimensions, such as the nature of the work (Koen et al., 2001), its characteristics (Zhang & Doll, 2001), its key success factors and activities (Khurana & Rosenthal, 1997; 1998) and the role of management (Poskela & Martinsuo, 2009), we argue that searching activities in these two distinct phases should be studied separately.

Coordination capability

The current and the next dimensions of openness competence are proposed to be the fundamentals of the coupled process (Enkel et al., 2009). Effective communication flows among members of a project team as well as between members of the project team and outside sources were found to have an impact on project success through the degree of uncertainty reduction (Lievens & Moenaert, 2000). Furthermore, Cheng et al. (2008) conducted a survey of 218 Chinese organisations and reported that coordination (defined as the "willingness of a partner to pursue mutually compatible interests rather than to act opportunistically" (p. 801)) has a positive impact on process innovation in e-commerce. More recently, for inter-firm NSD projects, Hsieh and Tidd (2012) found that higher levels of project innovativeness require a higher intensity of knowledge sharing and communication. These recommendations are consistent with the information-processing theory, which argues that, in order to effectively deal with complex tasks the information processing burden of decision makers should be shared with others possessing complementary knowledge and skills (Galbraith, 1974). In this study, the second dimension of openness competence – *'coordination capability'* – is defined as "project stakeholders' (both internal and external to the firm) ability to synchronise knowledge, resources and tasks to create superior new ways of executing activities in the FFE phase of service innovation" (adapted from Ettlie & Pavlou, 2006, p. 122).

Collective mind

The findings of the case study indicate the significance of mutual interest in achieving the project goals and in understanding of one's own roles and the roles of others, leading to high levels of contribution and harmonious work flows. This is consistent with the concept of *'collective mind'* (Weick & Roberts, 1993). Based on a study of two FFE teams developing large, complex real-time systems, Crowston and Kammerer (1998) suggested that strong collective mind could be a possible remedy for problems in software requirements analysis. Similarly, Hargadon and Bechky (2006) suggested that an innovation team with a high level of collective mind has the capacity to generate creative solutions by drawing from the past experiences of participants in ways that lead to new and valuable insights. On the other hand, the lack of collective mind leads to a loss of intelligence that is reflected in missed targets and slow change (Weick & Roberts, 1993, p. 369). Therefore, we postulate that the presence of collective mind is necessary to successful innovation partnerships in the FFE.

Absorptive capacity

Absorptive capacity has been proposed as a pre-condition for organising inbound open innovation activities (Spithoven et al., 2011). According to a survey study by Lichtenthaler (2009a), in environments where market and technological uncertainty is high, absorptive capacity was found to have a strong positive impact on innovation performance. On the contrary, in less turbulent settings, the effects of absorptive capacity on performance were limited. Caloghirou et al. (2004) discovered the positive effects of R&D capability, the intensity of R&D efforts, and highly qualified personnel (traditional measures of absorptive capacity) on innovation performance. Furthermore, Zahra and George (2002) conceptualised that absorptive capacity is comprised of two main components: potential absorptive capacity and realised absorptive capacity. The former involves the acquisition and assimilation of knowledge obtained from external sources which seem to be very important to the FFE, while the later includes the transformation and exploitation of newly acquired and assimilated knowledge. Based on this conceptualisation, Fosfuri and Tribó (2008) posited that firms with superior potential absorptive capacity obtain larger shares of their sales from new or significantly improved products.

Based upon the findings of the case study and a review of the literature, the current study hypothesises that the level of openness competence being formed by the four core components (i.e., searching capability, coordination capability, collective mind and absorptive capacity) is positively related to the degree of front-end uncertainty reduction. The later in turn positively influences service innovation success. The existing literature provides empirical support for this position. For example, a qualitative field research of 26 financial services firms by Alam (2006a) found that front-end fuzziness can be reduced by involving customers early in the innovation process. Langerak et al. (2004) studied relationships between market orientation, proficiency in FFE activities, new product performance, and organizational performance based on data collected from a survey of 126 firms in the Netherlands. They found that market orientation, which was defined as "a culture that creates an environment that maximizes opportunities for learning about markets, for sharing information among functions in the organization that allows common interpretation, and for taking coordination actions (p. 296)", is positively related to a proficiency in predevelopment activities (i.e., strategic planning, idea generation, and idea screening). Based on a case study of two innovation projects in a high-tech company, Stevens (2014) posited that the front-end team should use their customers' knowledge as a basis for decision-making in order to reduce uncertainty. He also found that the use of personal networks is crucial in the FFE phase due to the limited amount time and resources available in such an early stage of development.

***Hypothesis 3A (H3A)*: Openness competence** within the FFE positively influences the degree of **market uncertainty reduction** during the FFE.

***Hypothesis 3B (H3B)*: Openness competence** within the FFE positively influences the degree of **technical uncertainty reduction** during the FFE.

5.2.4 The indirect effect of openness competence on service innovation success through front-end uncertainty reduction

The FFE phase of innovation has traditionally been characterised by its low level of formalisation and its lack of structure (Khurana & Rosenthal, 1997; 1998). It often involves high levels of market and/or technical uncertainty (Verworn, 2009; Verworn et al., 2008). As mentioned in Chapter 2, scholars taking the information-processing view have suggested a link between the degree of uncertainty reduction during the FFE and innovation performance (Frishammar et al., 2011; Moenaert et al., 1995; Verworn, 2009; Verworn et al., 2008).

In the FFE phase in particular, several types of information from both internal and external sources are required to reduce uncertainty (Alam, 2006a; Kim & Wilemon, 2002; Zhang & Doll, 2001). Opening up the innovation process by searching for external innovation sources and co-developing with other organisations can be highly rewarding (Chesbrough, 2003). Openness to new ideas, inputs and sources of inspiration external to the firm's boundary is considered crucial for innovation projects, especially in the early stages (Fagerberg, 2005). In the service sector in particular, since formal R&D plays a much less important role than it does in manufacturing, service firms' innovation capacities strongly depend on access to external information sources (Muller & Zenker, 2001).

As discussed earlier, both the case study data and the literature uniformly suggest that a high level of a FFE team's openness competence leads to better outcomes of front-end uncertainty reduction activities (H3A and H3B). By virtue of these improved outcomes, a successful service innovation can be produced (H1A, H1B, H2A, and H2B). Thus, the following four hypotheses:

***Hypothesis 4A (H4A)*:** The degree of **market uncertainty reduction** during the FFE mediates the impact of **openness competence** within the FFE on the **financial success** of service innovations.

***Hypothesis 4B (H4B)*:** The degree of **technical uncertainty reduction** during the FFE mediates the impact of **openness competence** within the FFE on the **financial success** of service innovations.

***Hypothesis 5A (H5A)*:** The degree of **market uncertainty reduction** during the FFE mediates the impact of **openness competence** within the FFE on the **non-financial success** of service innovations.

***Hypothesis 5B (H5B)*:** The degree of **technical uncertainty reduction** during the FFE mediates the impact of **openness competence** within the FFE on the **non-financial success** of service innovations.

5.2.5 IT capability

Several important issues in the innovation process, such as process management, project management, knowledge management, and collaboration and communication, could be addressed by drawing from extant IS theories and models (Nambisan, 2003). IT can actively and directly support innovation activities because the effective use of IT can improve, for example, the efficiency of data analysis, communication and problem solving (Nambisan, 2003). In addition, ICTs, such as computers, the Internet, communication devices, etc., enable the exchange of distributed sources of information and support the shift towards more open and collaborative innovation practices (Dodgson et al., 2006).

Although the FFE seems to be the stage of innovation least suited to the use of IT, due to its fuzziness and unstructured nature (Gordon et al., 2008), there are however many areas of the FFE that could be enhanced by the adoption of particular IT systems. Cooperative work systems can help a team of innovators collaborate and communicate with one another. Such systems help innovation teams to work collaboratively with external partners, such as customers and suppliers (Gordon et al., 2008). Di Benedetto and colleagues (2008) empirically discovered that IT which facilitates cross-functional information flows is positively related to the number of radical innovations introduced by firms in the United States. This finding implicitly indicates that the use of IT to facilitate collaboration and communication may help innovation teams reduce development cycle time and increase productivity. Fiedler et al. (1996) reported that IT utilisation improves information processing and coordination activities in situations where uncertainty is high. In addition, the use of knowledge management and sharing systems can systematically reduce uncertainty in the early phase of innovation process (Kim & Wilemon, 2002). In the public sector, Kim and Lee (2006) also found a positive relationship between employees' usage of IT applications and their knowledge-sharing capabilities.

Some researchers have suggested that IT capability can only indirectly impact on a new product/service's success through the firm's innovation capability. Pavlou and El Sawy (2006) surveyed 180 NPD managers and discovered that the effective use of IT positively influences dynamic capabilities in NPD. Similarly, Ettlie and Pavlou (2006) empirically posited that superior IT support for the innovation process leads to a firm's superior ability to co-develop with its innovation partners (i.e., inter-firm NPD partnership dynamic capabilities). These two dynamic capabilities influence innovation success (Ettlie & Pavlou, 2006; Pavlou & El Sawy, 2006). In a similar vein, Tarafdar and Gordon (2007) suggested that six IS competencies – knowledge management, collaboration, project management, ambidexterity, IT/innovation governance, business-IS linkage – affect the conception, development and implementation phases of two service process innovation projects in a healthcare firm in the United States. More recently, Moos et al. (2013) discovered that the availability of knowledge management systems in a firm indirectly impacts the firm's innovation performance through its improved absorptive capacity. Specifically, the usage of knowledge management systems is associated with a firm's potential absorptive capacity, which in turn positively impacts the level of market and technical knowledge possessed by the innovating firm. Further, higher levels of market and technical knowledge lead to more successful innovations.

On the other hand, others propose direct contributions. Based on data collected from 174 Taiwanese IT firms, Chen and Tsou (2012) directly related a firm's IT capability to how often the firm is able to develop new process innovations. Di Benedetto et al. (2008) also found a positive relationship between the number of radical innovations and IT capability measured in terms of the possession of IT systems for NPD and cross-functional integration. In a similar way, the introduction of service delivery innovations has been found to be positively affected by the innovating firm's IT capability (Chen et al., 2009a). Finally, Froehle et al. (2000) surveyed service organisations in the United States and reported that the more sophisticated the IT systems used in NSD, the faster the speed of the NSD process and the more effective the firm's service innovation activities.

Although the analysis of the case study data identified IT capability as one of the key dimensions of openness competence, an additional review of the literature changed the author's view on the role of IT capability. There are two main reasons why we decided not to model IT capability as another dimension of openness competence. Firstly, as presented above, prior studies often viewed IT capability as a distinct capability. While some scholars have proposed the supportive role of IT capability (Ettlie & Pavlou, 2006; Pavlou & El Sawy, 2006), others have even suggested a more prominent impact of the ability to use IT on innovation performance (e.g., Chen et al., 2009a; Di Benedetto et al., 2008; Froehle et al., 2000). Secondly, we argue that the inclusion of IT capability would change the underlying meaning of the openness competence construct.

The current study defines *'IT capability'* as the extent to which a FFE team is aware of what generic IT tools have to offer and effectively utilises those tools to open up the front-end phase (adapted from Pavlou & El Sawy, 2006). Accordingly, it views IT capability as a support capability facilitating the FFE team's openness competence. This is consistent with the extant literature. Sambamurthy et al. (2003) theorised that a firm's IT competence indirectly affects the firm's innovative competitiveness through its ability to detect and seize opportunities for innovation. Prior studies on the use of IT in the FFE also posited that IT (e.g., ICTs, knowledge management or collaborative systems) should be used to help a FFE team open up its front-end process more efficiently and effectively (Dodgson et al., 2006; Gordon et al., 2008; Kim & Wilemon, 2002). Therefore, the final hypothesis is:

Hypothesis 6 (H6)**: IT capability** of the front-end team positively influences the team's **openness competence**.

In the next section, we describe the operationalisation of all key constructs incorporated in the research hypotheses and in the updated OSI model (Figure 5.1). Scales that were used to measure them are also provided.

5.3 Measurement

The key constructs of this study were operationalised following recommendations suggested by Peter (1979) and Jarvis et al. (2003). We first developed a conceptual model incorporating 11 research hypotheses (Figure 5.1) based on a compilation of our qualitative findings and an extensive review of the literature. After that, the domains of the constructs were specified; and a sample of items that could be used for measurement purposes were gathered. Whenever possible, the researcher relied on existing scales in prior works. For the openness competence construct in particular, we verified the appropriateness of the assumed direction of causality – i.e., whether the construct is formative or reflective – in accordance with the decision rules proposed by Jarvis et al. (2003, p. 203). The measurement items of all constructs can be found in Table 5.1 and Table 5.2.

5.3.1 Service innovation success

This study proposes that service innovation success should be measured regarding two main aspects; namely financial success and non-financial success. Items from Avlonitis et al.'s (2001) measurement scale on new service performance were employed. Respondents were asked about their perception of whether the new service achieves initial financial and non-financial success objectives, on a seven-point scale, anchored at 1 = "strongly disagree" to 7 = "strongly agree", with no N/A option. A total of 11 items were used to measure this construct, of which six of them concern financial success and the other five items measure non-financial elements of success.

5.3.2 Market uncertainty reduction

This construct was measured by scales from Lievens and Moenaert's (2000) measurement of innovative uncertainty. Five items were employed to assess the extent to which the FFE team possesses important information about competitors, customer's needs and the market. Measured on a seven-point scale, this semantic differential-type scale asked the respondents to evaluate how well they and other project members were informed about market information by the end of the FFE phase. The value 1 equalled "no knowledge existed for that subject", whereas the value 7 represented "we knew everything we had to know".

5.3.3 Technical uncertainty reduction

Similar to the previous construct, six measurement items from Lievens and Moenaert (2000) were used to measure how well the front-end team was informed about information on technology and available resources. This semantic differential-type scale had seven choices ranging from 1 which was anchored with "no knowledge existed for that subject" to 7 which meant "we knew everything we had to know".

5.3.4 Openness competence

The current study conceptualised openness competence (OPENNESS) as a reflective-formative type hierarchical component model (Hair et al., 2014) (see Figure 5.2). Therefore, Jarvis et al.'s (2003) four conceptual criteria were employed to determine whether a construct should be modelled as formative or reflective. The first criterion involves the direction of causality between the first-order constructs and the second-order construct. In order to identify core processes that constitute the nature of openness competence in the FFE of innovation, the researcher referred to the findings of the case study and the relevant literature. The four key dimensions of openness competence are searching capability (SEARCH), coordination capability (COOR), collective mind

(CMIND) and absorptive capacity (AB_CAP). We argue that openness competence is a composite of these four components, and changes in the components would lead to changes in the underlying meaning of the construct. We also believe that it would make more sense to hypothesise that if a front-end team possesses the four components, it is likely to have higher levels of openness competence, rather than saying that the team has the four components because it possesses openness competence.

The second criterion relates to the interchangeability of the first-order constructs. The four components are not interchangeable since they do not share a common theme. Each of the four capabilities represents distinct aspects of openness competence, thus dropping one of these components is likely to alter the conceptual domain of the second-order construct. Searching and coordination capabilities may be crucial for external knowledge searching and inter-organisation partnership during the FFE phase, respectively. Further, collective mind and absorptive capacity are posited as structural antecedents of the development team's ability to open up their front-end process efficiently and effectively.

Thirdly, according to Jarvis et al.'s (2003) criteria, questions about co-variation among the first-order constructs should be considered. We argue that the four components of openness competence do not necessarily co-vary with each other. To give an example, a front-end team may improve its coordination capability by putting in a lot of effort and resources, such as a new IT or a designated contact person, to facilitate seamless communication and collaboration with their partners. However, this does not necessarily mean that the team's ability to recognise the value of new, external information, and to assimilate and apply it (i.e., absorptive capacity) will be improved as well.

Finally, the fourth criterion concerns whether the lower-order components are expected to have the same antecedents and consequences or not. Although the four lower-order components may share similar antecedents and consequences, we would argue that this is not always the case. For example, investment in knowledge management systems may help improve the development team's absorptive capacity and searching capability. This, however, does not necessarily lead to improvements in the team's ability to coordinate and share a collective mind.

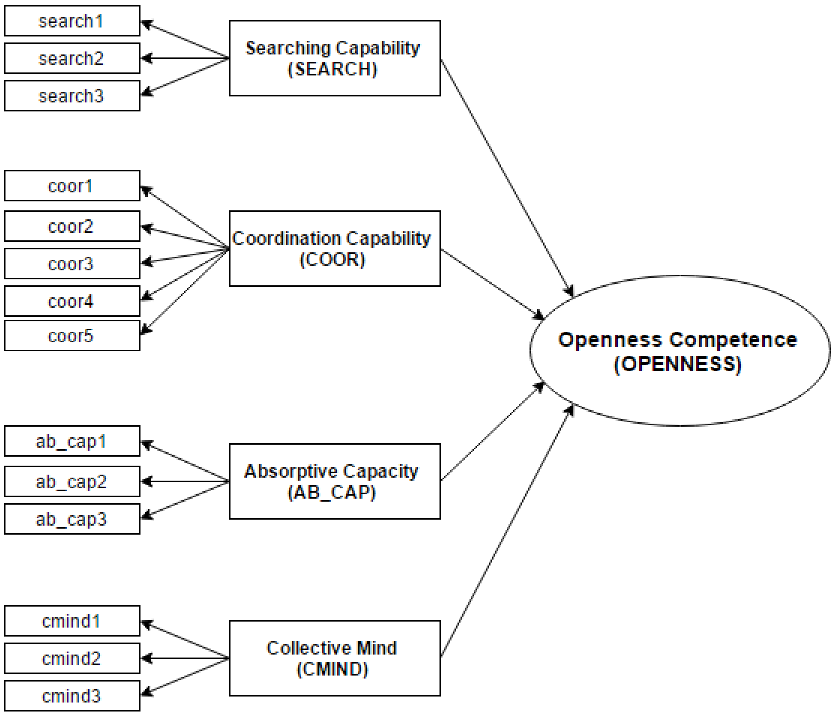

Figure 5.2: Conceptual representation of a hierarchical component model for openness competence

In terms of measurement, existing reflective-type scales were adopted for all four first-order constructs. For each of the four dimensions of openness competence, the selected items all shared common themes and were interchangeable, but not across the four first-order components. Every single item measuring the four dimensions was measured using a seven-point Likert scale with no N/A option. The options for all of the items were anchored from 1 equals "strongly disagree", to 7, labelled as "strongly agree".

The measure of searching capability was developed based on the organizational learning capability (OLC) measurement scales from Alegre and Chiva (2008). A three-item Likert scale measuring the "interaction with the external environment" dimension of the OLC was adopted. The respondents were asked about the extent to which the development team engaged in external knowledge searching during the FFE, and the sharing procedures or activities that took place during the FFE phase. Coordination capability was measured by a five-item Likert scale from Ettlie and Pavlou (2006). The items captured how well the front-end team members managed their knowledge, expertise and resources, synchronised tasks with, and allocated information, time, and resources to their innovation partners. The absorptive capacity dimension was captured with three items from Chen et al. (2009b). The questions focused on a development team's ability to effectively acquire and utilize external and internal knowledge that affects its ability to develop and commercialise new services. The final dimension, collective mind, was measured using three items from Ettlie and Pavlou (2006). The measurement scales were based on Weick and Roberts's (1993) theoretical description of collective mind consisting of three core elements, namely contribution, representation and subordination.

5.3.5 IT capability

The measurement scales for the IT capability construct focused on assessing the extent to which generic IT tools and functionalities were effectively used by the development team to facilitate external searches, communication, and collaborative working in the FFE phase. Specifically, how well they performed their tasks with the help of IT. However, it must be stressed that the scales focused only on the effectiveness of the use of the IT in the actual execution of specific openness activities, and not on the quality of the IT tools in general. IT capability was measured by five items from Menor and Roth (2007), on a seven-point Likert scale, anchored at 1 equals "strongly disagree", to 7, labelled as "strongly agree".

5.3.6 Control variables

To improve the internal validity of this study, several factors that the literature has been previously suggested to affect innovation success were included in this study. The first control variable is the *'years of experience'* of the respondent. Next, the *'experience of the project team'* was measured in terms of the front-end team members' average number of years of experience in IT development. The first two were included since it was suggested that decision-makers who have experience with the subject matter are more effective when making relatively unprogrammed decisions (Perkins & Rao, 1990). The next factor concerns *'innovativeness'* as prior studies have suggested that the development of innovations with different level of innovativeness requires different front-end approaches (Reid & De Brentani, 2004; Verworn, 2009; Verworn et al., 2008). Further, studies that do not concern the different degrees of newness of innovations may be biased (Menor et al., 2002). This variable was measured by two items from de Brentani (2001) on market and technological newness. Respondents were asked to rate the questions by using a seven-point Likert scale. The options ranged from 1 to 7, where 1 equals "strongly disagree" and 7 equals "strongly agree". Next, firms' ability to innovate is even more vital to success in a turbulent environment (Pavlou & El Sawy, 2006; Van Riel et al., 2004). The model thus includes *'competitive intensity'* which is measured in terms of the number of serious competitors as perceived by the respondent (Love et al., 2011). The final factor is *'firm size'*, which is often cited as being associated with innovation performance (Camisón-Zornoza et al., 2004; Damanpour, 1996). Firm size was measured in terms of the number of the innovating firm's employees. However, due to the high skewness value of the variable, we used a logarithm of the number of employees in PLS-SEM estimations.

The next section provides an in-depth description of the execution of the data collection and analysis of the second phase.

Table 5.1: Indicators measuring the key constructs and their description

Construct	*Indicator Description*
Openness Competence (OPENNESS)	2nd order construct, measured using repeated items of searching capability, coordination capability, collective mind and absorptive capacity.
Searching Capability (SEARCH)	**search1** - It was part of the work in the predevelopment phase to collect, bring back, and report information about what is going on outside the company. **search2** - There were systems and procedures for receiving, collating and sharing information from outside the company. **search3** - In the predevelopment phase, the team members were encouraged to interact with the environment: competitors, customers, technological institutes, universities, suppliers, etc.
Coordination Capability (COOR)	**In the predevelopment phase of this project, …** **coor1** - We ensured that the output of our work (knowledge, expertise, resources) is of a form useful to our partners. **coor2** - We ensured that the output of our work is available to our external partners when needed (at the right time). **coor3** - We ensured that the output of our work is synchronised with the work of our external partners. **coor4** - We ensured that the output of our work is available to our partners where it is needed (at the right place). **coor5** - We ensured an appropriate allocation of resources (e.g., information, time, reports) with our external partner.
Collective Mind (CMIND)	**In the predevelopment phase of this project, …** **cmind1** - Members from both inside and outside of the firm make their contributions to the joint outcome with attention and care. **cmind2** - Members from both inside and outside of the firm have a global perspective of each other's tasks and responsibilities. **cmind3** - Members from both inside and outside of the firm carefully interrelate actions to each other to maximize joint performance.
Absorptive Capacity (AB_CAP)	**In the predevelopment phase of this project, …** **ab_cap1** - We were able to apply new external knowledge commercially and invent new service product or process. **ab_cap2** - We were able to understand, analyse and interpret information from external sources. **ab_cap3** - We could successfully combine existing knowledge with the newly acquired and assimilated knowledge.

Table 5.2: Indicators measuring the key constructs and their description (Cont.)

Construct	***Indicator Description***
IT Capability (IT_CAP)	**IT_cap1** - IT was used to speed up the process of developing the new service concept. **IT_cap2** - IT was used to identify and diagnose customer needs in the predevelopment phase. **IT_cap3** - IT was used to share information that coordinates activities in the predevelopment phase. **IT_cap4** - Communication flow within the new service development project groups was facilitated through IT-based channels. **IT_cap5** - Our predevelopment team utilised technology to facilitate the flow of information to people participating in the new service development process.
Market Uncertainty Reduction (MKT_ UNCER_RED)	Shown below are some items concerning market information available during the predevelopment phase. Indicate for each item how well you and other project members were informed by the end of the predevelopment phase. **mkt_uncer1** - The customer's needs (user requirements) **mkt_uncer2** - The potential market **mkt_uncer3** - The buyer behaviour of the potential customer **mkt_uncer4** - The marketing strategy of the competition **mkt_uncer5** - The technological strategy of the competition
Technical Uncertainty Reduction (TECH_ UNCER_RED)	Shown below are some items concerning technical information available during the predevelopment phase. Indicate for each item how well you and other project members were informed by the end of the predevelopment phase. **tech_uncer1** - The quality of the applied technologies (e.g., information technologies) **tech_uncer2** - The user-friendliness of the technologies **tech_uncer3** - The cost-efficiency of the technologies **tech_uncer4** - The required R&D strategy for this project **tech_uncer5** - The required technological support for this project **tech_uncer6** - The required personnel for this project
Financial Success (FIN_SUC)	**fin_suc1** - The new service was profitable. **fin_suc2** - Total sales of the service were high. **fin_suc3** - The new service had a large market share. **fin_suc4** - The new service exceeded its profit objectives. **fin_suc5** - The new service exceeded its sales objectives. **fin_suc6** - The new service exceeded its market share objectives.

Non-financial Success (NONFIN_SUC)	**nonfin_suc1** - The new service had a positive impact on the company's perceived image. **nonfin_suc2** - The new service improved the loyalty of the company's existing customers. **nonfin_suc3** - The introduction of the new service enhanced the profitability of other company products. **nonfin_suc4** - The new service attracted a significant number of new customers to the company. **nonfin_suc5** - The new service gave to the company an important competitive advantage.

5.4 The Survey

5.4.1 Data collection

The main data collection method of the current phase is a large-scale survey of project managers in Thai IT service provider firms. The sampling frame of this study was a list of IT service providers from the Department of Business Development of Thailand's business data warehouse. The database was filtered by three criteria: (1) the firm's business description (i.e., the target businesses were "software package providers", "website design and networking services" and "software consultancies"), (2) the firm's assets are more than 2,000,000 Baht (~40,000 GBP) and (3) the firm's headquarters are in Bangkok. As a consequence, we obtained a list of 598 companies from the database. From this list, we randomly selected 200 firms as our samples. However, we were unable to reach 56 firms due to out-of-date contact information. HR managers of 144 firms were contacted by phone asking for their participation. A total of 83 firms agreed to take part in this study. The process of gaining access took approximately one month.

The target respondents of the survey are project managers who had recently participated in the FFE of an IT-based service innovation project. While data from different perspectives (e.g., executives, project managers and senior developers) would produce a richer picture of the FFE, collecting multiple responses from the same project would prove very challenging given the intention to test the model through quantitative analysis. Furthermore, in the interviews in the case study phase, we perceived that executives tended to focus mainly on the marketing side of the projects (e.g., marketing strategy, commercialisation, sales, etc.), while senior developers are likely to possess only information associated with the technical side of the project (e.g., technologies being employed, performance specifications, timelines, etc.). Projects managers, however, seemed to be in the middle of these two constituencies. Project managers know about both the market and technical sides of the projects and are thus, arguably, the most appropriate source of information regarding market and technical uncertainty reduction during the FFE. Moreover, concerning the two success measures, we observed that executives seemed to be concerned about the performance of a portfolio of projects, whereas developers focused on the performance of a particular phase of a project, while project managers seemed to possess knowledge about the outcomes at a project level.

The HR managers who were willing to participate were requested to act as a gatekeeper, being responsible for the distribution and collection of the questionnaires. The number of copies of the questionnaire that were sent ranged from 1 to 5 depending on the number of project managers the firm had. The number was suggested by the gatekeeper. A total of 294 paper questionnaires were delivered to 64 participating gatekeepers. The other 19 firms either asked for the link to the online version of the questionnaire or for an electronic copy of the questionnaire to be sent via email. Two weeks after the questionnaires were delivered, we contacted the gatekeepers in order to ask for the return of completed questionnaires, as well as to remind them about the importance of the study and their contributions. Two more reminder calls, one week apart, were made to those who had yet to return the questionnaires. The process started in May 2014 and ended in August 2014.

At the end of the data collection period, a total of 210 paper and 9 online responses were received – i.e., a 69.97% response rate (219 responses / (294 paper questionnaires + 19 emails) * 100). The responses were checked for their validity and completeness. The responses of those who had indicated that they participated in the FFE phase of their most recent service innovation project, and had provided a brief description of the project, were classified as usable. Based on these criteria, we excluded a total of 101 responses because the respondents had neither participated in the FFE, nor had provided a brief description of the project, resulting in a total of 128 usable responses. Some of the usable responses were further excluded because they seemed to have either suspicious response patterns or missing data (see Section 5.5.1 for more details). As a result, a total of 122 responses were considered valid – i.e., a 38.98% valid response rate (122 valid responses / (294 paper questionnaires + 19 emails) * 100). The valid response rate is relatively high in comparison to similar studies that focused on innovation at a project level (e.g., Verworn et al., 2008 (28% response rate); Van Riel et al., 2004 (16.7% response rate)). These response rates are considerably higher than other similar studies might be because (1) personal communication was established with the gatekeepers (HR managers); (2) the HR manager of each firm distributed the questionnaires to the respondents, not the researcher; and (3) the number of questionnaires to be sent was suggested by the gatekeepers.

5.4.2 Data analysis

The researcher performed data analysis procedures with the help of SmartPLS software version 3.1.3 (Ringle et al., 2014). The particular method employed was a second-generation multivariate technique – i.e., PLS-SEM. In comparison with CB-SEM, there are several considerations that make PLS-SEM more suitable for the data analysis of this study. Firstly, in situations where the prior theory is strong and the objective of the research is testing and confirmation, CB-SEM is the more appropriate approach due to a lack of global goodness-of-fit criteria of PLS-SEM. On the other hand, PLS-SEM is preferable than CB-SEM when the theory is less developed and the primary objective is theory development and prediction (Hair et al., 2014; Hair et al., 2011). This study's research context fits the latter situation. Although openness has been discussed in previous research on service innovation, limited research studies have investigated its role in the FFE phase and its impact on service innovation success through early uncertainty reduction. Further, to the best of our knowledge, the current study might be the first to conceptualise the front-end team's openness competence as a hierarchical components model.

Secondly, PLS-SEM can efficiently handle small sample sizes and complex structural models. The reason is that the PLS-SEM algorithm uses ordinary least squares (OLS) regressions to estimate the model's partial regression relationships, thus it does not compute all parts at the same time (Hair et al., 2014). To provide empirical evidence, Reinartz et al. (2009) recently conducted a simulation study and reported that PLS-SEM performed well with small sample sizes.

Thirdly, since the openness competence construct is hypothesised as a reflective-formative hierarchical component model, employing PLS-SEM is more appropriate. This is because PLS-SEM can easily handle both reflective and formative measurement models (Hair et al., 2014). Although formative measures can also be used with CB-SEM, relatively complex and limiting specification rules must be complied (Hair et al., 2011).

Finally, scholars have suggested that PLS-SEM's statistical properties provide very robust model estimations with data that have extremely non-normal distributions (Reinartz et al., 2009; Ringle et al., 2009). Following Hair et al.'s (2014, p. 54) recommendations, two measures of distributions were examined – skewness (measuring the extent to which a variable's distribution is symmetrical) and kurtosis (assessing whether the distribution is too peaked). We found that not all distributional properties of the variables in the current study follow a normal distribution. Thus, PLS-SEM is preferable to CB-SEM.

In the next section, the details of the data analysis processes and the PLS-SEM analysis results are provided.

5.5 Analysis Results

In this section, we describe the data analysis procedures and present the analysis results. The section begins with the data examination results. Then, the descriptive information of the respondents is presented. Prior to the PLS-SEM analysis, both non-respondent bias and correlation analyses were performed. The final two sub-sections describe the PLS estimation results of the measurement models and the structural model, respectively.

5.5.1 Data examination

Data examination is particularly important in research using SEM techniques (Hair et al., 2014). When questionnaires are used to collect data, there are several issues that must be addressed before further application of SEM is performed. Those issues are missing data and suspicious response patterns, outliers, and data distribution.

Missing Data and suspicious response patterns

Missing data are often a problem in research using survey strategy (Hair et al., 2014). A response with more than 15% of data missing or a high portion of missing data for a single construct, or both, should be deleted from the data file (Hair et al., 2014). Based on this guideline, the researcher examined the data set and removed two observations. Furthermore, with regard to the key constructs, there were a few missing data points (see Table 5.9 and Table 5.10). Following the suggestion by Hair et al. (2014,

p. 51), we used a "mean value replacement" option to handle missing values in the data in cases where there were less than 5% of values missing per indicator.

Reponses with suspicious response patterns should also be removed from the data set (Hair et al., 2014). Straight lining response patterns as well as inconsistency in answers were examined. For the latter, we checked the consistency of the answers to the two screening questions (Q1 and Q3 in the questionnaire - Appendix B). As a consequence, one of the responses was removed as it suffered from severe straight lining and three of the usable questionnaires were omitted due to the issues of inconsistency.

Outliers

Outliers are observations that have data values which are distinctively different from the majority of the observations (Hair, 2010). According to Hair (2010, p. 66-67), there are three main methods of detecting outliers. First, univariate detection involves examining the distribution of cases for each variable. Rules of thumb are that, for small samples (80 or fewer), outliers are those cases with standard scores of 2.5 or greater. For larger samples, the threshold value is 4 standard scores. The second method is bivariate detection. Such a method visually assesses pairs of variables (e.g., independent versus dependent variables) using scatterplots with confidence intervals at a specific alpha level (e.g., 0.1 or 0.05). Finally, multivariate detection evaluates each case across a set of variables. This method uses the Mahalanobis D^2 statistic that measures "each observation's distance in multidimensional space from the mean centre of all observations, providing a single value for each observation no matter how many variables are considered (Hair, 2010, p. 66)." Higher D^2 values represent the further distance of the cases in multidimensional space. As suggested by Hair (2010), a level of significance of 0.005 should be used for small samples, whereas, for large sample sizes, a level of significance of 0.001 should be used as the threshold value for designation of an outlier.

The multivariate method for detecting outliers was employed. The Mahalanobis D^2 values were calculated using SPSS Version 22.0 software (IBM, 2013). The results are presented in Appendix E. Several cases were identified as outliers for multiple construct. We further re-examined these observations using univariate detection in order to gain better understanding of their uniqueness. After the re-examination, we decided to retain all observations because none of the outlier cases demonstrated distinct differences on a sufficient number of variables to be considered unrepresentative of the population. Furthermore, according to Hair (2010), deletion of outliers could jeopardise the generalisability of the study, unless those outliers are clearly unusual and not representative of any segment of the population.

Data distribution

PLS-SEM is a non-parametric statistical method, thus being resilient to non-normal data distributions (Hair et al., 2014). Nevertheless, extremely non-normally distributed data inflate the standard errors estimated from the PLS bootstrapping procedure. As a consequence, this decreases the chance that some parts of the model will be found to be significant (Hair et al., 2014; Hair et al., 2011). Following Hair et al.'s (2014) recommendations, the researcher examined two measures of distribution – i.e., skewness and kurtosis describing the balance of the distribution, and the peakedness and flatness of the data distribution, respectively. Specifically, a positive value of skewness denotes a distribution that skews to the left, while a negative value represents a distribution that skews to the right. For kurtosis, a positive value reflects a peaked distribution, whereas a negative value indicates a flatter distribution. In addition, the closer the values of both measures are to zero, the closer the distribution of the data is to a normal distribution (Hair, 2010, p. 71) (p., 71).

The analysis results indicated that the data distributions of a number of variables deviate from normal (the values of skewness and kurtosis of all variables can be found in Appendix F). Therefore, it is appropriate to use PLS-SEM which relies on a non-parametric bootstrap procedure to test the significance of path coefficients (Hair et al., 2014).

5.5.2 Respondent characteristics

The majority of the respondents identified their current positions as project managers or department managers (38.5%), 30.3% of the respondents indicated themselves as either developers or senior developers, 15.7% indicated executive positions, and the rest (14.9%) could be categorised as "others". The mean value of years of experience of the respondents is 4.41 years. More than half of the respondents (63.9%) reported that they have been working in their current position for more than 3 years, whereas only 4.1% of the respondents have less than one year's experience. Furthermore, on average, almost half of the front-end teams had more than five years' experience (43%), while only 2.5% of the teams had less than one year's experience. The mean value of the average number of years of experience of the front-end team members is 7.92 years.

Regarding the newness of the service innovations, according to the typology proposed by Garcia and Calantone (2002), the majority of the new services were identified by the respondents as "radical" (46.7%) – i.e., they were new to market and adopted technology that was new to the firm. Further, 42 out of 122 projects (34.4%) were described as "really new" since they were either new to market or involved new technology, while the rest (18.9%) were suggested as more familiar to the customers and involving well-known technology or "incremental" innovations. The new service offerings have, on average, 3 serious competitors. However, since the missing rate is quite high (23.77%), we, consequently, decided to exclude this control variable from the analysis. The reason behind this high missing rate may be that the respondents were reluctant to disclose such sensitive information. Next, the majority of the service innovation projects included in the survey (59.8%) were developed in small-size firms. Further, 19.7% and 20.5% of the projects were introduced by medium-size and large-size companies, respectively. Finally, the average age of the participating firms is 13.06 years. The summary of the descriptive data is displayed in Table 5.3.

Table 5.3: The descriptive statistics of the demographic information of the responses

	Min	*Max*	*Mean*	*Median*	*Mode*	*SD*	*Valid N*	*Missing*
Years of experience of the respondents	0.20	25.00	4.41	3.00	3.00	3.92	122	0
Average number of years of experience of the front-end team members	0.33	36.00	7.92	3.20	3.00	9.70	121	1
Number of serious competitors	0	10	3	3	3	3	93	29
Number of employees	5	100000	1376	40	30	9157	122	0
Firm age	1.00	68.00	13.06	10.00	10.00	11.10	121	1

In terms of knowledge searching activities, the data suggest that the front-end team searched for knowledge and ideas from various sources (see Table 5.4). 54.1% of the respondents reported that, during the predevelopment phase, their team gathered knowledge and ideas from clients or customers to a high degree. The other important sources are: technical/trade press and computer databases on the Internet (53.3%), technical standards (43.4%), suppliers of equipment, materials, components, or software (31.1%), competitors (25.4%), and affiliates (16.5%). On the other hand, innovation-support organisations, such as academics, private and commercial research institutions, and government agencies were arguably not utilised as much as they could have been since more than 60% of the respondents indicated that they did not look for new ideas and knowledge from those sources during the FFE phase.

Table 5.4: External searching sources used by the front-end teams

External search sources	*None*	*Low*	*Medium*	*High*	*Mean*
Clients or customers	8 (6.6%)	13 (10.7%)	35 (28.7%)	66 (54.1%)	2.30
Suppliers of equipment, materials, components, or software	16 (13.1%)	27 (22.1%)	41 (33.6%)	38 (31.1%)	1.83
Affiliates – parent companies or subsidiaries	33 (27.3%)	34 (28.1%)	34 (28.1%)	20 (16.5%)	1.34
Competitors	26 (21.3%)	30 (24.6%)	35 (28.7%)	31 (25.4%)	1.58
Commercial laboratories/R&D enterprises	85 (70.2%)	27 (22.3%)	7 (5.8%)	2 (1.7%)	0.39
Universities or other higher education institutes	78 (64.5%)	24 (19.8%)	13 (10.7%)	6 (5.0%)	0.56
Private research institutes	93 (76.9%)	21 (17.4%)	7 (5.8%)	0 (0.0%)	0.29
Government research organisations	93 (76.9%)	18 (14.9%)	6 (5.0%)	4 (3.3%)	0.35
Other public sector, e.g., business links, government offices	82 (67.8%)	19 (15.7%)	15 (12.4%)	5 (4.1%)	0.53
Professional conferences, meetings	49 (40.5%)	26 (21.5%)	35 (28.9%)	11 (9.1%)	1.07
Academic conferences	66 (56.4%)	32 (27.4%)	19 (16.2%)	0 (0.0%)	0.60
Trade associations	78 (63.9%)	28 (23.0%)	14 (11.5%)	2 (1.6%)	0.51
Technical/trade press, computer databases on the Internet	11 (9.0%)	14 (11.5%)	32 (26.2%)	65 (53.3%)	2.24
Fairs, exhibitions	52 (42.6%)	40 (32.8%)	23 (18.9%)	7 (5.7%)	0.88
Technical standards	14 (11.5%)	12 (9.8%)	43 (35.2%)	53 (43.4%)	2.11

Table 5.5 shows the survey results concerning the importance of collaboration with external partners. In terms of innovation partnerships, almost half of the informants (45.1%) reported that customer involvement was highly important to the front-end of their project, and only 7.1% did not collaborate with their customers. Other important innovation partners are: suppliers and affiliates (who have an average value of importance at 1.58 and 1.20 respectively – i.e., the scales of importance range from 0 = none, 1 = low, 2 = medium and 3 = high). Interestingly, there is a similar trend of innovation-support

organisations, such as academics, private and commercial research institutions, venture capitals and government agencies being underutilised since around 70% of the respondents did not mention any collaboration with them during the predevelopment phase of their service innovation project.

Table 5.5: External innovation partners cooperated with the front-end team

External innovation partners	*None*	*Low*	*Medium*	*High*	*Mean*
Clients or customers	9 (7.4%)	20 (16.4%)	38 (31.1%)	55 (45.1%)	2.14
Suppliers of equipment, materials, components, or software	24 (19.7%)	27 (22.1%)	47 (38.5%)	24 (19.7%)	1.58
Affiliates – parent companies or subsidiaries	43 (35.2%)	30 (24.6%)	30 (24.6%)	19 (15.6%)	1.20
Competitors	68 (55.7%)	29 (23.8%)	15 (12.3%)	10 (8.2%)	0.73
Firms in other industries	70 (57.4%)	24 (19.7%)	24 (19.7%)	4 (3.3%)	0.69
Consultants	73 (59.8%)	18 (14.8%)	19 (15.6%)	12 (9.8%)	0.75
Venture capital enterprises	90 (73.8%)	15 (12.3%)	14 (11.5%)	3 (2.5%)	0.43
Commercial laboratories/R&D enterprises	92 (75.4%)	14 (11.5%)	12 (9.8%)	4 (3.3%)	0.41
Universities or other higher education institutes	88 (72.1%)	18 (14.8%)	11 (9%)	5 (4.1%)	0.45
Private research institutes	97 (79.5%)	14 (11.5%)	11 (9%)	0 (0%)	0.30
Government research organisations	101 (82.8%)	11 (9%)	6 (4.9%)	4 (3.3%)	0.29
Other public sector, e.g., business links, government offices	85 (69.7%)	18 (14.8%)	15 (12.3%)	4 (3.3%)	0.49
Trade associations	89 (73%)	18 (14.8%)	12 (9.8%)	3 (2.5%)	0.42
Intellectual property organisations	82 (67.2%)	15 (12.3%)	21 (17.2%)	4 (3.3%)	0.57

5.5.3 Evaluation of non-response bias

Prior to the data analysis, the 122 valid responses were tested for non-response bias. To clarify, non-response bias refers to "the mistake one expects to make in estimating a population characteristic based on a sample of survey data in which, due to non-response, certain types of survey respondents are under-represented" (Berg, 2005, p. 865). Simply put, non-response bias occurs in a situation where non-respondents have opinions that are systematically different from the opinions of those who respond to the survey. To check for non-response bias, we compared the responses of those who returned the questionnaire within two weeks of receiving it to those who returned the questionnaire later. The latter is representative of non-respondents. In this survey, there were 59 people who responded to the surveys early and 63 people responded later than two weeks after receiving the questionnaire.

The Mann-Whitney U test was performed to compare differences in the answers for each question between early and late respondents since the majority of the variables in this study have non-normally distributed data. Distributions of the scores of all of the questions for early and late respondents were similar, as assessed by a visual inspection of the population pyramid histograms. The Mann-Whitney U test results (Table 5.6) suggest only two questions with statistically significant differences (i.e., at the significance level of 0.05) between the median of the two groups of respondents out of 40 tested. Note that all of the 40 questions have options ranging from 1, labelled as "strongly disagree", to 7, labelled as "strongly agree". Therefore, it seems that there is no pattern of difference in the opinions of the two groups of respondents, and thus we conclude that non-response bias is not an issue.

Table 5.6: Mann-Whitney U test results of responses from early and late respondents

Variable	***Mann-Whitney U***	***z-score***	***p-value***	***Median (Early)***	***Median (Late)***
search3 - In the predevelopment phase, the team members were encouraged to interact with the environment: competitors, customers, technological institutes, universities, suppliers, etc.	1427.50	-2.272	0.023*	6	5
nonfin_suc1 - The new service had a positive impact on the company's perceived image.	2308.00	2.241	0.015*	6	6

* The median difference is significant at the level of 0.05 (2-tailed)

5.5.4 A preliminary analysis of correlation

To check whether the constructs are independent and fit for further examination, a correlation matrix was generated (Table 5.7). Cohen (1988, p. 79-81) provided guidelines on the interpretation of correlation strength, i.e., values of 0.1 to 0.29 represent small strength; 0.30 to 0.49 reflect medium strength; and large strength values are between 0.50 and 1.00. Regarding the endogenous variables, the results of the correlation analysis show strong relationships between the four first-order constructs and openness competence. Furthermore, the strength of the correlation between market uncertainty reduction and technical uncertainty reduction is also high. Other relationships are small and medium with values ranging from 0.118 to 0.482. In terms of exogenous variables, according to Pallant (2010), a pair of independent variables with a bivariate correlation value of more than 0.7 or more should be concerned. In this case, the researcher may have to either exclude one of the constructs or form a composite variable from the two highly correlated variables. As displayed in Table 5.7, the correlation values of the relationships between the exogenous constructs range from 0.324 to 0.521, thus leading us to retain all independent variables.

The current study employed PLS-SEM as the main data analysis technique. In order to test the proposed research model and hypotheses, path coefficients and their significance values were estimated using SmartPLS software version 3.1.6 (Ringle et al., 2014). The PLS-SEM analysis results of both the measurement model and the structural model are presented in the next two sub-sections, respectively.

Table 5.7: Correlations between constructs

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
SEARCH (1)	1													
COOR (2)	0.429	1												
CMIND (3)	0.324	0.44	1											
AB_CAP (4)	0.493	0.42	0.442	1										
OPENNESS (5)	0.673	0.866	0.699	0.722	1									
IT_CAP (6)	0.463	0.385	0.521	0.445	0.573	1								
MKT_UNCER _RED (7)	0.329	0.324	0.118	0.311	0.365	0.208	1							
TECH_UNCER _RED (8)	0.242	0.297	0.243	0.223	0.344	0.326	0.542	1						
FIN_SUC (9)	0.303	0.431	0.31	0.264	0.458	0.32	0.442	0.349	1					
NONFIN _SUC (10)	0.364	0.387	0.302	0.302	0.456	0.394	0.404	0.346	0.482	1				
EXP (11)	0.142	0.138	0.043	-0.079	0.097	-0.041	0.018	0.013	0.085	0.103	1			
TEAM (12)	-0.098	-0.154	0.032	-0.046	-0.109	-0.005	-0.219	-0.159	-0.144	-0.151	0.041	1		
NEW (13)	0.179	0.177	0.185	0.046	0.2	0.074	0.234	0.187	0.273	0.339	0.055	-0.157	1	
SIZE (14)	-0.233	-0.201	-0.058	-0.119	-0.208	-0.038	0.09	-0.037	-0.125	0.08	0.082	0.019	-0.159	1

5.5.5 Evaluation of the measurement models

The first step of model evaluation involves an assessment of the measurement model (Figure 5.3). In order to assess the validity and reliability of the reflective measures employed in this study, we followed Hair et al.'s (2014) recommendations by assessing internal consistency reliability, convergent validity, and discriminant validity.

The statistics that the researcher checked in order to assess the quality of the reflective models are displayed in Table 5.8, Table 5.9, and Table 5.10. For the first criterion, composite reliability and Cronbach's alpha were checked. As shown in Table 5.9 and Table 5.10, for all constructs, Cronbach's alpha and composite reliability values are above the required threshold of 0.7 (Hair et al., 2014; Hair et al., 2011).

Regarding convergent validity, the researcher assessed the outer loadings of the indicators as well as the average variance extracted (AVE). Almost all indicators of the reflective constructs have outer loadings greater than the acceptable level of 0.7. For the first order loadings, the few exceptions are the indicators search1, it_cap1, it_cap2, mkt_uncer1, tech_uncer5 and tech_uncer6 (Table 5.9 and Table 5.10). However, as recommended by Hair et al. (2014), rather than automatically remove any items with outer loadings lower than the threshold of 0.7, a careful examination of the effects of the removal on the composite reliability, as well as the construct's content validity should be conducted. The researcher decided not to remove any indicators because the removal of these indicators did not result in a substantial increase in the composite reliability values of the constructs. Also, removing indicators might diminish a construct's content validity. Further, the AVE of all constructs, apart from openness competence, are well above the recommended value of 0.5. An AVE value of 0.5 or over indicates that, on average, the construct explains more than 50% of the variance of its indicators (Hair et al., 2014, p. 103). The only convergent validity criterion that is not met is the AVE of openness competence. The AVE value is 0.426, which suggests that the higher-order index may be problematic. However, given the exploratory nature of this study, the acceptable Cronbach's alpha, and composite reliability, the researcher retained all repeated indicators of the construct.

Table 5.8: Fornell-Larcker Criterion

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
SEARCH (1)	0.796									
COOR (2)	0.429	0.852								
CMIND (3)	0.324	0.44	0.907							
AB_CAP (4)	0.493	0.42	0.442	0.873						
OPENNESS (5)	0.673	0.866	0.699	0.722	0.653					
IT_CAP (6)	0.463	0.385	0.521	0.445	0.573	0.742				
MKT_UNCER_RED (7)	0.33	0.324	0.118	0.311	0.365	0.208	0.81			
TECH_UNCER_RED (8)	0.242	0.297	0.244	0.223	0.344	0.327	0.542	0.746		
FIN_SUC (9)	0.303	0.432	0.31	0.266	0.459	0.321	0.442	0.348	0.867	
NONFIN_SUC (10)	0.365	0.391	0.305	0.306	0.46	0.396	0.402	0.345	0.48	0.794

Finally, discriminant validity was evaluated by two criteria, namely, the cross loadings of the indicators and the Fornell-Larcker criterion. The cross loading table can be found in Appendix G. Regarding the Fornell-Larcker criterion, since the square root of each construct's AVE is greater than its highest correlation with the other constructs, the discriminant validity of the measurement models is satisfactory (Table 5.8). Note that the square root of the openness competence construct's AVE is lower than searching capability, coordination capability, collective mind, and absorptive capacity. These results were expected because they are the first order constructs that form the openness competence construct.

Table 5.9: Quality criteria of reflective measurements

Construct	*Indicators*	*Mean*	*SD*	*Loadings*	*Missing*
Openness Competence AVE = 0.426 CR = 0.910 α = 0.893	2nd order construct, repeated items measuring SEARCH, COOR, AB_CAP, and CMIND were employed.				
Searching Capability (SEARCH) AVE = 0.633 CR = 0.837 α = 0.714	**search1**	5.84	1.28	0.695	-
	search2	5.16	1.42	0.860	-
	search3	5.29	1.49	0.823	-
Coordination Capability (COOR) AVE = 0.726 CR = 0.930 α = 0.905	**coor1**	5.31	1.37	0.795	1
	coor2	5.16	1.55	0.838	-
	coor3	5.25	1.47	0.905	-
	coor4	5.11	1.53	0.873	-
	coor5	5.14	1.48	0.846	-
Collective Mind (CMIND) AVE = 0.823 CR = 0.933 α = 0.893	**cmind1**	5.47	1.23	0.867	-
	cmind2	5.57	1.18	0.928	-
	cmind3	5.63	1.22	0.926	-
Absorptive Capacity (AB_CAP) AVE = 0.763 CR = 0.906 α = 0.845	**ab_cap1**	5.88	1.09	0.84	-
	ab_cap2	5.57	1.05	0.905	-
	ab_cap3	5.84	1.01	0.874	-
IT Capability (IT_CAP) AVE = 0.550 CR = 0.857 α = 0.794	**it_cap1**	6.14	1.19	0.571	-
	it_cap2	5.56	1.39	0.692	-
	it_cap3	6.09	1.06	0.798	1
	it_cap4	6.02	.99	0.784	-
	it_cap5	5.90	1.07	0.834	-

Table 5.10: Quality criteria of reflective measurements (Cont.)

Construct	*Indicators*	*Mean*	*SD*	*Loadings*	*Missing*
Market uncertainty reduction (MKT_UNCER_RED) AVE = 0.656 CR = 0.904 α = 0.867	**mkt_uncer1**	5.56	1.35	0.671	-
	mkt_uncer2	4.98	1.40	0.85	-
	mkt_uncer3	5.01	1.57	0.83	-
	mkt_uncer4	4.34	1.72	0.86	-
	mkt_uncer5	4.55	1.74	0.824	1
Technical uncertainty reduction (TECH_UNCER_RED) AVE = 0.556 CR = 0.882 α = 0.839	**tech_uncer1**	5.79	.99	0.789	
	tech_uncer2	5.71	1.07	0.792	-
	tech_uncer3	5.46	1.24	0.79	-
	tech_uncer4	5.48	1.25	0.782	-
	tech_uncer5	4.50	1.53	0.621	-
	tech_uncer6	5.52	1.27	0.684	-
Financial success (FIN_SUC) AVE = 0.752 CR = 0.948 α = 0.934	**fin_suc1**	4.93	1.43	0.846	-
	fin_suc2	4.60	1.34	0.904	-
	fin_suc3	4.46	1.38	0.862	1
	fin_suc4	4.25	1.34	0.858	-
	fin_suc5	4.25	1.41	0.891	-
	fin_suc6	4.35	1.37	0.839	1
Non-financial success (NONFIN_SUC) AVE = 0.631 CR = 0.895 α = 0.853	**nonfin_suc1**	5.80	1.21	0.837	-
	nonfin_suc2	5.48	1.34	0.828	-
	nonfin_suc3	5.23	1.49	0.732	-
	nonfin_suc4	5.19	1.30	0.79	-
	nonfin_suc5	5.39	1.15	0.779	-

As this study employed the sequential latent variable score method, or the two-stage approach (Ringle et al., 2012; Wetzels et al., 2009), a repeated indicator approach was used in the first-stage (Figure 5.3) and the latent variable scores of the first-order constructs were then used as indicators for the higher-order construct in the models tested in a separate second-stage (Figure 5.4). To evaluate the formative higher-order construct – i.e., openness competence, the researcher checked for multicollinearity using the variance-inflation factor (VIF) as well as the significance of the formative indicators' outer weight (Hair et al., 2014). The results are displayed in Table 5.11. The VIF values are well below the cut-off value of 5, thus there are no concerns about collinearity issues (Hair et al., 2011).

Regarding the significance of the outer weights, the bootstrapping procedure (with 5,000 bootstrap samples and 122 bootstrap cases and using the no sign changes option – these settings were used in all of the subsequent bootstrapping estimations) suggests that the outer weights of three indicators – i.e., searching capability, coordination capability, and collective mind – are statistically significant. Even though, the outer weight of absorptive capacity is not significant, its outer loading is well over the acceptable level of 0.5; and its t value is 7.735 indicating a significance at $p < 0.001$. Moreover, the findings of the case study, as well as the open innovation literature (Chesbrough, 2003; Chesbrough et al., 2006) provide support for absorptive capacity as an important element of openness. Thus, following Hair and colleagues' (2014) guidelines, we decided to retain absorptive capacity (AB_CAP) as a formative indicator of openness competence even though its outer weight is not significant.

Table 5.11: Quality criteria of formative measurements

Formative Construct	***Formative Indicators***	***Outer Weights (Outer Loadings)***	***T Statistics***	***VIF***
OPENNESS	SEARCH	0.394** (0.772)	2.644	1.438
	COOR	0.423** (0.809)	2.942	1.439
	CMIND	0.301* (0.704)	1.773	1.381
	AB_CAP	0.200 (0.705)	1.381	1.537

* The path coefficient is significant at the level of 0.1 (2-tailed)
** The path coefficient is significant at the level of 0.01 (2-tailed)

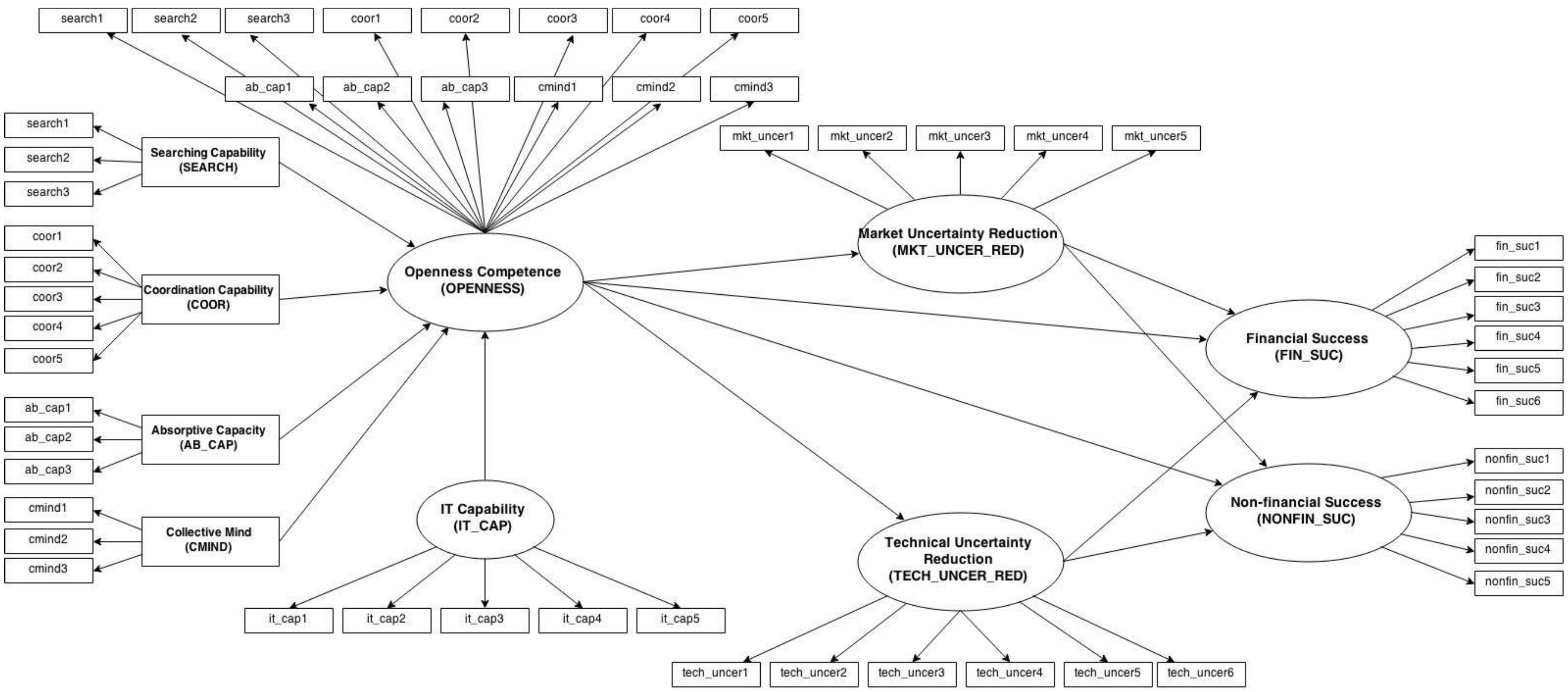

Figure 5.3: The first stage of the measurement model evaluation

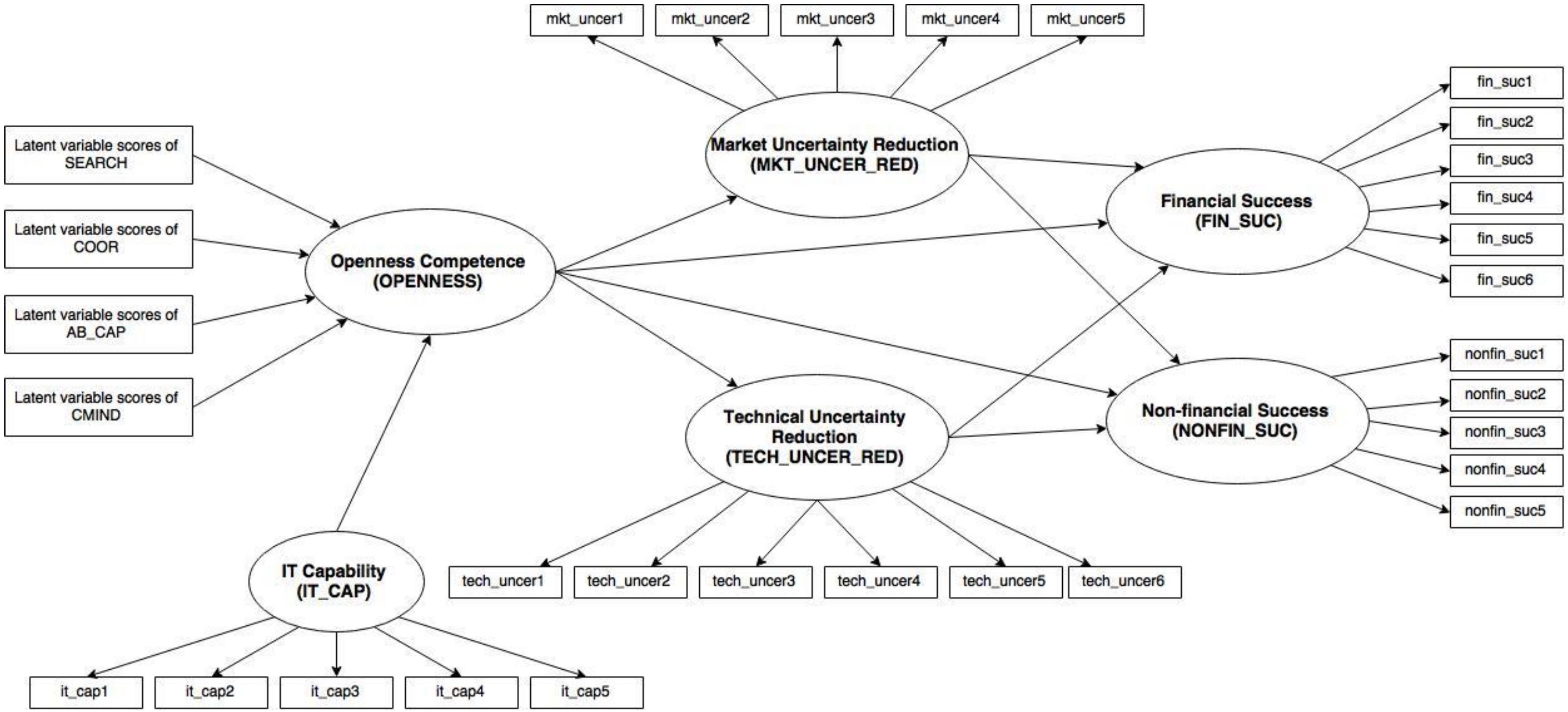

Figure 5.4: The second stage of the measurement model evaluation

5.5.6 Evaluation of the structural model

Once the reliability and validity of the measurement models have been confirmed, the next step of the analysis is an evaluation of the structural model. We first analysed the mediation effects of market and technical uncertainty reduction on the relationship between openness competence and service innovation success. This step aims to test 4 hypotheses (i.e., H4A, H4B, H5A, and H5B) that concern the mediating roles of the market and technical uncertainty constructs. Then, we evaluated the OSI model (Figure 5.1). The researcher followed a systemic approach suggested by Hair et al. (2014) for assessing PLS-SEM structural model's predictive capabilities. The PLS analysis of the OSI model addresses the other research hypotheses (i.e., H1A, H1B, H2A, H2B, H3A, H3B, and H6).

The mediation effects of front-end uncertainty

Since this study is framed by the information processing theory, both market and technical uncertainty reduction during the FFE phase were hypothesised to mediate the effects of openness competence within the FFE on the financial and non-financial success of service innovation projects (H4A, H4B, H5A and H5B). The mediating effects of market and technical uncertainty reduction were analysed individually using an analysis procedure suggested by Preacher and Hayes (2008).

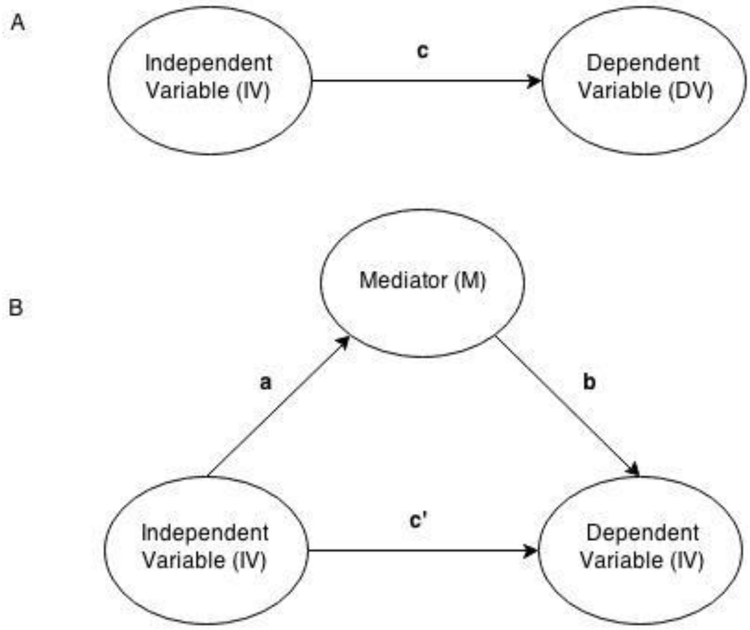

Figure 5.5: (A) Illustration of a direct effect - IV on DV. (B) Illustration of a mediating effect - IV is hypothesised to indirectly impact DV through M (adopted from Preacher and Hayes (2008)).

The process has two main steps (see Figure 5.5). The first step involves carrying out the bootstrapping procedure for significance testing of the structural model without including the mediator (Figure 5.5A). This step aims to identify whether there is a significant direct relationship between the independent variable (IV) and the dependent variable (DV), thus obtaining the total effect of IV on DV – i.e., path c in Figure 5.5A. In the second step, the mediator is introduced to the model (Figure 5.5B). This step calculates the indirect effect (path c’), the effect of IV on M (path a) and the effect of M on DV (path b). According to Preacher and Hayes (2008, p. 880), the total effect of IV on DV can be expressed as the sum of the direct and indirect effects: c = c’ + ab.

Figure 5.6: (A) Model I – for testing the direct effects of openness; (B) Model II-A – for testing the mediation effect of market uncertainty reduction; (C) Model II-B – for testing the mediation effect of technical uncertainty reduction

We analysed the mediating effects of market and technical uncertainty reduction individually. The first step analysed Model I (Figure 5.6A), while the second step addressed two slightly different models (Figure 5.6B and Figure 5.6C).

With market uncertainty reduction as the mediator (H4A and H5A), the bootstrap estimations of the Model II-A (Figure 5.6B) are presented in Table 5.12 and Table 5.13.

In addition, the researcher also calculated the variance accounted for (VAF) in order to determine "the extent to which the variance of the dependent variable is directly explained by the independent variable and how much of the target construct's variance is explained by the indirect relationship via the mediator variable": VAF = ab/(ab + c') (Hair et al., 2014, p. 225). The VAF value of the relationship between openness competence and financial success through market uncertainty reduction is 0.285 (i.e., 0.113 / (0.113 + 0.284)). This suggests a partial mediation of market uncertainty reduction on the impact of openness on financial success of the service innovations (Hair et al., 2014), therefore H4A is supported. In contrast, market uncertainty reduction mediates only 15.7% of the impact of openness competence on non-financial success (VAF = 0.157 – i.e., 0.069 / (0.069 + 0.370)). The mediating effect of market uncertainty reduction has not been found since the VAF value is less than 20% (Hair et al., 2014), thus rejecting H5A.

Table 5.12: Bootstrapping results of the mediation model – IV is openness competence and DV is financial success through market uncertainty reduction (M)

	Coefficients	***t-values***	***p-values***	***Significance Level***
Total effect (c) of OPENNESS on FIN_SUC	0.396	4.430	0.000	***
Direct effect (c') of OPENNESS on FIN_SUC	0.284	3.218	0.001	**
Indirect effect (ab) of OPENNESS on FIN_SUC through MKT_UNCER_RED	0.113	2.749	0.006	**
Effect of OPENNESS on MKT_UNCER_RED (a)	0.364	3.737	0.000	***
Effect of MKT_UNCER_RED on FIN_SUC (b)	0.311	4.047	0.000	***

** The path coefficient is significant at the level of 0.01 (2-tailed)
*** The path coefficient is significant at the level of 0.001 (2-tailed)

Table 5.13: Bootstrapping results of the mediation model – IV is openness competence and DV is non-financial success through market uncertainty reduction (M)

	Coefficients	***t-values***	***p-values***	***Significance Level***
Total effect (c) of OPENNESS on NONFIN_SUC	0.439	5.768	0.000	***

Direct effect (c') of OPENNESS on NONFIN_SUC	0.370	4.284	0.000	***
Indirect effect (ab) of OPENNESS on NONFIN_SUC through MKT_UNCER_RED	0.069	1.594	0.111	NS
Effect of OPENNESS on MKT_UNCER_RED (a)	0.364	3.737	0.000	***
Effect of MKT_UNCER_RED on NONFIN_SUC (b)	0.189	1.968	0.049	*

* The path coefficient is significant at the level of 0.05 (2-tailed)
*** The path coefficient is significant at the level of 0.001 (2-tailed)
NS The path coefficient is not significant

With regard to technical uncertainty reduction (H4B and H5B), the same analysis procedure was applied to Model II-B (Figure 5.6C). The bootstrapping results are displayed in Table 5.14 and Table 5.15. For openness competence and financial success, technical uncertainty reduction mediates only 16.9% of the relationship (VAF = 0.169 – i.e., 0.067 / (0.067 + 0.330)). Since it is less than the cut-off of 20%, the mediation effect is negligible (Hair et al., 2014). Furthermore, both the indirect path of openness competence to non-financial success and the direct path between technical uncertainty reduction and non-financial success are insignificant suggesting no mediation. As a result, both H4B and H5B are rejected.

Table 5.14: Bootstrapping results of the mediation model – IV is openness competence and DV is financial success through technical uncertainty reduction (M)

	Coefficients	***t-values***	***p-values***	***Significance Level***
Total effect (c) of OPENNESS on FIN_SUC	0.397	4.327	0.000	***
Direct effect (c') of OPENNESS on FIN_SUC	0.330	3.407	0.001	**
Indirect effect (ab) of OPENNESS on FIN_SUC	0.067	2.072	0.038	*
Effect of OPENNESS on TECH_UNCER_RED (a)	0.338	4.697	0.000	***
Effect of TECH_UNCER_RED on FIN_SUC (b)	0.199	2.538	0.011	*

* The path coefficient is significant at the level of 0.05 (2-tailed)
** The path coefficient is significant at the level of 0.01 (2-tailed)
*** The path coefficient is significant at the level of 0.001 (2-tailed)

Table 5.15: Bootstrapping results of the mediator model – IV is openness competence and DV is non-financial success through technical uncertainty reduction (M)

	Coefficients	*t-values*	*p-values*	*Significance Level*
Total effect (c) of OPENNESS on NONFIN_SUC	0.439	5.778	0.000	***
Direct effect (c') of OPENNESS on NONFIN_SUC	0.380	4.204	0.000	***
Indirect effect (ab) of OPENNESS on NONFIN_SUC	0.059	1.463	0.143	NS
Effect of OPENNESS on TECH_UNCER_RED (a)	0.338	4.697	0.000	***
Effect of TECH_UNCER_RED on NONFIN_SUC (b)	0.173	1.825	0.068	NS

*** The path coefficient is significant at the level of 0.001 (2-tailed)
NS The path coefficient is not significant

To assess the research model in Figure 5.1, the researcher followed a systemic approach suggested by Hair et al. (2014). The approach included five key criteria for assessing PLS-SEM structural model's predictive capabilities. The first criterion concerns a collinearity assessment of the predictive constructs. Secondly, the structural model's path coefficients must be examined for significance and relevance. The third criterion concerns the coefficient of determination (R^2). Fourthly, the f^2 effect sizes should also be evaluated. The final measure involved examining the predictive relevance (Q^2) and the q^2 effect sizes. Based on these criteria, the results of the evaluation are presented below.

Criterion 1: Collinearity Assessment

To assess collinearity, each set of predictors in the structural model was examined. As shown in Table 5.16, the VIF values of all predictor constructs were higher than 0.2 and lower than 5.0 (Hair et al., 2014). The first column contains the IT capability construct, which is a predictor of openness competence. The second set includes the predictor of market and technical uncertainty reduction constructs. The final set of variables involves three independent variables and four control variables that are the predictors of financial and non-financial success constructs. The results indicate no concern over collinearity issues.

Table 5.16: Collinearity assessment

First Set		*Second Set*		*Third Set*	
Constructs	***VIF***	***Constructs***	***VIF***	***Constructs***	***VIF***
IT_CAP	1.000	OPENNESS	1.000	OPENNESS	1.310
				MKT_UNCER_RED	1.618
				TECH_UNCER_RED	1.469
				EXP	1.034
				TEAM	1.068
				NEW	1.124
				SIZE	1.136

Criterion 2: Structural model path coefficients

To obtain estimates of the structural model relationships, the researcher ran the PLS-SEM algorithm using SmartPLS software version 3.1.6 (Ringle et al., 2014) with a path weighting scheme, initial outer weights of +1, maximum iterations of 300, and a stop criterion of 10^{-7}. A summary of the resultant path coefficients is displayed in Figure 5.7.

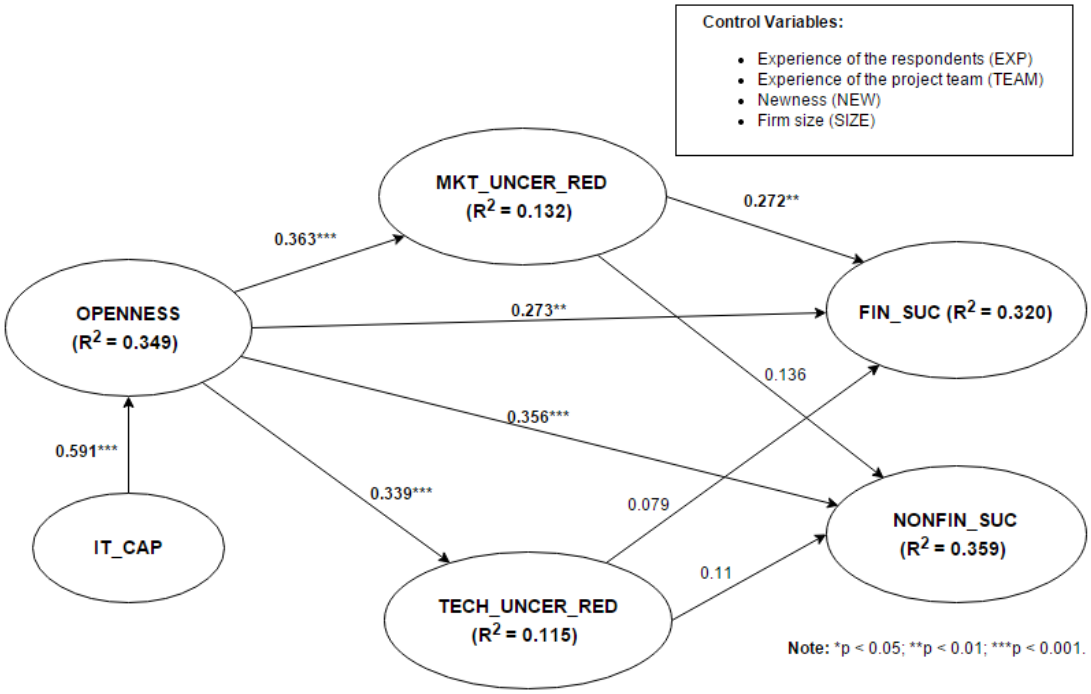

Figure 5.7: PLS-SEM algorithm results

Path coefficients represent hypothesised relationships among the constructs (Hair et al., 2014). Estimated path coefficients that are close to +1 and -1 represent strong positive and negative relationships between the constructs, respectively, and the closer a coefficient is to 0, the weaker the relationship. A bootstrapping procedure was performed in order to obtain the empirical *t* value. When the empirical *t* value is larger than the critical value, it can be said that the path coefficient is significant at a certain significance level (Hair et al., 2014). The critical values that are commonly used for two-tailed tests are: 1.96 (significance level of 0.05), 2.57 (significance level of 0.01), and 3.29 (significance level of 0.001). Table 5.17 shows the path coefficients calculated by PLS-SEM procedures and their significance, which are discussed below.

With respect to H1A, H1B, H2A and H2B, we considered the impacts of market and technical uncertainty on service innovation success measures. The results provide support for H1A, while failing to reject the null hypotheses of the others (see Model II in Table 5.17). Whereas the degree of market uncertainty reduction during the FFE positively impacts on financial aspects of service innovation success ($\beta = 0.272$, $p < 0.01$), reducing technical uncertainty does not. Surprisingly, both market and technical uncertainty reduction does not influence innovation with regard to the non-financial aspect of success. Furthermore, as anticipated, the path coefficients suggest positive impacts of openness competence on market and technical uncertainty reduction during the FFE with $\beta = 0.363$, $p < 0.001$, and $\beta = 0.339$, $p < 0.001$, respectively. Therefore, H3A and H3B are accepted. IT capability has also been found to have a strong and positive effect on openness competence, thereby supporting H6.

Table 5.17: The summary of PLS-SEM estimation results

	Financial Success (FIN_SUC)			*Non-Financial Success (NON_FIN_SUC)*		
	Control variables	**Model I**	**Model II**	**Control variables**	**Model I**	**Model II**
R^2	0.107	0.238	0.320	0.158	0.318	0.359
Change in R^2		0.131	0.082		0.160	0.041
Control variables						
Experience of the respondents (EXP)	0.084	0.037	0.048	0.085	0.022	0.033
Experience of the team members (TEAM)	-0.116	-0.084	-0.026	-0.078	-0.076	-0.035
Newness (NEW)	0.246*	0.170	0.119	0.353**	0.263*	0.233
Firm size (SIZE)	-0.092	-0.018	-0.071	0.126	0.210**	0.185**
Variables of interests						
Openness competence (OPENNESS)		0.391***	0.273**		0.434***	0.356***
Market uncertainty reduction (MKT_UNCER_RED)			0.272**			0.136
Technical uncertainty reduction (TECH_UNCER_RED)			0.079			0.110

	Market Uncertainty Reduction (MKT_UNCER_RED)		*Technical Uncertainty Reduction (TECH_UNCER_RED)*	
	Model I	**Model II**	**Model I**	**Model II**
R^2		0.132		0.115
Openness competence (OPENNESS)		0.363***		0.339***

	Openness Competence (OPENNESS)	
	Model I	**Model II**
R^2	0.364	0.349
Change in R^2		-0.015
IT capability (IT_CAP)	0.604***	0.591***

* The path coefficient is significant at the level of 0.05 (2-tailed)
** The path coefficient is significant at the level of 0.01 (2-tailed)
*** The path coefficient is significant at the level of 0.001 (2-tailed)

Criterion 3: Coefficient of determination (R^2 value)

The coefficient of determination assesses the model's predictive capabilities. It represents the exogenous latent variables' combined effects on the endogenous latent variable (Hair et al., 2014, p. 174). The R^2 value ranges from 0 to 1. The closer the R^2 value is to 1, the higher the levels of predictive accuracy. The R^2 values of openness competence, financial success and non-financial success, are moderate (0.349, 0.320 and 0.359, respectively). The model explains 32.0% of the variance in financial success and 35.9% of the variance in non-financial success of the service innovation projects. The R^2 values of all endogenous constructs in the model are displayed in Table 5.18.

Criterion 4: The f^2 effect sizes

The effect size f^2 allows the researcher to assess to what extent an exogenous construct contributes to the R^2 value of an endogenous latent variable. More specifically, the f^2 effect size measures the change in the R^2 value when a specified exogenous construct is removed from the model in order to evaluate whether the omitted construct has a substantive impact on the endogenous constructs (Hair et al., 2014, p. 177). The values of 0.02, 0.15 and 0.35 represent small, medium, and large effects, respectively (Hair et al., 2014). The resultant effect size f^2 values are displayed in Table 5.19. Contrary to our expectation, the technical uncertainty reduction construct has no effect on either the financial success or the non-financial success of service innovation projects. In addition, early reduction of market uncertainty does not contribute to the R^2 value of the non-financial success construct. These provide additional support for the rejection of H1B, H2A and H2B mentioned earlier.

Table 5.18: R^2 and Q^2 values of the endogenous latent variables

Endogenous Latent Variables	*R^2 Value*	*Q^2 Value*
OPENNESS	0.349	N/A
MKT_UNCER_RED	0.132	0.083
TECH_UNCER_RED	0.115	0.051
FIN_SUC	0.320	0.223
NONFIN_SUC	0.359	0.204

Criterion 5: The predictive relevance (Q^2 value) and the q^2 effect sizes

The Q^2 value is a measure of the model's predictive relevance. More specifically, the predictive relevance of a PLS-SEM model reflects the model's ability to predict the data points of indicators in reflective measurement models of endogenous constructs and endogenous single-item constructs (the procedure does not apply to formative endogenous constructs) (Hair et al., 2014, p. 178). Q^2 values larger than 0 indicate that the model has predictive relevance for the endogenous construct under consideration. On the contrary, Q^2 values of 0 or lower indicate that the model lacks predictive relevance (Hair et al., 2014). To obtain the Q^2 values, the blindfolding procedure was conducted with an omission distance of 7. The Q^2 values of the two dependent variables are considerably above zero, thus providing support for the model's predictive relevance (Hair et al., 2014). The results are displayed in Table 5.18. Furthermore, similar to how the f^2 effect size assesses the contribution of an exogenous construct to the R^2 value of an endogenous construct, the relative impact of predictive relevance can be compared by using the values of the q^2 effect size (Hair et al., 2014). The effect size q^2 values are displayed in Table 5.19. For general guidelines, q^2 values of 0.02, 0.15, and 0.35 indicate that an exogenous construct has a small, medium, or large predictive relevance for a certain endogenous construct (Hair et al., 2014). Consistent with the f^2 effect size, the q^2 values find no predictive relevance of early technical uncertainty reduction on the two performance measurements, and of market uncertainty reduction on the non-financial success construct.

Table 5.19: Coefficients, f^2 values, and q^2 values of all paths in the model

Paths	***Coefficients***	***f^2 Effect Size***	***q^2 Effect Size***
IT_CAP -> OPENNESS	0.591***	-	-
OPENNESS -> MKT_UNCER_RED	0.363***	-	-
OPENNESS -> TECH_UNCER_RED	0.339***	-	-
OPENNESS -> FIN_SUC	0.273**	0.084	0.050
OPENNESS -> NONFIN_SUC	0.356***	0.151	0.070
MKT_UNCER_RED -> FIN_SUC	0.272**	0.067	0.041
MKT_UNCER_RED -> NONFIN_SUC	0.136^{NS}	0.018	0.013
TECH_UNCER_RED -> FIN_SUC	0.079^{NS}	0.006	0.004
TECH_UNCER_RED -> NONFIN_SUC	0.110^{NS}	0.013	0.004

** The path coefficient is significant at the level of 0.01 (2-tailed)
*** The path coefficient is significant at the level of 0.001 (2-tailed)
NS The path coefficient is not significant

5.6 Summary of the Chapter

In this chapter, we proposed an OSI model (Figure 5.1) incorporating 11 research hypotheses. We used existing scales in the literature to measure all constructs in the model and conducted a survey of IT service providers in Thailand. PLS-SEM procedures have been applied in order to analyse the collected data. The measurement models have been assessed and the results were satisfactory. With regard to the structural model, the analysis results surprisingly suggested strong direct effects of openness competence on the two performance measures – i.e., financial and non-financial success. Furthermore, the effective reduction of technical uncertainty was found to have no significant contribution to any of the success measures. The mediation analysis indicated a partial mediation of early market uncertainty reduction on the influence of openness competence on financial success. However, the proposed relationship between market uncertainty reduction and non-financial success was not found. Additionally, a development team's IT capability is a key factor influencing the team's ability to be more open in the FFE. Table 5.20

summarises the outcomes of the hypothesis testing. The next chapter discusses these findings as well as compares and contrasts them with the extant literature.

Table 5.20: The summary of the hypothesis testing results

	Hypotheses	***Supported or Rejected***
H1A:	The degree of **market uncertainty reduction** during the FFE positively influences the **financial success** of service innovations.	***Supported***
H1B:	The degree of **technical uncertainty reduction** during the FFE positively influences the **financial success** of service innovations.	*Rejected*
H2A:	The degree of **market uncertainty reduction** during the FFE positively influences the **non-financial success** of service innovations.	*Rejected*
H2B:	The degree of **technical uncertainty reduction** during the FFE positively influences the **non-financial success** of service innovations.	*Rejected*
H3A:	**Openness competence** within the FFE positively influences the degree of **market uncertainty reduction** during the FFE.	***Supported***
H3B:	**Openness competence** within the FFE positively influences the degree of **technical uncertainty reduction** during the FFE.	***Supported***
H4A:	The degree of **market uncertainty reduction** during the FFE mediates the impact of **openness competence** with in the FFE on the **financial success** of service innovations.	***Supported***
H4B:	The degree of **technical uncertainty reduction** during the FFE mediates the impact of **openness competence** within the FFE on the **financial success** of service innovations.	*Rejected*
H5A:	The degree of **market uncertainty reduction** during the FFE mediates the impact of **openness competence** within the FFE on the **non-financial success** of service innovations.	*Rejected*
H5B:	The degree of **technical uncertainty reduction** during the FFE mediates the impact of **openness competence** within the FFE on the **non-financial success** of service innovations.	*Rejected*
H6:	**IT capability** of the front-end team positively influences the team's **openness competence**.	***Supported***

6. Discussion

6.1. Introduction

The main purpose of this research study is to gain a better understanding of how to foster openness in the FFE phase and how the front-end team's ability to be more open (i.e., openness competence) affects service innovation success through the amount of market and technical uncertainty that had been reduced during the FFE. Our research questions are:

RQ1: What are the key dimensions of openness competence within the FFE of service innovation?

RQ2: Does openness competence within the FFE contribute to service innovation success?

RQ3: If yes, does openness competence contribute to service innovation success through the degree of market and technical uncertainty reduction during the FFE phase?

To answer these research questions, we conducted a mixed method study that began with an exploratory case study aiming to uncover the key dimensions of openness competence within the FFE. This was followed by a confirmatory survey in the context of Thai IT-based service providers. By analysing the survey data, we statistically verified the proposed dimensions. Also, several new insights concerning the impact of openness competence on service innovation success were discovered.

The key empirical findings from both phases are listed below.

- From the case study, we found that there are four key dimensions of openness competence within the FFE: searching capability, coordination capability, collective mind, and absorptive capacity.

- As indicated in RQ3, we expected openness competence to impact service innovation success by helping the FFE team reduce the market and technical uncertainty related to front-end activities. However, the findings suggested that the effect of openness competence on success is only partially mediated by market uncertainty reduction. While market uncertainty reduction is associated with the financial success of service innovation projects, it was not linked to the non-financial aspects of success. Further, technical uncertainty reduction was found to have no effects on either the financial or the non-financial success of service innovation projects.
- As we anticipated, a front-end team's ability to open up the FFE phase (i.e., openness competence within the FFE) positively influences the amount of market and technical uncertainty that had been reduced during the FFE phase.
- Unexpectedly, the findings suggested that rather than being mediated by front-end uncertainty reduction, the effect of openness competence on both the financial and non-financial success of service innovations is direct and positive.
- It was also found that a FFE team with superior IT capability is likely to have superior openness competence.

In the following sections, these key findings are extensively discussed with respect to the case study data and the existing literature as we aim to identify possible explanations of their existence.

6.2. Key Dimensions of Openness Competence

Drawing on the extant literature and the case data, we propose four key dimensions of openness competence within the FFE. They are: searching capability, coordination capability, collective mind and absorptive capacity. Based upon this discovery, in the second quantitative phase, openness competence was conceptualised as a reflective-formative type hierarchical component model. The four key dimensions were the first order constructs that formed the second order construct. The analysis results presented in Section 5.5.5, Chapter 5 confirmed this conceptualisation.

Regarding the first dimension, openness to external sources of knowledge allows firms to identify business and technological opportunities lying outside. As suggested by Chesbrough et al. (2006), since the landscape of knowledge has shifted away from internal R&D towards the outside world, a closed innovation approach is likely to overlook the business opportunities from this large pool of knowledge. Based on the case study, we found that, in the more successful cases, the front-end teams were more outward-looking and searched across a larger variety of innovation sources – i.e., searching capability. Prior research consistently suggested that searching widely and deeply can provide ideas and knowledge that help firms gain and exploit innovative opportunities which in turn lead to superior innovation performance (Chiang & Hung, 2010; Laursen & Salter, 2006; Lee et al., 2010). In addition, inter-organisational collaboration in innovation has been suggested as key to innovation success (e.g., Baum et al., 2000; Eisingerich et al., 2009; Ettlie & Pavlou, 2006; Han et al., 2012). The findings of this study suggested that FFE teams with an ability to effectively coordinate and communicate with external innovation partners (i.e., coordination capability); and the existence of mutual interests and understandings of all participants (i.e., collective mind) are important for success in both intra- and inter-organisational innovative collaboration. This is consistent with prior research on innovative communication flows (Blazevic & Lievens, 2004; Lievens & Moenaert, 2000), organisational knowledge creation (Schulze & Hoegl, 2008) and collective mind (Hargadon & Bechky, 2006; Weick & Roberts, 1993). The final dimension involves absorptive capacity. The case study findings suggest that prior related knowledge allows the FFE team to recognise and make use of new insights gathered from external searching as well as to effectively communicate with external partners. Similarly, the literature on open innovation often identifies absorptive capacity as one of the key antecedents of successful open innovation practices (Chesbrough et al., 2006; Lichtenthaler & Lichtenthaler, 2009).

One of the possible explanations for the significance of these four dimensions to the FFE phase may be the abstract characteristics of such an early phase. Since the early stages of the innovation process mainly involve identifying, evaluating and developing interesting, unsolidified ideas (Alam, 2006a), it may be crucial for the FFE team to be able to search for information and knowledge and to co-develop with external partners with compliment resources and expertise. These processes could help identify ideas with high potential and solidify those ideas into more concrete product/service concepts, which later can be developed into successful innovations. This line of reasoning is empirically supported by Langerak et al. (2004). They discovered the positive effect of market orientation (defined as "a culture that creates an environment that maximizes opportunities for learning about markets, for sharing information among functions in the organization that allows for common interpretations, and for taking coordinated actions." (p. 296)) on the proficiency in executing several front-end activities, namely strategic planning, idea generation, and idea screening. However, in the same study, market orientation was not found to make a direct contribution to either innovation or organisational performance.

6.3. The Impact of Uncertainty Reduction on Service Innovation Success

By separating uncertainty related to the FFE into the two domains of market and technical uncertainty, we were be able to identify the different effects of these two types of front-end uncertainty on service innovation success. In contrast to our expectations, the findings suggest no relationships between the degree of technical uncertainty reduced during the FFE and service innovation success. Further, we found that market uncertainty reduction in the FFE contributes only to the financial success but not to the non-financial success of service innovations. A discussion of the reasons behind these unexpected results is found below.

6.3.1. Market uncertainty reduction and service innovation success

Consistent with previous research (Lievens & Moenaert, 2000; Verworn et al., 2008), the current study found support for the contribution of early market uncertainty reduction to the financial success of service innovation projects. However, no such relationship could be found between the early reduction of market uncertainty and non-financial success.

The unexpected result, that there are no links between market uncertainty reduction and the non-financial success of service innovations, could be explained by the absence of the development phase in our study. As posited by Verworn (2009), while early market uncertainty reduction has no direct impact on the overall project success, it helps decrease deviation from specifications during the development phase; and improve intra- and inter-communication. The quality of communication within a NPD team during the following development stages in turn positively affects project success.

Another possible explanation could be that imitation of competitors' products or incremental improvement from products available in the market, inspired by feedback from the existing customers, may hinder the non-financial or long-term success of the innovations. The information collected during the first phase provides clues as to why gathering customer intelligence during the FFE phase may not be significant to long-term success:

> "I did not think that customers would be able to provide advanced requirements. We had to think by ourselves. […] This is because customers usually become attached to the concepts of the old systems [their competitors' systems]." (CEO – Case 4: OnlineShopCreator)

> "If we were to ask for their [the customers] comments in the early stages, the development process would have been more difficult. Because it would be chaotic if someone were to direct us 'you should put this button here', 'labels should be named like this or that' or 'I want this colour not that one'. Moreover, since this product belongs to our company, […] we should have the control of how the design or usability should be so that the final product will have the scent of our company or have our signature on it." (Senior marketing executive – Case 6: OnlineStockTrade)

These quotes imply that gathering intelligence with respect to competition, customer needs and market situations during the FFE may not prompt the innovation team to create radical new services that may provide the firm with the benefits of competitive advantage, improved company image or the emergence of new markets. Interestingly, one of the interviewees commented on the type of users that should be involved in the FFE phase:

> "Sometimes, feedback from customers may not be very useful – like what Steve Jobs said 'people don't know what they want until you show it to them.' Nevertheless, I still believed that there are some groups of people that can envisage what we are trying to achieve. They are very rare though. You need to put a lot of effort into finding them. They could be some geeks who are not ordinary users, who play a lot of apps and enjoy innovations." (CTO – Case 3: MobileShopApp)

Therefore, to achieve long-term success with radical new services, a FFE team might have to be selective with regard to the use of external sources of knowledge or innovation partnerships. We argue that, for the development of radical innovations, unorthodox sources of market intelligence, such as lead users (Mahr et al., 2014), firms in other industries (Brunswicker & Hutschek, 2010; Enkel & Mezger, 2013) and crowdsourcing (Ebner et al., 2009), may be more preferable than traditional sources, such as ordinary users or competitors. Similar suggestions can be found in prior studies. Mahr et al. (2014)

empirically proposed that co-creation with customers who possesses closed relationships with the innovating firm leads to more highly relevant, but less novel knowledge, whereas the involvement of lead users generates novel and relevant knowledge. In addition, the use of competitor intelligence and of co-opetition seems have a negative impact on the degree of novelty of innovation (Mention, 2011; Nieto & Santamaría, 2007).

6.3.2. Technical uncertainty reduction and service innovation success

Strikingly, the reduction of knowledge gaps concerning technology and resource requirements was found to have no impact on either the financial or non-financial success of service innovation projects. Such findings contradict prior studies in product innovation contexts. Scholars taking the information-processing view have suggested that, concerning new product development, technical uncertainty reduction is more important to the success than market uncertainty reduction (Frishammar et al., 2011; Moenaert et al., 1995; Moos et al., 2013; Perkins & Rao, 1990; Verworn, 2009; Verworn et al., 2008). For example, Perkins and Rao (1990) reported empirical support indicating that a development team's proficiency in technology seems to contribute more to product innovation performance than proficiency in marketing activities.

On the contrary, studies in service innovation contexts yield different results (Carbonell et al., 2009; Jaw et al., 2010; Lievens & Moenaert, 2000; Van Riel et al., 2004). Carbonell et al. (2009) found that the greater the technological turbulence and the newness of the technology embodied in the new service, the greater the degree of customer involvement required. Similarly, Van Riel et al. (2004) argued that, although the acquisition of technological information may be an important operational factor, customer information seems to play a more important role in the introduction of successful new services in high-technology service industries. Insight into the minds of customers and current market situations leads to the ability to provide solutions that fit customer needs. Such insight may play a more important role in service innovation success than the use of sophisticated technologies that remains invisible to most customers (Van Riel et al., 2004). In addition, service firms that are less market-oriented are less likely to venture into innovation (Agarwal et al., 2003). Jaw et al. (2010) found that efforts in market orientation positively impact service innovation performance.

Furthermore, our findings on the more pronounced effect of market intelligence on service innovation success are consistent with the S-D logic (Vargo & Lusch, 2008; Vargo & Lusch, 2004) as it highlights the importance of customer orientation (FP8) over goods (i.e., technologies), which are suggested to be only a distribution mechanism of service provision (FP3). A similar trend was also identified from the case study data. As shown in Table 4.6 (Section 4.4.3, Chapter 4), the less successful cases (with a closed FFE) tended to focus only on the technology side of the project, while the more successful ones (with an open FFE) seemed to emphasise on reducing market over technology uncertainty.

Another possible explanation could be attributed to the technology-driven nature of the IT service industry. Projects managers in such a high-technology industry may arguably be overconfident about their technology knowledge, which reflects in the relatively higher mean values of most of the questions concerning technical uncertainty reduction compared to those of the questions about market knowledge (see Table 5.9 in Section 5.5.5, Chapter 5).

6.4. Openness Competence and Front-End Uncertainty Reduction

The current research provides important empirical evidence revealing the significant role of openness competence in the FFE of service innovation, for which we developed a new measurement scale. According to the results of both the case study and the survey, the level of openness competence possessed by the FFE team emerged as an important predictor of the amount of market and technical uncertainty that had been reduced during the FFE phase (H3A and H3B were supported). Consistent with prior research on the FFE, several open approaches to front-end uncertainty reduction were suggested:

- Gathering and assimilating information and knowledge about customers, technology and competition (Zhang & Doll, 2001),
- Cooperation with intermediaries and suppliers (Khurana & Rosenthal, 1998; Kim & Wilemon, 2002),
- Early customer involvement (Alam, 2006a; Magnusson, 2009; Mahr et al., 2014), and
- The use of informal networks to obtain new ideas and recruit the required competencies (Björk & Magnusson, 2009; de Brentani & Reid, 2012; Stevens, 2014).

The information-processing theory (Galbraith, 1974) could be used to explain the relationship between openness competence and uncertainty reduction found in the current study. The information-processing theory suggests that lateral relationships should be established in order to relieve the information-processing burden from the development team to others sharing the problem (Galbraith, 1974). Accordingly, we argue that a FFE team with a high level of openness competence is likely to possess a high level of information-processing capacity which allows it to effectively perform highly uncertain tasks, such as the front-end of innovation.

6.5. The Impact of Openness Competence on Service Innovation Success

Surprisingly, the analysis of the survey data uncovered a direct contribution of openness competence to overall project success. Such a discovery is contrary to our expectations. The findings only supported one of this study's four hypotheses concerning the mediating roles of front-end uncertainty reduction on the effect of openness competence on project success (i.e., H4A was supported, whereas H4B, H5A and H5B were rejected). Although the data suggested that openness competence is positively associated with the degree of market and technical uncertainty reduction during the FFE phase, only market uncertainty reduction can be related to one of the two success measures (i.e., financial success).

One of the possible explanations could be that, apart from improving uncertainty reduction during the FFE phase, a high level of openness competence can also translate into effectiveness in executing other front-end activities, such as opportunity identification, idea generation and concept development. The effective execution of these activities in turn leads to project success. Similar recommendations on the direct contribution of openness competence on innovation success can be found in the literature on open innovation (Chesbrough, 2003; Chesbrough et al., 2006). Chesbrough (2003) argued that exploration and acquisition of external knowledge, and cooperation with external partners (i.e., inbound open innovation) enable firms to lower their R&D costs, increase innovation productivity and reduce time to market. For example, in the case of P&G's connect and develop initiative, the firm aimed to double its innovation capacity at no increase in cost. In 1999 when they started the program, P&G had roughly 8,200 people working on innovations: 7,500 inside the company, 400 with suppliers and around 300 external people. Due to the success of the programme, in 2004, the firm increased its innovation capacity with a total of 16,500 innovation workers: 7,500 inside, 2,000 with suppliers and 7,000 virtual and extended partners (Chesbrough, 2007). Furthermore, according to the literature on dynamic capability, in order to identify and shape opportunities, a firm must scan, search and explore customer needs and technological possibilities (i.e., sensing capability). It is crucial that the firm understands latent demand, the structural evolution of industries and markets, and likely supplier and competitor responses (Teece, 2007, p. 1322). In service innovation contexts in particular, sensing capability, comprising of customer-linked service sensing, service system sensing, internal service sensing, and technology exploitation, has been proposed as one of the essential dynamic capabilities (Kindström et al., 2013).

With regard to empirical evidence, as presented in Section 2.9.1, Chapter 2, some scholars have identified a positive impact of external searching (e.g., Chen et al., 2011; Chiang & Hung, 2010) and co-developing with innovation partnerships (e.g., Ettlie & Pavlou, 2006; Ordanini & Parasuraman, 2011; Zeng et al., 2010), whereas others found negative effects of too much openness (e.g., Knudsen & Mortensen, 2011; Laursen & Salter, 2006). The current study's discovery of the direct effects of openness competence within the FFE phase on both the financial and non-financial success of service innovation projects could be used to explain these conflicting findings. The information-intensive characteristics of FFE activities are likely to lend themselves better to greater external openness, which sometimes incurs higher costs and is more time-consuming (Knudsen & Mortensen, 2011), than activities in the subsequent development and commercialisation phases. This is because the cost and time required to generate several potential ideas is considerably lower than the resources needed for implementing any one idea (Reid & De Brentani, 2004), thus the FFE may not suffer as much as the later stages from the extra costs of openness. Prior studies have consistently posited the importance of openness in the FFE phase of innovation (de Brentani & Reid, 2012; Kim & Wilemon, 2002; Love et al., 2011; Stevens, 2014). We argue that openness may be more important to the early stages of the innovation process than to the later stages.

6.6. The Role of IT Capability in the FFE Phase

The findings of the PLS analysis (Chapter 5) showed that the higher the level of a FFE team's IT capability, the higher its ability to open up the front-end process. Such findings are in line with scholars taking a resource-based view that propound no direct contribution of the use of IT to business performance either at a process level (Pavlou &

El Sawy, 2006; Ray et al., 2005) or at a firm level (Rivard et al., 2006; Wade & Hulland, 2004). The essence of their argument is that "information systems exert their influence on the firm through complementary relationships with other firm assets and capabilities" (Wade & Hulland, 2004, p. 109). Therefore, in this case, IT seems to exert its influence through the ability to innovate. In the IT services industry in particular, generic IT packages (e.g., project management software, communication and collaboration tools, or knowledge management and sharing systems) are likely to be ubiquitous, thus arguably there can be no strategic differentiation between firms in such a high-technology industry. IT may however be able to make contributions to a firm's competitive advantage by facilitating a more open approach to the FFE phase of innovation. The analysis of the case study data supports such an explanation. In all cases, it was found that similar generic IT tools were used to some extent during the FFE phase to gather and share knowledge and ideas from the outside, to manage and coordinate resources, and to facilitate both intra- and inter-organisational innovative communication and collaboration.

In addition to the benefits of the effective utilisation of generic IT tools in the innovation process (Di Benedetto et al., 2008; Menor & Roth, 2007; Moos et al., 2013; Pavlou & El Sawy, 2006), prior research has also encouraged the adoption of IT tools with more advanced features, such as data mining, simulation and model building, and visual and rapid prototyping (Dodgson et al., 2006; Gordon et al., 2008). However, when looking at the case data gathered in this study's first phase, only the use of generic IT tools to facilitate front-end activities was found. This may be because those more advanced IT tools tend to be more expensive and require a high level of maintenance and training. The lack of utilisation of advanced IT in the firms that we studied may be due to the fact that they are small- and medium-sized firms, and thus may opt for less costly, low-maintenance options.

6.7. Summary of the Chapter

This chapter discussed the key findings of this thesis. The findings from the case study presented in Chapter 4 and from the survey presented in Chapter 5 were combined and discussed with regard to the current knowledge in the literature with the aim of achieving the research objectives and answering the research questions. Importantly, four key dimensions and an antecedent of openness competence within the FFE were identified. Further, the data suggested several unexpected outcomes. We discovered that, rather than exerting its effect through front-end uncertainty reduction, openness competence within the FFE positively and directly influences service innovation success. Possible explanations for these surprising results were provided. The next chapter is the conclusion chapter that summarises the current study and provides the theoretical and practical implications of its key findings. Also, a number of limitations and suggestions for future research are suggested.

7. Conclusion

The present research study was set out to explore the FFE phase of IT-based service innovation in IT service provider firms in Thailand. Looking through the S-D logic analytical lens, we were able to identify four key dimensions and an antecedent of openness competence within the FFE. Recommendations on how to improve those dimensions, which could lead to a higher level of openness competence, were also provided. Furthermore, the current study has sought to find out whether openness competence can impact service innovation success by helping the development team reduce market and technical uncertainty during the FFE.

Current knowledge about the FFE phase of service innovation in emerging economies is still lacking. In addition, although scholars have proposed the importance of both the FFE and openness, little has been done to provide empirical evidence of their integrative effects. This thesis is therefore an attempt to provide answers to three research questions:

RQ1: What are the key dimensions of openness competence within the FFE of service innovation?

RQ2: Does openness competence within the FFE contribute to service innovation success?

RQ3: If yes, does openness competence contribute to service innovation success through the degree of market and technical uncertainty reduction during the FFE phase?

To aid the reader, this final chapter starts with a review of the data collection and analysis methods that were employed. It then provides a summary of the main findings that converge to answer the research questions. Next, we offer several contributions to both research and practices. Finally, limitations and suggestions for research opportunities are identified.

7.1. Review of the Methodology

This exploratory sequential design study had two main phases. The first phase involved the interviews of 12 people participating in the FFE of 6 online service innovation projects. The interview questions were developed based on an initial conceptual framework regarding openness and the information-processing view (Figure 2.3 in Section 2.10, Chapter 2). The service innovations of interest took the form of either mobile or web application or both. Three of them were classified as having a more open FFE phase, while the other three were considered more closed. In terms of data analysis, we first performed a within-case analysis and then searched for cross-case patterns. The principal objectives of this first qualitative phase were to unearth the key dimensions of openness competence within the FFE as well as to confirm the initial framework (Figure 2.3). The findings of the case study, together with relevant prior works, were then synthesised in order to develop a measure of openness competence (i.e., a formative second-order construct formed by the key dimensions identified in the first phase). This enabled us to establish a series of research hypotheses and an OSI model. In the second quantitative phase, a large-scale survey of IT service providers in Thailand was conducted with the aim of providing verification for the OSI model and testing the research hypotheses. The target respondents were project managers who were involved in the FFE phase of service innovation projects. A total of 122 responses were returned, producing a valid response rate of 38.98%. Several statistical tests were conducted to ensure the validity and reliability of the data. To test the research hypotheses, PLS-SEM (Hair et al., 2014) was adopted.

7.2. Summary of the Main Findings

This section consolidates the empirical findings to answer the three research questions.

- What are the key dimensions of openness competence within the FFE of service innovation?
    - The four key dimensions of openness competence are (1) searching capability, (2) coordination capability, (3) collective mind, and (4) absorptive capacity. Based on the case study data, the teams in the more open cases seemed to possess higher levels of these four dimensions than the teams in the more closed cases. As a consequence, the former were better able to conduct knowledge searching and collaborate with external partners. On the other hand, in the more closed cases, the informants did not seem very concerned about the four fundamental capabilities of openness as they were more narrow-minded and dismissed openness as an inconvenience.
    - The significant role of generic IT tools was also discerned from the interview data. While the FFE teams' ability to utilise available IT tools (e.g., ICTs or knowledge management software) did not seem to directly influence the quality of the FFE outcomes, IT was found to facilitate external searching, project and resource management, communication, and collaborative works during the FFE phase. The review of the literature however guided us towards hypothesising IT capability as an antecedent rather than as another dimension of openness competence.
    - Based on the findings of the case study, we conceptualised openness competence as a reflective-formative type hierarchical component model (see Figure 5.2 in Section 5.3.4, Chapter 5). The four key components were the first-order constructs forming the second-order construct – i.e., openness

competence. This conceptualisation was supported by the results of PLS-SEM estimations and bootstrapping procedures.

  - The analysis of the quantitative data suggested a strong link between IT capability and openness competence. Thus, a FFE team with superior IT capability is likely to have superior openness competence.

- Does openness competence within the FFE contribute to service innovation success?
  - In contrast to our expectations, the analysis of the survey data indicated that openness competence in the FFE phase directly and positively affects the perceived success of service innovation projects measured financially and non-financially.
  - In addition to the direct contribution of openness competence, we also found that the ability to open up the front-end process positively affects the amount of market and technical uncertainty that had been reduced during the FFE phase.
- If yes, does openness competence contribute to service innovation success through the degree of market and technical uncertainty reduction during the FFE phase?
  - Regarding the effects of the early reduction of market and technical uncertainty on service innovation success, the study found that only the former positively influences the financial success of service innovation projects.
  - Surprisingly, while imitation of competitors' products and gathering customer intelligence (typically used to reduce market uncertainty in the case study) were found to influence the financial success, it may hinder the non-financial or long-term success of the new services since the end products may just be an incremental improvement of what is already out there in the market. One of the informants gave an interesting comment on this issue: "I did not think that customers would be able to provide advanced requirements. We had to

think by ourselves. […] This is because customers usually become attached to the concept of the old systems [their competitors' systems]." (CEO – Case 4: OnlineShopCreator)

- The quantitative findings suggested that a reduction in knowledge gaps concerning technology and resource requirements produces no significant impact on either the financial or non-financial success of service innovations. A similar pattern was also discovered in the case data since the more closed and less successful cases tended to only focus on technology, while the more open and more successful ones seemed to emphasise the market over the technical aspects of the projects.
- With regard to the financial success of service innovation, rather than being mediated by technical uncertainty reduction, the effect of openness competence within the FFE on monetary success was found to be direct and positive. However, market knowledge seems to play a more prominent role, as early market uncertainty reduction partially mediates the effect of openness competence on the financial success of service innovation projects.
- Regarding the non-financial aspect of success, the findings indicated no significant contributions from either market or technical uncertainty reduction during the FEE, thus declining the hypothesised mediating effects.

7.3. Theoretical Implications

Concerning the first research question, the identification of the four key dimensions of openness competence within the FFE phase as well as the operationalisation of the construct as a reflective-formative type second-order construct being formed by four first-order constructs (i.e., searching capability, coordination capability, collective mind, and absorptive capacity) contributes to research on the FFE and on open innovation. Furthermore, the current study exemplifies the usefulness of applying PLS-SEM in evaluating structural models with reflective-formative type hierarchical latent variable models (Becker et al., 2012; Jarvis et al., 2003).

To provide answers to the other two research questions, we statistically tested the proposed OSI model and the research hypotheses. Both the expected and unexpected results generated several contributions to theory and research.

By uncovering the different effects of market uncertainty reduction on the two success measures, the current study provides several new insights. Market orientation research has long suggested a link between market orientation and innovativeness (Atuahene-Gima, 1995; Han et al., 1998; Hult et al., 2004; Jaw et al., 2010). Nevertheless, conflicting results, suggesting no direct effect of market orientation on innovation performance, have also been found (Atuahene-Gima, 2005; Langerak et al., 2004). A possible cause of these conflicting results might be that prior studies aggregately used both financial and non-financial measures to assess innovation success (e.g., Jaw et al., 2010; Langerak et al., 2004; Verworn et al., 2008) or they just employed the newness of the new products/services as the dependent variable (e.g., Hult et al., 2004). Since we found that the early use of market intelligence impacts short-term financial success but not non-financial success or long-term success, our findings reveal a more complex relationship between market uncertainty reduction and innovation success, and suggest the need to be strategic when benefiting from external market sources during the FFE phase. We therefore argue that the impact of a development team's levels of knowledge about competitors, customer's needs and market situations on innovation success depends on how success is measured. The conflicts in the literature on market orientation could be alleviated if the impact of market orientation were to be tested separately on different aspects of innovation success.

The surprising results, dismissing the significance of early technical uncertainty reduction, make at least three contributions to service innovation research. Firstly, the current study discovered a more prominent role of market intelligence over knowledge about technology. These findings provide empirical support for the applicability of the key principles of the S-D logic to service innovation management (Lusch et al., 2007) by stressing the importance of value co-creation and customer orientation over technology (Vargo & Lusch, 2008; Vargo & Lusch, 2004).

Secondly, the findings of the present study demonstrate the distinct impact that the choice of different kinds of information (market versus technical) has on different types of innovations (product versus service innovations). While prior research has proposed a more pronounced role of technical uncertainty reduction in developing new products (Moenaert et al., 1995; Moos et al., 2013; Verworn, 2009; Verworn et al., 2008), previous works in service innovation contexts suggested otherwise (e.g., Carbonell et al., 2009; Van Riel et al., 2004). Consistent with the latter, our findings highlight the less pivotal role of technical knowledge, when comparing to market intelligence, in the development of successful new services.

Thirdly, when one collectively considers the effects of front-end market and technical uncertainty reduction uncovered in the current study, one might question the validity of the information-process theory (Galbraith, 1974). In the FFE of innovation – a task involving high levels of uncertainty and requiring a high level of creativity, the successful reduction of uncertainty may tell just half the story. While the possession of necessary market and technical knowledge may help with activities like idea evaluation, idea selection, and concept development, it may be less useful when it comes to generating new ideas particularly in the case of new-to-the-world innovations.

Although prior studies on the FFE have suggested openness as a way to reduce front-end uncertainties (Alam, 2006a; Chesbrough & Crowther, 2006; de Brentani & Reid, 2012; Stevens, 2014), quantitative empirical evidence is still limited. From a theoretical perspective, the current study makes a contribution by providing empirical evidence for the relationship between a FFE team's proficiency in inbound open innovation activities and front-end uncertainty reduction. In addition, by branching front-end uncertainty into market and technology, we were able to identify that the effect of openness competence on market uncertainty reduction is stronger than on technical uncertainty reduction. This implies that, during the FFE, innovation teams tend to open up their process with the intention to reduce market uncertainty rather than to reduce uncertainty related to the technology.

The unexpected findings of the direct effects of openness competence on both financial and non-financial success may shed some light on previous research's conflicting results with regard to the contribution of openness to innovation performance (presented in Section 2.9.1, Chapter 2). We argue that different stages of the innovation process require different openness strategies. The early stages may be better off with a more open and collaborative innovation strategy, whereas a more closed approach to innovation may be more appropriate in the later stages. Another contribution is to research focusing on the FFE of innovation. The discovery of the direct effects of openness competence within the FFE on innovation success highlights the significance of such an early phase, which has long been promulgated by FFE scholars (e.g., Alam, 2006a; Chang et al., 2007; de Brentani & Reid, 2012; Khurana & Rosenthal, 1998; Kim & Wilemon, 2002). The rejection of three of the hypothesised mediating effects also underline the importance of the adoption and utilisation of open innovation concepts in the ideation stages (Chesbrough, 2003; Chesbrough et al., 2006). The surprising discovery conveys an interesting idea that openness may be more than just a tool for uncertainty reduction. Early openness could possibly benefit other key activities in the FFE.

Regarding the role of IT capability in the FFE phase, the current study makes three contributions to research. Firstly, the value provided by this study is as empirical evidence of the implications of the effective use of generic IT to support innovation capabilities, thus contributing to the IS literature. In addition, while many have investigated the infusion of IT in product/service innovation (e.g., Breidbach et al., 2013; Chen et al., 2009a; Chen & Tsou, 2012; Moos et al., 2013; Pavlou & El Sawy, 2006; Tarafdar & Gordon, 2007), studies focusing on the benefits of using IT during the early stages of innovation are mainly conceptual or qualitative (e.g., Gordon et al., 2008; Kim & Wilemon, 2002; Montoya-Weiss & O'Driscoll, 2000; Schmidt et al., 2001). To our knowledge, this study is among the first to have statistically tested the contribution of IT capability to openness in the FFE of service innovation. Secondly, the strong relationship between a FFE team's IT ability and the team's ability to be more open during the FFE phase identified in the current study suggests the strategic value of IT capability to a firm's competitive advantage at a business process level (Ray et al., 2004). Since the IS literature seems to pay more attention to the strategic benefits of IT at a firm level (e.g., Rivard et al., 2006; Sambamurthy et al., 2003), we argue that strategic effects of IT at a lower (process) level should not be overlooked. Finally, our findings make a contribution to the open innovation literature by providing quantitative empirical support for the use of IT in enabling a more open approach to the front-end of innovation. While such an important role has been suggested by prior exploratory research (Awazu et al., 2009; Dodgson et al., 2006; Veugelers et al., 2010), attempts to confirm those findings have been limited.

Although the current study focuses on IT-based service innovation in IT service provider firms, we argue that the findings could benefit innovation in non-IT related service or even in manufacturing contexts, for the following reasons. Firstly, this study took the services-dominant (S-D) logic integrative approach, which strongly claims that in order to compete through service, firms must shift from a good-dominant (G-D) logic to the S-D logic regardless of the sector they are in (Lusch et al., 2007). The results of the analysis showing the greater importance of market intelligence over technical knowledge provide support for several fundamental principles of the S-D logic and also suggest the significance of value co-creation and customer orientation over technology. Further, our discovery of the direct contribution of openness competence on success strengthens the S-D logic's claims of the vital role of operant resources. It suggests that firms should draw upon skills and knowledge lying outside of the firm and proactively co-create with others (Lusch et al., 2007; Vargo & Lusch, 2008; Vargo & Lusch, 2004). Therefore, we argue that these findings might be relevant to non-IT related service innovations in both the service and manufacturing sectors.

Secondly, we propose that the FFE of non-IT related service innovation could also benefit from high levels of openness competence within the FFE. As discussed in Section 2.3.2, service companies (e.g., hotels, catering services, transport, etc.) other than specialised/science-based service firms are substantial technology users (Miozzo & Soete, 2001). Innovations from technology suppliers are often adopted and implemented by those firms (Den Hertog, 2000), for example, automatic light control systems, package delivery by drones and GPS tracking technologies. Since technologies incorporated in non-IT related service innovations are often supplied by technology suppliers (or partners in the supply chains, who have complementary skills and competences), searching for knowledge and information from and collaborating with them early in the innovation process might lead to a greater chance of success for the innovation project. In addition to collaborating with technology suppliers, scholars have explored the phenomenon of user innovation in both service and manufacturing contexts (Carbonell et al., 2009; Oliveira & von Hippel, 2011; Von Hippel, 2005). Therefore, in addition to co-developing with technology suppliers, we argue that a practice of early customer involvement could also be adopted in the development process of non-IT related innovations.

7.4. Managerial Implications

By drawing on the case study's findings, we suggest that, in order to increase the level of openness competence within the FFE, managers must focus on enhancing four core components. Firstly, top management support may be crucial for knowledge searching activities in the front-end phase (Proposition 1). Top management should put emphasis on creating a shared norm and supportive organisational settings to support openness. Secondly, for successful cooperation in innovation, we encourage front-end managers to assign sufficient resources and time to facilitate communication and coordination with their innovation partners (Proposition 2). Thirdly, it is also important to make sure that the interests of all parties are aligned around the project goals with a clear understanding of the roles of themselves and others (Proposition 3). Finally, in the FFE phase of highly innovative projects, managers might wish to employ a team with prior related knowledge to allow effective knowledge searching and innovative collaboration (Propositions 4a and 4b).

Having highlighted that openness competence and front-end uncertainty reduction are closely related, our findings encourage service firms to acquire new ideas and knowledge from outside of the firm and to co-develop with external partners in order to achieve an effective diminution of front-end uncertainty. Although we believe that both market and technical uncertainty should be reduced as much as possible during the FFE phase, this may be very difficult to achieve in practice. Since resources and time are likely to be limited in such an early phase, managers must be selective when it comes to which types of uncertainty (i.e., market versus technical) they need to focus on. We propose that, during the FFE of service innovation, front-end managers should pay more attention to gathering information and knowledge concerning customers, competitors and market situations, rather than to solving potential technical problems.

As the findings have shown, openness competence within the FFE directly and positively influences not only the amount of uncertainty reduced during the FFE but also the overall success of service innovation projects. Therefore, managers are encouraged to employ a more open approach to effectively achieve a reduction of uncertainty associated with the FFE. In addition, as openness competence seems to exert its influence on project success through other channels, rather than through the degree of front-end uncertainty reduction, the current study argues that greater openness competence could also possibly benefit other front-end activities (e.g., idea generation, opportunity identification, project planning, etc.).

Finally, based on the acceptance of the final hypothesis (H6), we suggest that managers should raise the project team's awareness of the benefits of generic IT tools in supporting knowledge searching, collection and sharing, in project planning and resources management, and in facilitating smooth communication and collaboration within the FFE phase. In addition, IT training and human development within the R&D unit are recommended to fully reap the benefits of IT to innovation.

7.5. Limitations and Directions for Future Research

The current study has a number of limitations. As for the first qualitative phase, the primary data source of the theory-building case study was interviews. Interviews are a highly efficient way to collect data when "the phenomenon of interest is highly episodic and infrequent" (Eisenhardt & Graebner, 2007, p. 28) as in the FFE phase of innovation.

However, interviews are not without challenges since the interviewees have to take about what happened in the past and may try to impress the interviewer. To limit bias, we followed Eisenhardt and Graebner's (2007) recommendation by interviewing participants from different hierarchical levels and functionalities, and triangulating the interview data with other sources (i.e., corporate websites, user stats and news on the Internet). In addition, since qualitative studies are subjected to interpretation of the researchers during the data analysis, we strictly followed the procedure suggested by Miles et al. (2013) to ensure a close fit between the emerging theories and the data.

As case studies are typically context-specific (Yin, 2009), we do not claim that the key dimensions identified in this study are generalisable and inclusive because case studies conducted in different industries and organisational settings may produce different results. Concerning the proposed dimensions of openness competence, there are a number of questions that future research might find interesting. For example, what are the inter-relationships between the proposed dimensions of openness competence? Which of the proposed dimensions are more important than the others? and why? Although this research has provided initial suggestions on how to foster the proposed dimensions, a study involving a larger number of cases that aims to identify the best practices for promoting openness competence and its key components could prove a fruitful one.

For the second quantitative phase, there are several limitations related to the research design that should be concerned. In terms of threats to reliability, as the respondents filled in the questionnaire after the project was completed, they might have forgotten some detail. In addition, the single-informant approach and the use of self-reported performance measures might have led to a common method bias (Lee & Lings, 2008). Note that, at a project level of analysis, it may be difficult to obtain objective success measurement (Pavlou & El Sawy, 2006). Future work should therefore try to mitigate such bias by striving to collect objective performance data at the innovation project level.

Concerning internal validity issues, it is often much more difficult to control all possible sources of extraneous variation in a survey study than in an experiment (Lee & Lings, 2008). To mitigate the negative effects, this study included a set of control variables, e.g., newness, firm size, the development team's experience, etc., which the literature has suggested to affect innovation performance.

Since this is a cross-sectional study, comparing the before and after effects in order to establish a robust causal relationship is not possible (Lee & Lings, 2008). Therefore, caution is advisable when drawing cause-effect inferences. The findings of this research should rather be treated as supporting evidence of established causal theories. As this study was limited to evaluating the two performance measures in a cross-sectional fashion, an extension to this study would be to conduct longitudinal research assessing the performance measures over time in order to confirm the tentative causal links proposed in the current study.

With respect to external validity, since the focus of the present study is on IT-based service innovation projects in Thailand, any attempts to generalise the findings to other types of innovations or countries may not be justified (Saunders et al., 2009). In addition, although the proposed OSI model was tested with a small sample size of survey data, the statistical technique being adopted – i.e., PLS-SEM – has been suggested as being capable and suitable for handling small sizes (Henseler et al., 2009). A larger data set would, of course, be preferable because some of the insignificant relationships might have become significant with a larger sample size. In addition, a larger sample size might also increase the AVE value of the openness competence construct, which was found to be below the recommended value of 0.5 in this study (AVE values are discussed in Section 5.5.5).

The current study's results also point to some additional avenues for future research. The findings suggested that early market uncertainty reduction leads to the financial success of service innovation projects, while the non-financial aspect of success is not affected by such a practice. The questionnaire data, however, did not enable the research to uncover the reasoning behind such a striking result. It would be interesting to investigate the different effects of gathering market intelligence on the two performance measures through a softer methodology. Moreover, technical uncertainty reduction during the FFE was found to have no effect on any of the success measures. The decision to focus solely on the FFE phase may be a possible explanation of the non-significant effects of front-end uncertainty reduction. Future research may investigate potential mediating mechanisms of activities in the following development and commercialisation phases. For instance, it is possible that technical uncertainty reduction influences project success through a development team's ability to develop the innovation on time and on budget.

Instead of being mediated by front-end uncertainty reduction, openness competence with in the FFE exerts its influence directly on service innovation success. Specifically, apart from the partial mediation of market uncertainty reduction, the other three hypothesised mediation effects were rejected. These unanticipated results suggest a need for other front-end activities (e.g., opportunity identification, idea generation, concept development, project planning, etc.) to be studied with respect to the impact that openness might have on them and their contributions to project success. Moreover, the strong impact of openness competence within the FFE on both the financial and non-financial success of service innovation suggests that openness might have a prominent impact on success when applied to the FFE phase, rather than to the later stages of the innovation process. A future attempt to compare the impact of openness in different phases and activities could therefore benefit the current body of knowledge.

While a relationship between the FFE team's ability to utilise generic IT tools and their openness competence was found to be significant, prior studies have also recommended the use of more advanced IT, such as data mining and simulation tools, during the early stages of innovation (Dodgson et al., 2006; Gordon et al., 2008). Therefore, the use of advanced IT tools in the FFE could be an interesting avenue for future research.

Ultimately, the generalisability of the current study's findings can be improved if future studies test the OSI model with data from other developing countries or by comparing and contrasting the results of this study with a replication in a country with a more advanced economy.

7.6. Closing Remarks

The current thesis was among the first to examine openness in the FFE phase in a Thai IT-based service innovation context. It included interview data from 6 online service innovation projects and survey responses from 122 project managers who participated in the FFE phase of IT-based service innovation projects. Its main purpose was to identify and verify the key dimensions of openness competence within the FFE as well as to understand the impact openness competence on service innovation success. Overall, the contributions of this research enhance the current knowledge of openness and the FFE of innovation. The study also provides new insights to guide innovation practitioners.

8. Appendices

Appendix A: Service Innovation Success Questionnaire

Six months after launch, to what extent do you agree or disagree with the statement below:

- The new service exceeds sales objectives.
- The new service exceeds market share objectives.
- The new service exceeds profit margin objectives.
- The new service increased customer satisfaction and loyalty.
- The new service improved our competitive position.
- The new service enabled expansion into new markets.

(Options: a 7-point Likert scale, where 1 represents ‘strongly disagree’ and 7, ‘strongly agree’)

Appendix B: Open Service Innovation Questionnaire

Cover page

April, 2014

Dear the project manager,

I am conducting a study about the role of openness in the predevelopment phase of service innovation projects and how to promote a more open approach to innovation. Your answers are very important for us to learn how being more open can help reduce uncertainties in the predevelopment phase and, as a result, improve service innovation project's success. In addition, your knowledge and experience can also help us identify what should be done to encourage the development team to be more open in the predevelopment phase

Your company was randomly selected to help in this study. Your email address has been provided by your company who agreed to participate in this research. All information provided will remain confidential and your identity will also remain anonymous. Your responses will be used only as the main data set for this research project.

The questionnaire should only take about 15-20 minutes to complete. Please follow the instructions and answer each question in the survey as completely and accurately as possible. Participation is strictly voluntary; therefore you may stop answering the questions at any time.

By taking a few minutes to share your thoughts and knowledge about managing a successful predevelopment of service innovation projects, you will be helping us a great deal. I hope you find filling in the questionnaire pleasurable, and thank you for your time and contribution to this survey.

If you would like a copy of the survey results or have any questions regarding this open service innovation survey, please contact Bundit Thanasopon by telephone at (+66)97-047-4949 or by email at B.Thanasopon@2011.hull.ac.uk.

Sincerely,

Bundit Thanasopon

If you would like to participate in this survey, please continue to the next page.

The questionnaire

INSTRUCTION: Please read this page carefully as these 2 terms will frequently appear throughout this questionnaire

THE PREDEVELOPMENT PHASE

Generally, The process of new service or product development consists of two main phases: **the ‘predevelopment’ phase** and **the ‘development’ phase**. The main focus of this survey is on the former.

The **predevelopment phase** of an innovation project typically involves three main stages:

1. **Idea generation** – this stage starts by identifying the opportunities that the company might want to pursue. Additional information may need to be gathered (e.g., by conducting focus group or market studies, or by involving cross-functional teams or collaborating with customers or other organisations) in order to shape the opportunity into a more concrete idea.
2. **Idea screening** – this stage involves choosing which ideas to pursue in order to achieve the most business value. Market and technology risks, competitive situation, the firms’ strengths and weaknesses, and financial returns may need to be considered.
3. **Concept development** – the final stage involves the development of a product/service concept based on estimates of market potential, customer needs, resource requirements and technology unknowns. The outcomes of this stage are generally a prototype, a process flow diagram, and a project plan.

SERVICE INNOVATIONS

A Service Innovation is an offering not previously available to a firm’s customers resulting from organisational development, work process improvement or changes in the service delivery; or the addition of a new service offering.

Two main components of service innovations are:

1. **Service product innovations** - the new or improved service offerings, such as, Apple App’s Store (marketplace of mobile applications), Google Maps (maps and directions services) or even valet parking services in top department stores.
2. **Service process innovations** - the new or improved processes employed to generate the service offerings or to make them available to the customers which could be the outcomes of:
    - organisation development, e.g., flattening organisational structures;
    - work process improvement, e.g., the use of IT to facilitate the reduction of the amount of steps required to complete a passport application; and
    - changes in service delivery, e.g., online banking (an additional channel that allows customers to make financial transactions by themselves without the need of visiting the bank)

SECTION 1: YOUR EXPERIENCE WITH SERVICE INNOVATION PROJECT

INSTRUCTION: Please answer the following questions by putting ✓ in the relevant box (□) or writing down your answer in the space provided.

Q1. During the past two years, have you ever involved in **the predevelopment phase** of any project that can be categorised as a service innovation project? ☐ Yes ☐ No (Go to Q43, page 9)

Q2. Please provide a brief description of the most recent service innovation project that you involved or are currently involving in its **predevelopment phase**:

____

____

____

____

____

____

Q3. In what stages are you involved in **the predevelopment phase** of the project mentioned in Q2? (Please select all that apply)

☐ Idea generation

☐ Idea screening

☐ Concept development

☐ Other: ______________________________

SECTION 2: OPENNESS IN THE PREDEVELOPMENT PHASE

INSTRUCTION: Please answer the following questions by putting ✓ in the relevant box (□).

EXTERNAL INNOVATION SEARCH

Q4. Please indicate the extent to which your team used each of the following sources of ideas, knowledge or information in **the predevelopment phase** of this project:	**Degree of Use**			
Clients or customers	☐ None	☐ Low	☐ Medium	☐ High
Suppliers of equipment, materials, components, or software	☐ None	☐ Low	☐ Medium	☐ High

Affiliates – parent companies or subsidiaries	☐ None	☐ Low	☐ Medium	☐ High
Competitors	☐ None	☐ Low	☐ Medium	☐ High
Commercial laboratories/R&D enterprises	☐ None	☐ Low	☐ Medium	☐ High
Universities or other higher education institutes	☐ None	☐ Low	☐ Medium	☐ High
Private research institutes	☐ None	☐ Low	☐ Medium	☐ High
Government research organisations	☐ None	☐ Low	☐ Medium	☐ High
Other public sector, e.g., business links, government offices	☐ None	☐ Low	☐ Medium	☐ High
Professional conferences, meetings	☐ None	☐ Low	☐ Medium	☐ High
Academic conferences	☐ None	☐ Low	☐ Medium	☐ High
Trade associations	☐ None	☐ Low	☐ Medium	☐ High
Technical/trade press, computer databases	☐ None	☐ Low	☐ Medium	☐ High
Fairs, exhibitions	☐ None	☐ Low	☐ Medium	☐ High
Technical standards	☐ None	☐ Low	☐ Medium	☐ High

EXTERNAL INNOVATION PARTNERS

Q5. what is the importance of the collaboration with the following external partners in **the predevelopment phase** of this project:	**Degree of Importance**			
Clients or customers	☐ None	☐ Low	☐ Medium	☐ High
Suppliers of equipment, materials, components, or software	☐ None	☐ Low	☐ Medium	☐ High
Affiliates – parent companies or subsidiaries	☐ None	☐ Low	☐ Medium	☐ High
Competitors	☐ None	☐ Low	☐ Medium	☐ High

Firms in other industries	☐ None	☐ Low	☐ Medium	☐ High
Consultants	☐ None	☐ Low	☐ Medium	☐ High
Venture capital enterprises	☐ None	☐ Low	☐ Medium	☐ High
Commercial laboratories/R&D enterprises	☐ None	☐ Low	☐ Medium	☐ High
Universities or other higher education institutes	☐ None	☐ Low	☐ Medium	☐ High
Private research institutes	☐ None	☐ Low	☐ Medium	☐ High
Government research organisations	☐ None	☐ Low	☐ Medium	☐ High
Other public sector, e.g., business links, government offices	☐ None	☐ Low	☐ Medium	☐ High
Trade associations	☐ None	☐ Low	☐ Medium	☐ High
Intellectual property organisations	☐ None	☐ Low	☐ Medium	☐ High

INSTRUCTION: To what extent do you agree with each of the following statements in the left column? Please indicate your answer by putting ✓ in the relevant box (☐).

SEARCHING CAPABILITY	Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree
Q6. It was part of the work in **the predevelopment phase** to collect, bring back, and report information about what is going on outside the company.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
Q7. There were systems and procedures for receiving, collating and sharing information from outside the company.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
Q8. In **the predevelopment phase**, the team members were encouraged to interact with the environment:	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7

competitors, customers, technological institutes, universities, suppliers, etc.

CO-ORDINATION CAPABILITY	Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree
In **the predevelopment phase** of this project, …							
Q9. We ensured that the output of our work (knowledge, expertise, resources) is of a form useful to our partners.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
Q10. We ensured that the output of our work is available to our external partners when needed (at the right time).	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
Q11. We ensured that the output of our work is synchronised with the work of our external partners.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
Q12. We ensured that the output of our work is available to our partners where it is needed (at the right place).	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
Q13. We ensured an appropriate allocation of resources (e.g., information, time, reports) with our external partner.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7

COLLECTIVE MIND	Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree
In **the predevelopment phase** of this project, …							
Q14. Members from both inside and outside of the firm make their contributions to the joint outcome with attention and care.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
Q15. Members from both inside and outside of the firm have a global perspective of each other’s tasks and responsibilities.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7

Q16. Members from both inside and outside of the firm carefully interrelate actions to each other to maximize joint performance.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
ABSORPTIVE CAPACITY	Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree
In **the predevelopment phase** of this project, …							
Q17. We were able to apply new external knowledge commercially and invent new service product or process.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
Q18. We were able to understand, analyse and interpret information from external sources.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
Q19. We could successfully combine existing knowledge with the newly acquired and assimilated knowledge.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
USE OF INFORMATION TECHNOLOGY (IT) TO FACILITATE PRDEVELOPMENT ACTIVITIES	Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree
Q20. IT was used to speed up the process of developing the new service concept.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
Q21. IT was used to identify and diagnose customer needs in **the predevelopment phase**.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
Q22. IT was used to share information that coordinates activities in **the predevelopment phase**.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
Q23. Communication flow within the new service development project groups was facilitated through IT-based channels.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
Q24. Our **predevelopment team** utilised technology to facilitate the flow of	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7

information to people participating in the new service development process.	

SECTION 3: UNCERTINATY REDUCED DURING THE PREDEVELOPMENT PHASE

MARKET UNCERTAINTY REDUCTION

Q25. Shown below are some items concerning market information available during **the predevelopment phase**. Indicate for each item how well you and other project members were informed by the end of **the predevelopment phase**.

Instruction: The choice runs from 1 (no knowledge existed for that subject) to 7 (we knew everything we had to know). Values between 1 and 7 reflect different levels of knowledge in the respective areas. Please put ✓ in the box (□) in front of the number that best reflects your choice.

The customer's needs (user requirements)	No knowledge existed for that subject	□ 1	□ 2	□ 3	□ 4	□ 5	□ 6	□ 7	We knew everything we had to know
The potential market	No knowledge existed for that subject	□ 1	□ 2	□ 3	□ 4	□ 5	□ 6	□ 7	We knew everything we had to know
The buyer behaviour of the potential customer	No knowledge existed for that subject	□ 1	□ 2	□ 3	□ 4	□ 5	□ 6	□ 7	We knew everything we had to know
The marketing strategy of the competition	No knowledge existed for that subject	□ 1	□ 2	□ 3	□ 4	□ 5	□ 6	□ 7	We knew everything we had to know
The technological strategy of the competition	No knowledge existed for that subject	□ 1	□ 2	□ 3	□ 4	□ 5	□ 6	□ 7	We knew everything we had to know

TECHNICAL UNCERTAINTY REDUCTION

Q26. Shown below are some items concerning technical information available during **the predevelopment phase**. Indicate for each item how well you and other project members were informed by the end of **the predevelopment phase**.

Instruction: The choice runs from 1 (no knowledge existed for that subject) to 7 (we knew everything we had to know). Values between 1 and 7 reflect different levels of knowledge in the respective areas. Please put ✓ in the box (□) in front of the number that best reflects your choice.

The quality of the applied technologies (e.g., information technologies)	No knowledge existed for that subject	□ 1	□ 2	□ 3	□ 4	□ 5	□ 6	□ 7	We knew everything we had to know

The user-friendliness of the technologies	No knowledge existed for that subject	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	We knew everything we had to know
The cost-efficiency of the technologies	No knowledge existed for that subject	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	We knew everything we had to know
The required R&D strategy for this project	No knowledge existed for that subject	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	We knew everything we had to know
The required technological support for this project	No knowledge existed for that subject	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	We knew everything we had to know
The required personnel for this project	No knowledge existed for that subject	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	We knew everything we had to know

SECTION 4: PROJECT'S SUCCESS

INSTRUCTION: To what extent do you agree with each of the following statements in the left column? Please indicate your answer by putting ✓ in the relevant box (□).

FINANCIAL SUCCESS	Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree
Q27. The new service was profitable.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
Q28. Total sales of the service were high.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	□ 6	☐ 7
Q29. The new service had a large market share.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
Q30. The new service exceeded its profit objectives.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
Q31. The new service exceeded its sales objectives.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
Q32. The new service exceeded its market share objectives.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7

NON-FINANCIAL SUCCESS	Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree
Q33. The new service had a positive impact on the company's perceived image.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
Q34. The new service improved the loyalty of the company's existing customers.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
Q35. The introduction of the new service enhanced the profitability of other company products.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
Q36. The new service attracted a significant number of new customers to the company.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
Q37. The new service gave to the company an important competitive advantage.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7

SECTION 5: DEMOGRAPHIC INFORMATION

INSTRUCTION: Please answer the following questions by putting ✓ in the relevant box (□) or writing down your answer in the space provided.

YOUR WORK EXPERIENCE AND PROJECT INFORMATION

Q38. What is your current position? ______________________________

Q39. How long have you been working in the current position? ____________________ years

Q40. What is the average number of years of experience of **the predevelopment team** members? ____________________ years

Q41. Shown below are some statements concerning the innovativeness of the new service innovation. Indicate to what extent that you agree with each statements.	Strongly disagree	Disagree	Somewhat Disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree

The new service is highly innovative; nothing like it on the market; replace vastly inferior service.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
The new service exploited technology that was totally new to the firm.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
Q42. How many major competitors of the new service?	________________ competitors						
COMPANY INFORMATION							
Q43. How many employees does your company have?	________________ employees						
Q44. When was your company founded? (year)	________________						
Q45. Do you consider your company as a start-up company?	☐ Yes	☐ No					

Appendix C: Quotes Relevant to FFE Activities and Openness

Case No. 1 - SmartEdu

Participant	*Front-end Activities*	*External Search*	*External Partnerships*
Project manager	**Opportunity identification** "Our company has always interested in applying technology – [mobile] applications – to the service sectors. We developed projects in health care, retail, and hotel sectors. So, we thought about education sector … in which aspect that we could possibly apply the technology." "We normally do some research first. In this case, since we focused on doing something that relates to education, we studied Thai education to find its weaknesses." **Idea generation** "We tried to think from the broadest perspective … the whole picture. [We thought] about what [features] we should have … 1, 2, 3, 4, and so on. After that, we then thought about where should we start? Where should we focus first? What are the most important things?"	**The Internet** "I kept updated with the news on the internet. Especially, last year's news on education about [the government's] tablet procurement and distribution dates." **Competitors** "For some products [of the competition], they [the features of those products] did not feel right. However, I thought that the competitors must have thought through about those features. They must have the reasons [why they included those features]. So if we want to compete with those products, we must come up with something better, right? So I gathered more information and tried to find better products." **Events and seminars** "As mentioned earlier, we wanted to focus on education. We investigated in more	**Communication – the firm and a pilot school** (teachers, parents and sixth primary level students are the pilot subjects) "I phoned or emailed them around 2 times per week on average. I also went [to the pilot school] to discuss with them once a week." "Both we and the school were happy with the partnership. We always communicated and updated with each other. […] We always updated them on the progress of the project." **Mutual interest and understanding** "There was a problem regarding the coordination between the ministry of ICT and the pilot school – about documentation. This is because both parties had to sign a mutual agreement document concerning the pilot of the SmartEdu system. […] The document that we had written was agree upon by the

	Concept development “After we had got the general ideas [of what the system can do], we then started to get into more detail. For instance, since we focused on using tablets to encourage participation in classrooms, we tried to think about more detailed features – e.g., what kind of actions that the teacher should be able to record?” **Piloting** “We interviewed the student, parents, and teachers who piloted the system. […] We observed the classrooms when teachers and students were using the application. We observed students’ actions. For example, the application provides four ways of answering a question, i.e., multi-choice, yes/no, short text and long text. We wanted to know how the students answered the questions and their typing habits in order to make modifications, such as what changes should be made to the UI [user interface].”	detail about the OTPC (One Tablet Per Child) campaign. Was this really practical? How could the tablets be used, etc.? Then, we analysed the information. Additionally, we studied our competitors. And, if there were any seminars and events about education, we went.” **Past experience** ““[When considering which ideas gathered from both local and foreign competitors’ products are interesting,] I used my past experience [the interviewee used to work as a teacher in a secondary school] when I taught in the classroom to think about what teachers really want based on my direct experience.” **End-users** “In addition, I also discussed with my friends who are teachers on what are their requirements? and how will they use the technology [tablets] if it is available?” “I observed a student’s daily life to whom I provided extra tuition sessions outside. Although, I did not interview the student, I observed his behaviour.”	ministry of ICT, whereas the director of the school suggested that some should be added to the document. Sometimes, the time frame of each party conflicted. […] As a result, the delivery of the tablets had to be postponed and, consequently, the pilot sessions had to be postponed as well.” “All parties knew each other’s role and responsibility very well. For example, since I always communicated and updated with the school on every steps of the process, when the postponement of the delivery of tablets happened, they understood that it was our [the company’s] responsibility for negotiating with the ministry of ICT [who is the provider of tablets for the pilot].” **Contribution** “The engineers who work in this project did not stand by for me all of the time. They had several projects. […] Since they did not entirely focus on this project, there were some bugs when I showed the application to our partner.”

		Academics "Later in the process, when I already had something to show (a prototype), I consulted a lecturer who teaches at the faculty of education of Chulalongkorn university whom I am familiar with. […] The lecturer is an expert in primary school education. I focused on asking about children habit and behaviour because her expertise is not in technology."	
Senior developer	**Feasibility analysis** "After we received the requirements [from the marketing team], we analysed the possibility of each of the requirements. Which can be done and which cannot. […] We discussed with the marketing team regarding the technical feasibility of each of the requirements." **Project planning** "I planned the timeline, such as when to launch, the development period, etc. Also, I assigned the personnel to support the project"	**Competitors** "We downloaded the competitors' products [from the internet]. We looked at them from a user perspective. We were able to try out which user-interface designs are easy to use and which features are good." **The internet** "When someone [in the team] found something interesting, we share them in meetings. We discussed about the ideas [that we gathered] concerning whether they can be applied to our project or how much time required to implement them etc. […] The 'drag & drop' feature is a good example. The team had not implemented this feature before. However, from the internet searches done in previous	**The respondent did not contact with any external partners. The respondent's responsibility was on the technical side of the project.**

	Piloting "We piloted with a school in order to find out whether there were any new requirements that we had not thought of or any user interface issues."	projects, the team had seen other apps that had this feature. So, we were sure that it can be done. What needs to be done is some additional research, so they used less time to gather the information since they had already known where to look?" **Assimilation of external knowledge** "We regularly had small meetings for sharing knowledge and ideas [from external searching]. We shared what we found and discussed how those ideas can benefit our project. Are the impacts positive or negative? How much time do they need?"	

Case No. 2 - AppCreator

Participant	*Front-end Activities*	*External Search*	*External Partnerships*
Business development manager	**Opportunity identification** "When businesses or shops want to implement a loyalty programme, club card or discount voucher, they usually use paper or plastic cards. If you are a regular at 10 shops, you will end up with 10 – 20 cards in your wallet. Some women have to have a purse of cards, right? But if you are a man, you might just throw them away. So, we thought: why does it have to be this way? Mobiles – iPhones or BBs – and the Internet have increasingly been playing an important role in our lives. We thought a 'mobile app can handle this!', so this project emerged." **Idea evaluation** "Our marketing team did some research on the competitors – what were they doing? What did the market wants? And where the trend was going? For example, we registered to competitors' website and created applications to see whether the process was as easy as they advertised or not. We called this process 'competitor research'. By of doing this with many	**Why external search is important?** "Before we started the process of generating ideas or doing anything. Typically, we studied others to see what they were doing, how can we do better? We needed to understand others [the competition] and the market. […] Because if we do not understand the others [competitors' products], we cannot produce something better." "When a new technology came to the market, NFC technology for an example, our marketing team and engineers had to do some research. The marketing team studied the possibility of supporting the redemption privilege mechanic with NFC technology, while the engineers researched on how others were using NFC. Was it technically possible to use NFC to support our redemption processes?" **Academics** "We consulted a marketing professor from Chula [a university in Thailand]. Actually, he did not involve in the idea generation	**Supplier - Microsoft (Windows phone)** "Before they [Microsoft] allied with Nokia, they supported the development of our system for Windows phones' platform by providing us training and seminars. They also helped us to public on their store since there was no Thai app store at that time." **Presence of a workable prototype** "Before they [their partners] decided to partner with us, they asked about our expertise and resources. The most important thing was that we had a prototype to show them. This was very important since a prototype reflected many things, such as professionalism, expertise and understanding of the market, etc."

	competitors, we can analyse them to find their strengths and weaknesses." **Idea generation** "The features of this product were based on feedback from customers, marketing research findings and competition research. The four of us [members of the front-end team] did the research and then brainstormed on what features we should have" **Concept development** "We assigned responsibility for each of us [in the front-end team]. For example, one was assigned to think in more detail regarding the business side – how to make money? Another was responsible for the marketing side – what the users should see? – [concerning] the screen design or IU [user interface] and the process or UX [user experience]. Another was to come up with technical feasibility – whether a particular feature can be implemented?"	stage. We went to him for his advice after we finished thinking. He gave us his opinions concerning the feasibility of this project based on his experience. He also gave advice on what should be included in order to meet customer needs." **Prospective customers** "The initial idea was to move from plastic cards and paper vouchers to mobiles. After trial and error for a while. We started to feel that this did not address customer needs, because customers wanted to have their own [mobile] application […] [The inspiration for the AppCreator project was] from (1) observations, (2) feedback from customers and (3) When we participated at 'CommunicAsia' in Singapore last year [2012], we received a customer's comment saying that 'This loyalty programme application is what I wanted, this is the right feature but I wanted to have it with my shop's name'[…] It [AppCreator] transformed [from an application used to store loyalty cards and vouchers or a cardholder replacement] to an application creator platform specialised in the loyalty programme features."	

		End-users and customers "We also conducted marketing research by asking our target groups, i.e., females aged 18-25 who carried a card holder bag for their cards [e.g., loyalty cards or paper voucher] and had an iPhone. […] The other target group are businesses or merchants who used the [AppCreator] system to create a mobile application or a loyalty programme on mobile. […] We interviewed and asked small and medium-sized business owners (e.g., coffee shops, restaurants or tailor shops), whom our team members know in person, to fill in a questionnaire." **Competitors** "Our marketing team did some research on the competitors – what were they doing? What did the market wants? And where the trend was going? For example, we registered to competitors' website and created applications to see whether the process was as easy as they advertised or not. We called this process 'competitor research'. By of doing this with many competitors, we can analyse them to find their strengths and weaknesses."	

		"I stressed to the team that we need to study the others first to know what they have been doing. In order to do as good as or even better than others, we need to understand them first." **The internet** "In addition to studying the competitors and conducting marketing research, we followed the market trend from reading news [on the Internet]. We also read technology news. What is hot right now? What is the latest technology? Because some new technologies could be used to support our product."	
Project manager	**Opportunity identification** "When we started, I heard about a Thai record company wanted its artists to have their own [mobile] app. I was thinking that if creating an app takes 4 months, the artist may be dated by the time the app is finished. So, I did some research on the internet and found that Madonna has her own app which was created from Mobile Roadie website [http://mobileroadie.com/]. Instead of focusing on celebrities [like Mobile Roadie], we targeted on small	**Two key aspects focused during knowledge search** "It should be divided into two aspects: technology and competitor. For the technology aspect, I had to say that we tried to keep up with new innovations coming out for both iPhone and Android devices. Our system must be able to support them. For example, earlier this year, Apple introduced Passbook [in iOS 6]. AppCreator should also able to add contents into Passbook. […] In addition, we always read news and followed media. The developers sometimes came to me	**Pilot shops** "We had several pilot projects. We approached organisations to give them a free trial of our product e.g., a beauty shop, an online cloth shop and many more. We piloted with around 10 organisations with the aim to test whether our product can be commercially used in real situations." "We asked them [the pilot shops] about their opinions on the product. We wanted to check their attitude toward the product and the possibility of buying the product.

	businesses, loyalty program and app creator as our three core elements." **Technological feasibility analysis** "[We were concerned about] the technological viability of this project. If the senior engineer who was responsible for investigating the issue suggested that it was not possible to develop such a product, the project would have been terminated. This was the main risk." **Project planning** "[In the FFE phase] we summed up the requirements and identified the specifications of the prototype and planned the timeline – i.e., in 2-3 months' time, what we should be able to accomplish." **Idea screening** "We had to present [the idea] to the board [of the firm]. Before we started specifying the requirements we had to convince them of investing in this project."	with interesting ideas from playing new gadgets or their mobiles that had interesting features. With regard to the competition, it was quite obvious that if we wanted to compete with competitors, we must have some features that are better than theirs. We analysed competitors' products in order to identify what [features] they already had and what that they did not. If the competitors cannot do anything we must be able to do it. We also competed in pricing. What was our positioning in the market? Which price range that allowed to be able to compete? We did not do price war though. [In sum,] We knew our strengths and always kept up with the competitors." **Competitors** "We conducted a research on the cost of creating an app in the US. We found that it ranges from 1,000 USD to 50,000 USD. Actually, the 1,000 USD was quite rare. The average cost that we calculated was around 10,000 USD which was very expensive in Asia or even in the US."	What do they think about the price we set? What additional features do they want?" **Dedicated contact point** "We assigned one marketing staff to support [the partner and pilot organisations]. […] This one person – his job was to closely take care of the partners who co-developed their (mobile) application with us. What are their needs? Does our system capabilities match their needs?" **Lack of Background knowledge** "Since our partners were not in the IT business, they sometimes did not know what they really wanted. So, our marketing team had to interpret their requirements, their problems. Occasionally, this led to confusion or missing the main points." **Mutual interest** *Interviewee:* "In this project, all team members placed their utmost importance on common interests. They were ready to work hard so that the whole project went

		Customers *Interviewee:* “We talked to stationary shop owners, cloth shop owners, restaurant owners, cake shop owners, car showroom owners and resort owners. We asked them ‘do they want an app?’ They said they wanted to have an app. We also asked them about what the acceptable price range is and what kind of features that they want to have on their app […]” *Interviewer:* “Could you please give me some examples of the ideas that you got from them and eventually applied to the product?” *Interviewee:* “They wanted to be able to sell through the application created from our system. They wanted the application to make money for them. For example, the cloth shop suggested that the customer should be able to create purchase orders on the app. We took that comment and came up with a requirement to have the m-commerce plugin attached to the app created from our system. We also topped up that idea by planning to allow the shops to create products on our system that will be published on their mobile account. At the same time, the data will be synced to the inventory [data] of their cashier [point of sale system].”	smoothly. This may be due to our working relationships which were like a family.” **Understanding of roles and responsibilities** “We work like a family. We do not use corporate rules and regulations to force the employee. We trust that everybody knows their role. I think it is called ‘internal marketing’ which means that everybody works with care and think of others in the team as if they were customers.”

		Past experience "Prior to this [AppCreator] we developed an application providing services focusing on loyalty programmes on mobile. Many shops had used it and a lot of users downloaded the app. We gathered complaints from that and we knew which feature had never been used by the users. […] We used past experiences to envisage the future" **Background knowledge** "The team must have a strong foundation knowledge so that they can cope with the ever changing world of technology […] Regarding technology, the R&D team was be able to quickly understand and implement new technologies. They had good foundation knowledge so they were ready to adapt. In the front-end phase, our marketing did their homework quite well and gathered enough information."	

Case No. 3 - MobileShopApp

Participant	***Front-end Activities***	***External Search***	***External Partnerships***
Senior designer	**Idea generation** "In the front-end phase, I gathered the requirements, both from users and our marketing team. Also I studied other applications in the market." **Idea evaluation** "We showed screenshots to users. Specifically, we invited two groups of users: (1) users that were new to 'MobileShopApp' and (2) users that had have previously used the app. We let them play the app [the prototype] first to observe how they use it and whether they face with the problems that we anticipated. When they found the problems, we then showed them various screenshots and asked them whether these could solve the problems, or not."	**End-users** "Users told us their problems, e.g., their product pictures did not look attractive [in the application]. We gathered all the problems." "[When testing the prototype with users] the interviewer had to observe the users' face at all times. Must read what they [the users] anticipate when pressing a button. When they say something likes 'it is ok', it is usually negative when 'it is ok' comes up. If it is really ok, they will not say. They will just continue." **Competitors** *Interviewee:* "At the very beginning, I played a lot of apps. I stored [the ideas] in my personal repository. When I had a problem, I rifled through [the repository] in order to find how others had solved the problem."	**Intermediary** – JFDI (Joyful Frog Digital Incubator) "The team participated in a boot camp organised by JFDI. The company facilitated us by providing mentors who were specialised in the fields related to the product." [Mobile Shopping App were runner-ups of a start-up competition in Thailand. As a result, they had the opportunity to join the 100-day boot camp in Singapore organised by JFDI.] **Sponsors** – A Thai telecommunication service provider company (the main sponsor of the start-up competition that Mobile Shopping App team attended) "The firm supported us with user database and information of their services. For example, as they have their Apps Store, they told us what we could do with the store. They also had 2-3 million users following their Line [the most popular messenger app in Thailand] account. They also provided us the information about their SMS services. We needed this

		Mentors "[At the boot camp] A mentor advised me that I should design the marketplace screen with 3 pictures per row not 4. I was choosing between 3 or 4 pictures per row. He strongly suggested that I should do 3 columns. He told me that he did 3 columns and his transaction figures went up. Since then I have never changed the three-column design." "When we were in Singapore [i.e., the boot camp], we had a lot of mentors. They gave us advice on various topics, e.g., business, design, and coding. Not many mentors for designing though, whereas we had a lot of business mentors. Mentors who advised about coding gave us suggestions on which works and which does not work [technologically]." **Background knowledge** "Actually, my background was not as a graphic designer. I was a furniture designer before. […] Since I have an undergrad degree in product design, it was like I had the foundation knowledge of design. I just had to do some additional study in the Internet on the basic rules of [mobile] application or website design."	information to help us determine the direction of our application." **Balancing the needs** "Balancing [the needs] was the most difficult part. I had to negotiate with both parties [i.e., users versus programmers]. I hardly negotiated with the users though. I always listened to their requests and then discussed with the programmers about the possibility. If they said it cannot be done, I will go back to the users again or may be revise my design. Repeat this process until everybody was happy." **Mutual interest** "The benefit of us joining the boot camp in Singapore was that all parties [intermediaries, investors and mentors] thought that this project was their work as well. Since they thought that our project was their work, they were willing to help, no holding back."

		Assimilation of external knowledge "If we just copied [other products], it is possible that it might not work because the nature of each product is different. For example, one of the mentors told me that I should use sidebar over tabbar at the bottom like Facebook App. However, from my experience [from the previous project] tabbar was actually better."	
Marketing director and co-founder	**Feasibility analysis and project planning** "The CTO estimated technological feasibility, while the business team looked at the business side. The design team did the initial design constrained by both the business and technology [requirements]. I used this information to prioritised tasks." **Prototyping** "At the very beginning, we just developed a series of screenshots. We then put them on our website where people can register for updates. With this [process], we can prove that there was a need for this kind of service, that we could build traction. After we knew that this concept is ok, we then developed a prototype which was used to test with users again. […] Risks and	**The internet** "We always read 'Techcrunch' and 'Mashable'. The business team usually shared articles about start-ups in other countries. We tried to follow Silicon Valley on their activities, interesting new products and innovations, and models that they employed to be successful. We used to use a bookmark sharing service – i.e., Delicious [https://www.delicious.com]. But now we are using Facebook group." **Mentors** "At the boot camp [organised by an intermediary - JFDI], the accelerator [JFDI] provided us with a variety of mentors – i.e., investors, CEOs, graphic designers, etc. They helped advising on our product."	**Mutual interest** "Mentors, they wanted us to be successful as well. They saw us as a promising start-up. They suggested and helped us to improve the product. One of them told me that he wanted to see this product because this was innovative and he had never seen one. […] The accelerator [JFDI] also tried to push forward our product to the investors because they all wanted to see a good product be successful." **Understanding of roles and responsibilities** "Everyone knew their responsibilities. For example, issues related to payment gateway was responsible by the CTO.

	uncertainty were gradually reduced at each step.”	**Top management support** “Actually, initially most of our team prefer working in their comfort zone. However, our visionary CEO told us that he adheres to the principle that you have to get out of the building in order to ask others for ideas or attend seminars. […] Finally, we tried to find the time to go out.” **Event and seminars** “We benefited a lot from the boot camp, the mentors and their suggestions were very helpful. There were also seminars gave by CEOs on how did they run their company and what kind of technologies that they used.” **Background knowledge** “Before we know about any tasks well enough, it is always very difficult to estimate [the development time]. However, in this project, since we had some experience [in web and mobile app development], we was be able to estimate the development time.”	Regarding user experience, I always asked the designers.”

Chief technology officer and co-founder	**Feasibility analysis and project planning** "When there were new features or requirements from the business team, we would have a small meeting [involving] one from the business team, one from the design team and me representing the developers. We discussed on timeline and feasibility." **Prototyping** "The business team tested the product [the prototype] with users for comments on features, ease of use and the validity of the product concept. We then discussed about the feedback."	**Top management support** "We had weekly meetings for sharing new ideas. For interesting ideas, I asked the team to dig deeper. […] When an application shut down, I asked [the development team] for its flow chart and the reasons why this particular app was shutting down." **Competitors** "In the next room, actually, there is a flow chart of a competitor's application. We drew it step-by-step. Press this button and go to where? How many steps 1-2-3-4-5 needed for logging in? In the case that we wanted to have a similar feature, we would study the competition's process. What are their weaknesses and how to improve?" **Information overload** "Since we discussed with many partners [i.e., users, mentors, investors, etc.], a lot of ideas were obtained. For example, we may receive ten different comments from ten people. […] Information overload sometimes happened."	**Knowing partners' expertise** "Prior to a discussion with a mentor, we must know about the mentor's expertise and what do we want from him or her?" "When we meet with mentors, we usually went with a team of 2-3 people. […] We usually started with a short introduction about our background knowledge so the mentor can gain a brief understanding on our team." **Presence of a workable prototype** "[In the meetings with mentors,] we showed them our product … our prototype so that they can comment on it. Mentors usually asked whether we had a product [a workable prototype]." **Understanding of roles and responsibilities** "As mentioned earlier, we usually attended mentor meetings with 2-3 people from our team. This is because each of us has different expertise. For example, the business took responsibilities for business questions and I had to response to technical questions and technically

			analysed mentors' recommendations. Each of us knew our responsibilities." **Benefits from participating in the boot camp during the FFE phase of this project** "We learned about the [innovation] process from the boot camp. […] When we came back, since the development process had been set, we can now focus on how to improve other aspects of the project. I did not have to set up a process and assign responsibilities. Everything have been planned [during the FFE phase at the boot camp]."

Case No. 4 - OnlineShopCreator

Participant	***Front-end Activities***	***External Search***	***External Partnerships***
Chief executive officer	**Opportunity identification** "Prior to this project, we provided [website] hosting services. However, the customers requested for services that were more advance. They wanted to have a website but did not know how to build one. At that time, we just recommended using content management system (CMS) [e.g., Joomla, WordPress, etc.]. In general, CMS was not built for Thai users. [The CMS is] Quite difficult to use. Moreover, systems of the most famous online shopping websites, i.e., market.com and shopping.com, at that time were outdated. […] So, we decided to develop this system." **Short FFE phase** "Actually, we did not spend much time [on the FFE phase]. Because we are developers, so we just roughly visualised the product concept. […] The idea generation phase was very short. We started developing some of the parts and then went back to discuss how we can improve them."	**Similar products** "We compared the features of Thai websites with foreign websites. We took what we thought useful and ignored those that we thought unnecessary." **The internet** "For the back-end systems [shop administration systems], we focused on making it easy for the customers to make adjustment and decoration to their online shops. For the user interface, the design team searched in the Internet studying how foreign websites were doing. Were they really easy to use? And How can we improve?" **Government agencies** "At that time, there were training sessions focusing on business planning organised by Software Park Thailand [http://www.swpark.or.th/]. We attended the training and wrote up the business plan of this project."	**Confusion over roles and responsibilities** "We never have a clear organisational chart. […] There was also some problems particularly for issues requiring long term attention. For example, recently, we had to submit a document to the Bank of Thailand. However, nobody was directly assigned to do this task. I thought that the other guy in the team would do it. But he thought that it was my responsibility. As a result, we missed the deadline." **Why not involve external partners** "I did not ask for ideas or help from others outside because I used to develop e-commerce websites and have also been involved in almost every stage of the e-commerce process. […] Therefore, I think I know what a [e-commerce] website wants. […] I and another in the team [who also has knowledge about e-commerce] understood the user's perspective to some extent, so we hardly asked for comments from the outside."

		"Software Park Thailand had [an organisation called] NEC [New Entrepreneur Creation]. […] Their job was to support SMEs like us. Since we seemed to show some potential, they kept in touch with us and invited us to attend their seminars and training sessions. Recently, they provided us a consultant to advise us on management, HR and marketing. " **Why not ask customers?** "It [this type of services] was not something new. We knew what we needed to know by studying the competitors. I did not think that customers would be able to provide more advanced requirements. We had to think by ourselves. […] This is because customers usually become attached to the concepts of the old systems [their competitors' systems]."	
Managing director	**Idea generation** "Initially, I checked Thai competitors whether they had a particular feature, or not. If not, did their customers complain? If they were to have, I would have a better one. After that, I looked into similar foreign products."	**Similar products** "In the front-end, I did not come up with many features myself. Many ideas actually came from similar foreign products. They were way more advanced than us."	**Why not involve VC** "Actually, we did have several venture capital (VC) firms showing interest in our product but we declined their offers. VC usually focuses mainly on making money. […] Moreover, VC might come in and change our company directions and visions in order to make more profit. And, it

	Concept development "After we had the main ideas of what we were going to develop, we started designing it. How would it look? [user interface or UI] How would it work? [user experience or UX]"	**Past experience as a substitute for external knowledge** "For the back-end systems, since the CEO used to sell online before, he knew all difficult, problematic parts of the process. He knew where in the delivery and payment processes that could go wrong. We used his knowledge to improve our back-end systems."	would be worst if our company were to be sold to foreigners." **Overlapping roles and responsibilities** "Each of the team members were responsible for multiple tasks which sometimes overlapped. Some tasks were similar which had been taken care of by two people with overlapping responsibilities instead of one."

Case No. 5 - PriceCompare

Participant	***Front-end Activities***	***External Search***	***External Partnerships***
System architect and co-founder	**Opportunity identification** "At the very beginning, we discussed about venturing into IT business. Each of us evaluated what their wanted to do and present to the others. At that time, although the internet was thriving in Thailand, but it was not the case for e-business. Since Thailand was still far behind other [developed] countries, we did some research on interesting online services in other countries." **Idea generation** "We studied [similar] websites operating in other countries. What information does it provide? What features does it have? […] We tried to gather the good parts of each websites and chose the parts that we thought may work with Thai people." **Idea evaluation** "We discussed about competitor uncertainty when we evaluated this idea.	**Similar products** "We studied [similar] websites operating in other countries. What information does it provide? What features does it have? […] We tried to gather the good parts of each websites and chose the parts that we thought may work with Thai people." **End users** "We interviewed end-users [friends] about the website. We gathered their comments in an excel file." **The internet** "We searched for ideas and knowledge from the internet. For me, I personally read books on online marketing or online entrepreneurs in order to know what did they do? and how did they do it?"	**Co-development with consultancy** "We knew that we were unskilful in some areas, so we hired an expert from the outside. We hired a website designer to design the user interface. However, we controlled the main concept and features."

	We did a SWOT analysis in order to understand the competition." **Resource planning** "After that, we studied on how to actually implement it [a price comparison website]. We assigned tasks based on expertise of the members. One member who is good at coding was assigned to find the technology that should be used for the engine. Another did some research on the front-end [the front-end of the website or website design] and the other worked on business model." **No workable prototype** "We did not see much about developing a prototype. We started planning on the timeline – when should we lunch and how long should it take of each of the tasks."		

Case No. 6 - OnlineStockTrade

Participant	***Front-end Activities***	***External Search***	***External Partnerships***
Project manager	**Idea generation** “After we decided to serve Android users, we then considered about what technology that we should use. There were two options (1) pure app and (2) web embedded in app. However, we discovered several problems related to the first option.” **Idea evaluation** “I asked my friends who developed Andriod applications. They warned me of several problems. Since there were a lot of potential problems and we anticipated only a moderate volume of users. Based on our marketing research, the majority of people who trade stock on their mobile use iPhone or IPad. Therefore, we did not want to spend a lot of effort for little return. So, we decided to develop with the ‘web embedded in app’ concept. However, we knew that there was a risk of displeasing the users because [the response time of] an app-based [application] would be a lot faster than a web-based [application] for sure. […] But we went with this decision	**Similar products** “Actually, prior to this project, we knew that Facebook app was also using web embedded in app. We did not particularly enjoy Facebook app experience at that time because it was not very smooth. Nevertheless, the performance was acceptable. Therefore, we decided to go into that direction.” **Competitors** “Our marketing team always kept update with the competition. If they found that the competitor had an interesting feature, they would email us asking whether we had a similar feature if not they would update us and we would discuss. What should be done? Should we include the new feature?” **Events and seminars, the internet and experts (friends)** “We sent our people to training focused on Android app development, however, not related to ‘web embedded in app’. Therefore, we had to search for more information from the Internet – finding out about components that can be used	**Understanding of roles and responsibilities** “It was made clear about who was responsible for which tasks. No need to argue about who do what. It was very clear that which person was responsible for design, which person was responsible for presenting the design to the higher-ups, which team consulted with brokerage firms. […] In this company, this kind of role structure is similar in other projects as well.”

	since the objective of this project was only to provide a new channel [for their existing users] not to compete with the competition.” **Concept development** “This final step [of the FFE phase] was screen design. This was done by the marketing team. They designed the website to look as similar to a [native] mobile application as possible.”	to help us code easier, faster and tidier. Moreover, we asked experts outside of the firm for their opinions and advice, actually, from my friends who develop Android apps.” **Encouraging external search** “I asked them [team members] to find me a solution for the issue. They will go to find and present me with several options. Sometimes, I asked others [outside of the team] about the problems. As they suggested several solutions, I then asked my team to do more research about the options. My team members were fast learners and eager to learn.” “The developers in our team usually kept up-to-date with new technology. They sometimes came to me with the ideas of applying a new technology [to the product].” **Background knowledge** “We had a problem with the [mobile] application part which we had never implemented before. Basically, we can develop it. We can make it work. However, we did not know how to make it work well because we did not have any background in it before.”	

Senior marketing executive	**Idea evaluation** “During the design phase, we discussed on the architecture of the application – a native app or a web-based program [i.e., web embedded in app]. We discussed on the possibilities regarding both options in various aspects. In addition to functionalities, we also focused on performance issues associated to the users’ experience.” **Concept development** “After we thought through the main functionalities [of the product], we designed the layout. Then, we talked with higher-ups who had the power to make the decisions. […] We discussed about the layout and usability. The most important thing was the usability – the existing users must be able to use with ease and not to be confused.”	**The internet** “I searched for information in the internet mostly information that was shared in blogs about Andriod. Also, I checked users’ comments of the competitor’s product in the Google Play store to find issues that might concern us.” **Background knowledge** *Interviewee:* “The testing suffered severe delay. Some weird bugs were found in some models [mobile devices], but not in others.” *Interviewer:* “What do you think caused the problems? Why did the bugs had not been discovered earlier?” *Interviewee:* “In the front-end phase, we could not test because we only have a prototype not the completed program. In addition, we did not have any experience in Andriod application development.” **Assimilation of knowledge** “We made decisions on the inclusion of any features based on the amount effort needed and the constraint that any new features must not make the core system more complicated.”	**Why not involve customers?** “If we were to ask for their [the customers] comments in the early stages, the development process would have been more difficult. Because it would be chaotic if someone were to direct us ‘you should put this button here’, ‘labels should be named like this or that’ or ‘I want this colour not that one’. Moreover, since this product belongs to our company, […] we should have the control of how the design or usability should be so that the final product will have the scent of our company or have our signature on it.”

Appendix D: Quotes Relevant to Uncertainty Reduction during the FFE Phase

Case No. 1 - SmartEdu

Participant	*Market Uncertainty*	*Technical Uncertainty*
Project manager	**Uncertainty about different kind of users** "The other uncertainty is that there are many types of school. For example, schools in Bangkok may be different from provincial schools. We did not collect the information from schools located in rural areas though. We planned to collect more information in the same time period as the government. The government planned to measure the OTPC campaign's performance six months after they distributed all tablets." **User acceptance** "We also concerned about the teachers whether they will understand all functionalities of the system or not. Actually, it does not have as many functionalities as the foreign platforms. Nevertheless, this is very new to the teachers. We were not sure that they would be able to understand." **Past experience could be used to reduce requirement uncertainty** "[When considering which ideas gathered from both local and foreign competitors' products are interesting] I used my past experience [as a teacher] when I taught in the classroom to think about what teachers really want based on my direct experience."	**Production environment vs. development environment** "Since we are an IT firm, there are differences between the test environment in the company and the real environment in the schools. For an example, we were using Mac while they were using Windows XP. Due to the difference, there was a situation when I was presenting our system to the teacher, the application just stopped working. So, now we encourage our engineers to test every scenarios."

	Uncertainty in the government policy “Right now, Thailand is preparing to participate in the AEC [Asean Economic Community]. In the current situation, there are 8 subject areas in total. Initially, we planned to build one app for each subject area. However, the recent news say that the subject areas may be reduced to only 6. Which will be included in those 6 subject areas? We cannot precisely predict.”	
Senior developer	**The informant did not perceive any risks or uncertainty associated to users or the market. This is because her responsibilities mainly involves technical aspects of the project.**	**Lack of technical knowledge may cause deviation in the timeline.** “There were two risks. The first one involved screen resolution. Secondly, some features, such as dragging an answer and dropping it into the right place, we were not familiar with such a feature. We did not sure whether it would work smoothly or not. We had to do some research first that it was actually feasible to implement this feature. We found that it can definitely be done but we still did not know how long it would take to actually implement it. This is a risk so I estimated additional development time for this feature.” **Past experience can help mitigate technical uncertainty** “For the screen resolution problem [i.e., different models of Android devices have different screen resolutions], it is a general problem. Our development team had a lot of experience from previous projects. They knew how the screen should be placed to support all devices. Moreover, early in the development process, we tested with various models.”

Case No. 2 - AppCreator

Participant	***Market Uncertainty***	***Technical Uncertainty***
Business development manager	**Customer uncertainty** "Most importantly, we must understand the customers. To understand the customers, we conducted market research by asking target groups, business customers, and end-users. This helped us to know the needs of each type of customer. […] This also helped reduce uncertainty related to customers, in the case of selling the product to business customers in particular." **Competition uncertainty** In case that a big IT company, e.g., Google or Facebook, comes into play in the same field as the product that we are going to develop, this would considered as competitor uncertainty." **Uncertainty regarding the marketability of the new service** "We consulted a marketing professor from Chula [a university in Thailand]. Actually, he did not involve in the idea generation stage. We went to him for his advice after we finished thinking. He gave us his opinions concerning the feasibility of this project based on his experiences. He also gave advice on what should be included in order to meet customer needs."	**Being a first-mover or not** "Secondly, technological uncertainty. It concerned when a new technology comes to the market, we have to trade-off either being a first mover or playing it safe. If we are fast to react but the technology never reaches the mainstream, we may risk wasting both time and money. For example, when Passbook was first available in the iPhone – in iOS 5, if we mistakenly thought that a lot of people would use it and tried to support it, we would have wasted our resources."

	Uncertainty about pricing strategy "Our concerns involved businesses who may want to use our system. Typically, when a new technology is available to them, they have to weigh the benefits gained from using the technology against the costs. […] If the cost of doing the old way is more affordable, although it may be difficult to obtain the stat [if they use the old paper-based methods], they may not choose to use our product."	
Project manager	**Concerns on marketing strategy** "Uncertainty about marketing strategy was a concern. What do we have to do to sell? How should we price? Sell to whom? And where to sell?" **Uncertainty in market situation** "When we first designed the screen size. We thought that the best screen size should be the iPhone 5's. As a result, we based our design on the iPhone 5's screen. However, recently, the sales of Android devices have increased significantly. We had to adjust the screen size to support 5-inch Android phones."	**Technical uncertainty was reduced by studying the technology that similar products are using** "We saw some [similar products] were using the technology [that was employed in this project]. However, the majority of the similar products in the market were actually mobile site builders. They only created a mobile site and a mobile application that can only show the mobile site in the middle. […] It might have the flexibility of a website, and it might not need to be re-published [to the mobile application marketplaces] but it is very slow and laggy." **Project management uncertainty** "The risk of project management was also high. In my opinion, this [product] could be considered new-to-the-world [based on their previous experiences]. We could not set the timeline based on previous experiences. … Everything depends on our development team [Technological] capability."

Case No. 3 - MobileAppShop

Participant	*Market Uncertainty*	*Technical Uncertainty*
Senior designer	**Keep up-to-date with the market situation** "We did not really afraid [of market uncertainty]. At that time, we felt that the timing was right. Because we started 8-9 months after Instagram started being popular in Thailand. We also felt that the number of people who used smartphones were constantly increasing. At that time, although Facebook mobile was still suck, Instagram however did show the 'WOW' factor of using smartphones. Therefore, we thought that, for Thai people, the timing was right. […] Last year, more and more people started selling things on Facebook. We thought that was not the right channel. Facebook did not built for selling things. So, we thought that MobileShopApp was the right answer [for online shopping]."	**Use of proved technology** "[Technologically,] Our product was not that innovative, not that new. At that time, some of the functionalities had been proved by others already. The uniqueness of MobileShopApp was essentially its ability to bring sellers and buyers together. The other functions were similar to others [similar applications]; and thus had been proved by the others. For example, taking photos by mobile, the design of the feed page, etc." **Consulting experts to reduce uncertainty** "That [consulting with mentors] is very important, because mentors can give us what they learned when they were working on their project like us now. […] For example, when I was deciding whether to go with 3 or 4 rows of pictures in the feed page, they told us with confidence that we must have only 3 rows. They told us that when they used 3 rows their transactions went up significantly."
Marketing director and co-founder	**Market and user uncertainty reduction** "At the very beginning, we just developed a series of screenshots. We then put them on our website where people can register for updates. With this [process], we can prove that there was a need for this kind of service, that we could build traction. After we knew that this concept is ok, we then developed a prototype which was used to test with users again. […] Risks and uncertainty were gradually reduced at each step."	**Concerns on capital funding** "Financially, we focused on three topics: recruitment, acquisition and performance. For example, if the performance [of the system] is not as expected, we might have to acquire more servers or even have hire more staff to help improve the performance. These all cost a lot of money. Also, we had to forecast on further investment after the service has been launched."

	Market uncertainty "The main concern was that the service may not be able to build traction. We were worried that the number of people who register may not reach the target. This was the most important factor affecting the attractiveness of our application. Attractive to investors and others. Also, if we publish the app to the app stores and nobody downloads, it would be a failure. […] We depended on the mentors' guidance. They guided us on promotional channels, ways to attract users, PR methods."	**Past experience help in project planning** "Before we know about any tasks well enough, it is always very difficult to estimate [the development time]. However, since we had some experience [in web and mobile app development], we was be able to estimate the development time."
Chief technology officer and co-founder	**User needs** "The most important concern was whether the problem that the product is trying to solve really exists. Even though we asked the users – 7 out of 10 users said yes, I was still worried that the product may only serve [the needs of] a small group of people which may not be enough to build a business on. […] [To mitigate the risk,] We conducted a survey and uploaded a series of screenshots to a mock website saying a new mobile application was about to launch. We asked those who were interested in the product to register." **Product Quality** "The next uncertainty was about whether our product can actually help solve user problems. I mean the functionality of the product. […] To reduce the uncertainty, we did involve users in the design phase. We showed them the design. I thought that users might be able to identify problems in the design. We did not have to waste the time developing [a workable prototype] and found out later that it does not work."	**Project team uncertainty** "I also concerned about the team. We cannot know how long everybody in the team will still be working together. We had to thing about this uncertainty. In the case that one day a team member quits, this person's knowledge must not lost." **Users involvement help prioritise tasks** "There were also uncertainty regarding resources and timing. Some ideas were not possible to implement without prerequisite features. For example, based on the fact that users told us that they wanted a credit card payment system, we wanted to implement a payment system. However, after some research, we found that it was a requirement that merchants have to provide us with some kind of identification. Trust and security issues were the main concern. Consequently, we concluded that this feature was not viable since too many prerequisite features were required. Let's assume that there were 5 prerequisite functions. In this case, we asked the users – 'which of the five is the most important?' We then prioritised the tasks accordingly."

Case No. 4 - OnlineShopCreator

Participant	Market Uncertainty	Technical Uncertainty
Chief executive officer	**Market uncertainty** "One of the problems [that might happen after launch] was that the initial growth of the user base might struggle because we were new to the market. We countered the problem by not charging for our basic package."	**Study competitor's mistakes and come up with preventive measures** "Because we saw how the competitor's servers went down, we put in preventive measures at the very beginning of the development process. The main problem of this particular competitor was that their servers went down quite often and for a long period of time which put off the customers. The cause [of the problem] was that they only had one set of servers to serve several hundred thousand stores [customers' online stores]. So, the failures were unavoidable. We therefore split up our system into many sub-systems […] to mitigate the risks."
Managing director	**No real concern about market uncertainty** "We did not concern about traction. We were quite confident that the product is good and people will like it. If things are not as we expected, we will just have to find another way to make it works. We were not really worried during the idea generation phase." **Balancing the needs** "There were risks about what the customers (who shop in the merchants' website) would think about the features. Will they like it? Will they have any bad feelings if we come up with a feature that the merchants (who use the website creator and hosting services of the firm) like, but the customers hate. We had to balance their needs."	-

Case No. 5 – PriceCompare

Participant	Market Uncertainty	Technical Uncertainty
System architect and co-founder	**Competitor uncertainty** "We discussed about competitor uncertainty when we evaluated this idea. We did a SWOT analysis in order to understand the competition." **Business model uncertainty** "We were concerned about how to make money. The initial business model was to generate revenue from advertising so we did some research about it." **Did not concern about other uncertainty** "At that time [i.e., the FFE phase], we were all working part-time on this project. We just wanted to break even and the website can continue running by its own money. […] We were not really worried about anything. If it did not work and we had to shut it down, it was fine."	-

Case No. 6 - OnlineStockTrade

Participant	Market Uncertainty	Technical Uncertainty
Project Manager	**User satisfaction issues** “We knew that there was a risk of displeasing the users because [the response time of] an app-based [application] would be a lot faster than a web-based [application] for sure. […] But we went with this decision since the objective of this project was only to provide a new channel [for their existing users] not to compete with the competition.”	**Lack of background knowledge** “The first concern was the lack of knowledge of Android app development and also ‘web embedded in app’. We really did not know what the results would be – a success or a failure. All we could do was learn from similar products. […] We also tried to study and understand the technology as much as possible.” **Technical uncertainty was reduced by consulting experts** “I asked my friends who developed Android applications. They warned me of several problems. Since there were a lot of potential problems and we anticipated only a moderate volume of users. Based on our marketing research, the majority of people who trade stock on their mobile use iPhone or IPad. Therefore, we did not want to spend a lot of effort for little return. So, we decided to develop with the ‘web embedded in app’ concept.” **Concerns on maintenance of the new service** “The maintenance of this app would also require a lot of effort [because of several technology issues e.g., the difference in screen size of Android devices]. So, it did take a very long time to make the go/no go decision of this project. It was very likely that the required effort may be high and the income may be low. We had to ask ourselves ‘how many users we need to be on par with

		the effort required?' But, ultimately, we decided to do it because the competitor has made their move already."
Senior marketing executive	**Revenue uncertainty** "One concern was that Android users were not the cream of the crop like the iPhone and iPad [users]. Therefore, we were worried that the amount of transaction fee generated by this project may be incomparable to the iPhone's and iPad's"	**Concerns on maintenance of the new service** "The most important concern was the cost of maintaining several versions of the application [because Android devices vary in terms of screen size]. From what I knew, there were five different screen ratios. If we were to develop a native Android application and wanted it to look great on all devices, we would have five different versions of the app. This was the main reason why we decided not to do it." **Technological concerns** "For the web-base [application], we concerned about responsiveness. The responsiveness of the web-based is slower than the native option's. Moreover, we understood that, provided that the same browser are used, a web-based app will always display exactly the same results regardless of the devices it is running on. Also, my research on the internet suggested the same conclusion."

Appendix E: Multivariate Outliers

Constructs	Case No.	D^2 Statistic	*p*-value
Searching capability	80	16.852	0.00076
	104	14.456	0.00235
	40	13.992	0.00292
	88	13.235	0.00415
Coordination capability	3	31.224	0.00001
	79	22.870	0.00036
	17	20.401	0.00105
Collective mind	5	20.472	0.00014
	79	13.125	0.00437
Absorptive capacity	50	17.225	0.00064
	104	14.891	0.00191
	24	14.674	0.00212
	1	14.341	0.00248
	52	13.076	0.00447
IT capability	49	43.866	0.00000
	24	35.255	0.00000
	5	28.028	0.00004
	4	25.259	0.00012
	52	22.723	0.00038
	75	20.195	0.00115
	102	18.681	0.00220
Market uncertainty reduction	56	24.449	0.00018
	100	20.088	0.00120
	31	19.803	0.00136
	91	19.035	0.00189
Technical uncertainty reduction	31	41.506	0.00000
	5	26.711	0.00016
	24	25.351	0.00029
	101	21.626	0.00142
	79	20.021	0.00275
	80	18.671	0.00476
	49	18.574	0.00495
Financial success	82	60.218	0.00000
	1	28.482	0.00008
	19	28.280	0.00008
	21	26.274	0.00020
	39	24.417	0.00044

	32	21.648	0.00140
	23	19.443	0.00348
Non-financial success	104	40.621	0.00000
	24	32.196	0.00001
	80	31.818	0.00001
	58	25.388	0.00012
	32	20.411	0.00105
	57	20.210	0.00114
	1	16.937	0.00462

Appendix F: Data Distribution

	Skewness		Kurtosis	
	Statistic	Std. Error	Statistic	Std. Error
ext_search1	-0.979	0.219	0.063	0.435
ext_search2	-1.041	0.219	1.132	0.435
ext_search3	-0.937	0.219	0.371	0.435
coop1	-0.767	0.220	0.171	0.437
coop2	-0.842	0.219	0.208	0.435
coop3	-1.078	0.219	0.955	0.435
coop4	-0.918	0.219	0.324	0.435
coop5	-0.906	0.219	0.556	0.435
cmind1	-0.687	0.219	0.198	0.435
cmind2	-1.028	0.219	0.924	0.435
cmind3	-0.753	0.219	-0.081	0.435
ab_cap1	-1.201	0.219	1.872	0.435
ab_cap2	-0.998	0.219	1.433	0.435
ab_cap3	-1.284	0.219	2.462	0.435
it_cap1	-1.901	0.219	4.389	0.435
it_cap2	-1.263	0.219	1.615	0.435
it_cap3	-1.347	0.220	2.267	0.437
it_cap4	-0.766	0.219	0.027	0.435
it_cap5	-1.360	0.219	3.454	0.435
mkt_kn1	-1.059	0.219	0.886	0.435
mkt_kn2	-0.637	0.219	0.226	0.435
mkt_kn3	-0.870	0.219	0.270	0.435
mkt_kn4	-0.470	0.219	-0.494	0.435
mkt_kn5	-0.621	0.220	-0.429	0.437
tech_kn1	-0.911	0.219	1.073	0.435
tech_kn2	-0.755	0.219	0.327	0.435
tech_kn3	-1.013	0.219	1.577	0.435
tech_kn4	-1.305	0.219	2.727	0.435
tech_kn5	-0.580	0.219	0.083	0.435
tech_kn6	-0.799	0.219	0.118	0.435
fin_suc1	-0.996	0.219	0.858	0.435
fin_suc2	-0.737	0.219	0.726	0.435
fin_suc3	-0.381	0.220	0.259	0.437
fin_suc4	-0.441	0.219	0.221	0.435
fin_suc5	-0.228	0.219	0.078	0.435
fin_suc6	-0.276	0.220	0.170	0.437
nonfin_suc1	-1.521	0.219	3.264	0.435

nonfin_suc2	-1.090	0.219	1.247	0.435
nonfin_suc3	-0.894	0.219	0.473	0.435
nonfin_suc4	-0.632	0.219	0.792	0.435
nonfin_suc5	-0.569	0.219	0.761	0.435

Appendix G: Cross Loadings

	SEARCH	COOR	CMIND	AB_CAP	IT_CAP	MKT_UNCER_RED	TECH_UNCER_RED	FIN_SUC	NONFIN_SUC
search1	**0.695**	0.136	0.205	0.403	0.249	0.163	-0.009	0.042	0.126
search2	**0.86**	0.391	0.311	0.427	0.431	0.251	0.243	0.288	0.34
search3	**0.823**	0.436	0.246	0.363	0.394	0.348	0.279	0.332	0.357
coor1	0.517	**0.795**	0.353	0.453	0.378	0.287	0.304	0.335	0.422
coor2	0.33	**0.838**	0.366	0.353	0.278	0.21	0.11	0.407	0.292
coor3	0.317	**0.905**	0.381	0.396	0.355	0.299	0.256	0.381	0.337
coor4	0.279	**0.873**	0.353	0.287	0.306	0.288	0.26	0.397	0.299
coor5	0.377	**0.846**	0.421	0.289	0.317	0.293	0.329	0.319	0.31
cmind1	0.226	0.314	**0.867**	0.32	0.394	0.01	0.199	0.217	0.214
cmind2	0.342	0.426	**0.928**	0.443	0.528	0.13	0.268	0.332	0.319
cmind3	0.301	0.445	**0.926**	0.426	0.485	0.163	0.193	0.283	0.286
ab_cap1	0.373	0.303	0.389	**0.84**	0.365	0.211	0.123	0.11	0.173
ab_cap2	0.535	0.416	0.418	**0.905**	0.435	0.33	0.214	0.352	0.302
ab_cap3	0.366	0.371	0.348	**0.874**	0.36	0.263	0.24	0.211	0.318
it_cap1	0.256	0.174	0.14	0.377	**0.565**	0.103	0.224	0.162	0.238
it_cap2	0.36	0.215	0.354	0.245	**0.706**	0.024	0.175	0.213	0.269
it_cap3	0.38	0.251	0.431	0.342	**0.8**	0.146	0.268	0.221	0.302
it_cap4	0.344	0.253	0.352	0.327	**0.776**	0.192	0.249	0.151	0.319
it_cap5	0.37	0.453	0.547	0.373	**0.833**	0.252	0.286	0.38	0.333
mkt_uncer1	0.264	0.352	0.11	0.354	0.139	**0.671**	0.565	0.23	0.194
mkt_uncer2	0.294	0.252	0.084	0.205	0.243	**0.85**	0.393	0.364	0.412
mkt_uncer3	0.273	0.326	0.132	0.233	0.247	**0.83**	0.54	0.41	0.405
mkt_uncer4	0.242	0.19	0.063	0.257	0.091	**0.86**	0.376	0.385	0.284

mkt_uncer5	0.262	0.196	0.085	0.242	0.091	**0.824**	0.33	0.374	0.286
tech_uncer1	0.255	0.226	0.233	0.178	0.336	0.448	**0.783**	0.285	0.218
tech_uncer2	0.248	0.262	0.271	0.184	0.3	0.412	**0.789**	0.345	0.307
tech_uncer3	0.17	0.113	0.084	0.151	0.238	0.338	**0.788**	0.225	0.274
tech_uncer4	0.202	0.173	0.077	0.233	0.164	0.445	**0.785**	0.211	0.278
tech_uncer5	0.099	0.316	0.162	0.175	0.19	0.432	**0.629**	0.241	0.199
tech_uncer6	0.072	0.216	0.222	0.061	0.201	0.337	**0.686**	0.213	0.256
fin_suc1	0.264	0.399	0.289	0.276	0.323	0.34	0.246	**0.846**	0.322
fin_suc2	0.281	0.419	0.288	0.312	0.312	0.42	0.274	**0.904**	0.406
fin_suc3	0.271	0.407	0.281	0.293	0.268	0.452	0.323	**0.862**	0.495
fin_suc4	0.242	0.364	0.28	0.185	0.287	0.315	0.334	**0.858**	0.414
fin_suc5	0.268	0.293	0.218	0.166	0.275	0.36	0.318	**0.891**	0.395
fin_suc6	0.246	0.345	0.246	0.118	0.201	0.39	0.319	**0.839**	0.454
nonfin_suc1	0.352	0.384	0.378	0.378	0.388	0.272	0.328	0.37	**0.837**
nonfin_suc2	0.276	0.346	0.228	0.169	0.378	0.326	0.335	0.366	**0.827**
nonfin_suc3	0.339	0.291	0.126	0.289	0.337	0.234	0.176	0.41	**0.732**
nonfin_suc4	0.248	0.325	0.224	0.209	0.242	0.357	0.165	0.392	**0.79**
nonfin_suc5	0.234	0.19	0.215	0.156	0.217	0.412	0.341	0.383	**0.779**

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