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The Impact of Social Capital on Innovation Intermediaries

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by

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Abstract

In today's open business environments, innovation happens in globally dispersed organizations that exchange technological knowledge across increasingly permeable boundaries. Innovation intermediaries play an important role in these technology transfer processes. They operate as middle-men between solution seekers (companies seeking technological knowledge for solving their problems) and problem solvers (experts with specialized knowledge and solutions) and thus help to connect suppliers and customers of technological knowledge. Currently, clients that select an intermediary organization and managers of intermediary organizations that assign agents to a project have very little guidance as to what type of an intermediary they should select to guarantee that the intermediation process is successful. This study will provide much needed guidance.

Successful technology transfer is operationalized as gains in efficiency and/or improved innovativeness, though it is likely that a trade-off exists between these two goals. This is commonly referred to as the productivity dilemma. To be successful, intermediaries need to understand the solution seeker's problem (problem framing) and reach into their networks of contacts or connections with various experts (social capital) to match the right expert to the problem. The literature on technical problem solving states that problem solvers that frame a problem as the need to reduce uncertainty solve the problem by reaching for readily available resources and tend to provide solutions that are similar to previous solutions. These incremental improvements are efficient, but not very innovative. Problem solvers that frame a problem as the need to reduce ambiguity do not

expect the solution to be found in readily available sources and reach further. The outcome of this problem solving is likely to be dissimilar to the previous outcome, resulting in radical changes and high innovativeness.

I argue that an innovation intermediary's choice in problem framing is likely to be dictated by two different focuses (bonding versus bridging) in the social capital of the agent. The agent with a high level of bonding social capital generally reinforces existing relationships (deepening the connections) and can easily access the appropriate experts. Consequently, bonding social capital is related to uncertainty reduction problem framing and, in turn, efficiency improvement outcome. As for the agent with a high level of bridging social capital, the agent tends to build and seek new contacts from different fields of expertise and specialization (broadening the connections), thus the agent can always reach different experts in different fields of specialization. Consequently, bridging social capital is related to ambiguity reduction problem framing and, in turn, innovativeness improvement outcome.

The aim of this study is to contribute to the body of knowledge in technology management by exploring the relationship (that has never been explicitly identified in the past) between problem framing, social capital and the outcomes of innovation intermediation process. This indeed provides a much needed means to match intermediaries and projects in ways that lead to the desired levels of innovativeness and efficiency. In this study, the research model that identifies the relationship between problem solving, social capital and outcomes of the intermediation process is developed

from the literature review of three different streams of research, namely technical problem solving, social capital and innovation intermediary. The hypotheses are set according to the relationship identified in the research model. Then, the data on the innovation intermediation process is collected from an intermediary organization in Thailand called iTAP which provided full access to its intermediary agents and archival records of its projects, resulting in a rich data set that is thoroughly analyzed by appropriate statistical models to explore the relationship in the research model.

The results indicate that there are strong relationships between social capital and the outcomes of intermediation process. Specifically, ease of reach is a dimension of social capital that has a positive impact on both the outcome with efficiency improvement and the outcome with innovativeness improvement; while trust and mutual understanding show a negative relationship with the outcomes. The results also support the linkage between social capital and ambiguity reduction in problem framing. However, the other linkages between social capital and uncertainty reduction in problem framing, and between problem framing and outcomes, do not have statistical evidence but the data are in favor of the research model. An additional alternative theory of temporal and dynamic problem framing variables is introduced and thoroughly discussed to explain the innovation intermediation process.

In summary, this study suggests that while more is better for bridging social capital, there should be a balance in bonding social capital. By bridging the relationships with different and diverse groups of people, the intermediary agents gain greater benefit in

broadening their network of contacts that can help in solving the problems with both efficiency improvement and innovativeness improvement. On the other hand, by deepening the relationships with their existing network of contacts, the intermediary agents may also benefit by gaining more trust from the network but the closeness of their relationships may also hinder them from looking for better answers to the problems due to the false assumption (groupthink) and familiarity with the network (not-invented-here syndrome). The key to success for managing the successful innovation intermediation process is to promote strong bridging social capital and balanced bonding social capital of the innovation intermediary agent.

Dedication

To all past, present, and future scholars in Engineering and Technology Management and related fields,

whose hard work serves as a basis for continuing growth of knowledge for future generations.

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Chapter 1

Introduction

This chapter describes the problem statements (from both practical perspective and theoretical perspective) which inspire the research conducted in this dissertation. The research gaps are identified. Then, the objectives of the research are elaborated and the research framework is explained, following by the associated research questions. Lastly, the chapter concluded with the detailed structure of this dissertation.

1.1 Problem Statements

The "movement" or the "flow" of knowledge and technology is one of the most vital elements in the increasingly competitive business environment today as supported by a number of literature in technology transfer [1]–[3], technology diffusion [4] and system of innovation [5]–[12]. Moreover, such movement or flow of knowledge and technology becomes even more complex due to the emerging paradigm of "open innovation" [13]–[22] (as opposed to the traditional setting of closed innovation) which suggests that a company could and should utilize external knowledge to complement its internal generated knowledge in order to expand its competitive capability. Usually, there are many parties with different objectives involved in this complex process, causing a need for a "middle-man" or an entity who acts as a broker between these parties to help facilitate the movement or flow of knowledge and technology. Such an entity is known as "innovation intermediary" in the system of innovation literature [23]–[26].

In general, the main task of innovation intermediary agent is to find the appropriate problem solvers that perfectly match with the solution seekers. Thus, in order to succeed, the intermediary agent has to know exactly what the problem is and where to find the right problem solvers. This process heavily relies on tacit knowledge of the agent (i.e., the agent's experience and understanding of the subject matter) as well as the agent's social capital (i.e., the network of potential solvers that the agent is aware of and can reach to). The theory of social capital explains how people bond within their peer group and bridge into groups that are different from them. Because different groups of people can provide different solutions to the same problem, it implies that the intermediary agent should be able to identify the appropriate solution to the problem and use his social capital to reach out and match the appropriate problem solvers with solution seekers.

However, currently there is no theory that clearly explains how intermediary agents should operate and use their social capital in order to achieve a desired outcome. A highly referenced study on technical problem solving by Schrader, Riggs and Smith [27] merely suggests (with propositions but no hypothesis testing) that two different outcomes in technical problem solving, namely innovation and efficiency improvement are a result of the problem solvers' framing of the problem as either ambiguity or uncertainty. The choice of problem framing is conscious and it is a result of the resources available to the problem solvers, including social capital [27]. There is no study or empirical evidence to support or deny the claim, meaning that there is no evidence of either the relationship between social capital and problem framing or the relationship between problem framing and outcome of intermediation process.

This has practical implications in the form of unanswered management questions. Should people who hire or manage innovation intermediaries, such as technology transfer organization and their clients, consider the intermediary agents' social capital at all or does it not matter for outcomes? If it does matter, how should they match intermediary agents (and their social capital) to projects to achieve desired outcomes? Which aspects of social capital should they help intermediary agents to develop in order to achieve efficiency, or innovation, or both?

To answer these questions, this dissertation empirically investigates and further develops the theoretical foundations of the intermediation process by proving the existence (or the lack thereof) of the relationship between social capital and problem framing as well as the relationship between problem faming and outcome of intermediation process. The theoretical explanation will enable much needed practical recommendations for the intermediary agents and the intermediary organization to determine the proper way to operate in order to achieve the desired outcomes.

1.2 Research Gaps

As stated earlier, social capital plays a vital role in understanding the functioning of innovation intermediaries because it determines the knowledge sources that are reachable through a network of contacts as well as the level of trust and norms that are needed to transfer knowledge from problem solvers to solution seekers. A better understanding of the relationship between social capital and choice in problem framing of innovation intermediaries can lead to a better intermediation process. There are some studies that indicate the relationship between social capital and innovation at firm level [28], [29] and team level [30], [31]. However, there are a limited number of studies that indicate the linkage of social capital and innovation intermediary at individual level (for example, see Kirkels and Duysters [32]). These studies do not clearly explain the nature of the linkage and cover only some specific facets of social capital. From literature review of three different streams of research, namely innovation intermediaries, technical problem solving and social capital, there is no published study or research regarding the relationship between social capital of innovation intermediary agent, the choice in problem framing and the outcome of the intermediation process. This is clearly a gap identified in the literature from the theoretical perspective. The review of these three streams of research (innovation intermediaries, technical problem solving and social capital) and the identification of the gaps are presented with more detail in Chapter 2.

With the open innovation paradigm, more companies seek the service of innovation intermediary both for commercializing their unused knowledge (outbound open innovation) and tapping into the pool of available knowledge (inbound open innovation). There are a small number of studies that suggest the guideline for companies to utilize the innovation intermediary [33]. However, there is no study from the operational point of view of the innovation intermediary, i.e., how the intermediary agents should perform the intermediation process. This is a gap identified in the literature from the perspective of innovation intermediary. Upon successfully filling this gap, the intermediary agent should be able to operate more efficiently which leads to the benefits for all parties involved. Moreover, the upper management in intermediary organization can develop strategy of operation to achieve the desired outcome.

1.3 Research Objectives

The objective of this research is twofold: one is to identify the relationship between social capital, the choice in problem framing and the possible outcomes of the intermediation process. In particular, this relationship differentiates between the focus on bonding social capital (deepening the bonds of the relationships) and bridging social capital (broadening the relationships) of innovation intermediary, different choices in problem framing, and ultimately the different outcomes of intermediation process, either the efficiency improvement or the innovativeness improvement.

The other objective of this research is to identify the practical strategy for innovation intermediary organization and its stakeholders to achieve their desired outcomes. The theoretical contribution of the proposed research is expected to provide managerial implications which can be used as a guideline by the intermediary organization for setting an appropriate strategy in order to fulfill its mission.

1.4 Research Framework

Without innovation intermediaries, solution seekers have to solve the problem by themselves, i.e., they have to frame the problem in the right way and find the solution either by performing an in-house research or searching for appropriate solution from outside. The expected outcome of the problem solving process is the improvement of the operation either by increasing of efficiency or effectiveness of operation. This situation is shown in Figure 1.

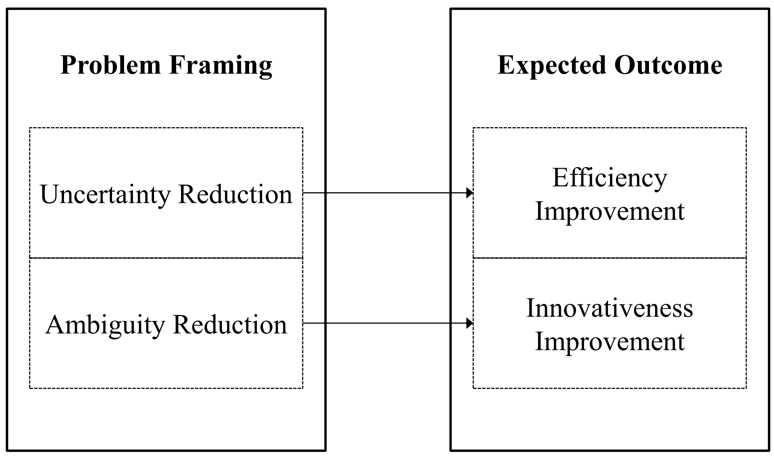

Figure 1–Relationship between problem framing and excepted outcome

The innovation intermediary helps the solution seekers framing the problem properly with the experiences and other available resources of the intermediary agents. The innovation intermediary also helps the solution seekers finding the appropriate problem solvers from the pool of experts available to the intermediary agents via their social capital. The expected outcome of the intermediation process is generally similar to the expected outcome of the problem solving process when it occurs without the help of innovation intermediary: it can either result in improved efficiency or result in innovation.

If the intermediary agent facilitates the matching of problem and solution, the emphasis of the agent on different aspects of social capital has an impact on the choice of problem framing, thus extending the relationship in Figure 1. The relationship between social capital and innovation intermediation process, especially the problem framing process and the problem solvers (experts) searching process, is of interest and is presented as research framework as shown in Figure 2.

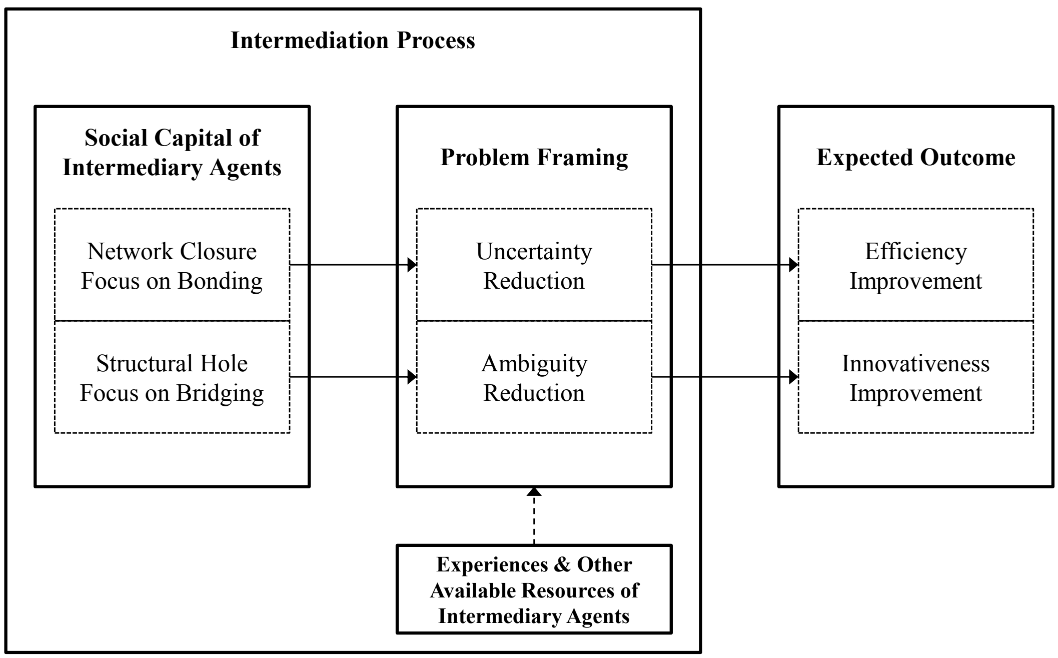

Figure 2–Research framework

1.5 Research Questions

The research questions are based on the identified gaps and research objectives as well as the research framework as explained earlier. The research questions are listed below.

Research Question 1: What is the relationship between the social capital of intermediary agent and the choice in problem framing?

Research Question 2: What is the relationship between the choice in problem framing and the outcome of intermediation process?

Research Question 3: What aspects of social capital are the enabling factors that improve the operational efficiency of the innovation intermediary and how to promote such factors for innovation intermediary organizations?

Research Question 4: What aspects of social capital are the inhibiting factors that prevent the innovation intermediary from improving the operational efficiency and how to eliminate or reduce such factors for innovation intermediary to achieve operational improvement?

The link between research gaps, research objectives and research question of this proposed research is presented in Table 1.

Table 1–Summary of research gaps, research objectives and research questions

Research Gaps	Research Objectives	Research Questions
1. Lack of understanding of innovation intermediary and its process.	1. To identify the relationship between social capital, problem framing and outcome of innovation intermediary.	1. What is the relationship between the social capital of intermediary agent and the choice in problem framing?
2. Lack of study of the relationship between social capital, technical problem solving and innovation intermediary.		2. What is the relationship between the choice in problem framing and the outcome of intermediation process?
3. Practical need of innovation intermediary organization to improve its operational efficiency.	2. To propose the appropriate strategy for innovation intermediary and its stakeholders to achieve desired outcome.	3. What aspects of social capital improve the operational efficiency of the innovation intermediary and how to promote such factors for innovation intermediary organizations?
4. Practical need of company to understand and utilize innovation intermediary (open innovation paradigm).		4. What aspects of social capital prevent the innovation intermediary from improving the operational efficiency and how to eliminate or reduce such factors for innovation intermediary to achieve operational improvement?

1.6 Structure of the Dissertation

This dissertation is structured as follows. From the introduction and problem statement that formulated the research questions as presented here (Chapter 1), the literature review of the three research streams involved in this research (i.e., innovation intermediary, problem solving, and social capital) is elaborated in Chapter 2. Chapter 3 illustrates the research methodology by indicating the research hypotheses and the research design including the data collection process as well as the data analysis process. The results of the research are presented in Chapter 4 along with the discussion and in-depth analysis of the results in Chapter 5. Chapter 6 concludes the dissertation by addressing all of the research questions by demonstrating the contribution and managerial implication of the research as well as discussing the limitation of the research and possible future reserach.

Chapter 2

Review of Literature

There are three main literature streams that relate to this research, namely innovation intermediaries, technical problem solving and social capital. The literature review is conducted along these topics and is presented in this chapter.

2.1 Innovation Intermediaries

Technology transfer and commercialization process involves a number of different stakeholders including academic institutions which predominantly produce and transfer knowledge, industrial institutions which produce goods and services and thus commercialize knowledge, and government institutions which control, regulate and support the cooperation of academy and industry. Moreover, with an emerging paradigm of "open innovation" [13]–[16] in which organizations exchange and transfer their knowledge and R&D efforts across previously closed boundaries, technology transfer and commercialization process has become even more complicated. Since there are many parties with different objectives involving in this complex process, there is a need for an entity that acts as an agent or broker to help facilitate knowledge exchange and transfer between these parties. This entity is characterized as "innovation intermediary". From the viewpoint of economic theory, innovation intermediaries exist because they provide sufficient economic benefits for partnerships (e.g., overall cost reduction and risk sharing) that overcome the negative aspects of collaboration (e.g., partnership transaction cost and outgoing knowledge spillover) [34]. Furthermore, from strategic perspective, innovation intermediaries provide competitive advantage to the partnerships by enabling their partners to gain additional resources from the collaborations [35], [36].

2.1.1 Definition and Role of Innovation Intermediaries

Innovation intermediaries are widely discussed in the study of innovation, technology transfer, and technology diffusion. A variety of terminologies and definitions are used in different studies. To synthesize the stream of literature, Howells [26] provides a definition for innovation intermediary as “an organization or body that acts as agent or broker in any aspect of the innovation process between two or more parties” (page 720) [26]. Howells further described that the activities of innovation intermediary should include “helping to provide information about potential collaborators; brokering a transaction between two or more parties; acting as a mediator, or go-between, bodies for parties that are already collaborating; and helping to find advice, funding and support for the innovation outcomes of such collaborations” (page 720) [26]. Dalziel [37] expanded Howells’ definition and defined innovation intermediary on the basis of its organizational purpose as “organization or group within organization that works to enable innovation, either directly by enabling the innovativeness of one or more firms, or indirectly by enhancing the innovative capacity of sectors, regions, or nations” (page 3) [37]. Innovation in this context is not only limited to technological innovation but covers the broader sense of innovation as defined by Schumpeter [38], i.e., a new or improved good, a new method of production or distribution, the opening of a new market, the use of new supplies or engagement of new suppliers, or a new mode of industrial organization (as cited in [37], page 4). Hence, under the definition based on organizational purpose, industry and trade associations, economic development agencies, chambers of commerce, science parks (or technology parks or business parks), business incubators, research consortia and networks, research institutes, and standard organizations can all be classified as innovation intermediaries because their institutional purpose is to enable innovation. As for university technology transfer offices, even though the main purpose of the offices is to serve the host universities by facilitating research and educational activities, protecting intellectual property and generating revenues [39], they could also be considered as innovation intermediaries. It is so because these activities are somehow related to the enabling of innovation for the universities, the regions or the nations [40]. Thus, university technology transfer offices can be fitted in the definition of innovation intermediaries.

Table 2 shows a list of various studies that focused on innovation intermediaries in chronological order using the work of Howells [26] as a starting point and updating it to the present.

Table 2–List of various studies in innovation intermediaries

Term for Actors	Definition/Role	Author(s)	Year
Intermediaries	Role in technology exploitation.	Seaton and Cordey-Hayes [41]	1993
Intermediary agencies	Role in formulating research policy.	Braun [42]	1993
Intermediaries	Role in effecting change within science networks and local collectives.	Callon [43]	1994
Consultants	Role of bridge building in the innovation process.	Bessant and Rush [44]	1995

Term for Actors	Definition/Role	Author(s)	Year
Intermediaries	Public and private organizations that act as agents transferring technology between hosts and users.	Shohert and Prevezer [45]	1996
Bricoleurs	Agents seeking to develop new applications for new technologies outside their initial development field.	Turpin et al. [46]	1996
Superstructure organizations	Organizations that help to facilitate and coordinate the flow of information to substructure firms.	Lynn et al. [47]	1996
Technology brokers	Organizations that exploit their network position by working for clients in a variety of industries.	Hargadon and Sutton [48], [49]	1997
Knowledge brokers	Combining existing technologies in new ways.	Hargadon [50]	1998
Intermediary level bodies	Orienting the science system to socio-economic objectives.	Van der Meulen and Rip [51]	1998
Innovation intermediaries	Proactive role of service firms within an innovation system.	Howells [52]	1999
Regional institutions	Providing 'surrogate ties' by serving as functional substitutes for firm's lack of 'bridging ties' in a network.	McEvily and Zaheer [53]	1999
Boundary organizations	Role of boundary organization in technology transfer and 'co-production' of technology.	Guston [54]	1999
Network incubators	Providing partnership among start-ups and facilitate the flow of knowledge and talent across companies.	Hansen et al. [55]	2000
Boundary organizations	Role of coordination in technology transfer.	Cash [56]	2001
Bridging institutions	Acting as information exchanges within the technological system to disseminate knowledge as well as improve the absorptive capability of the system.	Carlsson et al. [57]	2002
Knowledge intermediaries	Facilitating a recipient's measurement of the intangible value of knowledge received.	Millar and Choi [58]	2003
Innomediaries	Aggregating and disseminating knowledge to fill structural holes between company and customers in the market.	Sawhney et al. [59]	2003
Systematic intermediaries	Acting as bridging institutions from policy initiatives to overcome problem of market failure.	Van Lente et al. [60]	2003

Term for Actors	Definition/Role	Author(s)	Year
Matchmakers (in technological listening posts)	Acting as a mediator to establish multidimensional relationships within the regional scientific community.	Gassmann and Gaso [61]	2004
Innovation intermediaries	Organizations or entities that act as agents or brokers in any aspect of the innovation process between two or more parties.	Howells [26]	2006
Virtual knowledge brokers	Connecting, recombination and transfer knowledge to facilitate innovation in virtual environment.	Verona et al. [62]	2006
Innovation intermediaries	Offering a wide range of innovation technologies necessary for design, simulation, modeling, and visualizing the technologies.	Dodgson et al. [63], [64]	2006
Innovation intermediaries	Connecting companies with appropriate modes of external sources of innovation.	Nambisan and Sawhney [65]	2007
Knowledge entrepreneurs	The organizations with the ability of interpreting and transforming available knowledge into products or new business models that benefit surrounding economics.	Cooke and Porter [66]	2007
Innovation brokers	Acting as members of a network of actors in an industrial sector that enable other organizations to innovate by providing neutral space for the development of research agenda.	Winch and Courtney [67]	2007
Intermediary organizations	Translating, coordinating and brokering between disconnected parts to increase the available information between the actors involved.	Boon et al. [68]	2008
Knowledge brokers	Facilitating the sharing of knowledge between knowledge sources and knowledge needs.	Sousa [69]	2008
Knowledge hubs	Organizations that are associated with generating tacit knowledge and technology transfer, especially within the region.	Youtie and Shapira [70]	2008
Linkages (between university and industry)	Providing firms and universities with the opportunity and information about potential partners and assist firms to acquire resources necessary for engaging in collaborations.	Kodama [71] and Yusuf [72]	2008
Open Innovation Accelerators	Facilitating a new form of collaboration between an innovating company and its environment.	Diener and Piller [73]	2010

It should be noted that all of the definitions in Table 2 identify the intermediary as "innovation intermediary" because the intermediary operates, communicates and interacts with multiple actors through explicit and/or tacit knowledge to enable innovation as the main purpose of interaction. This differs significantly from other kinds of intermediary in other disciplines such as financial intermediary (economics) or organizational intermediary (political science). The main difference is the purpose of interaction between actors and the unit of transaction. Financial intermediary provides financial services with profit-making and economic efficiency as its main objective. Organizational intermediary is non-government organization (NGO) that binds different groups of people from different level of society together under social or political objective. In contrast, the focus of innovation intermediary is on the technological knowledge and the needs for innovation.

As shown in Table 2, there are numerous studies of innovation intermediaries, many of which use different terminology. However, all of these studies refer to common characteristics of innovation intermediaries, in particular their role to facilitate, connect, and coordinate the sharing of knowledge and/or technology between two or more organizations. Howells [26] identified ten different functions and activities performed by innovation intermediaries. Built upon Howells' work, Lopez-Vega [74] added, modified and clustered the functions of innovation intermediaries into three categories, namely, facilitating collaboration, connecting actors, and providing services for stakeholders. The activities and functions of innovation intermediaries are summarized as follows.

1. Facilitating collaboration: The functions in this category mainly facilitate the collaboration between organizations. These functions include:

- Knowledge processing, generation and combination with the activity such as combining knowledge of different partners as shown in Shohet and Prevezer [45] and Turpin, Garrett-Jone and Rankin [46] and generating in-house research and technical knowledge to combine with partner knowledge as shown in Hargadon [50], Hargadon and Sutton [48], [49], Cooke and Porter [66], Sousa [69] and Youtie and Shapira [70].

- Technology diagnostics with the activity such as technology foresight (identifying and planning for new technology that strategically supports the organization), technology forecasting (prediction for the future characteristics of useful technology) and technology roadmapping (planning technological solutions that match both short-term and long-term goal of the organization) as shown in Siegel, Waldman, and Link [41] and van der Meulen and Rip [51].

- Technology scanning and information processing with the activity such as technology scanning (information gathering, scoping and filtering on new and potential technology) and technology intelligence (identification of potential collaborative partners for new technology) as shown in Bessant and Rush [44] and Gassmann and Gaso [61].

- Commercialization with the activity such as market research, business planning, supporting in the selling and commercialization process and finding potential capital funding as shown in Howells [26].

2. Connecting actors: The functions in this category mainly focus on connecting services between organizations and their environment. These functions include:

- Gatekeeping and brokering with the activity such as matching organizations to work together, facilitating negotiation and deal making, and providing contractual advice as shown in Braun [42], Lynn, Reddy and Aram [47], Carlsson et al. [57], Kodama [71] and Yusuf [72].

- Intermediating between experts and industry with the activity such as matching solution seekers to problem solvers as shown in Chesbrough [13], [14], Chesbrough, Vanhaverbeke and West [15], Hansen et al. [55], Cash [56], and van Lente et al. [60].

- Evaluation of outcomes with the activity such as general performance assessment of technologies and specific evaluation of products in the market as shown in Winch and Courtney [67].

- Demand articulation with the activity such as meditating between users (customers) and industry in order to learn about the needs for new and emerging technologies as shown in Boon et al. [68].

3. Providing services for stakeholders: The functions in this category encompass a set of special tasks in innovation process. These functions include:

- Testing and validation with the activity such as providing testing chambers and laboratories, providing prototypes and pilot facilities, providing manufacturing modeling to overcome bottlenecks in scale-up production, providing validation of new technology and providing training for the use of new technology as shown in Dodgson et al. [63] and Dodgson, Gann and Salter [64]

- Regulation with the activity such as setting formal or informal rule of conducts and providing informal regulation and arbitration as shown in Howells [26].

- Accreditation and standards with the activity such as setting specification or providing advice for standards as well as formal standards setting and verification as shown in Howells [26].

- Protecting results with the activity such as providing advice for intellectual property (IP) rights regarding outcomes of the collaboration and performing IP management for clients as shown in Howells [26].

Table 3 shows a summary of the studies in innovation intermediaries by focusing on their functions and activities under three different categories.

Table 3–Functions and activities of innovation intermediaries

Function	Activity	Terminology	Definition	References
Category 1: Facilitating the collaboration between actors				
Knowledge processing, generation and combination	Combining knowledge of different partners	Bricoleurs and boundary riders	Bricoleurs and boundary riders are organizations attempting to bridge basic research and innovation by relocating science into the productive forms.	Turpin et al. [46]
		Intermediaries	Intermediaries provide a liaison service and signposting to complementary assets.	Shohert and Prevezer [45]
	Generating new knowledge and recombining	Knowledge entrepreneurs	The organizations with the ability of interpreting and transforming available knowledge into products or new business models that benefit surrounding economics.	Cooke and Porter [66]
		Technology brokers and knowledge brokers	Technology brokers exploit their network position by working for clients in a variety of industries.	Hargadon [50]; Hargadon and Sutton [48], [49]
		Knowledge hubs	Knowledge hubs are universities or organizations that are associated with generating tacit knowledge and technology transfer, especially within the region.	Youtie and Shapira [70]
Foresight and diagnostic	Foresight, forecasting and technology road mapping	Intermediary level bodies or technology top institutes	Intermediary level bodies (or technology top institutes) collaborate in the foresight activity of technologies, linking basic research to socio-economic objectives and orienting public research toward industry needs.	Van der Meulen and Rip [51]

Function	Activity	Terminology	Definition	References
		Intermediaries	Intermediaries provide a model for technology transfer and support the “scan, evaluate, and implement” process.	Seaton and Cordey-Hayes [41]
Scanning and information processing	Information scanning and technology intelligence	Consultants	Consultants assist and advice firms to bridge the gap between technological opportunity and user needs by providing a flexible interaction with information and related services.	Bessant and Rush [44]
		Matchmakers	Matchmakers act as a mediator to establish multidimensional relationships within the regional scientific community.	Gassmann and Gaso [61]
Commercialization	Business planning, support in commercialization process and early stage capital investment	Intermediaries	Intermediaries provide market research and sales channel as well as find potential capital funding and organizing funding or offering.	Howells [26]
Category 2: Connecting actors				
Gatekeeping and brokering	Matching and brokering	Superstructure organizations	Superstructure organizations coordinate the flow of information and the activities involving in the commercialization of new technologies for their substructure organizations.	Lynn et al. [47]
		Bridging institutions	Bridging institutions act as information exchanges within the technological system to disseminate knowledge as well as improve the absorptive capability of the system.	Carlsson et al. [57]

Function	Activity	Terminology	Definition	References
		University-Industry linkages	University-Industry linkages provide firms and university with the opportunity and information about potential partners and assist firms to acquire resources necessary for engaging in collaborations.	Kodama [71]; Yusuf [72]
		Mission agencies	Mission agencies encourage research in politically interesting area to build up a scientific community and support the transfer of scientific knowledge and its application.	Braun [42]
Intermediating between entrepreneurs, science policy and industry	Negotiating and deal-making	Network incubators	Network incubators provide partnership among start-ups and facilitate the flow of knowledge and talent across companies.	Hansen et al. [55]
		Open innovation intermediaries	Open innovation intermediaries identify the problem that needs to be solved and find the appropriate solution from pools of available solvers outside of company's boundary.	Chesbrough [13], [14]; Chesbrough et al. [15]
		Boundary organizations	Boundary organizations mediate science and technology policy at different levels of organization and facilitate the transfer and usage of scientific and technical information across organization boundary.	Cash [56]

Function	Activity	Terminology	Definition	References
		Systematic intermediaries	Systematic intermediaries act as bridging institutions from policy initiatives to overcome problem of market failure.	Van Lente et al. [60]
Evaluation of outcomes	Technology and performance assessment	Innovation brokers	Innovation brokers act as members of a network of actors in an industrial sector that enable other organizations to innovate by providing neutral space for the development of research agenda.	Winch and Courtney [67]
Demand articulation	Mediation between users, public and private organizations	Intermediary organizations	Intermediary organizations translate, coordinate and broker between disconnected parts to increase the available information between the actors involved.	Boon et al. [68]
Category 3: Providing services for stakeholders				
Testing and validation	(a) Testing and diagnostics (b) Prototyping and pilot facilities (c) Scale-up (d) Validation (e) Training	Innovation intermediaries	Innovation intermediaries offer a range of innovation technologies necessary for design, simulation, modeling, and visualizing the technologies.	Dodgson et al. [63]; Dodgson, Gann and Salter [64]
Regulation	Regulation, self-regulation, informal regulation and arbitration	Intermediaries	Intermediaries provide formal or quasi-formal regulation for parties involved or act as informal arbiters among different groups.	Howells [26]
Accreditation and standards	Specification setter or standard advice provider	Intermediaries	Intermediaries provide formal or de facto standards for parties involved.	Howells [26]
Protecting results	Intellectual property rights advice and management	Intermediaries	Intermediaries provide intellectual property related assistances.	Howells [26]

2.1.2 Types of Innovation Intermediaries

From Table 2, it can be seen that there are a number of terminologies representing innovation intermediaries with different functions and activities. However, there is no consensus on specific typology in the classification of intermediaries because of the numerous focuses on diverse roles, functions and activities of the intermediaries. Nevertheless, Diener and Piller [73] identified some characteristics of innovation intermediaries that could be obviously distinguishable to categorize.

Firstly, it is possible to categorize the intermediaries by their main operating environment – either in the traditional non-virtual environment or in the virtual environment (made possible by the advance in computer technology and the widespread usage of the internet). The difference of intermediaries working in physical non-virtual environment and those working in virtual environment is mainly the reach (or accessibility) of generated knowledge [62] because the virtual environment opens the door for intermediaries to tap into a larger pools of actors previously inaccessible or difficult to access in non-virtual environment.

Secondly, the aspect of intermediary that could be obviously distinguishable is the main content of knowledge that the intermediary handles – one of which is industry specific (within single industry sector) and the other is dealing with multiple industries (across multiple industry sectors).

Thirdly, the source of funding might dictate different kind of intermediaries for different objectives, i.e., the intermediaries with private funding tend to have the business oriented goal (profits for the organizations) while the intermediaries with public funding tend to aim at supporting the public policy for the benefit of the public (which does not necessary have to generate profit as the highest priority).

Table 4 illustrates the classification of intermediaries in the innovation process along with an example of such intermediaries as found in the literature.

Table 4–Classification of innovation intermediaries

Classification			Type of intermediaries	Example of intermediaries
Operating environment	Content specification of knowledge	Source of funding		
Non-virtual environment	Within single industry sector	Private	Co-operative technical organization	Industry association
		Public	Innovation broker	Technology licensing office of a research institute
	Across multiple industry sectors	Private	Knowledge intensive business service	Consultancy firm
		Public	Innovation incubator	Science park
Virtual environment	Within single industry sector	Private	Virtual knowledge broker	Innovation marketplace operator
		Public	Not known to exist in literature	
	Across multiple industry sectors	Private	Virtual knowledge broker	Innovation marketplace operator
		Public	Not known to exist in literature	

Based on the classification described in Table 4, there are five different types of intermediaries, namely, co-operative technical organization, innovation broker, knowledge intensive business service, innovation incubator and virtual knowledge broker. It should be noted that, currently, there is no acknowledgement in the literature of intermediary who operates in a virtual environment with public funding in any specific industry sector. If this type of intermediary were to exist, it would possibly be a platform for trading special knowledge using problem broadcasting and solution seeking which is operated by a publicly funded institution (like National Science Foundation in the U.S.). The industry sectors, the government sectors and the general public could clearly profit from better knowledge transfer between research laboratory and industry via such platform [73].

The characteristics and key objectives of each type of intermediaries are discussed as follows:

Co-operative Technical Organizations

Rosenkopf and Tushman [75] introduced the term co-operative technical organizations to describe the collaborative organizations that bind together diverse actors in an innovation network. They fit into innovation intermediaries type as the agents that work in non-virtual environment within one specific industry sector under a private funding. They perform a role as facilitator of innovation and reduce the uncertainty around new ideas by establishing standards that all actors in a network agree upon. Examples of this intermediary type include: technical committees (established by professional societies; such as the Royal Aeronautical Society Flight Simulation Technical Committee [76]), task forces and standard bodies (established by industry trade association; such as the Wi-Fi Alliance [77]), and consortia (such as SEmiconductor MAnufacturing TECHnology or SEMATECH [78], [79] and the World Wide Web Consortium or W3C [80]). This type of intermediary has as its main objective promoting the standards around the new ideas so that the member firms could operate with confidence, thus increasing efficiency of the operation and reducing the cost from uncertainty.

Knowledge Intensive Business Services

In comparison with co-operative technical organizations, knowledge intensive business services are the agents that work in non-virtual environments across boundaries of multiple industrial sectors with private funding [67]. They rely heavily on professional knowledge, and supply intermediate knowledge based services. Such services include knowledge brokering that could be performed in a way that solutions for clients in one industrial sector could be taken from earlier solutions for clients in other industrial sectors. Over time, the services accumulate a large stock of knowledge to solve the problems for clients. This is possible because of their network position between sources of ideas and potential implementations as well as a wide range of contacts in different industrial sectors. A typical example for this type of intermediary is a consultancy firm such as McKinsey & Company whose knowledge network includes more than 1,500 consultants providing rapid access to specialized expertise and business information from all over the world [81]. The key objective of this type of intermediary is mainly the improvement of business performance. The intermediary helps its clients to achieve higher operating performance as it gets payment as compensation for its service to generate more revenue.

Innovation Broker

Innovation broker is broadly defined as an organization acting as a member of a network of actors in an industrial sector that is focused neither on the generation nor the implementation of innovation, but on enabling other organizations to innovate [67]. In this sense, it is operated by the agents in physical environment within specific industry sector and it is publicly funded. This type of intermediary solely focuses on facilitating the generation and implementation of new ideas by other parties. Particularly, it could help shaping research problems and providing resources for the solutions. An example of this type of intermediary includes the technical licensing offices or technology transfer offices of publicly funded university or research institute such as Max Planck Innovation – a subsidiary of the renown German research institute Max Planck Society established to transfer technologies developed by Max Planck Institutes into the marketplace [82] or government sponsored innovation network such as the US Manufacturing Extension Partnership (MEP) Program [83]–[86], the Canadian Industrial Research Assistance Program (IRAP) [87]–[89], the UK Supernet program [90], the Finish Tekes technology clinics [91] or the Thai Industrial Technology Assistance Program (iTAP) [92]. (See Rush, Bessant and Hobday [93] for more extensive list of examples.) The main objective of this type of intermediary is to fulfill the need of a firm and a society to progress in technological development which would in turn benefit the public both directly and indirectly. Generating profit should not be the highest priority of this type of intermediary. The revenue from the service (and public funding) should be enough to cover the operating cost but does not necessarily have to generate profit for the organization.

Innovation Incubator

Similar to an innovation broker, an innovation incubator provides a neutral platform for idea development and innovations not specific in any industrial sectors. Thus, it would be beneficial for organizations that utilize this type of intermediary to collaborate and gain different ideas from different knowledge sectors. In analogy with the difference between co-operative technical organizations and knowledge intensive business services, innovation incubator differs from innovation broker in the sense that it deals with multiple industrial sectors operating in non-virtual environment under public funding. An example of this type of intermediary is a business incubator such as a regional science park or a technology park [94]–[96], or a publicly funded research association such as the European Association of Research and Technology Organizations (EARTO) [97]. This type of intermediary has a key objective of providing public service in innovation serving the companies in need. Similar to other publicly funded agencies, the financial gain should not be the top priority of this type of intermediary.

Virtual Knowledge Broker

Virtual knowledge broker is the extension of the classical knowledge broker in a virtual environment [62], made possible by advanced digital communication and the internet especially the emergence of Web 2.0 technology (the internet application that facilitates interactive information sharing and user collaboration on the World Wide Web). This allows a broader and more efficient integration of external actors [98] as the communication and interaction between intermediaries and actors become more cost-effective and diminish the trade-off between richness and reach of information. Operating in a virtual space allows the intermediary to connect with a greater numbers of actors and provides opportunity to gather more complex information than the operation in non-virtual environment [99]. It should be noted that, for virtual knowledge broker, there is hardly any difference in operating by focusing on a single industrial sector or across multiple industrial sectors because there is no physical limitation in virtual environment. An example of this type of intermediary is an innovation marketplace operator such as the web-based company InnoCentive [100]. InnoCentive enables its clients (solution seekers) to post their problems online and to find the potential problem solvers in exchange of a financial reward. It also helps its clients to frame the problem and to manage the transfer of intellectual property rights of the solution as well as financial reward between seekers and solvers who remain anonymous to each other [101]. Similar to its counterpart in non-virtual environment, the main objective of this type of intermediary is twofold: (1) to increase operational efficiency of the clients via the knowledge brokering services and, as a result, (2) to improve business performance of the clients and the organization itself as it is the general goal for the existence of privately funded entity.

2.1.3 Generalizability of Innovation Intermediaries

It should be noted that this research on impact of social capital on innovation intermediaries aim at covering the intermediaries that operate in non-virtual environment. All types of intermediaries in non-virtual environment are generalizable in this study in the sense that they represent the entity that connects two or more parties together and helps facilitating the "movement" or the "flow" of specific knowledge; they accommodate the process which would be difficult or impossible to achieve otherwise. The intermediary agents in non-virtual environment employ their tacit knowledge on technical problem solving skill and their social capital (network of potential problem solvers or experts) to fulfill the needs of solution seekers by correctly understanding the problems and appropriately matching the right problem solvers to the particular solution seekers. The intermediaries in virtual environment are excluded from the study because they operate in different condition from their counterparts in a non-virtual environment, mainly on the ability to reach wider and larger number of actors via virtual environment which might or might not diminish the importance of social capital; this is the topic that pertains to different research agenda.

2.2 Technical Problem Solving

Schrader, Riggs and Smith [27] stated that technical problems are solved under two different conditions, namely uncertainty and ambiguity. In contrast to past research, they asserted that problem framings and the levels of uncertainty and ambiguity in the problems are not given to the problem solvers but, instead, it is a deliberate and conscious choice of the problem solvers to choose the level of uncertainty and ambiguity in the problems. For the success of the problem solving process, the problem solvers have to make a correct choice in framing the problem and determining the appropriate level of uncertainty and ambiguity to match with the corresponding characteristics of the problem solving process; such characteristics include (but not limited to) the prior problem solving experiences, organizational context and available resources. Both problem solving under uncertainty and problem solving under ambiguity involve different sets of tasks, thus they require different organizational structure setting and different types of resources are needed in problem solving process under those conditions.

2.2.1 Definition and Terminology of Problem Solving Process

According to Andries and Debeckere [102], based on the definition provided by Schrader, Riggs and Smith [27], uncertainty is defined as "a situation in which the relevant decision variables are known, but [the problem solver] does not know the exact values these variables should take". On the other hand, ambiguity is defined as "an inability to recognize and articulate variables and their functional relationships" or a situation with "unknown unknowns". It should be noted that the definition of ambiguity varies by field of study[1].

[1] According to Andries and Debeckere [102], for example, in economics, the term "ambiguity" may be referred to as "Knightian uncertainty" which assumes that the relevant decision variables and their causal connections are known; only the probability distributions of their possible outcomes are unknown [103]. Ambiguity as defined by Schrader, Riggs and Smith [27] implied that the relevant decision variables and outcomes are not known. Economists refer to this as "unawareness" or "unforeseen contingencies" [104]; scholars in public policy have used the term "wicked problems" [105].

Schrader, Riggs and Smith [27] proposed that problem solving under uncertainty is characterized by a situation where problem solvers have a clear mental model of what to do and what specific information to look for; while problem solving under ambiguity is characterized by a situation where problem solvers do not have a clear mental model of the problem because of the lack of knowledge of related decision variables or their functional relationships or both. Consequently, uncertainly reduction requires tasks related to information gathering and integration; while ambiguity reduction requires tasks related to model building, evaluating and reframing the relationship of inputs, processes and outputs to identify decision variables and their functional relationships. In other words, uncertainty reduction requires a translation and transfer of information whereas ambiguity reduction requires in addition a translation and transfer of frameworks. Typically, the expected outcome of problem solving with purely uncertainty reduction is likely similar to the outcomes in the past with incremental improvement in the result. Thus, Schrader, Riggs and Smith [27] concluded that uncertainty reduction leads to an outcome with efficiency improvement. In contrast, the expected outcome of problem solving with ambiguity reduction is likely to be different from past outcomes with radical change as a result; which means that ambiguity reduction leads to outcome with innovation improvement.

Schrader, Riggs and Smith [27] also claimed that the same problem may be framed differently using different combinations of uncertainty and ambiguity based on the different views of individual problem solvers. The following example (adapted from the different case examples provided by Schrader, Riggs and Smith [27]) illustrates this claim.

Suppose that in a semiconductor manufacturing plant, a production manager (the problem solver) is faced with the problem of planning the production program to improve the average yield of the production line. If the manager considers himself to have a sufficiently good understanding of the plant manufacturing process or, in other words, the manager thinks that the variables and the functional relationship of these variables that drive the production yield are well understood but the exact values of these variables are not known, the manager may frame this problem as uncertainty reduction and investigates the values of the unknown variables. In this case, the manager may consider the complexity of the semiconductor chips and the skill of the workers at production lines to be variables that affect production yield. The manager finds the right combination of the workers operating on different production lines for different level of complexity of the chips and implements the production plan accordingly. The result should be an efficiency improvement in the production yield based on uncertainty reduction problem framing.

On the other hand, in this same situation, the manager may frame the problem under ambiguity if the manager feels that he does not fully understand the variables and their functional relationships. In this case, the manager might also consider looking into the complexity of the semiconductor chips and the skill of the workers as decision variables but the manager might feel that there are more variables involved and the relationships of those variables are not fully understood. Upon successfully solving the problem using ambiguity reduction, the manager might find an innovative way to improve the production yield, such as implementing a new step in the production procedure to reduce the waste in production process. This innovation improvement might not be realized if the manager considers only the known variables by using problem solving under uncertainty.

The two different expected outcomes of problem solving described by Schrader, Riggs and Smith [27], namely efficiency improvement and innovation improvement, are also discussed by Abernathy [106] in his productivity dilemma model which differentiates between two patterns of innovation; one reflects a flexible (fluid) state of innovation and the other represents a rigid (specific) state of innovation. The model explains the innovation and process change in a productive unit by using the U.S. automotive industry as an illustrative case. The model indicates that for each production unit, the initial stage of product development undergoes a higher rate of radical innovation (fluid state) with ideas originating from outside of production unit boundary; then as time goes by, the production goes through the normal direction of transition to the terminal stage where innovation is incremental (specific state) and focuses on increasing efficiency of production. The productivity dilemma model is clearly in an agreement with the expected outcomes of problem solving that a production unit (or solution of the problem) can either be improved in efficiency (be more efficient) or be improved in innovation (be more innovative).

2.2.2 Problem Solving Process and Its Solutions

As indicated in the work on problem solving theory by Newell and Simon [107] and Baron [108], the problem solving process generally consists of (1) the problem framing and/or problem representations under the specified problem spaces and (2) the problem solving methods that problem solvers deem appropriate to use in solving the problem. According to Simon et al. [109] and Baron [108], the problem solving methods fundamentally involve different kinds of selective search process through a number of possibilities to reach a goal. The search can be done by a primitive way of "trial and error" which is the easiest but also the weakest method because the problem solvers might have to try many different ways until reaching the goal or giving up the search without being able to solve the problem. A more sophisticated method in searching is to use a "hill climbing" procedure where the problem solvers have a way to evaluate whether they are closer to the goal or not and then determine where to move (or search) next based on the current position. However, the search procedure guided by hill climbing has a shortfall that the problem solvers might get struck at the sub-optimal solution. A more powerful and commonly used procedure for guiding the search is "means-ends analysis" approach. In this case, the problem solvers compare the current situation with the goal, calculate the difference between the two and then search for actions that would reduce such difference.

<u>Problem Solving Process under Uncertainty</u>

According to Schrader, Riggs and Smith [27], problem solving process that has been framed as uncertainty reduction requires resources which are readily available or easily accessible to the problem solvers. This implies that the search process for the solution under this particular problem framing would probably focus on "local" resources. Lovett and Anderson [110] confirmed the significance of local search for such resources by showing that problem solvers usually adapt the experience, knowledge, methods or solutions that are successful in the past (which is collectively referred to as "history of success") along with the current context of the problem in order to solve the problem at hand. The solution to the problem that is framed to reduce uncertainty tends to be the solution that involves in the efficiency improvement.

Problem Solving Process under Ambiguity

Schrader, Riggs and Smith [27] indicated that problem solving process that has been framed toward ambiguity reduction requires resources which have not yet been obviously available to the problem solvers. Thus, it could be implied that the search process for the solution of this type of problem framing should focus on "external" resources which lead to the solution that is associated with innovation.

The Limitation of Local Search

The significance of external search for innovative solution and the limitation of local search in achieving such solution have been shown in a number of studies. For example, Luchins [111] coined the term "Einstellung effect" and Luchins and Luchins [112] explained the term to describe a situation where past experience of successful problem solving biases the problem solving process in such a way that the problem solvers tend to use the same method in solving the new problem even when a better method exists. A research along the same line of reasoning included the issue of "functional fixedness," which was originally studied by Duncker [113] and further confirmed by Adamson [114]. Functional fixedness is a situation where problem solvers tend to use the tools to solve the problem according to their familiarity and have difficulty in applying the tools in different ways. These examples clearly show the limitation of local search and the need for external knowledge to achieve innovative solution.

The Significance of External Search

Several researches have demonstrated the importance of external sources of information in innovation process as pointed out by Cohen and Levinthal [115] in their seminal work on the concept of "absorptive capacity" which explained the capability of an organization in understanding the value of external information and using it for benefit of the organization. Allen and Cohen [116], Taylor [117] and Allen [118] discussed the role of individuals in the organization who act as technological gatekeepers by (informally) connecting with external environment and bringing in valuable information to the organization. With the idea closely related to the aforementioned concept of technological gatekeepers, Allen [118], Tushman [119], Tushman and Scanlan [120], [121] and a number of other researchers [122]–[124] explained the effect of boundary spanning activities that help individuals and organizations reaching out to various sources of external knowledge and information, either as intra-organizational spanning or inter-organizational spanning, with various channels such as alliances or mobility of staff. Furthermore, Iansiti [125] provided empirical evidence from technical problem solving processes in mainframe computer product development that a broad base of disciplinary expertise (including the previously unrelated knowledge bases) is required for technological innovation.

Broadcast Search: Extension to External Search

In another stream of research, building upon the argument that a novel problem in one (scientific) field might have related solution in another (scientific) field [126] and a problem solver from outside with different perspective is free of local search biases, Lakhani [127] and Jeppesen and Lakhani [128] proposed the use of broadcast search in problem solving. By using broadcast search, a problem is broadcasted to prospective external problem solvers who would self-select to solve the problem and are highly likely to provide an innovative and successful solution because of their different perspectives and ideas in problem solving. It should be noted that successful solutions from broadcast search often come from problem solvers who are considered to be at the periphery or margin of specific technical field, meaning that the problem solver's field of technical expertise is far from the focal field of the problem.

In summary, the literature in technical problem solving agrees that problem framing under uncertainty utilizing the local or "internal" search process that leads to the solution with efficiency improvement while problem framing under ambiguity mainly utilizing the "external" search process that leads to the solution with innovativeness improvement.

2.3 Social Capital

Aside from the knowledge and understanding in the problem, the success of intermediation process strongly depends on the network of potential problem solvers that the intermediary agents have and how the agents reach as well as match the seekers and solvers together. This aspect of intermediation process can be explained with the concept of social capital, especially in term of the ability of the agents to bridge the structural holes (i.e., gaps between nodes in social network) [129]–[131] and the ability of the agents to bond with their networks of relationships (i.e., network closure) [131]. In this sense, higher social capital means a higher possibility in reaching diverse group of people and successfully connecting solution seekers and problem solvers together which, in turn, translates to a higher probability of success in finding possible solutions for the problems.

2.3.1 Definition of Social Capital

Intuitively, the concept of social capital encompasses the general idea that relationship among people matters. A person can utilize the relationships with other people (that have been made and cultivated over time) to achieve a specific goal which could be of great difficulty or impossible otherwise. In fact, the topic of social relationship and trust has been studied widely in the past. The concept of social capital has been introduced and gained a significant interest in multiple disciplines because it is easy to grasp and it is so versatile that it could be used to explain many different concepts without losing its core concept that focuses on the relationship between people. International organizations such as the World Bank and Organization for Economic Co-operation and Development (OECD) have also officially adopted and acknowledge the terminology in their official publications such as the World Development Report [132] and the Well-being of Nations [133] which, in turn, has made the concept become more popular and widespread.

Originally, social capital was used as a metaphor to explain the situation where some people have advantages over other people because of their connections or networks of relationship. Subsequently, the metaphor was transformed into the concept of a "capital" that is used to complement the other forms of capital (i.e., from the basic definition in economics for a capital in a tangible sense as a factor of production, e.g., money and resources, to the definition of a capital in an intangible sense such as human capital, e.g., the stock of knowledge). Three distinctive scholars from different fields are considered to have contributed to the state of knowledge on social capital in modern usage. These three scholars, who work independently from different perspectives but have come up with coherent definition of social capital that consists of personal connections and interpersonal interaction, are a French sociologist named Pierre Bourdieu, an American sociologist named James Coleman, and an American political scientist named Robert Putnam [134].

Bourdieu had developed his concept of social capital during the 1970s and 1980s from his interest and his research which is mainly focused on the persistence of social class and the remnants of established inequality in European society that lead to unequal access to resources [134]. Based on his claim (under a Marxist framework) that economic capital is at the root of all other types of capital and that capital is accumulated labor that takes time (and effort) to accumulate, Bourdieu used cultural capital (which was his initially proposed concept that encompassed the later developed concept of social capital) to explain the unequal academic achievement of children from different social classes and from different groups within social classes [135]. With the view of social capital as resources that result from social structure, Bourdieu [136] defined social capital as follows: "social capital is the sum of resources, actual or virtual, that accrue to an individual or a group by virtue of possessing a durable network of more or less institutionalized relationships of mutual acquaintance and recognition."

Coleman, like Bourdieu, had come to a contribution in the concept of social capital from his attempt to explain the relationship between social inequality and academic achievement in American schools [134]. In a broader sense, Coleman tried to develop an inter-disciplinary concept that integrated both economic and sociology theory. Based on rational choice theory which assumes that individuals would automatically and basically act in a way that serves their own interests, Coleman [137] defined social capital as a function of social structure that becomes a useful resource; "social capital is defined by its function. It is not a single entity, but a variety of different entities having two characteristics in common: they all consist of some aspect of a social structure, and they facilitate certain actions of individuals who are within the structure. Like other forms of capital, social capital is productive, making possible the achievement of certain ends that would not be attainable in its absence." It should be noted that, along with the idea of individuals pursuing self-interest, cooperation as defined by social capital in Coleman's point of view relies heavily on trust and norms of relationship [134]. Coleman regarded trust and norms as the basis of the network closure or, in other words, the mutual reinforcement of relationship between individuals that enforces obligation to act in certain ways and sanctions free-riders.

Building upon Coleman's work, Putnam developed the concept of social capital to explain the role of civic engagement in generating political stability and economic prosperity in society [134]. Putnam is widely recognized from his work which claimed that there was such a strong decline of social capital in the U.S. that rendered much of urban America ungovernable [138], [139]. According to Putnam [140], "social capital here refers to features of social organization, such as trust, norms, and networks, that can improve the efficiency of society by facilitating coordinated action." Putnam also contributed to the concept of social capital by introducing a distinction between two aspects of social capital: bonding (or exclusive) and bridging (or inclusive). The bonding aspect of social capital reinforces exclusive identities and maintains homogeneity – it acts as a kind of sociological superglue that maintains strong in-group loyalty and reinforces specific identity; while the bridging aspect of social capital brings together people from diverse social divisions which leads to better linkage to external assets and information – it acts as a kind of sociological lubricant that can generate broader identities and reciprocity [134].

2.3.2 Structural Holes and Network Closures

Ronald S. Burt also presented two different views of social capital, namely structural holes and network closure. The structural holes argument has been mainly developed from the work of Granovetter [141], [142] on the strength of weak ties which was built upon the assumption that information in the network is not uniformly distributed; strong ties provide a flow of homogenous information between strongly connected individuals while weak ties enable the transfer of heterogeneous and new information between connected individuals. Thus, individuals who have connections with more weak ties are likely to be able to access broader information. Weak ties between individuals in the network structure can be viewed as structural holes, which separate non-redundant sources of information between different groups of individuals. An individual whose relationships span across more structural holes, or bridge the holes between different networks, would have more advantage in terms of broader and richer information access. Burt backed up his argument on the benefit of bridging structural holes with a number of empirical studies [129]–[131]. One of his studies, which looked at the networks around managers in a large American electronics company, explicitly pointed out that creativity and innovation are associated with networks of individuals and groups that span across structural holes [130]. In this context, the view of social capital from structural holes by Burt can be compared with the bridging aspect of social capital by Putnam, both of which point to a coherent argument that innovation and creativity mainly originate from heterogeneous information outside of the groups.

Referring to Coleman's view of social capital that focusing on trust between individuals in the network, Burt [131] proposed the network closure as a form of social capital in such a way that closed relationships between individuals with high levels of trust in the network is beneficial to all members of the networks. It is so because closed and strong ties provide a reliable communication channel for information flow while trust in network closure facilitates sanctions, thus preventing individuals from violating the norms of conduct which, in turn, makes it less risky for individuals in a network to trust one another, resulting in a reinforcement of strong ties. A number of studies also support the argument that strong ties lead to less conflict and a more productive environment [143], [144]. Similar to the structural holes and bridging argument, the view of network closure as social capital can be compared with the bonding aspect of social capital, both of which describe closed relationships that rely on trust and norms to create homogeneity and, in turn, improve the efficiency of performances of both individuals and groups.

Even though there are two different aspects of social capital (structural holes/bridging argument versus network closure/bonding argument) that focus on different network mechanisms, Burt [131] concluded that both aspects of social capital are important and contribute to the performance of individuals and groups. The conclusion stems from the fact that bridging and spanning across structural holes is the source of added value while bonding and closure of network is critical to realizing the value buried in the structural holes.

2.3.3 Dimensions of Social Capital

According to Nahapiet and Ghoshal [145], there are multiple aspects or facets of social capital, thus, it is helpful to group these different facets into clusters which could be referred to as dimensions of social capital. Table 5 shows three different dimensions of social capital, namely, the structural dimension, the relational dimension and the cognitive dimension, along with their associated facets and detailed explanations of each element [146].

Table 5–Dimensions of social capital

Dimension	Facet	Explanation
Structural dimension	Network ties	The specific ways that the actors in the networks related to each other.
	Network configuration	The pattern of linkages between all members of the network.
	Network stability	The rate of change in membership of the network.
Relational dimension	Trust	The social judgments of the actors in the network and the assessment of costs or risk associated with the judgments.
	Norms	The degree of consensus among the actors in the network that indirectly controls their actions.
Cognitive dimension	Shared language and codes	The common ways for the actors in the network to communicate and understand each other.
	Shared goal	The degree of common understanding and approach to the achievement of the tasks shared by all of the actors in the network.

It should be noted that bridging and bonding social capital can also be explained in the context of these three dimensions of social capital. Specifically, Taylor [147] indicates that bridging social capital can be indicated by the structural dimension of social capital based on the argument of Burt [129]; whereas bonding social capital can be explained by the relational dimension and the cognitive dimension of social capital according to the argument of Coleman [148].

It has been shown in the literature that the different dimensions of social capital can be applied to explain the integration of social capital concept with other disciplines. For example, Munkongsujarit [149] and Munkongsujarit, Jetter and Daim [150] demonstrate the relationship between social capital and knowledge transfer process by using the case study of technology transfer in R&D and new product development activities in high-tech industry setting. Along a similar line of argument in Munkongsujarit [149] and Munkongsujarit, Jetter and Daim [150], based on the fact that knowledge and information transfer between solution seekers and problem solvers via an innovation intermediary is an important part of the innovation intermediation process, it can be showed that social capital is also one of the important elements in the innovation intermediation process. This relationship is also supported by the argument of Fukuyama [34] regarding the economic function of social capital which helps "to reduce the transaction cost associated with formal co-ordination mechanisms" (page 10) [34], hence making it easier and more preferable to transfer knowledge and information with people whom you know and trust. Thus, the dimensions of social capital can be applied to explain the relationship between social capital and the innovation intermediation process. The research model and research hypotheses based on the theoretical foundations as explained in this chapter are presented in Chapter 3.

Chapter 3

Research Method

This chapter discusses the research methodology used in this dissertation starting from the research hypotheses and research model based on the theoretical foundations from the literature. The chapter continues with the research design by explaining unit of study and the samples in this research, the measurement of variables for hypotheses testing, the questionnaire used for collecting the data, the data collection process (face-to-face interview and document analysis) and the data analysis process.

3.1 Research Hypotheses

In general, social capital can be viewed as a kind of "resource" (for example, see Burt [129], Coleman [137], Tsai and Ghoshal [151]) that the intermediary agents can utilize in order to achieve desired outcomes. Social capital provides competitive advantage to the agents in the intermediation process according to the resource-based view as explained by Barney [35], [36]. There are several studies that explain the relationship between social capital and innovation through resource-based view, for example Tura and Harmaakorpi [152] explored the relationship between social capital and regional innovative capability, Nielson [153] examined the role of social capital in innovation processes, and Chisholm and Nielson [154] specifically looked into the relationship between social capital and resource-based view of the firm. However, these studies focus on the macro-level of the relationship between social capital and innovation (e.g., at regional level between firms and other organizations in the "region" as indicated by Tura and Harmaakorpi [152] or at firm and inter-firm level as indicated by Chisholm and Nielson [154]). As a matter of fact, the building blocks of the firms are individuals which are the intermediary agents in this case. Thus, it can be inferred that that there might be a relationship between social capital and the outcomes of the intermediation process at the operational level (intermediary agents) which leads to the following hypotheses[2]:

Hypothesis 1: Social capital of intermediary agents is associated with successful projects with efficiency improvement.

Null Hypothesis 1: Social capital of intermediary agents is not associated with successful projects with efficiency improvement.

Hypothesis 2: Social capital of intermediary agents is associated with successful projects with innovativeness improvement.

Null Hypothesis 2: Social capital of intermediary agents is not associated with successful projects with innovativeness improvement.

In an innovation intermediation process, problem solving is an important task of the intermediary agent who tries to connect solution seekers with problem solvers. Schrader, Riggs and Smith [27] suggest that, in a problem solving process, the problem solvers have a choice in framing a problem by focusing on uncertainty reduction or ambiguity

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[2] In Chapter 1, the linkages of social capital and outcomes of intermediation process as specified by Hypothesis 1 and Hypothesis 2 are not explicitly stated in the research framework (Figure 2) because the relationships are implied through a two-step process, i.e., (1) the relationship between social capital and problem framing and (2) the relationship between problem framing and the outcomes of intermediation process. In this chapter, the hypotheses are explicitly spelled out along with the associated null hypotheses.

reduction. The choice in framing the problem impacts the outcome of the problem solving process: problem framing geared at uncertainty reduction is expected to result in efficient outcomes whereas problem framing with a focus on ambiguity reduction is associated with innovative outcomes. Schrader, Riggs and Smith [27] propose that the availability of problem-solving resources biases problem solvers toward framing the problem so that these resources can be utilized in the problem-solving process. If many solution-specific resources are available, problem framing occurs with a focus on reducing uncertainty by putting these resources to work. On the other hand, if non-solution-specific resources are available, problem solvers are more likely to frame the problem as ambiguous. As innovation intermediaries try to connect solution seekers to problem solvers, one of their most important resources is their social capital. Two different but correlated views of social capital, i.e., bonding and bridging aspects of social capital, can be used to identify the tendency of the intermediary agent in choosing different ways of framing a problem which would lead to different types of outcomes.

The bonding aspect of social capital (network closure argument) that puts the emphasis on trust and a closed relationship is expected to cause an intermediary agent to frame the problem by focusing on uncertainty reduction so that the existing base of knowledge can be used to solve the problem. This is also supported by Lazarova and Taylor [155] who indicate that the utilization of exploitative knowledge (or knowledge that builds upon prior available knowledge for efficiency improvement) is associated with the emphasis on strong and frequent relationship (network closure/bonding argument). Moreover, Taylor [147] (based on Coleman [148]) points out that the bonding aspect of social capital can be described by relational and cognitive dimensions of social capital, namely trust and common visions or goals among the parties involved. This leads to the following hypothesis.

Hypothesis 3: Intermediary agents with strong bonding social capital tend to choose uncertainty reduction more frequently than the agents with lower bonding social capital do.

Null Hypothesis 3: Intermediary agents with strong bonding social capital do not tend to choose uncertainty reduction more frequently than the agents with lower bonding social capital do.

Schrader, Riggs and Smith [27] also propose that the availability of non-solution-specific resources may induce problem solvers to frame a problem as containing reducible ambiguity. The bridging aspect of social capital (structural holes argument) provides the intermediary agents with a chance to connect to a number of experts from different disciplines, and thus enables the intermediary agents to frame the problem focusing on ambiguity reduction. The idea of ambiguity reduction by identifying and utilizing novel knowledge from variety of sources (bridging structural holes) also resonates well with the use of exploratory knowledge as mentioned by Lazarova and Taylor [155]. Taylor [147] (based on Burt [129]) also indicates that the bridging aspect of social capital can be described by the structural dimension of social capital, namely the effective flow of knowledge and coordination through the networks of relationships. This leads to the following hypothesis.

Hypothesis 4: Intermediary agents with strong bridging social capital tend to choose ambiguity reduction more frequently than the agents with lower bridging social capital do.

Null Hypothesis 4: Intermediary agents with strong bridging social capital do not tend to choose ambiguity reduction more frequently than the agents with lower bridging social capital do.

According to Schrader, Riggs and Smith [27], the outcomes of the problem-solving process are different depending on the choice in problem framing. If the problems are framed as uncertain, the activities in uncertainty reduction will build upon and improve the existing technologies and skills, which in turn increase the efficiency of operation. On the other hand, if the problems are framed as ambiguous, the activities in ambiguity reduction will potentially constitute challenges to current approaches and try to come up with novel ways of operating, which in turn contribute to higher level of innovation. This leads to the following hypotheses.

Hypothesis 5: Problem framing with a focus on uncertainty reduction is associated with solutions that result in efficiency improvement.

Null Hypothesis 5: Problem framing with a focus on uncertainty reduction is not associated with solutions that result in efficiency improvement.

Hypothesis 6: Problem framing with a focus on ambiguity reduction is associated with innovative solutions.

Null Hypothesis 6: Problem framing with a focus on ambiguity reduction is not associated with innovative solutions.

Figure 3 shows the research model based on the research hypotheses and the proposed research framework (as presented in Figure 2).

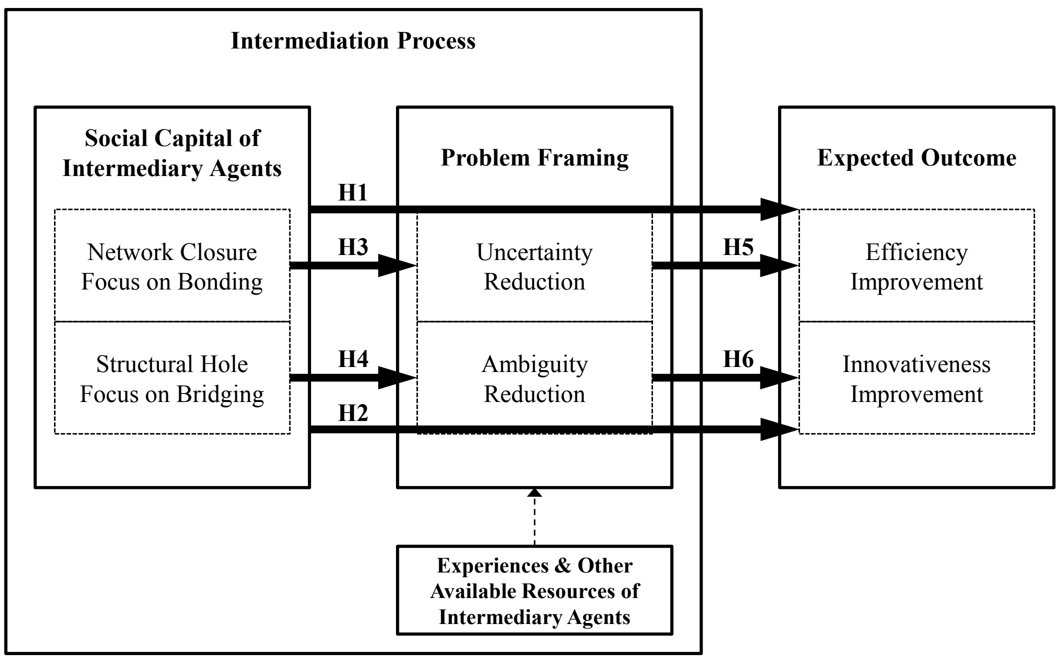

Figure 3–Research hypotheses and research model

3.2 Research Design

This section discusses the research design by first presenting the unit of study for this research and the nature of the sample. Then, the section continues with the explanation of the measurement of variables required for hypotheses testing as well as the associated questionnaire. Finally, the section concludes with the data collecting procedure and data analysis procedure.

3.2.1 Unit of Study and Samples

The unit of study for this research is an intermediary organization called Industrial Technology Assistance Program (iTAP), which is a part of Technology Management Center (TMC) at the National Science and Technology Development Agency (NSTDA) of Thailand. The mission of iTAP is to become the national technology support program for small and medium-sized enterprises (SMEs) in order to help them meet technological challenges and to promote their competitiveness and sustainable development. There are three official objectives of iTAP, namely (1) to further develop potential for Thai SMEs by encouraging high level development of technology-based products and processes in order to increase innovations and exports, (2) to support industrial business clusters by connecting industrial groups in the near-by area to research institutes and government organizations that provide services to SMEs, and (3) to support transferring of technology by obtaining funds for research and development of technology, innovations and inventions both from inside Thailand and from overseas as well as finding ways to apply these technologies to improve and create new industrial processes and products in the market [156].

The operation of iTAP is explained in detail by Munkongsujarit and Srivannaboon [157] and can be summarized as follows. The prospective SMEs who have science and technology related problems contact iTAP for assistance. Upon reviewing the initial request and identifying the technology-related challenges of the SMEs, iTAP appoints specific personnel called Industrial Technology Advisor (ITA) to work together with the SMEs to come up with a proposal for project according to the problem they have. With the approval of the proposal from iTAP, ITAs try to search for the potential problem solvers which could be a person from the networks of national laboratories and universities or an expert from the industries either based locally in Thailand or internationally. Acting as mediator and broker, ITAs match the appropriate experts with the SMEs and oversee the problem solving process, as well as related activities (e.g., financial and legal support) if necessary until the project is completed. A simplified work flow of iTAP's operations (adapted and modified from [157]) along with the occurrences of problem framing, social capital and outcome in the intermediation process is shown in Figure 4. This shows that iTAP is a potential intermediary organization to identify the relationship between problem framing, social capital and outcome of the intermediation process.

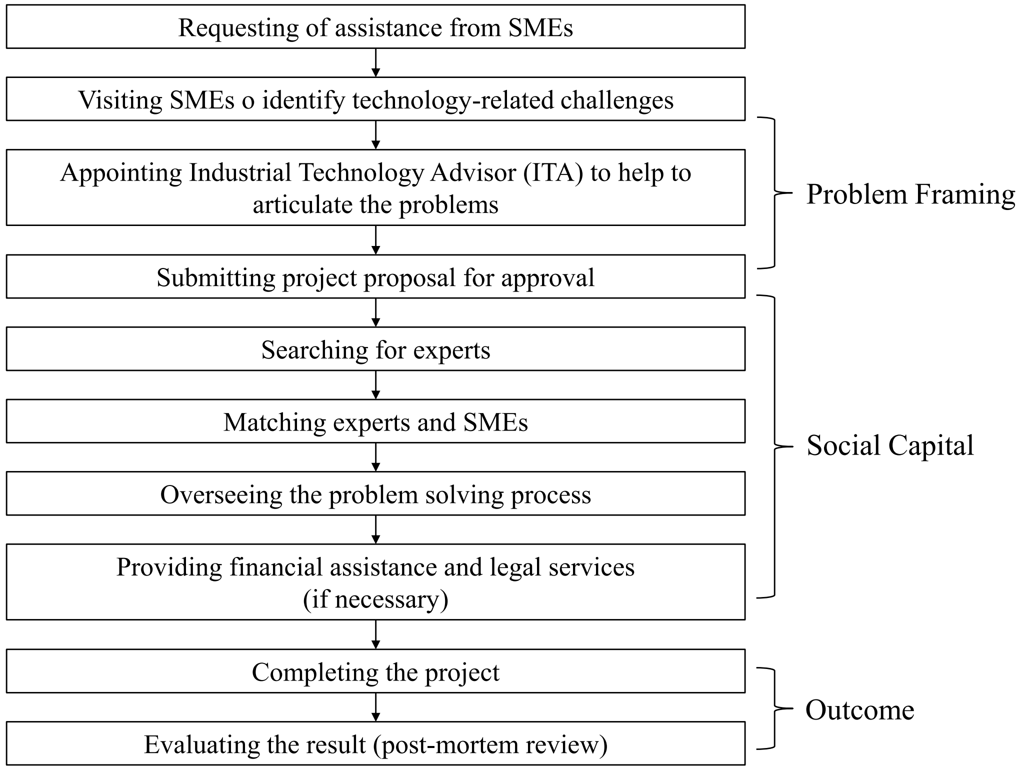

Figure 4–A simplified flow chart of iTAP's operations

Figure 4 shows that iTAP clearly fits the definition of an innovation intermediary organization. The ITAs act as the innovation intermediary agents who involve in the innovation intermediation process between SMEs and experts. Thus, the results of the analysis of the data acquired from this sample of full population of ITAs in iTAP can be generalized to explain the relationship of social capital, problem framing and innovation intermediation process (according to the research model in Figure 3) of any innovation intermediary agents who perform similar activities of connecting the solution seekers to the appropriate problem solvers, regardless of the affiliation and/or physical locations of the innovation intermediary organization.

3.2.2 Measurement of Variables for Hypotheses Testing

Based on the research hypotheses, the list of necessary variables is generated and the questionnaire is constructed to obtain all of the data from the unit of study, which is iTAP in this case. The variables are divided into three categories according to the topics they represent and are listed accordingly.

1. Social capital variables
    1.1. Nature of (social capital) network[3]
        - Organization homogeneity
        - Knowledge homogeneity
        - Organization heterogeneity
        - Knowledge heterogeneity

    1.2. Dimension of social capital
        - Structural dimension: ease of reach
        - Relational dimension: trust
        - Cognitive dimension: mutual understanding
2. Problem framing variables
    - Attitude toward uncertainty tolerance
    - Attitude toward ambiguity tolerance

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[3] The term nature of social capital network in this context represents the different types of social capital relationships that an intermediary agent has, focusing on the difference and similarity of affiliation and expertise in the relationship. This group of variables will be referred to as "nature of network" variables (omitting the obvious implication of social capital from the text) throughout this dissertation.

3. Outcome variables

- Annual average of number of successful projects with efficiency improvement
- Annual average of number of successful projects with innovativeness improvement

The detailed information of each variable is presented as follows:

Nature of Network

For the variables representing the nature of the network of contacts, the data is derived from the questionnaire by utilizing egocentric network survey (as used by Johannisson [158], Levin and Cross [159], and Burt, Hogarth and Michaud [160] as "name generator") where the ITAs are asked to list the name of their co-workers or experts that they have been in contact with in the past year along with their affiliation and expertise. An example of the egocentric network survey that is used in the questionnaire is shown in Table 6 (see Appendix A for the full context of this survey in the questionnaire). The variable for organization homogeneity (denoted as *SIM_ORG*) is simply a count of number of (internal) contacts who work within the same organization with the agent (co-workers); while the variable for organization heterogeneity (denoted as *DIFF_ORG*) is a count of number of (external) experts who work in different organization. The variable for knowledge homogeneity (denoted as *SIM_KNOW*) is a count of number of contacts who share similar expertise (knowledge domain) with the agent; while the variable for knowledge heterogeneity (denoted as *DIFF_KNOW*) is a count of number of contacts who have different expertise from the agent. The agents also have a choice to indicate that they have "somewhat" similar/different expertise with each contact; in such case the value for the count of the contact is equally divided between knowledge homogeneity variable and knowledge heterogeneity variable (i.e., the value of 0.5 is added to both variables).

Table 6–Example of egocentric network survey part of the questionnaire

No.	Name	Affiliation	Expertise (Please select one)			Rating Score (From 1 to 10)		
			Similar	Somewhat Similar	Different	Q1	Q2	Q3
1.	Mr. AAA	ABC company	×			10	10	9
2.	Mr. BBB	XYZ university			×	8	8	8
3.	Ms. CCC	123 laboratory		×		7	5	10

It should be noted that nature of the network of contacts (homogeneity and heterogeneity) can be used to determine the level of bonding and bridging social capital. This follows the characterization of bonding and bridging social capital by Coffé and Geys [161] who indicate that "heterogeneous associational membership is likely to be associated with more bridging potential, whereas homogeneous associational membership is associated with more bonding potential" (page 122) [161]. The operationalization of homogeneity and heterogeneity variables is also supported by Geys and Murdoch [162], [163] in their works on the measurement of bonding and bridging social capital.

This set of nature-of-network variables has discrete value dictating by a count of number of contacts and the value of 0.5 increment (in the case of "somewhat" similar/different expertise for knowledge homogeneity/heterogeneity). The possible minimum value for each variable in this set is zero, indicating no particular type of network of contacts existing for the agents. The possible maximum value for the variable is the maximum number of contacts that the agents provide.

Ease of reach (*REACH*)

This variable represents a commonly accepted measure of structural dimension of social capital, used by Nahapiet and Ghoshal [145]. It represents the level or the degree of ease for intermediary agent to reach out to a person (how easy it is to contact a person to ask for help or ask for information). The statement in the questionnaire that is associated with this variable is adapted from the definition of network ties as defined by Inkpen and Tsang [164] as the ways that the actors in the networks related to each other.

The value of this variable is acquired from the questionnaire by asking each of the intermediary agents to rate the agreement to the statement from the scale of one to ten (the value of one being strongly disagree and the value of ten being strongly agree). The statement associated with this variable is "Q1: It is easy to reach out to this person for help or information" (see Appendix A for the full context of this statement in the questionnaire). The value of the variable is the average of the perception scores that the agent gives to each of the contacts that they provide. Thus, the variable has an approximately continuous numerical value ranging from one to ten.

<u>Trust (*TRUST*)</u>

This variable represents a commonly accepted measure of relational dimension of social capital, used by Nahapiet and Ghoshal [145]. The variable is based on the definition of trust as defined by Inkpen and Tsang [164] as the social judgments of the actors in the network and the assessment of costs or risk associated with the judgments. Levin and Cross [159] (based on the theoretical foundation by Mayer, Davis and Schoorman [165]) identified two types of trust that contribute to the knowledge transfer, namely benevolence-based trust and competence-based trust. The intermediary agents should have confidence in the capability in all of contacts in order to work with them. In other words, the agents should establish similar level of competence-based trust with their contacts. However, benevolence-based trust differs from person to person based on the willingness to help. Thus, the benevolence-based trust is chosen as a proxy of the level of relational dimension of social capital. In the questionnaire, the agents were asked to provide the level of benevolence-based trust that they perceive toward their contacts by rate the agreement to the statement from scale of one to ten (the value of one being strongly disagree and the value of ten being strongly agree). The statement regarding trust in this context is modified from the survey item on benevolence-based trust by

Levin and Cross [159] and the questionnaire item on interpersonal trust by Cook and Wall [166][4].

Similar to the variable for structural dimension of social capital, the value of this variable is calculated from the average value of the rating scores on the statement that the agents give to each of contacts that they provide. The statement associated with this variable is "Q2: I trust that this person is willing to go the extra mile to help me" (see Appendix A for the full context of this statement in the questionnaire). The variable is an approximately continuous numerical value with the lower bound of one and the upper bound of ten.

Mutual understanding (*MUTUAL*)

This variable represents a commonly accepted measure of cognitive dimension of social capital, used by Nahapiet and Ghoshal [145]. It conveys the level of mutual understanding that the intermediary agents perceive toward their contacts. This is based on two facets of social capital namely shared languages and codes (the common ways for the actors in the network to communicate and understand each other) as defined by Nahapiet and Ghoshal [145], and shared goals (the degree of common understanding and approach to the achievement of the tasks shared by all of the actors in the network) as defined by Inkpen and Tsang [164].

[4] Levin and Cross [159] used seven-level Likert scale for the rating of benevolence-based trust with the statement "Prior to seeking information/advice from this person on this project, I assumed that he or she would go out of his or her way to make sure I was not damaged or harmed". Cook and Wall [166] also used a seven-level Likert scale for the rating of interpersonal trust at work under the category of faith in intentions with the statement "I can trust the people I work with to lend me a hand if I needed it".

The value for this variable is acquired from the face-to-face interview with the agents by asking each of them to rate the agreement to the statement from the scale of one to ten (the value of one being strongly disagree and the value of ten being strongly agree). The statement associated with this variable is "Q3: I understand how this person thinks" (see Appendix A for the full context of this statement in the questionnaire). The value of the variable is the average of the rating scores that the agents give to each of the contacts that they provide. Thus, the variable has an approximately continuous numerical value ranging from one to ten.

It should be noted that even though the concept of social capital indicates that the interaction between both parties should be somehow reciprocated in order for social capital to be considered useful, it is impractical (and even almost impossible) to measure the reciprocity level of social capital between the ITAs and their contacts. Thus, in this research, the subjective rating of the ITAs for all dimensions of social capital is a good proxy of how they perceive the value of their connection with the contacts which leads to the value of social capital.

Attitude toward uncertainty tolerance (*UNCERTAINTY*)

This variable indicates the level of familiarity or tolerance toward uncertainty that the intermediary agents have. Since the choice in problem framing is project specific, the best proxy to use for representing the probability that the intermediary agent would choose to frame the problem by focusing on uncertainty reduction is the level of tolerance toward uncertainty that the agents have. It is so because higher level of uncertainty tolerance implies that the agents have been familiarly working under a number of uncertainty circumstances. Thus, uncertainty tolerance can reflect the decision or choice in framing the problem to focus on uncertainty reduction under appropriate conditions.

The value of this variable is acquired from the questionnaire by asking the agents to respond to a series of statements regarding uncertainty circumstances with a five-level Likert scale (strongly disagree, disagree, neutral, agree, strongly agree). The statements are directly taken from part of a series of four questionnaires regarding the tolerance of ambiguity as presented in Furnham [167]. The rating score is transformed into a numerical value from one (for strongly disagree) to five (for strongly agree). Even though the nature of Likert scale is a set of categories, it is assumed to be numerical value from one to five with equal interval for each scale in this context. The value o this variable is simply an average value of the total rating score for the series of statements regarding uncertainty tolerance. Since the numerical value assigned to the rating score for each statement is ranging from one to five, the average value of total score will have a range from one as a minimum value to five as a maximum value.

<u>Attitude toward ambiguity tolerance *(AMBIGUITY)*</u>

This variable indicates the level of familiarity or tolerance toward ambiguity that the intermediary agents have. Similar to the case of uncertainty tolerance, because the choice in problem framing is project specific, the best proxy to use for representing the probability that the intermediary agent would choose to frame the problem by focusing on ambiguity reduction is the level of tolerance toward ambiguity that the agents have. The higher level of ambiguity tolerance implies that the agents have more experience in working under ambiguity circumstances. Thus, the level of attitude toward ambiguity tolerance of the agents can be a perfectly good proxy for the choice of the agents in framing the problem to focus on ambiguity reduction under appropriate conditions.

Similar to the attitude toward uncertainty tolerance, the value of this variable is acquired from the questionnaire by asking the agents to respond to a series of statements (which are also directly taken from Furnham [167]) pertaining the ambiguity circumstances with a five-level Likert scale (strongly disagree, disagree, neutral, agree, strongly agree). The rating score is transformed into a numerical value from one (for strongly disagree) to five (for strongly agree). Then, the value of the variable is calculated from the average value of the total rating score for the statements regarding ambiguity tolerance. Since the numerical value assigned to the rating score for each statement is ranging from one to five, the lower bound of this variable is one and the upper bound of this variable is five.

It should be noted that, for the case of the two problem framing variables in this research (attitude toward uncertainty tolerance and attitude toward ambiguity tolerance), the internal consistency of the responses to a series of statements in the questionnaire is measured in order to confirm that the responses correctly represent the true nature of the variables. A well-known measure for the internal consistency of a group of items in the questionnaire is a statistical parameter called “Cronbach’s alpha” which is also known as a coefficient of reliability. Cronbach’s alpha is calculated from the pairwise correlations between items and has a value between zero to one; the higher value indicates higher reliability. Generally, the acceptable value of Cronbach's alpha is greater than 0.7 [168]. However, a lower value of Cronbach's alpha is common when the variable is represented by fewer items in the questionnaire. In this case, another statistical parameter for internal consistency called "mean inter-item correlation" can be considered. Mean inter-item correlation is the mean value of all the correlation coefficients between items and has a value between zero to one. Briggs and Cheek [169] (as cited by Pallant [168]) indicated that "the optimal level of homogeneity [of the constructed variable] occurs when the mean inter-item correlation is in the 0.2 to 0.4 range" (page 115) [169][5].

Table 7 shows the value of Cronbach's alpha and mean inter-item correlation of both problem framing variables in this research (attitude toward uncertainty tolerance and attitude toward ambiguity tolerance).

Table 7–Reliability measurement for problem framing variables

Problem framing variable	Number of items in questionnaire	Cronbach's alpha	Mean inter-item correlation
UNCERTAINTY	3	0.453	0.256
AMBIGUITY	3	0.467	0.256

[5] Briggs and Cheek [169] justified their selection of the acceptable range of mean inter-item correlation as follows: "Lower than 0.1 and it is unlikely that a single total score could adequately represent the complexity of the items, higher than 0.5 and the items on a scale tend to be overly redundant and the construct measured too specific. The 0.2 to 0.4 range of intercorrelations would seem to offer an acceptable balance between bandwidth on the one hand and fidelity on the other" (page 115) [169].

It can be seen that even though the values of Cronbach's alpha for both problem framing variables are lower than the recommended value of 0.7, the values of mean inter-item correlation for both variables are in the acceptable range of 0.2 to 0.4. Therefore, both problem framing variables are acceptable to be used in the statistical analysis.

Annual Average of Number of Successful Projects with Efficiency Improvement *(ANN_EFF)*

This variable is considered to be a dependent variable in the regression analysis that represents the outcome of the projects owned by each intermediary agent. The outcome in this case is basically the successful projects that result in some kinds of efficiency improvement in the operation such as a better yield per area for agricultural plantation or a lesser loss in raw material in product manufacturing process. This variable indicates the average number of successful projects with efficiency improvement per year owned by each intermediary agent. The variable is calculated from the number of successful projects with efficiency improvement that the agents own since they start working as intermediary agent in the organization divided by the tenure (or the number of year) that the agents work in the intermediary agent position. The average number is used in this case so that the result is not in favor of the agents who have more stock of successful projects due to their longer tenure in the job. The criteria of the successful project are set and agreed upon by both the intermediary organization and the clients. Thus, the postmortem project report documents contain the result of the project according to such criteria. The interview session during the data collection process allows the agents to give the approximated number of the projects with efficiency improvement that they have worked on. However, the exact numbers of projects with efficiency improvement is confirmed and the value of this variable is taken from the official archival records of all of the projects at the organization where the "owners" of all projects along with the nature of their outcomes are officially verified.

As this variable represents the average of number of successful projects with efficiency improvement per year owned by each intermediary agent in the organization, it has an approximately continuous value with zero as the lower bound and the maximum annual average number of successful projects with efficiency improvement as the upper bound.

Annual Average of Number of Successful Projects with Innovativeness Improvement *(ANN_INN)*

This variable is another dependent variable in the regression analysis that represents the outcome of the projects owned by each intermediary agent. It describes the number of projects that are considered to be successful and resulted in innovativeness improvement of operation; the example of such improvement includes a new and novel way to use a machine in the production line or a new method and formula to mix the fertilizer, etc. The variable indicates the average of the number of successful projects with innovativeness improvement per year owned by each intermediary agent. Similar to the case of efficiency improvement outcome, this variable is calculated from the number of successful projects with innovativeness improvement that the agents own during their tenure as intermediary agent in the organization divided by the number of year that the agents work in the position. In the same manner as the projects with efficiency improvement, the agents have a chance to give the approximated numbers of projects with innovativeness improvement that they have worked on during the interview session but the exact numbers of projects with innovativeness improvement is confirmed and the value of this variable is taken from the official archival records of all of the projects at the organization.

This variable has an approximately continuous value with zero as the lower bound and the maximum average number of successful projects with innovativeness improvement in the organization history as the upper bound.

It should also be noted that the variables representing the number of projects with innovativeness improvement and the number of projects with efficiency improvement are mutually exclusive, as the categorization of the improvement of the projects follows the generally accepted differentiation between incremental (efficiency improvement) versus radical (innovativeness improvement) innovation by Abernathy [106] or continuous (efficiency improvement) versus discontinuous (innovativeness improvement) technological changes by Porter [170].

Table 8 summarizes the list of all variables required for the data set that is used for the statistical analysis models for hypotheses testing.

Table 8–List of variables for hypotheses testing

Variable name	Variable type	Lower bound	Upper bound	Meaning
SIM_ORG	Discrete numerical value	0	Max. number of contacts	Organization homogeneity – the number of contact within the same organization.
SIM_KNOW	Discrete numerical value	0	Max. number of contacts	Knowledge homogeneity – the number of contacts with similar expertise.
DIFF_ORG	Discrete numerical value	0	Max. number of contacts	Organization heterogeneity – the number of contact from external organization.
DIFF_KNOW	Discrete numerical value	0	Max. number of contacts	Knowledge heterogeneity – the number of contacts with different expertise.
REACH	Continuous numerical value	1	10	Ease of reach – the value of structural dimension of social capital.
TRUST	Continuous numerical value	1	10	Trust – the value of relational dimension of social capital.
MUTUAL	Continuous numerical value	1	10	Mutual understanding – the value of cognitive dimension of social capital.
UNCERTAINTY	Continuous numerical value	1	5	The attitude of the intermediary agent in choosing to frame the problem by focusing on uncertainty reduction.
AMBIGUITY	Continuous numerical value	1	5	The attitude of the intermediary agent in choosing to frame the problem by focusing on ambiguity reduction.
ANN_EFF	Continuous numerical value	0	Max. annual average number of successful projects with efficiency improvement	The annual average of number of successful projects with efficiency improvement outcome owned by the agent.
ANN_INN	Continuous numerical value	0	Max. annual average number of successful projects with innovativeness improvement	The annual average of number of successful projects with innovativeness improvement outcome owned by the agent.

3.2.3 Questionnaire

In this research, the questionnaire is used as a guideline for the interview session with ITAs at iTAP to extract the information for constructing the variables of hypotheses testing. The questionnaire is designed following the guideline as recommended by Bradburn, Sudman and Wansink [171]. The full questionnaire is included in Appendix A.

There are three main parts in the questionnaire. The first part comprises of several demographic characteristics and biographic data items (name, age, gender, educational backgrounds, work experiences) that serve the purpose of gathering the basic information of the ITAs and their works as well as familiarizing the ITAs with the interview session. The ITAs were also asked to provide the number of efficiency improvement projects and the number of innovativeness improvement projects that they have worked on during their job as an ITA at iTAP in this part of the questionnaire.

The second part of the questionnaire utilizes the standard egocentric network survey technique [158]–[160] (as used by Johannisson [158], Levin and Cross [159], and Burt, Hogarth and Michaud [160] as "name generator") by asking the ITAs to provide the list of experts and coworkers that they had been in contact with in the past year regarding their works as intermediary agents. From this list, the ITAs were asked to provide information on the job affiliation and expertise of these contacts which provide the information on the nature of the network of contacts of each ITA. Furthermore, to investigate the structural, relational and cognitive dimension of the social capital of the ITAs, they were asked to provide information on the nature of the relationship with each contact by giving a rating score (from the scale of zero to ten) to each contact with regard to the ease of reaching the contact, the trust toward the contact, and cognitive alignment with the contact.

Lastly, in the third and final part of the questionnaire, the ITAs were asked to give a rating on five-level Likert scale measurement of statements regarding the attitude toward uncertainty tolerance and ambiguity tolerance which is the proxy toward the problem framing process.

3.2.4 Data Collection Process

For this research, iTAP provides full access to its pool of intermediary agents (ITAs) as well as the records of past and present projects from its archival database. The main source of data comes from the face-to-face structured survey interviews with all of the ITAs at iTAP based on the pre-constructed questionnaire, included in Appendix A. In addition to the interviews with the ITAs, the archive of project proposals as well as project reports from iTAP database are reviewed as the secondary data source in order to verify the data regarding the ownership of the projects as well as the recorded outcomes of the projects. Table 9 shows the summary of sources of data, data collection methods and the content of data obtained from the data collection.

Table 9–Sources of data, data collection methods and content of data

Data sources	Data collection methods	Content of data
Intermediary agents (Industrial Technology Advisors at iTAP)	Face-to-face structured survey interviews	• Nature of the network of contacts • Level of social capital • Preference in problem framing • Perceived outcome of project
Archival records of current and past projects	Document analysis	• Ownership of the project • Actual outcome of the project

Face-to-face Interview

The face-to-face interview with a full population of ITAs in iTAP was conducted during a period of two months from May 2012 to June 2012. The interview session lasted 30 – 45 minutes for each ITA. Prior to the start of the data collection process, the top management of iTAP (the director of iTAP) sent out the invitation letter on behalf of the researcher asking for the cooperation of ITAs in this research. Out of the full population of 50 ITAs (N = 50) who were working at iTAP in various regional offices around Thailand during the research period, 46 qualified ITAs had agreed to set up a face-to-face interview with the researcher; resulting in the response rate of 92%. Table 10 illustrates the response rate of interviews based on the regional offices of iTAP. All ITAs agreed to give consent (by signing the consent form prior to the interview session) for using the data obtained from the interviews in this research. However, it should be noted that one ITA refused to complete a part of the questionnaire (regarding the rating of social capital dimension scores of the contacts) due to personal preference of unwillingness to give a "score" to any of the contacts (i.e., the ITA felt uncomfortable and reluctant to give a "score" to external experts of whom the ITA thinks highly and feels great respect), resulting in the missing items in the data set and, thus, exclusion of this respondent from the data set. The final usable number of data point equals 45 (n = 45).

Table 10–Response rate of the interviews

iTAP offices	Region	Number of ITAs	Number of ITAs being interviewed	Comments
Central Office	Bangkok	18	18	
National Science and Technology Development Agency (Northern Network)	North	4	4	
Khon Kaen University	Northeast	4	4	
Mahasarakham University	Northeast	2	2	
Suranaree University of Technology	Northeast	5	4	Missing one ITA; ITA not available.
Ubon Ratchathani University	Northeast	2	0	Missing two ITAs; ITAs not available.
Walailak University	South	2	2	
Faculty of Engineering, Prince of Songkla University	South	3	3	
Faculty of Agro-industry, Prince of Songkla University	South	3	2	Omitting one ITA; New to the job with no project ownership yet.
King Mongkut's University of Technology Thonburi	West	4	4*	One ITA did not complete the questionnaire.
Silpakorn University	West	2	2	
Thai-German Institute	East	1	1	
Total number of ITAs		50	46	Response rate = 46/50 = 92%

Validity of face-to-face Interview

Face-to-face interview is selected as a data collection procedure in this research because it provides the opportunity for the interviewer to explain any questions regarding the questionnaire to the interviewees as well as observing the reaction of the responses. This ensures the validity of the data obtained from the questionnaire as pointed out by Suchman and Jordan [172]–[174] that "the validity of data obtained through survey questionnaires hinges on the extent to which researchers who write the questions communicate their intended meaning to interviewers, who in turn convey the questions' meaning to respondents" (page 241) [173]. The advantage of face-to-face interview also resonates with the additional comment of Suchman and Jordan that "the interviewer be in a position to facilitate negotiations effectively about the meaning of the question whenever [that] necessity arises" (page 252) [174]. The disadvantage of face-to-face interview is the long amount of time required to conduct each interview session making it impossible for the research with a large sample size of the population to complete the data collection with this procedure in a timely manner. However, because iTAP has a reasonable sample size, coupling with the fact that the researcher has been granted full accessibility to the organization by the top management, it is possible and effective for this research to utilize the face-to-face interview method for data collection.

Validity of Questionnaire

The face-to-face interview with ITAs and the questionnaire is administered in Thai language. The questionnaire is translated into Thai language from the original design in English language. To ensure the validity of the translation, the questionnaire goes through the two-ways translations process as performed by Shane [175]. First the questionnaire is translated from its original English language into Thai language by a translator (the researcher in this case). Then these translations are retranslated back into English language by the other translators to check for any possible translation discrepancies. The translation process iterates until there is no discrepancies in both versions of the questionnaire.

Document Analysis

After the face-to-face interview sessions are completed, the archival records of the past and present projects that each ITA has worked on are reviewed. These include the project proposals, various internal request and review forms and the project reports. The data acquired from this source confirms the data from the interview with each ITA by providing the type of outcome of the projects (efficiency improvement or innovativeness improvement) and the recorded result of the projects (success or failure). Generally, during the interview session, the ITAs give approximate numbers of projects that they have worked on since they started their job as an ITA at iTAP. In most cases, the ITAs approximation of their numbers of projects is close to the official numbers from iTAP database. There are rare cases where ITAs give high discrepancy in numbers of projects, mainly due to the failure to recall the projects in the distant past. However, to ensure the reliability of the numbers of projects from each ITA, the official numbers of successful projects with efficiency improvement as well as the official numbers of successful projects with innovativeness improvement from the official iTAP archival database are used as data items in this research.

Data Preparation

To prepare the data for analysis, the information acquired from the face-to-face survey interviews and the document analysis is processed by transforming the responses of the questionnaire (numbers of contacts, rating scores and other related information) into numerical variables so that they can be used for hypotheses testing. This process yields a quantitative data set that includes three dimensions of social capital of each intermediary agent (the perception of easiness to reach each contact for structural dimension, the level of trust for relational dimension and the level of mutual understanding for cognitive dimension), the nature of the network of contacts of the agent, the choice in problem framing of the agents (representing by attitude toward uncertainty tolerance and attitude toward ambiguity tolerance) as well as the outcome of the intermediary projects owned by the agents (the number of successful projects with efficiency improvement and the number of successful projects with innovation improvement) as the variables. This data set is used in the data analysis process in order to test the hypotheses and address the research questions.

3.2.5 Data Analysis Process

In order to test the research hypotheses, a number of statistical analyses are performed using the variables from the acquired data set. First, correlation analysis is performed on all variables to explore the relationship between them. The standard Pearson correlation coefficients generated from the analysis indicate the level of linear association between two variables. Two variables could be positively correlated (i.e., when one variable increases, the other increases as well) or negatively correlated (i.e., when one variable increases, the other decreases) or non-correlated (i.e., when one variable changes, the other does not change at all). Thus, the correlation coefficients are used to interpret the preliminary relationship between social capital, choice in problem framing and outcome of the innovation intermediation process.

Then, a number of test models for regression analysis are employed in order to examine the relationship between the dependent variables representing by the outcomes of the intermediation process (which in this case include the number of successful projects with either efficiency improvement or innovativeness improvement) and the independent variables representing by all dimensions of social capital (structural dimension, relational dimension and cognitive dimension), the nature of the network of contacts (organization/knowledge homogeneity/heterogeneity), as well as the attitude toward uncertainty tolerance and attitude toward ambiguity tolerance. Simple linear regression models and multiple linear regression models are used to test the hypotheses following the models built upon the theoretical foundations. The results of the analyses lead to the acceptance of the hypotheses or the failure to accept the hypotheses.

It should be noted that all data analyses in this research are performed twice using two different statistical software programs, i.e., IBM SPSS Statistics for Windows, version 19.0 [176] and R statistical programing language [177]. First, the data is manually entered into SPSS, and the regression analyses are performed accordingly. Then, the same raw data is separately entered into R and all regression analyses are repeated. The results of the analyses from both software programs are compared to ensure that there is no discrepancy. This double crosscheck procedure eliminates human-error in data-entering process as well as in analysis process.

Table 11 summarizes the list of research hypotheses along with the corresponding statistical models for hypothesis testing and the associated variables.

The results of data analysis according to the research methodology are presented in Chapter 4; while the discussions as well as the in-depth analysis of the results are presented in Chapter 5.

Table 11–Statistical models for hypothesis testing and associated variables

Research hypothesis	Statistical model for hypothesis testing	Variable name		Type of variable
H1: Social capital of intermediary agents is associated with successful projects with efficiency improvement.	Simple linear regression and multiple linear regression	**Annual average of number of successful projects with efficiency improvement**	*ANN_EFF*	**Dependent variable**
		Organization homogeneity	*SIM_ORG*	Independent variable
		Knowledge homogeneity	*SIM_KNOW*	Independent variable
		Organization heterogeneity	*DIFF_ORG*	Independent variable
		Knowledge heterogeneity	*DIFF_KNOW*	Independent variable
		Ease of reach (structural dimension)	*REACH*	Independent variable
		Trust (relational dimension)	*TRUST*	Independent variable
		Mutual undemanding (cognitive dimension)	*MUTUAL*	Independent variable
H2: Social capital of intermediary agents is associated with successful projects with innovativeness improvement.	Simple linear regression and multiple linear regression	**Annual average of number of successful projects with innovativeness improvement**	*ANN_INN*	**Dependent variable**
		Organization homogeneity	*SIM_ORG*	Independent variable
		Knowledge homogeneity	*SIM_KNOW*	Independent variable
		Organization heterogeneity	*DIFF_ORG*	Independent variable
		Knowledge heterogeneity	*DIFF_KNOW*	Independent variable
		Ease of reach (structural dimension)	*REACH*	Independent variable
		Trust (relational dimension)	*TRUST*	Independent variable
		Mutual undemanding (cognitive dimension)	*MUTUAL*	Independent variable

Research hypothesis	Statistical model for hypothesis testing	Variable name		Type of variable
H3: Intermediary agents with strong bonding social capital tend to choose uncertainty reduction more frequently than the agents with lower bonding social capital do.	Multiple linear regression	**Attitude toward uncertainty tolerance**	***UNCERTAINTY***	**Dependent variable**
		Organization homogeneity	*SIM_ORG*	Independent variable
		Knowledge homogeneity	*SIM_KNOW*	Independent variable
		Trust (relational dimension)	*TRUST*	Independent variable
		Mutual understanding (cognitive dimension)	*MUTUAL*	Independent variable
H4: Intermediary agents with strong bridging social capital tend to choose ambiguity reduction more frequently than the agents with lower bridging social capital do.	Multiple linear regression	**Attitude toward ambiguity tolerance**	***AMBIGUITY***	**Dependent variable**
		Organization heterogeneity	*DIFF_ORG*	Independent variable
		Knowledge heterogeneity	*DIFF_KNOW*	Independent variable
		Ease of reach (structural dimension)	*REACH*	Independent variable
H5: Problem framing with a focus on uncertainty reduction is associated with solutions that result in efficiency improvement.	Simple linear regression	**Annual average of number of successful projects with efficiency improvement**	***ANN_EFF***	**Dependent variable**
		Attitude toward uncertainty tolerance	*UNCERTAINTY*	Independent variable
H6: Problem framing with a focus on ambiguity reduction is associated with innovative solutions.	Simple linear regression	**Annual average of number of successful projects with innovativeness improvement**	***ANN_INN***	**Dependent variable**
		Attitude toward ambiguity tolerance	*AMBIGUITY*	Independent variable

Chapter 4

Results

This chapter presents the results of statistical analysis as explained in Chapter 3. These include the descriptive statistics for all variables and the different regression models that are used to test the research hypotheses starting from the models that explain the relationship between social capital and the outcomes of intermediation process according to Hypothesis 1 and Hypothesis 2, then continuing with the models that show the relationship between social capital and problem framing as per Hypothesis 3 and Hypothesis 4, and concluding with the models that indicate the relationship between problem framing and outcomes of intermediation process as specified in Hypothesis 5 and Hypothesis 6. Additionally, more in-depth analyses are performed, including additional regression models that cover all social capital variables as independent variables instead of only bridging or bonding social capital variables for the relationship between social capital and problem framing (extension of models to test Hypothesis 3 and Hypothesis 4) and the additional descriptive statistics of problem framing variables for different groups of intermediary agents categorized by different level of outcomes (to see the relationship according to Hypothesis 5 and Hypothesis 6). Finally, the chapter concludes with the discussion on validity of the research, including construct validity, content validity and statistical conclusion validity.

The descriptive statistics including means and standard deviations (S.D.) of all variables using in the research models are shown in Table 12.

Table 12–Descriptive statistics and correlation coefficients of the variables

Variables		Mean	S.D.	1	2	3	4	5	6	7	8	9	10
Nature of social capital network	1. *SIM_ORG*	7.53	3.24										
	2. *SIM_KNOW*	5.78	4.07	.487**									
	3. *DIFF_ORG*	8.29	2.72	.240	.379*								
	4. *DIFF_KNOW*	10.00	4.13	.454**	−.346*	.477**							
Dimension of social capital	5. *REACH*	8.60	.88	−.207	.003	.098	−.098						
	6. *TRUST*	8.45	.96	.064	.228	.273	.011	.671**					
	7. *MUTUAL*	8.02	1.04	.207	.337*	.177	−.056	.277	.416**				
Problem framing	8. *UNCERTAINTY*	3.52	.63	−.065	.049	−.126	−.164	.014	.180	−.127			
	9. *AMBIGUITY*	3.64	.59	.001	.011	.301*	.196	.270	.276	−.146	.105		
Outcome	10. *ANN_EFF*	7.12	4.27	−.272	−.122	.078	−.032	.195	.044	−.246	.154	.169	
	11. *ANN_INN*	2.39	1.66	−.373*	.043	.046	−.298*	.393**	.078	.049	−.098	.031	.512**
				1	2	3	4	5	6	7	8	9	10

Notes: $n = 45$
$*p < .05$; $** p < .01$

4.1 Descriptive Statistics and Correlation Analysis

This section discusses general observation of the data. The descriptive statistics and the correlation coefficients (*r*) of all variables used in the research are shown in Table 12. The mean values of the variables and all significant pairs of correlated variables are explained in detail (by the types of variables) as follows.

4.1.1 Nature of Network Variables

The mean values of the variables acquired from the egocentric network survey as shown in Table 12 can give insight to the nature of the network that the ITAs have. In organizational affiliation perspective, an average ITA has been in touch with 7.53 internal contacts (*SIM_ORG*: organization homogeneity) regarding the intermediation process within the past year, comparing to 8.29 external experts (*DIFF_ORG*: organization heterogeneity). This means that, on average, the ITAs utilize external connection 10.09% more than internal one. As for the knowledge perspective, the average ITA has been in contact with 5.78 people with similar expertise to himself (*SIM_KNOW*: knowledge homogeneity) regarding the intermediation process within the past year, compared to 10.00 people with different knowledge domains (*DIFF_KNOW*: knowledge heterogeneity). This means that the ITAs generally use a variety of knowledge from different experts that differ from their expertise 73.01% more than relying on the experts with similar knowledge to them.

For a set of these nature-of-network variables, there are statistically significant correlations between all pairs of variables except between organization homogeneity and organization heterogeneity (i.e., organization homogeneity and knowledge homogeneity with $r(1,2) = 0.487$, $p < .01$; organization homogeneity and knowledge heterogeneity with $r(1,4) = 0.454$, $p < .01$; knowledge homogeneity and organization heterogeneity with $r(2,3) = 0.379$, $p < .05$; organization heterogeneity and knowledge heterogeneity with $r(3,4) = 0.477$, $p < .01$). These statistically significant positive correlations between organizational affiliation (internal and external) of the contact and the expertise (similar and different) of the contact indicate that when ITAs have an increase in number of internal (or external) contacts, it also accounts for the increase in number of experts from both similar filed of knowledge and different field of knowledge, which is not surprising because the increment in contacts means the increment in experts with either similar or different knowledge (in this case, the correlation coefficients show that both are statistically significant).

Lastly, for a set of four nature-of-network variables, there is a single statistically significant negative correlation between knowledge homogeneity and knowledge heterogeneity ($r(2,4) = -0.346$, $p < .05$) which indicates that if the ITAs have a higher number of experts with similar knowledge (expertise), they will tend to have a lower number of experts with different knowledge (expertise), and vice versa.

4.1.2 Dimension of Social Capital Variables

The mean values of the social capital rating score variables from Table 12 lead to the insight on the perception of different dimensions of social capital that the ITAs have toward their self-reporting contacts within the past year. For the ITAs at iTAP, the average rating scores for three dimensions of social capital are more than 8 out of 10 which are quite high, reflecting the highly positive perception that the ITAs have toward their contacts in the easiness to reach for help, the trust that they will get help and the level of mutual understanding. Among three dimensions of social capital, structural dimension (ease of reach) scores the highest average score at 8.60, following by relational dimension (trust) with the average score of 8.45 and cognitive dimension (mutual understanding) with the average score of 8.02.

The correlations among these three variables show statistically significant positive relationship between ease of reach and trust ($r(5,6) = 0.671$, $p < .01$) and between trust and mutual understanding ($r(6,7) = 0.416$, $p < .01$). Even though there is no statistically significant relationship between ease of reach and mutual understanding, the other statistically significant correlations show the closeness of these three dimensions of social capital variables. In particular, these statistically significant correlations indicate that when the perception on trust increase, both the perception on ease of reach and the perception on mutual understanding increase, and vice versa.

The other notable statistically significant correlation among social capital variables includes the positive correlation between knowledge homogeneity and mutual understanding ($r(2,7) = 0.337$, $p < .05$). This correlation indicates that the agents with higher number of contacts with similar knowledge (expertise) tend to see higher levels of cognitive alignment (mutual understanding) between themselves and their contacts. The reason for this is quite obvious because people who have similar knowledge domain are trained to think similarly by nature.

4.1.3 Problem Framing Variables

Problem framing variables are represented by the attitude toward ambiguity tolerance and the attitude toward uncertainty tolerance. The mean values of these variables from Table 12 indicate that on average the ITAs have the attitude toward ambiguity tolerance at the score of 3.64 out of 5 and the attitude toward uncertainty tolerance at the score of 3.52 out of 5. The mean values of attitude toward ambiguity tolerance and attitude toward uncertainty tolerance of the ITAs can be translated back to indicate that, on average, the ITAs are comfortable dealing with problems in both ambiguity and uncertainty situations. It is so because the average numerical scores fall into the neutral to agreement range of the five-level Likert scale.

Moreover, these two problem framing variables do not have a statistically significant correlation with each other and do not have any statistically significant correlation with another variable in the research except one case of statistically significant positive correlation between organization heterogeneity and attitude toward ambiguity tolerance ($r(3,9) = 0.301$, $p < .05$). This correlation simply indicates that the agents with higher number of contacts from different organizations tend to have a higher tolerance toward ambiguity. This means that the increase in the number of external experts goes along with the increase the level of ambiguity tolerance of the ITAs. The explanation for this particular correlation might be that the ITAs have to be more comfortable to the situation with unknown unknowns (ambiguity) when they are dealing more with external connections because they have to be fully aware and accept the fact that different organizational setting has different working environment with different set of rules and regulations.

4.1.4 Outcome Variables

The mean values of annual average of number of successful project with efficiency improvement and annual average of number of successful project with innovativeness improvement clearly indicate that the project portfolio at iTAP focuses more on outcome with efficiency improvement. As a matter of fact, the mean value of annual average number of successful project with efficiency improvement (the mean value of *ANN_EFF* = 7.12) is almost three times higher than the mean value of annual average number of successful project with innovativeness improvement (the mean value of *ANN_INN* = 2.39). Moreover, all of the ITAs have at least 50% (or more) of their project portfolio identified as projects with efficiency improvements. In fact, there are only five ITAs who have 50% of their projects in efficiency improvement category and 50% of their project in innovativeness improvement category (see Section 4.3.2 for additional information on different groups of ITAs with different project portfolio). The rest of the ITAs have less than half of their project portfolio identified as projects with innovativeness improvement. This reflects the fact that the nature of the intermediation process at iTAP demands and produces more outcomes with efficiency improvement than innovativeness improvement.

As for the correlation between these two variables, there is a strong correlation between both project outcomes ($r(10,11) = 0.512$, $p < .01$) indicating that the agents with higher annual average of number of successful projects in innovativeness improvement also have higher annual average of number of successful projects in efficiency improvement, and vice versa.

There are also several statistically significant correlations between outcome variables (dependent variables) and other variables (independent variables). One of these correlations is the negative correlation between organization homogeneity and outcome with innovativeness improvement ($r(1,11) = -0.373$, $p < .05$) indicating that the agents with higher number of contacts that belong to the same organization (internal contacts) have fewer projects resulting in innovation. Another correlation between independent variables and dependent variables includes positive correlation between ease of reach and innovativeness improvement outcome ($r(5,11) = 0.393$, $p < .01$) indicating that the agents who perceive their contacts to be easier to reach (higher levels of structural social capital) have more projects with successful innovativeness improvement outcome. Lastly, there is a negative correlation between knowledge heterogeneity and innovativeness improvement outcome ($r(4,11) = -0.298$, $p < .05$) indicating that the agents who have more experts with different fields of knowledge have less projects with successful innovativeness improvement outcome. These correlations (between dependent variables and independent variables) also support the results of various regression models as shown in the next section.

4.2 Regression Models

To ensure the robustness and reliability of the regression models, according to Tabachnick and Fidell [178] and Pallant [168], the correlation coefficients corresponding to each pair of independent variables of multiple linear regression analysis should not be too high in order to avoid the effects of multicollinearity[6] in the regression model. Pallant [168] recommends that the value of the correlation coefficients should be less than 0.7 ($r < 0.7$). In this research, it can be seen that there is no correlation coefficient of any pair of independent variables (variable number 1 to number 9 in Table 12) that exceeds the recommended value of 0.7. Moreover, to further ascertain that the models do not suffer from the effects of multicollinearity, the values of the variance inflation factor (VIF) and the tolerance of each variable should be calculated. For the regression model to be robust and reliable, the values of VIF should be less than 10 and the tolerance should be greater than 0.1 according to the recommendation of Pallant [168]. It can be seen from Appendix B that the four nature-of-network variables together in the models display extremely high multicollinearity effect. Thus, the models with four nature-of-network variables together were omitted from the analysis even though the models indicated statistically significant results. However, the models with a single nature-of-network variable or a pair of such variables are acceptable as long as the values of the variance inflation factor (VIF) and the tolerance of each variable conform to the recommended value. (See the in-depth explanation of models with multicollinearity

[6] According to Hair et al. [179], "multicollinearity represents the degree to which any variable's effect can be predicted or accounted for by the other variables in the analysis" (page 23) [179]. As multicollinearity increases, it is more difficult to ascertain the effect of any single independent variable because of their interrelationships. Thus, the robust and reliable multiple linear regression model should avoid multicollinearity of the independent variables.

effect and the examples of results of such models in Appendix B. One possible alternative to remedy the multicollinearity effect for nature-of-network variables is presented in Appendix C. The results from Appendix C justify the omission of the models with four nature-of-networks together.)

All of the regression models and the associated variables for testing the research hypotheses are listed in Table 11. The regression models that explain the relationship between social capital variables and outcomes variables (for testing Hypothesis 1 and Hypothesis 2) are presented, following by the models that explain the relationship between social capital variables and problem framing variables (for testing Hypothesis 3 and Hypothesis 4), and the models that explain the relationship between problem framing variables and outcomes variables (for testing Hypothesis 5 and Hypothesis 6), respectively.

4.2.1 Models for Testing Hypothesis 1 and Hypothesis 2

The simple linear regression models between each social capital variable as independent variable and the outcome variable as dependent variable are used to examine the relationship of each social capital variable and the outcome of the intermediation process. There are seven simple linear regression models where the dependent variable is annual average of number of projects with efficiency improvement and the independent variable is social capital variable, i.e., organization homogeneity (see model 1a in Table 13), knowledge homogeneity (see model 1b in Table 14), organization heterogeneity (see model 1c in Table 15), knowledge heterogeneity (see model 1d in Table 16), ease of reach (see model 1e in Table 17), trust (see model 1f in Table 18), and mutual understanding (see model 1g in Table 19). At the de facto confidence level of 95%, none of the simple regression models demonstrate statistically significant result. However, with more relaxed confidence level at 90%, one out of these seven models demonstrates statistically significant result. The single statistically significant model in this case is model 1a with organization homogeneity as independent variable (adjusted $R^2 = 0.052$, $p < .1$; standardized coefficient = −0.272, $p < .1$), indicating that this variable individually explains 5.2 percent of the variance in the outcome with efficiency improvement of the intermediary agents and that such relationship does not happen by pure chance at 90% confidence level.

As for the case of simple linear regression where the dependent variable is the annual average of number of projects with innovativeness improvement, there are also seven models that the independent variable is represented by social capital variable, i.e., organization homogeneity (see model 2a in Table 20), knowledge homogeneity (see model 2b in Table 21), organization heterogeneity (see model 2c in Table 22), knowledge heterogeneity (see model 2d in Table 23), ease of reach (see model 2e in Table 24), trust (see model 2f in Table 25), and mutual understanding (see model 2g in Table 26). Three out of seven models demonstrate statistically significant results at the confidence level of 95% and above, namely model 2a with organization homogeneity as independent variable (adjusted $R^2 = 0.119$, $p < .05$; standardized coefficient = −0.373, $p < .05$), model 2d with knowledge heterogeneity as independent variable (adjusted $R^2 = 0.068$, $p < .05$; standardized coefficient = −0.298, $p < .05$) and model 2e with ease of reach as independent variable (adjusted $R^2 = 0.135$, $p < .01$; standardized coefficient = 0.393, $p < .01$); indicating that these three variables individually contribute to the variable explaining the outcome with innovativeness improvement of the intermediary agents.

Table 13–Regression model 1a (statistically significant)

	Model 1a	
Dependent variable:	Annual average of number of projects with efficiency improvement	
	Unstandardized coefficients (Standard error)	Standardized coefficients
Intercept (Constant)	9.827*** (1.585)	
Independent variable:		
Organization homogeneity	−.359† (.194)	−.272†
R^2	.074	
Adjusted R^2	.052	
F	3.432†	
Number of observations	45	

Notes: $^{\dagger}p < .1$; $^{*}p < .05$; ** $p < .01$; *** $p < .001$

Table 14–Regression model 1b (not statistically significant)

	Model 1b	
Dependent variable:	Annual average of number of projects with efficiency improvement	
	Unstandardized coefficients (Standard error)	Standardized coefficients
Intercept (Constant)	7.863*** (1.118)	
Independent variable:		
Knowledge homogeneity	−.128 (.159)	−.122
R^2	.015	
Adjusted R^2	−.008	
F	.648	
Number of observations	45	

Notes: $^{\dagger}p < .1$; $^{*}p < .05$; ** $p < .01$; *** $p < .001$

Table 15–Regression model 1c (not statistically significant)

Dependent variable:	Model 1c Annual average of number of projects with efficiency improvement	
	Unstandardized coefficients (Standard error)	Standardized coefficients
Intercept (Constant)	6.112** (2.081)	
Independent variable:		
Organization heterogeneity	.122 (.239)	.078
R^2	.006	
Adjusted R^2	−.017	
F	.262	
Number of observations	45	

Notes: $^{\dagger}p < .1$; $*p < .05$; $** p < .01$; $*** p < .001$

Table 16–Regression model 1d (not statistically significant)

Dependent variable:	Model 1d Annual average of number of projects with efficiency improvement	
	Unstandardized coefficients (Standard error)	Standardized coefficients
Intercept (Constant)	7.451*** (1.703)	
Independent variable:		
Knowledge heterogeneity	−.033 (.158)	−.032
R^2	.001	
Adjusted R^2	−.022	
F	.043	
Number of observations	45	

Notes: $^{\dagger}p < .1$; $*p < .05$; $** p < .01$; $*** p < .001$

Table 17–Regression model 1e (not statistically significant)

Dependent variable:	Model 1e Annual average of number of projects with efficiency improvement	
	Unstandardized coefficients (Standard error)	Standardized coefficients
Intercept (Constant)	−.981 (6.253)	
Independent variable:		
Ease of reach	.942 (.723)	.195
R^2	.038	
Adjusted R^2	.016	
F	1.698	
Number of observations	45	

Notes: $^{\dagger}p < .1$; $*p < .05$; $** p < .01$; $*** p < .001$

Table 18–Regression model 1f (not statistically significant)

Dependent variable:	Model 1f Annual average of number of projects with efficiency improvement	
	Unstandardized coefficients (Standard error)	Standardized coefficients
Intercept (Constant)	5.460 (5.783)	
Independent variable:		
Trust	.197 (.680)	.044
R^2	.002	
Adjusted R^2	−.021	
F	.084	
Number of observations	45	

Notes: $^{\dagger}p < .1$; $*p < .05$; $** p < .01$; $*** p < .001$

Table 19–Regression model 1g (not statistically significant)

Dependent variable:	Model 1g Annual average of number of projects with efficiency improvement	
	Unstandardized coefficients (Standard error)	Standardized coefficients
Intercept (Constant)	15.238** (4.904)	
Independent variable:		
Mutual understanding	−1.011 (.606)	−.246
R^2	.061	
Adjusted R^2	.039	
F	2.782	
Number of observations	45	

Notes: $^{\dagger}p < .1$; $*p < .05$; $** p < .01$; $*** p < .001$

Table 20–Regression model 2a (statistically significant)

Dependent variable:	Model 2a Annual average of number of projects with innovativeness improvement	
	Unstandardized coefficients (Standard error)	Standardized coefficients
Intercept (Constant)	3.826*** (.592)	
Independent variable:		
Organization homogeneity	−.191* (.072)	−.373*
R^2	.139	
Adjusted R^2	.119	
F	6.966*	
Number of observations	45	

Notes: $^{\dagger}p < .1$; $*p < .05$; $** p < .01$; $*** p < .001$

Table 21–Regression model 2b (not statistically significant)

Dependent variable:	Model 2b Annual average of number of projects with innovativeness improvement	
	Unstandardized coefficients (Standard error)	Standardized coefficients
Intercept (Constant)	2.287*** (.436)	
Independent variable:		
Knowledge homogeneity	.017 (.062)	.043
R^2	.002	
Adjusted R^2	−.021	
F	.078	
Number of observations	45	

Notes: †$p < .1$; *$p < .05$; ** $p < .01$; *** $p < .001$

Table 22–Regression model 2c (not statistically significant)

Dependent variable:	Model 2c Annual average of number of projects with innovativeness improvement	
	Unstandardized coefficients (Standard error)	Standardized coefficients
Intercept (Constant)	2.157* (.808)	
Independent variable:		
Organization heterogeneity	.028 (.093)	.046
R^2	.002	
Adjusted R^2	−.021	
F	.424	
Number of observations	45	

Notes: †$p < .1$; *$p < .05$; ** $p < .01$; *** $p < .001$

Table 23–Regression model 2d (statistically significant)

Dependent variable:	Model 2d Annual average of number of projects with innovativeness improvement	
	Unstandardized coefficients (Standard error)	Standardized coefficients
Intercept (Constant)	3.581*** (.630)	
Independent variable:		
Knowledge heterogeneity	−.119* (.058)	−.298*
R^2	.089	
Adjusted R^2	.068	
F	4.186*	
Number of observations	45	

Notes: $^{\dagger}p < .1$; $*p < .05$; $** p < .01$; $*** p < .001$

Table 24–Regression model 2e (statistically significant)

Dependent variable:	Model 2e Annual average of number of projects with innovativeness improvement	
	Unstandardized coefficients (Standard error)	Standardized coefficients
Intercept (Constant)	$-3.952^{\dagger}$ (2.272)	
Independent variable:		
Ease of reach	.737** (.263)	.393**
R^2	.155	
Adjusted R^2	.135	
F	7.864**	
Number of observations	45	

Notes: $^{\dagger}p < .1$; $*p < .05$; $** p < .01$; $*** p < .001$

Table 25–Regression model 2f (not statistically significant)

Dependent variable:	Model 2f Annual average of number of projects with innovativeness improvement	
	Unstandardized coefficients (Standard error)	Standardized coefficients
Intercept (Constant)	1.251 (2.237)	
Independent variable:		
Trust	.134 (.263)	.078
R^2	.006	
Adjusted R^2	−.017	
F	.261	
Number of observations	45	

Notes: $^{\dagger}p < .1$; $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$

Table 26–Regression model 2g (not statistically significant)

Dependent variable:	Model 2g Annual average of number of projects with innovativeness improvement	
	Unstandardized coefficients (Standard error)	Standardized coefficients
Intercept (Constant)	1.760 (1.959)	
Independent variable:		
Mutual understanding	.078 (.242)	.049
R^2	.002	
Adjusted R^2	−.021	
F	.104	
Number of observations	45	

Notes: $^{\dagger}p < .1$; $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$

Additionally, since there are multiple social capital variables identified as statistically significant variables in simple linear regression models, the stepwise estimation technique[7] was used for all seven social capital variables as independent variables and outcome of intermediation process as dependent variable in order to find the appropriate independent variables to include in the optimal regression model. For the case of the model that has the annual average of number of projects with efficiency improvement as dependent variable, the result of stepwise estimation process is shown in Table 27 (model 1-final) where two independent variables were included in the model, i.e., ease of reach (standardized coefficient = 0.285, $p < .1$) and mutual understanding (standardized coefficient = −0.326, $p < .05$). The model is statistically significant at 95% confidence level ($p < .05$) with adjusted $R^2 = 0.095$, suggesting that ease of reach and mutual understanding jointly explain 9.5 percent of the variance in the annual average of number of projects with efficiency improvement of the intermediary agents. The result confirms Hypothesis 1 stating that "social capital of intermediary agents is associated with successful projects with efficiency improvement". It should be noted that this stepwise regression model does not include organization homogeneity variable which is found to be statistically significant (at lower confidence level) in simple regression model (model 1a). In other words, at more strict confidence level of 95% (rather than 90%), only ease of reach and mutual understanding are the two variables that demonstrate statistically significant relationship with the outcome with efficiency improvement.

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[7] According to Hair et al. [179], stepwise estimation is "a method of selecting variables for inclusion in the regression model" (page 84) [179]. It starts with selecting the best predictor of dependent variable and adds more independent variables based on the incremental explanatory power contributing to the regression model and deletes the variables if their predictive power dropped to the insignificant level.

Table 27–Regression model 1-final (statistically significant)

Dependent variable:	Model 1-final Annual average of number of projects with efficiency improvement			
	Unstandardized coefficients (Standard error)	Standardized coefficients	Collinearity statistics	
			Tolerance	VIF
Intercept (Constant)	5.981 (6.793)			
Independent variables:				
1. Organization homogeneity				
2. Knowledge homogeneity				
3. Organization heterogeneity				
4. Knowledge heterogeneity				
5. Ease of reach	1.378† (.722)	.285†	.923	1.083
6. Trust				
7. Mutual understanding	−1.336* (.613)	−.326*	.923	1.083
R^2		.136		
Adjusted R^2		.095		
F		3.300*		
Number of observations		45		

Notes: †$p < .1$; *$p < .05$; ** $p < .01$; *** $p < .001$

Table 28–Regression model 2-final (statistically significant)

Dependent variable:	Model 2-final Annual average of number of projects with innovativeness improvement			
	Unstandardized coefficients (Standard error)	Standardized coefficients	Collinearity statistics	
			Tolerance	VIF
Intercept (Constant)	−.617 (2.338)			
Independent variables:				
1. Organization homogeneity	−.201* (.078)	−.393*	.702	1.424
2. Knowledge homogeneity	.124† (.061)	.305†	.722	1.385
3. Organization heterogeneity				
4. Knowledge heterogeneity				
5. Ease of reach	.984** (.345)	.525**	.486	2.060
6. Trust	−.552† (.318)	−.319†	.487	2.055
7. Mutual understanding				
R^2		.341		
Adjusted R^2		.275		
F		5.180**		
Number of observations		45		

Notes: †$p < .1$; *$p < .05$; ** $p < .01$; *** $p < .001$

Lastly, for the case of the model that has the annual average of number of projects with innovativeness improvement as dependent variable, Table 28 (model 2-final) shows the result of stepwise estimation process where four independent variables were included in the model, i.e., ease of reach (standardized coefficient = 0.525, $p < .01$), trust (standardized coefficient = −0.319, $p < .1$), organization homogeneity (standardized coefficient = −0.393, $p < .05$), and knowledge homogeneity (standardized coefficient = 0.305, $p < .1$). The model is statistically significant at 99% confidence level ($p < .01$) with adjusted $R^2 = 0.275$, suggesting that these variables can explain 27.5 percent of the variance in the annual average of number of projects with innovativeness improvement of the intermediary agents. The result also confirms Hypothesis 2 stating that "social capital of intermediary agents is associated with successful projects with innovativeness improvement". It should be noted that this stepwise regression model does not include knowledge heterogeneity variable which is found to be statistically significant (at lower confidence level) in simple regression model (model 2d). In other words, at more strict confidence level of 99% (rather than 95%), knowledge heterogeneity does not have a statistically significant relationship with the outcome with innovativeness improvement.

In summary, the statistically significant relationship between social capital and outcome of intermediation process is depicted in Figure 5 which indicates the linkage between each variable based on the statistically significant results from multiple regression models (model 1-final at 95% confidence level and model 2-final at 99% confidence level).

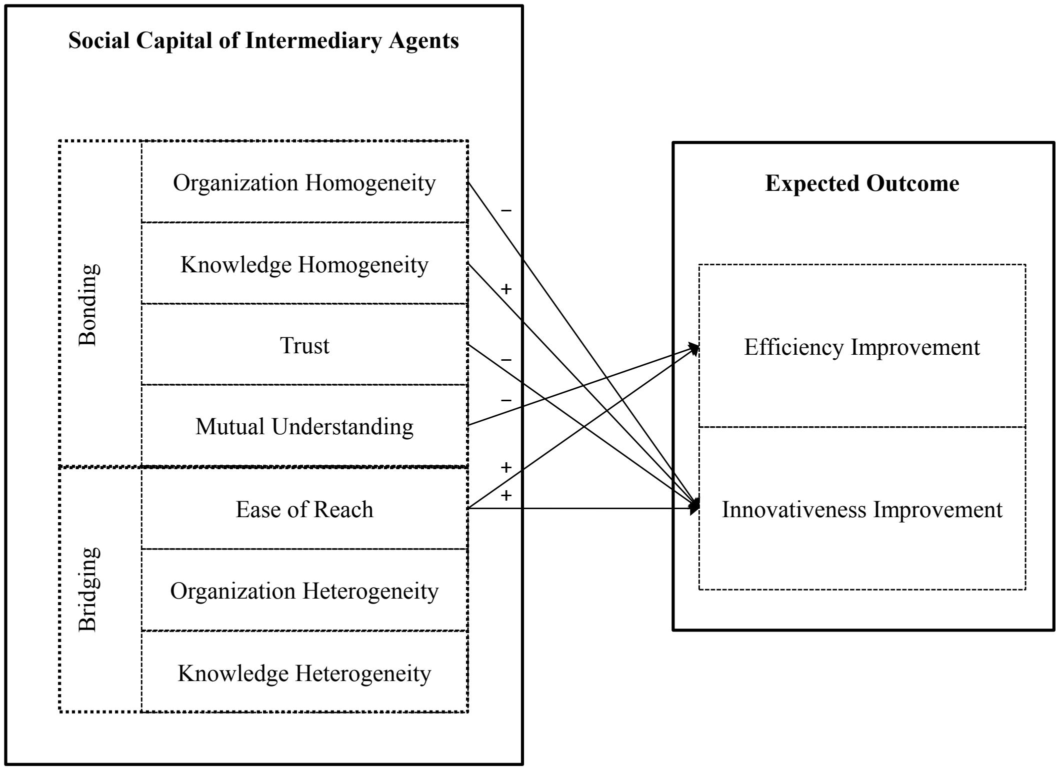

Figure 5–Relationship between social capital variables and outcome variables

4.2.2 Models for Testing Hypothesis 3 and Hypothesis 4

In order to test Hypothesis 3 regarding the relationship between bonding aspect of social capital and problem framing with uncertainty reduction, the multiple linear regression is performed using intermediary agents' attitude toward uncertainty tolerance as the dependent variable and social capital variables pertaining to bonding as independent variables. The independent variables thus include the "internal" nature-of-network variables, i.e., organization homogeneity and knowledge homogeneity, and the relational dimension (trust) as well as the cognitive dimension (mutual understanding) of social capital.

These bonding variables were selected to be included in the model according to the "internal perspective" of social capital as explained by Adler and Kwon [180] who indicate that "bonding views [of social capital] focus on collective actors' internal characteristics" (page 21) [180] and that "the internal approach to social capital is reflected in the sociocentric [181] and "whole-network" [182] variants of network sociology" (page 21) [180]. Organization homogeneity and knowledge homogeneity represent the "inside" ties in term of similar affiliation and similar expertise; while trust and mutual understanding represent the "internal" mental linkages between parties involved.

Table 29 shows the result of the multiple linear regression model 3 as described above. The model does not show statistically significant result, thus Hypothesis 3 could not be confirmed through this model. In other words, we accept the null hypothesis which states that "intermediary agents with strong bonding social capital do not tend to choose uncertainty reduction more frequently than the agents with lower bonding social capital do," as it could not be confirmed otherwise.

Table 29–Regression model 3 (not statistically significant)

Dependent variable:	Model 3 Attitude toward uncertainty tolerance			
	Unstandardized coefficients (Standard error)	Standardized coefficients	Collinearity statistics	
			Tolerance	VIF
Intercept (Constant)	3.317 (.972)			
Independent variables:				
1. Organization homogeneity	−.017 (.033)	−.086	.756	1.323
2. Knowledge homogeneity	.018 (.028)	.117	.693	1.443
3. Trust	.174 (.109)	.267	.813	1.230
4. Mutual understanding	−.156 (.104)	−.260	.761	1.315
R^2		.092		
Adjusted R^2		.001		
F		1.015		
Number of observations		45		

Notes: $^{\dagger}p < .1$; $^{*}p < .05$; $^{**} p < .01$; $^{***} p < .001$

As for Hypothesis 4, which considers the relationship between the bridging aspect of social capital and problem framing with ambiguity reduction, the multiple linear regression model used to test the hypothesis consists of the intermediary agents' ambiguity tolerance as the dependent variable and social capital variables pertaining to bridging as independent variables, which include the "external" nature-of-network variables, i.e., organization heterogeneity and knowledge heterogeneity, and the structural dimension (ease of reach) of social capital.

The bridging social capital variables were selected to be included in the model according to the "external perspective" of social capital as explained by Adler and Kwon [180]. In contrast to the bonding views of social capital, Adler and Kwon [180] state that "the bridging views [of social capital] focus primarily on social capital as a resource that inheres in the social network tying a focal actor to other actors" (page 19) [180] and that "[this external approach] of social capital is reflected in the egocentric variant of network analysis" (page 19) [180]. Organization heterogeneity and knowledge heterogeneity represent the "outside" ties in term of different affiliation and different expertise; while ease of reach represents the "external" linkages between parties involved.

The result of this model is shown in Table 30 which indicates that the model is statistically significant at 90% confidence level ($p < .1$) with adjusted $R^2 = 0.097$, suggesting that the bridging aspect of social capital can explain 9.7 percent of the variance in the attitude toward ambiguity tolerance of the intermediary agents.

The key finding from this model is that, in the presence of all bridging social capital variables, the structural dimension of social capital (ease of reach) has a statistically significant relationship with the attitude toward ambiguity tolerance of the intermediary agents (standardized coefficient = 0.260, $p < .1$). Ambiguity tolerance indicates that the intermediary agents are familiar with problem framing with ambiguity reduction. Thus, the result confirms Hypothesis 4 which states that "intermediary agents with strong bridging social capital tend to choose ambiguity reduction more frequently than the agents with lower bridging social capital do" (at 90% confidence level which is lower than the de facto standard of 95% level).

Table 30–Regression model 4 (statistically significant)

Dependent variable:	Model 4 Attitude toward ambiguity tolerance			
	Unstandardized coefficients (Standard error)	Standardized coefficients	Collinearity statistics	
			Tolerance	VIF
Intercept (Constant)	1.600 (.869)			
Independent variables:				
1. Organization heterogeneity	.047 (.036)	.220	.752	1.330
2. Knowledge heterogeneity	.017 (.023)	.117	.752	1.330
3. Ease of reach	$.172^{\dagger}$ (.097)	$.260^{\dagger}$	.963	1.038
R^2		.159		
Adjusted R^2		.097		
F		$2.582^{\dagger}$		
Number of observations		45		

Notes: $^{\dagger}p < .1$; $*p < .05$; $** p < .01$; $*** p < .001$

4.2.3 Models for Testing Hypothesis 5 and Hypothesis 6

For Hypothesis 5 and Hypothesis 6 regarding the relationship between choices of problem framing and expected outcomes of intermediation process, the simple linear regressions were performed between the outcome variables (annual average of number of successful project with efficiency improvement and annual average of number of successful project with innovativeness improvement) as dependent variables and the problem framing variables (attitude toward uncertainty tolerance and attitude toward ambiguity tolerance) as independent variables as shown in model 5 and model 6 in Table 31 and Table 32, respectively.

As there are no statistically significant results from both models, both Hypothesis 5 and Hypothesis 6 fail to be confirmed. Thus, the null hypotheses were accepted indicating that "problem framing with a focus on uncertainty reduction is not associated with solutions that result in efficiency improvement" and "problem framing with a focus on ambiguity reduction is not associated with innovative solutions," because there was no evidence to support otherwise.

Table 31–Regression model 5 (not statistically significant)

Dependent variable:	Model 5 Annual average of number of projects with efficiency improvement	
	Unstandardized coefficients (Standard error)	Standardized coefficients
Intercept (Constant)	3.064 (3.664)	
Independent variable:		
Attitude toward uncertainty tolerance	1.154 (1.026)	.169
R^2	.029	
Adjusted R^2	.006	
F	1.266	
Number of observations	45	

Notes: $^{\dagger}p < .1$; $^{*}p < .05$; ** $p < .01$; *** $p < .001$

Table 32–Regression model 6 (not statistically significant)

Dependent variable:	Model 6 Annual average of number of projects with innovativeness improvement	
	Unstandardized coefficients (Standard error)	Standardized coefficients
Intercept (Constant)	3.393* (1.581)	
Independent variable:		
Attitude toward ambiguity tolerance	−.276 (.429)	−.098
R^2	.010	
Adjusted R^2	−.013	
F	.415	
Number of observations	45	

Notes: $^{\dagger}p < .1$; $^{*}p < .05$; ** $p < .01$; *** $p < .001$

Figure 6 summarizes the results of regression analysis that were used to test the research hypotheses according to the research model.

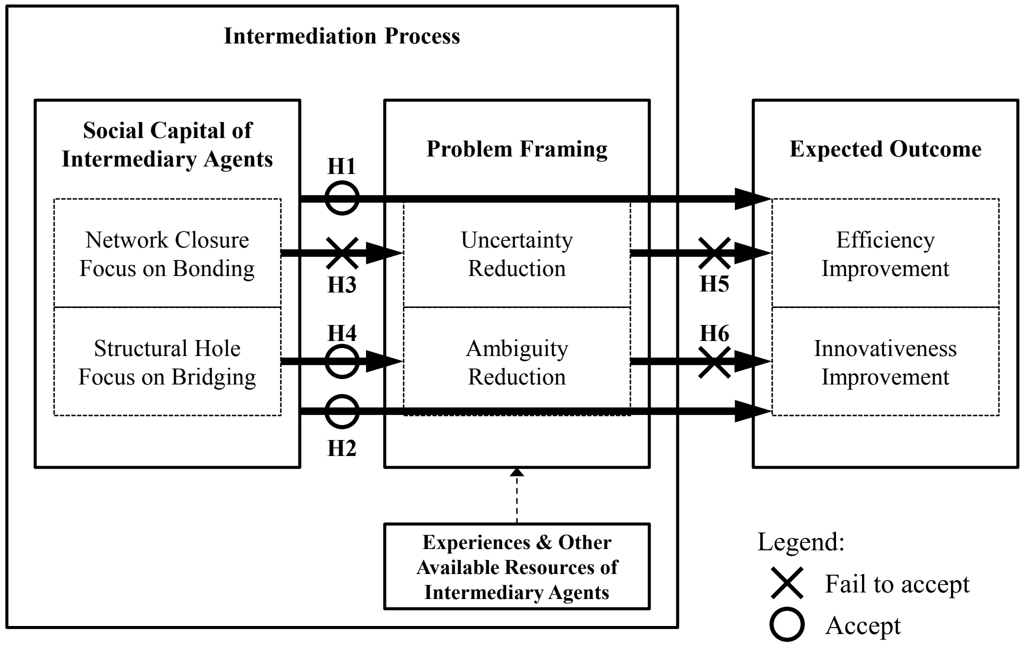

Figure 6–Results of regression analysis

4.3 Additional In-depth Analysis

The results of regression models for testing the research hypotheses in Figure 6 show that Hypothesis 1 is accepted at 95% confidence level, Hypothesis 2 is accepted at 99% confidence level, and Hypothesis 4 is accepted at 90% confidence level. Three research hypotheses (Hypothesis 3, Hypothesis 5 and Hypothesis 6) fail to be accepted, resulting in the acceptance of their null hypotheses. For hypotheses that are not accepted or only accepted at lower confidence level, additional analyses can confirm and/or investigate the linkage between these variables (or the lack thereof). This section elaborates on the additional analysis for the relationship between social capital and problem framing (linkages in Figure 6 which are signified as Hypothesis 3 and Hypothesis 4) as well as the relationship between problem framing and outcome of intermediation process (linkages in Figure 6 which are signified as Hypothesis 5 and Hypothesis 6).

4.3.1 Relationship between Social Capital and Problem Framing

In the research model (Figure 3), there are seven independent variables explaining different facets of social capital which were categorized into two categories namely bonding social capital and bridging social capital. Bonding social capital associates with "internal perspective" on nature of the network of the intermediary agents (organization homogeneity and knowledge homogeneity) along with relational dimension and cognitive dimension of social capital (trust and mutual understanding); while bridging social capital can be explained by "external perspective" on nature of the network (organization heterogeneity and knowledge heterogeneity) as well as structural dimension of social capital (ease of reach). Hypothesis 3 and Hypothesis 4 were tested using multiple linear regression models with specific social capital variables representing bonding social capital and bridging social capital, respectively. To confirm and further explore any additional relationships between social capital variables and problem framing variables, additional regression analyses were performed with all social capital variables as independent variables and problem framing variables as dependent variables. Similar to the models for testing Hypothesis 1 and Hypothesis 2 which have social capital variables as independent variables in the models, simple linear regression models with each social capital variable as independent variable and each problem framing variable as dependent variable were tested.

There are seven simple linear regression models where the dependent variable is the attitude toward uncertainty tolerance and the independent variable is social capital variable, i.e., organization homogeneity (see model 3a in Table 33), knowledge homogeneity (see model 3b in Table 34), organization heterogeneity (see model 3c in Table 35), knowledge heterogeneity (see model 3d in Table 36), ease of reach (see model 3e in Table 37), trust (see model 3f in Table 38), and mutual understanding (see model 3g in Table 39). All of these simple linear regression models do not show statistically significant results. Thus, the simple regression models in this case support the fact that there is no statistically significant evidence of the relationship between social capital variables and attitude toward uncertainty tolerance of intermediary agents. Moreover, the stepwise estimation technique is used with these seven social capital variables as independent variables and the attitude toward uncertainty tolerance as the dependent variable in order to select the independent variables for the optimal regression model. However, the stepwise estimation process fails to select any social capital variables to include in the optimal regression model, resulting in the conclusion that there is no regression model with statistically significant results in this case. This also agrees with the result of regression analysis for testing Hypothesis 3 as shown in Figure 6 where the result fails to confirm the hypothesis.

Table 33–Regression model 3a (not statistically significant)

Dependent variable:	Model 3a Attitude toward uncertainty tolerance	
	Unstandardized coefficients (Standard error)	Standardized coefficients
Intercept (Constant)	3.613*** (.241)	
Independent variable:		
Organization homogeneity	−.013 (.029)	−.065
R^2	.004	
Adjusted R^2	−.019	
F	.181	
Number of observations	45	

Notes: $^{\dagger}p < .1$; $*p < .05$; $** p < .01$; $*** p < .001$

Table 34–Regression model 3b (not statistically significant)

Dependent variable:	Model 3b Attitude toward uncertainty tolerance	
	Unstandardized coefficients (Standard error)	Standardized coefficients
Intercept (Constant)	3.475*** (.165)	
Independent variable:		
Knowledge homogeneity	.008 (.023)	.049
R^2	.002	
Adjusted R^2	−.021	
F	.104	
Number of observations	45	

Notes: $^{\dagger}p < .1$; $*p < .05$; $** p < .01$; $*** p < .001$

Table 35–Regression model 3c (not statistically significant)

Dependent variable:	Model 3c Attitude toward uncertainty tolerance	
	Unstandardized coefficients (Standard error)	Standardized coefficients
Intercept (Constant)	3.758*** (.303)	
Independent variable:		
Organization heterogeneity	−.029 (.035)	−.126
R^2	.016	
Adjusted R^2	−.007	
F	.690	
Number of observations	45	

Notes: $^{\dagger}p < .1$; $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$

Table 36–Regression model 3d (not statistically significant)

Dependent variable:	Model 3d Attitude toward uncertainty tolerance	
	Unstandardized coefficients (Standard error)	Standardized coefficients
Intercept (Constant)	3.767*** (.246)	
Independent variable:		
Knowledge heterogeneity	−.025 (.023)	−.164
R^2	.027	
Adjusted R^2	.004	
F	1.190	
Number of observations	45	

Notes: $^{\dagger}p < .1$; $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$

Table 37–Regression model 3e (not statistically significant)

Dependent variable:	Model 3e Attitude toward uncertainty tolerance	
	Unstandardized coefficients (Standard error)	Standardized coefficients
Intercept (Constant)	3.435** (.934)	
Independent variable:		
Ease of reach	.010 (.108)	.014
R^2	.000	
Adjusted R^2	.023	
F	.008	
Number of observations	45	

Notes: $^{\dagger}p < .1$; $^{*}p < .05$; ** $p < .01$; *** $p < .001$

Table 38–Regression model 3f (not statistically significant)

Dependent variable:	Model 3f Attitude toward uncertainty tolerance	
	Unstandardized coefficients (Standard error)	Standardized coefficients
Intercept (Constant)	2.524*** (.834)	
Independent variable:		
Trust	.118 (.098)	.180
R^2	.032	
Adjusted R^2	.010	
F	1.439	
Number of observations	45	

Notes: $^{\dagger}p < .1$; $^{*}p < .05$; ** $p < .01$; *** $p < .001$

Table 39–Regression model 3g (not statistically significant)

Dependent variable:	Model 3g Attitude toward uncertainty tolerance	
	Unstandardized coefficients (Standard error)	Standardized coefficients
Intercept (Constant)	4.130*** (.736)	
Independent variable:		
Mutual understanding	−.076 (.091)	−.127
R^2	.016	
Adjusted R^2	−.007	
F	.701	
Number of observations	45	

Notes: $^{\dagger}p < .1$; $*p < .05$; $** p < .01$; $*** p < .001$

As for the case of simple linear regression where the dependent variable is the attitude toward ambiguity tolerance, there are also seven models in which the independent variable is represented by a social capital variable, i.e., organization homogeneity (see model 4a in Table 40), knowledge homogeneity (see model 4b in Table 41), organization heterogeneity (see model 4c in Table 42), knowledge heterogeneity (see model 4d in Table 43), ease of reach (see model 4e in Table 44), trust (see model 4f in Table 45), and mutual understanding (see model 4g in Table 46). Three out of seven models demonstrate statistically significant results at the confidence level of 90% and above, namely model 4c with organization heterogeneity as independent variable (adjusted R^2 = 0.069, $p < .05$; standardized coefficient = 0.301, $p < .05$), model 4e with ease of reach as independent variable (adjusted R^2 = 0.051, $p < .1$; standardized coefficient = 0.270, $p < .1$) and model 4f with trust as independent variable (adjusted R^2 = 0.055, $p < .1$; standardized coefficient = 0.276, $p < .1$). These results indicate that these three variables individually contribute to the variance of the attitude toward ambiguity tolerance of the intermediary agents.

Table 40–Regression model 4a (not statistically significant)

Dependent variable:	Model 4a Attitude toward ambiguity tolerance	
	Unstandardized coefficients (Standard error)	Standardized coefficients
Intercept (Constant)	3.636*** (.226)	
Independent variable:		
Organization homogeneity	.0001 (.028)	.001
R^2	.000	
Adjusted R^2	−.023	
F	.000	
Number of observations	45	

Notes: †$p < .1$; *$p < .05$; ** $p < .01$; *** $p < .001$

Table 41–Regression model 4b (not statistically significant)

Dependent variable:	Model 4b Attitude toward ambiguity tolerance	
	Unstandardized coefficients (Standard error)	Standardized coefficients
Intercept (Constant)	3.628*** (.154)	
Independent variable:		
Knowledge homogeneity	.002 (.022)	.011
R^2	.000	
Adjusted R^2	−.023	
F	.006	
Number of observations	45	

Notes: †$p < .1$; *$p < .05$; ** $p < .01$; *** $p < .001$

Table 42–Regression model 4c (statistically significant)

Dependent variable:	Model 4c Attitude toward ambiguity tolerance	
	Unstandardized coefficients (Standard error)	Standardized coefficients
Intercept (Constant)	3.101*** (.273)	
Independent variable:		
Organization heterogeneity	.065* (.031)	.301*
R^2	.090	
Adjusted R^2	.069	
F	4.274*	
Number of observations	45	

Notes: †$p < .1$; *$p < .05$; ** $p < .01$; *** $p < .001$

Table 43–Regression model 4d (not statistically significant)

Dependent variable:	Model 4d Attitude toward ambiguity tolerance	
	Unstandardized coefficients (Standard error)	Standardized coefficients
Intercept (Constant)	3.359*** (.229)	
Independent variable:		
Knowledge heterogeneity	.028 (.021)	.196
R^2	.038	
Adjusted R^2	.013	
F	1.716	
Number of observations	45	

Notes: †$p < .1$; *$p < .05$; ** $p < .01$; *** $p < .001$

Table 44–Regression model 4e (statistically significant)

Dependent variable:	Model 4e Attitude toward ambiguity tolerance	
	Unstandardized coefficients (Standard error)	Standardized coefficients
Intercept (Constant)	2.100* (.841)	
Independent variable:		
Ease of reach	.179† (.097)	.270†
R^2	.073	
Adjusted R^2	.051	
F	3.372†	
Number of observations	45	

Notes: $^{\dagger}p < .1$; $*p < .05$; $** p < .01$; $*** p < .001$

Table 45–Regression model 4f (statistically significant)

Dependent variable:	Model 4f Attitude toward ambiguity tolerance	
	Unstandardized coefficients (Standard error)	Standardized coefficients
Intercept (Constant)	2.210** (.762)	
Independent variable:		
Trust	.169† (.090)	.276†
R^2	.076	
Adjusted R^2	.055	
F	3.548†	
Number of observations	45	

Notes: $^{\dagger}p < .1$; $*p < .05$; $** p < .01$; $*** p < .001$

Table 46–Regression model 4g (not statistically significant)

Dependent variable:	Model 4g Attitude toward ambiguity tolerance	
	Unstandardized coefficients (Standard error)	Standardized coefficients
Intercept (Constant)	4.297*** (.686)	
Independent variable:		
Mutual understanding	−.082 (.085)	−.146
R^2	.021	
Adjusted R^2	−.001	
F	.941	
Number of observations	45	

Notes: $^{\dagger}p < .1$; $*p < .05$; $** p < .01$; $*** p < .001$

Lastly, since the simple regression models with attitude toward ambiguity tolerance as the dependent variable identified multiple statistically significant independent variables as shown in model 4c, model 4e and model 4f, stepwise estimation technique was used for all seven social capital variables as independent variables to select the variables to include in the optimal linear regression models. Table 34 (model 4-final) shows the result of the stepwise estimation process: three independent variables were included in the model, i.e., organization heterogeneity (standardized coefficient = 0.321, $p < .05$), ease of reach (standardized coefficient = 0.319, $p < .05$) and mutual understanding (standardized coefficient = −0.292, $p < .1$). The model is statistically significant at 95% confidence level ($p < .05$) with adjusted $R^2 = 0.169$; indicating that three social capital variables (organization heterogeneity, ease of reach and mutual understanding) jointly contribute to 16.9 percent of the variance in the attitude toward ambiguity tolerance of the intermediary agents. While organization heterogeneity and ease of reach positively relate to the attitude toward ambiguity tolerance, mutual understanding has negative relationship with the attitude toward ambiguity tolerance.

Table 47–Regression model 4-final (statistically significant)

Dependent variable:	Model 4-final Attitude toward ambiguity tolerance			
	Unstandardized coefficients (Standard error)	Standardized coefficients	Collinearity statistics	
			Tolerance	VIF
Intercept (Constant)	2.560** (.898)			
Independent variables:				
1. Organization homogeneity				
2. Knowledge homogeneity				
3. Organization heterogeneity	.069* (.030)	.321*	.966	1.035
4. Knowledge heterogeneity				
5. Ease of reach	.211* (.095)	.319*	.921	1.086
6. Trust				
7. Mutual understanding	−.164† (.081)	−.292†	.901	1.110
R^2		.225		
Adjusted R^2		.169		
F		3.937*		
Number of observations		45		

Notes: †$p < .1$; *$p < .05$; ** $p < .01$; *** $p < .001$

Figure 7 shows the relationship according to the results from these additional regression models (i.e., model 4c, model 4e, model 4f, and model 4-final). The solid lines in Figure 7 indicate the statistically significant relationships identified by the model with stepwise estimation process (model 4-final at 95% confidence level) whereas the dotted lines indicate the relationship identified as statistically significant in simple linear regression model (model 4f at 90% confidence level) but the variable is not selected to be included in the stepwise estimation process.

It can be seen from Figure 7 that there is a relationship between social capital and the attitude toward ambiguity tolerance of intermediary agents. Thus, the results from Figure 7 provide adequate evidence to accept Hypothesis 4 (bridging social capital and ambiguity tolerance) as well as identify additional relationship between bonding social capital and ambiguity tolerance. The results show no relationship between social capital and the attitude toward uncertainty tolerance.

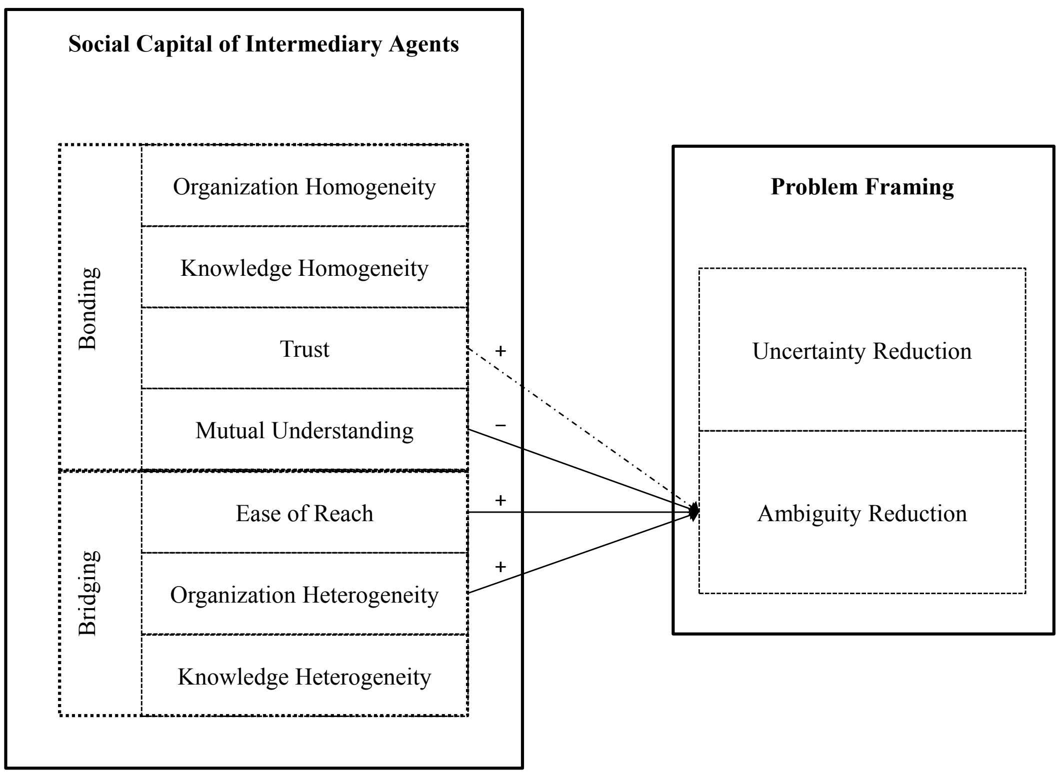

Figure 7–Relationship between social capital variables and problem framing variables

4.3.2 Relationship between Problem Framing and Outcome of Intermediation Process

The regression models for testing Hypothesis 5 and Hypothesis 6 do not provide statistically significant results to support the relationship between problem framing variables and the outcome variables as shown in Figure 6. However, it is possible to look at the descriptive statistics (means and standard deviations) of different groups of the intermediary agents in order to identify the differences (if any) in the problem framing variables. In this case, the intermediary agents were separated into three groups according to the different level in the type of project outcomes, namely (1) the agents with higher percentage of successful projects with innovativeness improvement comparing to overall project outcomes, (2) the agents with higher percentage of successful projects with efficiency improvement comparing to overall project outcomes, and (3) the rest of the agents in the middle range between the first and the second group.

The percentage of successful projects with innovativeness improvement compared to overall project outcomes is calculated as the ratio of the annual average of number of successful projects with innovativeness improvement of the agents and their total annual average of number of successful projects [*ANN_INN*/(*ANN_INN* + *ANN_EFF*)]. There are five ITAs who have 50% or more of their successful projects identified with innovativeness improvement; they are categorized as group 1 (top innovation). Similar to group 1, the percentage of successful projects with efficiency improvement comparing to overall project outcomes is calculated from the ratio of the annual average number of successful projects with efficiency improvement of the agents and their total annual average of number of successful projects [*ANN_EFF*/(*ANN_INN* + *ANN_EFF*)]. There are four ITAs who have 95% or more of their successful projects identified with efficiency improvement; they are categorized as group 2 (top efficiency). The rest of the ITAs (36 out of 45), who do not fall into both extreme ends of the spectrum, are categorized as group 3 (middle of the road). The descriptive statistics (means and standard deviations) of problem framing variables (attitude toward ambiguity and attitude toward uncertainty) of the ITAs from all three groups were calculated and summarized in Table 48.

Table 48–Descriptive statistics of problem framing variables for groups of ITAs

Group of ITAs	No. of ITAs	Attitude toward ambiguity tolerance (*AMBIGUITY*)		Attitude toward uncertainty tolerance (*UNCERTAINTY*)		Difference between *AMBIGUITY* and *UNCERTAINTY*
		Mean	S.D.	Mean	S.D.	
Full sample	45	3.64	0.59	3.52	0.63	*AMBIGUITY* > *UNCERTAINTY* (3.64 – 3.52 = 0.12)
Group 1 – top innovation [*ANN_INN/(ANN_INN* + *ANN_EFF)* ≥ 0.50]	5	3.93	0.60	3.53	0.45	*AMBIGUITY* > *UNCERTAINTY* (3.93 – 3.53 = 0.40)
Group 2 – top efficiency [*ANN_EFF/(ANN_INN* + *ANN_EFF)* ≥ 0.95]	4	3.58	0.83	3.92	0.69	*UNCERTAINTY* > *AMBIGUITY* (3.92 – 3.58 = 0.33)
Group 3 – middle of the road [0.50 < *ANN_EFF/(ANN_INN* + *ANN_EFF)* < 0.95]	36	3.61	0.56	3.47	0.64	*AMBIGUITY* > *UNVERTAINTY* (3.61 – 3.47 = 0.14)

By comparing the mean values of attitude toward ambiguity tolerance among three groups of ITAs as identified by outcome variables, it can be seen that the ITAs with higher percentages of innovativeness improvement outcomes (group 1) have higher mean values than the rest of the ITAs, possibly pointing at a relationship between higher ambiguity tolerance and more successful projects with innovativeness improvement. Similarly, by comparing the mean values of attitude toward uncertainty tolerance among three groups of ITAs, the values of variables from Table 48 indicate that the ITAs with higher percentages of efficiency improvement outcomes (group 2) have higher mean values than the rest of the ITAs, pointing at a possible relationship between higher uncertainty tolerance and more successful projects with efficiency improvement.

These relationships (high ambiguity tolerance with high innovativeness improvement outcome and high uncertainty tolerance with high efficiency improvement outcome) are also supported by the comparison of the mean value of the difference between ambiguity tolerance and uncertainty tolerance among three groups of ITAs. For ITAs in group 1, the mean value for ambiguity tolerance is higher than the mean value for uncertainty tolerance (3.93 – 3.53 = 0.40). This difference of mean value in group 1 is similar to the difference in group 3 where mean value for ambiguity tolerance is also higher than the mean value for uncertainty tolerance (3.61 – 3.47 = 0.14) and similar to the difference in the full sample of ITAs (3.64 – 3.52 = 0.12). However, the difference in group 1 is higher than the difference in group 3 and the difference in the full sample of ITAs, indicating that there may be a relationship between higher levels of ambiguity tolerance and higher proportions of projects resulting in innovation versus efficiency improvement.

On the other hand, group 2 is the only group where the mean value of uncertainty tolerance is higher than the mean value of ambiguity tolerance (3.92 – 3.59 = 0.33), indicating a possible relationship between higher levels of uncertainty tolerance and higher proportions of efficiency improvement versus innovativeness improvement outcomes.

4.4 Summary of the Results

The results of the regression models and additional analyses can be summarized as shown in Figure 8 which is modified from the results of the initial regression analysis in Figure 6 to include the results of the additional regression models from Section 4.3.

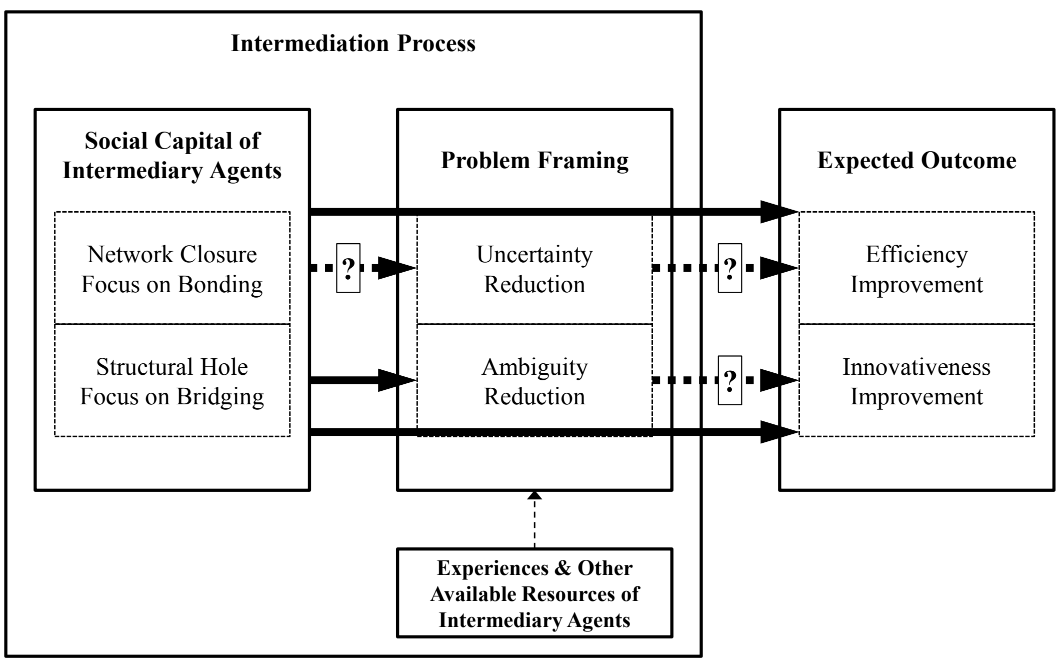

Figure 8–Summary of the research results

From the results of regression models and the additional analyses in Figure 8, it can be seen that there is a relationship between social capital of intermediary agents and the outcome of intermediation process. The relationship is supported by statistically significant results from multiple regression models as shown in Figure 5 which lead to the acceptance of Hypothesis 1 and Hypothesis 2 of this research. Moreover, there is also a relationship between social capital and the attitude toward the ambiguity tolerance of the intermediary agents which is supported by the statistically significant results from the regression models as shown in Figure 7. The results lead to the acceptance of Hypothesis 4 of this research (bridging social capital and ambiguity tolerance) along with additional relationship beyond the original hypothesis (bonding social capital and ambiguity tolerance). Thus, Figure 8 indicates the extended relationship beyond Hypothesis 4 between social capital of intermediary agents (a combination of bonding and bridging social capital) and the attitude toward ambiguity tolerance. Moreover, because the results of regression models and the additional models failed to accept Hypothesis 3, the relationship between social capital and the attitude toward uncertainty tolerance is questionable as it could not be proven (as depicted by the dotted line in Figure 8). Similarly, the results of regression models failed to accept Hypothesis 5 and Hypothesis 6. Even though the additional descriptive statistical analysis points at relationships between problem framing variables and outcome variables, the relationships are not supported by statistically significant models, resulting in questionable linkages between uncertainty tolerance and efficiency improvement outcome as well as between ambiguity tolerance and innovativeness improvement outcome (as depicted by the dotted lines in Figure 8).

The detailed analysis of the results from this chapter as shown in Figure 5, Figure 6, Figure 7 and Figure 8 is thoroughly discussed and presented in Chapter 5.

4.5 Validity of the Research

In general, validity refers to "the best available approximation to the truth or falsity of a given inference, proposition or conclusion" as defined by Cook and Campbell [183]. To ensure that the result of the research is valid, threats to different types of validity have to be carefully considered and prevented from happening during all stages of the research from the beginning stage of research design, through the middle stage of data collection process, to the ending stage of data analysis and reporting of the results. A number of scholars categorize various types of validity differently (for example, see Creswell [184], [185], Silverman [186], Denzin and Lincoln [187], and Trochim and Donnelly [188]). Nevertheless, there is an agreement that three types of validity (corresponding to different stages of research as mentioned earlier) should be thoroughly addressed. These three types of validity include construct validity (in research design), content validity (in research design and data collection), and statistical conclusion validity (in data analysis). This section discusses the consideration of these three types of validity in this research in detail.

4.5.1 Construct Validity

In this research, construct validity refers to the correct operationalization of the parameters or variables to measure and represent what they intend to measure. To ensure the construct validity, the operationalizations of the variables in this research follow or adapt from the methods identified in the literature. The variables in this research are divided into three groups according to the concept they represent which include social capital, problem framing and outcome of intermediation process.

For social capital variables, the research combines two ways of operationalization (nature-of-network variables and dimension of social capital variables) to enhance the validity; this is in agreement with Campbell and Fiske [189] as mentioned by Calder, Phillips and Tybout [190] that "validity is enhanced by employing multiple operationalizations of each construct" (page 201) [190]. Egocentric network survey was used to gather the social capital information which follows the standard practice as demonstrated by Johannisson [158], Levin and Cross [159], and Burt, Hogarth and Michaud [160]. The nature-of-network variables were measured according to the measurement of homogeneity and heterogeneity variables by Geys and Murdoch [162], [163] while dimension of social capital variables were measured according to the measurement of ease of reach by Inkpen and Tsang [164], the measurement of trust by Cook and Wall [166], and the measurement of mutual understanding by Nahapiet and Ghoshal [145] and Inkpen and Tsang [164].

For problem framing variables, the constructs in this research include the attitude toward ambiguity tolerance and the attitude toward uncertainty tolerance. These variables were represented by the questions which were adapted from four well-known questionnaires regarding the tolerance of ambiguity as presented in Furnham [167], thus ensuring the construct validity.

Lastly, for outcome variables, the constructs in this research cover the number of successful projects with efficiency improvement and the number of successful projects with innovativeness improvement. To ensure the construct validity, the numbers of the projects of both kinds were counted from the official archival records of past and present projects provided by ITAP and reconciled with the numbers provided by the ITAs themselves. Typically, all ITAs gave a very close estimate of the correct numbers of projects they owned; however, the exact numbers of projects were confirmed by the document analysis.

4.5.2 Content Validity

Content validity refers to the extent to which measurements of variables cover the subjects (or topics) of the research. This includes the coverage of the research on the subject matter and the adequate numbers of samples to correctly represent the study.

For the coverage of measurement of social capital, problem framing and outcome of intermediation process, the variables were selected according to the literature review to correctly represent the topics. Moreover, the two-steps pilot studies of the questionnaire were performed, firstly with a number of Ph.D. students in the department of engineering and technology management (ETM) at Portland State University (PSU) to ensure the logical flow of the questionnaire, and then, secondly, with an intermediary agent from ITAP who agreed to review and validate the questionnaire. The pilot studies showed no flaw in content validity as the review of the questionnaire indicated the coverage of all aspects of social capital, problem framing and outcome of intermediation process. However, the egocentric network survey was redesigned after the first round of pilot testing of questionnaire in order to make the questionnaire easier to answer for the respondents.

The initial idea of designing the egocentric network survey was to let the ITAs spell out one list of names and then ask for the associated work-affiliation and educational background of each person. However, during the pilot testing of the questionnaire, it was obvious that this part of the questionnaire was tedious and exhaustive for the respondents to complete. Thus, in order to reduce the repetitiveness and unnecessary data, the survey was redesigned by asking the respondents to provide names to two pre-determined lists (external contacts and internal contacts) as well as asking the respondents to select whether their expertise is similar, somewhat similar or different to the expertise of the people naming in the lists. By using two lists instead of one, the survey seemed to be less repetitive to the respondents. As for the case of letting the respondents select similarity or difference in expertise instead of asking for specific educational background of each contact, unnecessary data was avoided as the specific area of expertise is not a concern in this case comparing to the degree of similarity or difference between ITAs and their contacts. The concern that separating the list of names from one to two would create a response bias as the respondents may try to give equal numbers of names to two lists can be disregarded because the result shows that there is no statistically significant correlation between two variables representing number of external contacts and number of internal contacts (see correlation between variable *SIM_ORG* and variable *DIFF_ORG* in Table

12). This means that the two lists of names (external contacts and internal contacts) are mutually independent and the splitting of the list does not affect the choices of names that the ITAs provided.

As for the adequate numbers of samples, the research collected the data from 92% of the full population of ITAs at iTAP which perfectly represent the general population of intermediary agents who perform the similar process of connecting problem solvers to solution seekers. The sample size of the ITAs fulfilled the minimal requirement of sample size for studying small populations according to Appendix E, which in turn ensures content validity as well as statistical conclusion validity which is discussed next.

4.5.3 Statistical Conclusion Validity

Statistical conclusion validity is the degree to which the correct decision (conclusion) is made toward the relationships among variables [191]. It is justified by the appropriate "confidence level" in statistical test that the relationships do not exist by chance and the "power" of the statistical test to detect the existing relationships. The possible conclusion from the statistical test can be either the existence of the relationships or the lack of the relationships. Thus, the conclusion induces two possible ways of making incorrect decision according to two types of error that can occur, i.e., Type I error and Type II error (see detailed explanation of two types of error in Appendix F).

Factors Determining Statistical Conclusion Validity

According to Austin, Boyle and Lualhati [191], there are four related factors in determining the statistical validity for hypothesis testing as indicated by Cohen [192]. These four factors include alpha value, statistical power, effect size and sample size. When the values of three variables are fixed, the value of the forth variable can be determined. The statistical conclusion validity of the research can be determined by the balance of the interrelationship among these four factors (alpha, power, effect size, and sample size) [191].

The definition of four factors in determining the appropriate level of statistical conclusion validity is given as follows. The level of significance (α) and the statistical power are indicated by the correct decision to avoid Type I error and Type II error, respectively. Effect size is defined as the estimate of the degree to which the phenomenon being studied (for example, in the case of the research, the relationship of social capital, problem faming and outcome of intermediation process) exists in the population [179]. For multiple regression analysis, the effect size can be represented by f^2 which is the function of the coefficient of determination (R^2) which is the measure of the proportion of the variance of the dependent variable about its mean that is explained by the independent variables [179]. The value of effect size and R^2 has a range from zero to one; the higher the value is, the more explanatory power the regression model becomes and, thus, the larger the effect size is. Lastly, sample size is the number of observations or data points that is used to represent the population.

In the case of this research, the sample size (n = 45) satisfies the minimum requirement for the sampling of small populations as suggested by Noble et al. [193] (see Appendix E for the mathematical formula and calculation of the required sample size). With the fixed value of sample size, the standard value of statistical power, and the selected value of significance level, the effect size of hypothesis testing (f^2 and R^2 in this case of multiple linear regression) can be determined. The calculation of effect size is performed according to the method specified by Cohen and Cohen [194] based on the power analysis by Cohen [192] (see Appendix G for the detailed calculation of power analysis). Table 49 illustrates the different interactions between significant level and effect size in multiple linear regression in the case of this research.

Table 49–Factors for statistical conclusion validity in multiple regression analysis

Confidence level (α)	Statistical power	Effect size			
		4 independent variables	3 independent variables	2 independent variables	1 independent variable
90% ($\alpha = 0.10$)	0.80	$f^2 = 0.235$ $R^2 = 0.190$	$f^2 = 0.209$ $R^2 = 0.173$	$f^2 = 0.178$ $R^2 = 0.151$	$f^2 = 0.138$ $R^2 = 0.121$
95% ($\alpha = 0.05$)	0.80	$f^2 = 0.299$ $R^2 = 0.230$	$f^2 = 0.265$ $R^2 = 0.209$	$f^2 = 0.228$ $R^2 = 0.185$	$f^2 = 0.179$ $R^2 = 0.152$
99% ($\alpha = 0.01$)	0.80	$f^2 = 0.438$ $R^2 = 0.305$	$f^2 = 0.394$ $R^2 = 0.282$	$f^2 = 0.343$ $R^2 = 0.255$	$f^2 = 0.278$ $R^2 = 0.218$

Typically, the de facto standard for level of confidence is greater than or equal to 95% ($\alpha \leq 0.05$) and the acceptable value of power is 0.80 or higher as stated by Cohen and Cohen [194]. By choosing 95% confidence level ($\alpha = 0.05$) and statistical power at 0.80, the minimum effect size for multiple regression model with four independent variables (the maximum number of independent variables used in a single model for this research) from the sample size of 45 has the value of $f^2 = 0.299$, which can be transformed into an associated value of $R^2 = 0.230$. This means that in order to be satisfied with 95% confidence level that the relationship explained by the model does not happen by chance and that the model can detect such relationship 80% of the time when it occurs, the model has to be able to explain at least 23.0% of the variation in dependent variable from the maximum number of four independent variables. If the model yields lower R^2 (the model can explain less than 23.0% of the variation in dependent variable), the model cannot be deemed statistically significant. In other words, the model can detect the relationship between dependent variable and independent variables (if it exists) at $R^2 \geq 23.0\%$. However, if the confidence level is more restricted to be at 99% ($\alpha = 0.01$) while holding statistical power constant at 0.80 with the same sample size, the minimum effect size will become higher ($f^2 = 0.438$ or $R^2 = 0.305$). This means that, at more restricted confidence level, the model is required to detect stronger level of relationship between dependent variable and independent variables. In the case of this research, the maximum of four independent variables should indicate more than 30.5% in variation of dependent variables for the model to be statistically significant at 99% confidence level with 80% statistical power. On the other hand, if the confidence level is more relaxed to be at 90% ($\alpha = 0.10$) with the similar conditions of factors, the minimum effect size will become lower ($f^2 = 0.235$ or $R^2 = 0.190$). In other words, the model can detect weaker level of relationship at more relaxed confidence level as in this case where only 19.0% of the variation in dependent variable is required to be explained by the maximum of four independent variables in the model for it to be statistically significant at 90% confidence level with 80% statistical power. As the number of independent variables decreases (from four variables to one variable), the minimum effect size becomes lower. Thus, the model that detects weaker relationship between dependent variable and fewer numbers of independent variables becomes statistically significant at the same confidence level and statistical power.

In the case of the hypothesis testing by multiple linear regression analysis in this research, all the models that explain the relationships at specific confidence level conform to the value of factors in Table 49. For Hypothesis 1, model 1-final (Table 27) has $R^2 = 0.310$ at 99% confidence level ($p < .01$) which is higher than the minimum effect size requirement for the model with two independent variables to be statistically significant ($R^2 = 0.225$). Similarly for Hypothesis 2, model 2-final (Table 28) has $R^2 = 0.356$ at 99% confidence level ($p < .01$) which is higher than the minimum effect size requirement for the model with one independent variable to be statistically significant ($R^2 = 0.218$). Lastly for Hypothesis 4, model 4-final (Table 47) has $R^2 = 0.225$ at 95% confidence level ($p < .05$) which is higher than the minimum effect size requirement for the model with three independent variable to be statistically significant ($R^2 = 0.209$). Thus, the results of hypothesis testing in this research, which include the relationships between social capital variables and outcome variables (as depicted by the solid lines in Figure 5), the relationships between social capital variables and problem framing variables (as depicted by the solid lines in Figure 7) as well as the lack of the relationships, are ensured to have statistical conclusion validity at certain level of confidence and statistical power.

However, there are some regression models that indicate statistically significant result but the effect size is lower than the minimum effect size as indicated in Table 49. This is the case of statistically significant model with lower level of "observed" statistical power than the level of expected statistical power at 0.80. (The observed statistical power can be calculated using the power analysis method by Cohen [192] and Cohen and Cohen [194] as illustrated in Appendix G.) Even though the model has low value of observed power, the result is still statistically significant but the effect size is so small that the probability of not detecting the relationship in the model becomes higher. As a matter of fact, all of the independent variables from regression models with small effect size were not selected to include in the stepwise estimation process. These models include model 1f with $R^2 = 0.112$ at 95% confidence level ($p < .05$) which has the observed power of 0.65, model 2a with $R^2 = 0.087$ at 95% confidence level ($p < .05$) which has the observed power of 0.54, model 2f with $R^2 = 0.163$ at 99% confidence level ($p < .01$) which has the observed power of 0.61, and last but not least, model 4f with $R^2 = 0.076$ at 95% confidence level ($p < .05$) which has the observed power of 0.61. The relationships between these variables are depicted with the dotted lines in Figure 5 and Figure 7. The statistical conclusion validity still holds true in these cases at the lower level of statistical power; but the low observed power does not matter as power indicates the chance of not detecting the relationship while these "weak" relationships are detected by the models anyway.

Observations to Independent Variables Ratio

Moreover, besides the aforementioned power analysis (which included the absolute number of required minimum sample size), the validity of regression analysis in this research can also be justified by the ratio of the number of observations to the number of independent variables. Osborne [195] summarizes the recommended ratio by various researchers ranging from the minimum ratio of observations to independent variables at 5:1 (as recommended by Gorsuch [196], Hatcher [197] and Hair et al. [179]) to a widely-cited rule of thumb from Nunnally [198] at 10:1. For the case of this research, the number of independent variables in a regression model ranges from a single variable to the maximum of four variables for the sample size of 45 observations. Thus, the ratio of observations to independent variables ranges from 45:1 to 45:4 (or 11.25:1) which is greater than the minimum recommended ratio of 10:1 by Nunnally [198].

All in all, the regression analysis in this research is justified by the minimum sample size requirement (Appendix E), the power analysis and the minimum ratio of observations to independent variables requirement as explained in this section.

Chapter 5

Discussion

This chapter provides in-depth discussion of the results from Chapter 4. Firstly, the results of the regression models from Hypothesis 1 and Hypothesis 2, which indicate the relationship between social capital variables and outcomes of intermediation process, are discussed, following by the results of the models from Hypothesis 3 and Hypothesis 4, which show the relationship between social capital variables and problem framing variables (or the lack thereof). Then, these results (from Hypothesis 1, Hypothesis 2, Hypothesis 3, and Hypothesis 4) are analyzed from the bridging and bonding point of view of social capital. Lastly, the results of the regression models from Hypothesis 5 and Hypothesis 6 along with an additional in-depth analysis on descriptive statistics of problem framing variables are elaborated. The chapter concludes with the discussion of additional theory that can possibly explain these results in different perspectives.

5.1 Social Capital and Outcomes (Hypothesis 1 & Hypothesis 2)

The results of the multiple linear regression analysis from model 1-final (Table 27) and model 2-final (Table 28) clearly support Hypothesis 1 and Hypothesis 2 by suggesting that there are relationships between social capital and outcome of intermediation process as shown in Figure 5. For the successful projects with efficiency improvement, ease of reach (structural dimension of social capital) has a statistically significant positive relationship with the outcome of the intermediation process while mutual understanding (cognitive dimension of social capital) has a statistically significant negative relationship with the outcome at 95% confidence level. As for the successful projects with innovativeness improvement, two social capital variables, namely ease of reach and knowledge homogeneity, have statistically significant positive relationship with this type of outcome; while two other social capital variables, namely trust and organization homogeneity, demonstrate statistically significant negative relationship with innovativeness improvement outcome at 99% confidence level. It should be noted that all three dimensions of social capital variables have relationship (both positive and negative) with the outcome variables, whereas two out of four nature-of-network variables show relationship with only the outcomes with innovativeness improvement. There is no statistically significant evidence for the relationship between the outcome with efficiency improvement and nature-of-network variables. The summary of the relationship between social capital variables and outcome variables as depicted in Figure 5 is shown in Table 50.

Table 50–Summary of relationship between social capital variables and outcome variables

Outcome variable	Social capital variable	Sign	Supporting regression model	Supported by correlation
Efficiency improvement	Ease of reach	+	Model 1-final ($p < .05$)	No
	Mutual understanding	−	Model 1-final ($p < .05$)	No
Innovativeness improvement	Ease of reach	+	Model 2-final ($p < .01$), Model 2e ($p < .01$)	Yes $r(5,11) = 0.393$
	Trust	−	Model 2-final ($p < .01$)	No
	Organization homogeneity	−	Model 2-final ($p < .01$), Model 2a ($p < .05$)	Yes $r(1,11) = -0.373$
	Knowledge homogeneity	+	Model 2-final ($p < .01$)	No

The positive relationships between the two types of outcome (efficiency and innovativeness) and a dimension of social capital (ease of reach) support the resource-based view argument [35], [36] that regards social capital as a valuable resource [129], [137], [151]: the better its quality (indicated by ease of reach to the experts) the better the outcomes. In a more general sense, the ease to physically reach to the experts acts as one of the necessary conditions for the agents to actually contact the specific experts for help regarding particular projects. This argument validly applies to the general intermediation process regardless of the types of outcomes, either efficiency improvement or innovativeness improvement.

As for the negative relationships between social capital variables (trust, mutual understanding and organization homogeneity) and outcome variables, they can be explained by the theory of groupthink [199], [200]. Groupthink theory was made famous by Janis [201], [202] who defined the term as "a mode of thinking people engage in when they are deeply involved in a cohesive in-group, when the members striving for unanimity override their motivation to realistically appraise alternative courses of action" (page 9) [202]. Groupthink leads to defective decision making which is highly likely to result in bad and unsuccessful outcome. High group cohesiveness and homogeneity of group member are some of the antecedent conditions of groupthink. The high level of trust and mutual understanding of the agents creates the perception of group cohesiveness or the mental state of "sticking together" with the limited group of experts. This might prevent the agents from making a right decision to contact the appropriate experts for the problem because of the assumption that they understand what the experts think, resulting in unsuccessful outcome. These are examples of symptoms of defective decision making as identified by Janis [201], [202] which include the incomplete survey of alternatives (investigating a limited set of experts), poor information search (less effort in finding the appropriate experts), and selective bias in processing information (picking the experts based on incorrect assumption).

Moreover, especially for the case of homogeneity of group members which is reflected in the level of organization homogeneity variable, the negative relationship with innovative outcome can be explained by the fact that people from similar organizations might demonstrate "not-invented-here" (NIH) syndrome which is inhibitive to innovation as discussed by Katz and Allen [203]. Basically, the organization with NIH syndrome tends to reject ideas from outsiders even though those ideas are good and beneficial to the organization. In the case of the intermediary agents, a high level of organization homogeneity translates to high number of internal contacts which in turn takes precedence over external contacts (resulting in less out-of-the-box thinking or creativity and less boundary spanning effort). The high level of internal contacts limits the agents from external exposure of new and innovative ideas and ultimately causes lower innovation outcomes. Groupthink theory also supports the NIH syndrome argument because it is difficult (if not possible) to introduce and implement new and innovative ideas to the group with high level of homogeneity due to the lack of acceptance of outside ideas, resulting in the poor outcome with innovativeness improvement. It should be noted that the negative relationship between organization homogeneity and outcome with innovativeness improvement is also confirmed by the statistically significant negative correlation coefficient as shown in Table 12.

Lastly, there is a particular relationship between knowledge homogeneity and outcome with innovativeness improvement that seems counterintuitive. Specifically, model 2-final (Table 28) indicates that knowledge homogeneity has a statistically significantly positive relationship with outcome with innovativeness improvement at 99% confidence level, meaning that the agents with higher number of contacts with similar expertise have higher number of successful projects with innovativeness improvement. On the one hand, the expertise in particular field of knowledge may possibly lead to innovation. However, on the other hand, a number of literatures suggest that a variety of knowledge from different fields is highly likely to result in radical innovation (for example, see Iansiti [125], Chubin [126], Lakhani [127], and Jeppesen and Lakhani [128] as described in the literature review in Chapter 2). This unexpected relationship from model 2-final implies that a single field of expertise (knowledge homogeneity) has positive relationship with innovative outcome while diversity in the fields of expertise (knowledge heterogeneity) does not have such relationship. One possible explanation is the fact that, in model 2-final, knowledge homogeneity variable may have interaction effects with other independent variables in the model because this variable alone does not have a significant relationship with the innovative outcome variable (model 2b from Table 21 is not statistically significant). Moreover, knowledge homogeneity variable has a very low (and not statistically significant) value of correlation coefficient with the innovative outcome variable (from Table 12; $r(2,11) = 0.043$). Nevertheless, this unexpected and counterintuitive relationship is an avenue for future research.

5.2 Social Capital and Problem Framing (Hypothesis 3 & Hypothesis 4)

As for the in-depth analysis of the relationship between social capital variables and problem framing variables, Figure 7 illustrates the results from multiple regression analysis which support only Hypothesis 4 by suggesting that there are relationships between social capital variables and ambiguity tolerance. Various regression analysis models fail to accept Hypothesis 3 as all of those models are not statistically significant. In the case of social capital variables and ambiguity tolerance variable, model 4-final (Table 47) indicates a positive relationship for ease of reach and organization heterogeneity and a negative relationship for mutual understanding. It should be noted that trust also has a statistically significant positive relationship with ambiguity tolerance as indicating by simple regression model (model 4f as shown in Table 45) even though it is not included in the stepwise estimation multiple regression model (model 4-final). Table 51 summarizes the relationship between social capital variables and problem framing variables (only ambiguity tolerance in this case) as illustrated in Figure 7.

Table 51–Summary of relationship between social capital variables and problem framing variables

Problem framing variable	Social capital variable	Sign	Supporting regression model	Supported by correlation
Ambiguity tolerance	Ease of reach	+	Model 4-final ($p < .05$), Model 4e ($p < .10$)	No
	Trust	+	Model 4f ($p < .10$)	No
	Mutual understanding	−	Model 4-final ($p < .05$)	No
	Organization heterogeneity	+	Model 4-final ($p < .05$), Model 4c ($p < .05$)	Yes $r(3,9) = 0.301$
Uncertainty tolerance	No evidence of relationship			

The positive relationship between organization heterogeneity and ambiguity tolerance is also supported by the statistically significant correlation coefficient as shown in Table 12. The explanation from correlation analysis is still applicable in this case. The intermediary agents with high level of organization heterogeneity generally have a high number of contacts from different affiliations. Thus, they should have a high level of ambiguity tolerance and be more comfortable framing the problem in the situation with unknown unknowns than their peers who have fewer (external) contacts from different affiliations.

As for the three dimensions of social capital, two variables (ease of reach and mutual understanding) follow the pattern of the relationships between the social capital variables and the outcome variables as shown in Table 50, while trust demonstrate the opposite direction of relationship comparing to the sign in Table 50. Particularly, both ease of reach and trust positively relate to the level of ambiguity tolerance. The relational dimension of social capital (trust) allows the agents to feel comfortable contacting the experts while the structural dimension of social capital (ease of reach) provides the agents with an appropriate way to reach out to the experts for help in dealing with the problem with high ambiguity. On the other hand, mutual understanding is the only variable identified in the model to have a negative relationship with the level of ambiguity tolerance. The groupthink and NIH argument again holds true in this case. As the cognitive dimension of social capital (mutual understanding) increases, the perception level of group cohesiveness increases, resulting in the decrease in ambiguity tolerance level.

5.3 Bonding and Bridging Social Capital

As for the bonding and bridging aspect of social capital, the relationships from Figure 5 and Figure 7 clearly indicate that both aspects of social capital have an effect on problem framing variables and outcome variables. For the problem framing variables, bridging social capital (representing by ease of reach and organization heterogeneity) has positive relationship with ambiguity tolerance level of the intermediary agents, while bonding social capital has both a positive relationship (from trust) and a negative relationship (from mutual understanding) with ambiguity tolerance. For the outcome variables, bridging social capital (representing by ease of reach) has a positive relationship with both efficiency improvement and innovativeness improvement outcomes, while bonding social capital has a negative relationship from mutual understanding with efficiency improvement outcomes and a negative relationship from trust and organization homogeneity with innovativeness improvement outcome. Bonding social capital also has a positive relationship with innovativeness improvement outcome from knowledge homogeneity. Table 52 summarizes the relationships between social capital, problem framing and outcomes of intermediation process from Figure 5 and Figure 7 based on bridging and bonding aspect of social capital.

Table 52–Summary of relationships based on bridging and bonding aspects of social capital

Aspect of social capital	Social capital variable	Relationship variable	Sign	Confidence level
Bridging	Ease of reach	Ambiguity tolerance (problem framing)	+	95%
		Efficiency improvement (outcome)	+	95%
		Innovativeness improvement (outcome)	+	99%
	Organization heterogeneity	Ambiguity tolerance (problem framing)	+	95%
	Knowledge heterogeneity	No evidence of relationship		
Bonding	Trust	Ambiguity tolerance (problem framing)	+	90%
		Innovativeness improvement (outcome)	−	99%
	Mutual understanding	Ambiguity tolerance (problem framing)	−	95%
		Efficiency improvement (outcome)	−	95%
	Organization homogeneity	Innovativeness improvement (outcome)	−	99%
	Knowledge homogeneity	Innovativeness improvement (outcome)	+	99%

It should be noted from Table 52 that the bridging aspect of social capital has only a positive relationship with all dependent variables in the regression models (except in the case of uncertainty tolerance where there is no evidence to confirm the relationship) while the bonding aspect of social capital has both positive and negative relationships with various dependent variables. The insight from the exclusively positive relationship of bridging aspect of social capital confirms the favorable view of bridging social capital as supported by Granovetter's theory on the strength of weak ties [141], [142], Putnum's view of social capital [204] and Burt's structural hole theory [130]. By bridging the structural holes, the intermediary agents span and broaden their network to heterogonous sources of knowledge and information. Thus, bridging social capital is beneficial to the intermediation process. As for the positive and negative relationships set forth by the bonding aspect of social capital, they confirm the network closure theory of social capital as supported by the view of social capital by Coleman [134] and the network closure argument by Burt [131]. By focusing on bonding and network closure, the intermediary agents deepen their relationships with their existing network, resulting in less conflict and more efficiency in the transfer of knowledge and information. However, bonding can also prevent the intermediary agents from breaking out of the homogeneity of the group and the network that they are in with deep relationships. Thus, bonding social capital can be both beneficial and inhibitive to the intermediation process as shown in the contribution of both positive and negative relationships to the problem framing variable (ambiguity tolerance) and the outcomes of intermediation process (efficiency improvement and innovativeness improvement).

There is also another interesting insight on the interrelationship between the bridging and bonding aspect of social capital that can be seen from Table 52. For all three dependent variables with statistically significant regression models, there is a pattern of the relationship that shows a significantly positive relationship from ease of reach (bridging social capital) together with either significantly positive or negative relationship from trust and mutual understanding (bonding social capital). In this situation, bonding social capital (especially trust) can be seen as a supporting factor in helping the intermediary agents to make a decision to contact their network of experts in order to gain knowledge and information; while bridging social capital (ease of reach) is a main factor in achieving and realizing such a decision to make contact. In other words, bridging and bonding social capital seem to work together in the intermediation process. For the intermediation process to produce satisfactory outcomes, focusing on bridging social capital is a necessary, yet not sufficient condition: intermediary agents should also concurrently utilize bonding aspect of social capital in the intermediation process. The fact that bridging and bonding social capital are necessary together and should not be viewed separately is supported by a number of literatures. For example, Patulny and Svendsen [205] argued against binary classification of bridging and bonding social capital by citing Portes [206] on the simultaneous existence of both types of social capital. Woolcock [207] and Woolcock and Narayan [208] supported the "synergy" view of social capital by quoting Uphoff [209] that "we are commonly constrained to think in "either-or" terms–the more of one the less of the other–when both are needed in a positive-sum way to achieve our purposes" (page 273) [209].

This "bridging with bonding" argument also supports the adaptability of the ITAs in the intermediation process to align themselves with the project's objective. Such a qualification is in agreement with the concept of "organizational ambidexterity" which is defined by Gibson and Birkinshaw [210] as “the capacity to simultaneously achieve alignment and adaptability at a business unit level” (page 209) [210]. Thus, it can be implied that iTAP (as an organization employing ITAs) provides a supportive environment to ITAs which in turn enhances its organizational ambidexterity.

Specifically, bridging and bonding social capital enables the agents to appropriately choose, according to the problems, to explore the external knowledge sources or to exploit the internal knowledge sources. Exploration (of new possibilities) and exploitation (of old certainties) are two fundamentally different learning activities that require different strategies as indicated by March [211] and cited by Raisch and Birkinshaw [212] to emphasize the shift of focus on organizational research from a trade-off (either-or) scheme to a paradoxical (integration) scheme as in ambidexterity argument. In a particular study of network structure and organizational ambidexterity, Riedl, Hainzlmaier and Picot [213] demonstrated that internal ties (bonding social capital) are necessary for exploitative tasks, whereas external ties (bridging social capital) are necessary for explorative tasks. Finally, in the context of outcomes of intermediation process, the view of the collective stock of bridging and bonding social capital of the agents as the organizational resource enables the organization to achieve ambidexterity as defined by Tushman and O’Reilly [214] as the “ability to simultaneously pursue both incremental and discontinuous innovation” (page 24) [214]. In summary, both the synergy view of bridging and bonding social capital and the ambidexterity view of social capital harmoniously explain the relationships between social capital, problem framing and outcomes of intermediation process as shown in Table 52.

5.4 Problem Framing and Outcomes (Hypothesis 5 & Hypothesis 6)

As shown in Figure 6, the results from regression models for Hypothesis 5 and Hypothesis 6 indicate that there is no statistically significant relationship between problem framing variables and outcomes of intermediation process. However, the in-depth analysis on descriptive statistics of problem framing variables in three different groups of ITAs shows some interesting patterns of relationship as illustrated in Table 48.

The group of ITAs with higher percentage of efficiency improvement projects has higher mean value of uncertainty tolerance level, comparing to the rest of ITAs. This means that uncertainty tolerance may have a relationship with efficiency improvement outcomes. Higher level of uncertainty tolerance makes it possible for the ITAs to comfortably operate with uncertainty, which in turn allows the ITAs to comfortably make a conscious choice in framing the problem as uncertain. Even though these descriptive statistical values are not supported by statistically significant regression model, they are in agreement with Hypothesis 5 which indicates that problem framing with focus on uncertainty reduction is associated with solutions that result in efficiency improvement.

As for the case of ambiguity tolerance level, it can be seen from Table 48 that the group of ITAs with higher percentage of innovativeness improvement projects has higher mean value of ambiguity tolerance level, comparing to the rest of ITAs. This shows that ambiguity tolerance may somehow have a relationship with innovativeness improvement outcomes. In the similar way with the level of uncertainty tolerance, high level of ambiguity tolerance allows the ITAs to work more comfortably with ambiguity, which leads to the acceptable comfort level for ITAs in choosing to frame the problem as ambiguous. Even though there is no statistically significant evidence, these descriptive statistical values are in agreement with Hypothesis 6 which states that problem framing with focus on ambiguity reduction is associated with innovative solutions.

5.5 Additional (Alternative) Theory

These patterns of relationship (high uncertainty tolerance with high efficiency improvement and high ambiguity tolerance with high innovativeness improvement) agree with Hypothesis 5 and Hypothesis 6 which are set in accordance with the propositions of Schrader, Riggs and Smith [27]. The proposition regarding uncertainty states that "problem framing that allows only uncertainty results primarily in problem-solving outcomes that are similar in type to past problem-solving outcomes" (proposition 5a, page 91) [27] while the proposition regarding ambiguity states that "problem framing that allows ambiguity may result in outcomes that are dissimilar in type to past outcomes" (proposition 5b, page 91) [27]. The premise of these propositions is built upon the framework that deliberately gives the choice to the problem solvers in choosing how to frame the problem based on their prior problem-solving experiences, organizational context and available resources. In this regard, Schrader, Riggs and Smith [27] claim that problem framing is not given but it is an intentional choice for the problem solvers to choose the level of ambiguity and uncertainty of the problem. For any particular problem, the level of ambiguity and uncertainty that the problem solvers can choose in problem framing can be categorized into five cases according to the uncertainty-ambiguity matrix as shown in Figure 9 (reproduced from page 81 of Schrader, Riggs and Smith [27]).

UNCERTAINTY REDUCTION

	Uncertainty low	Uncertainty high
Ambiguity low	Case 1: Model using • Variable known • Values known • Functional relationships known	Case 2: Model using • Variable known • Values unknown • Functional relationships known
Ambiguity high Ambiguity level 1	Case 3: Model building • Variables known • Values known • Functional relationships unknown	Case 4: Model building • Variables known • Values unknown • Functional relationships unknown
Ambiguity level 2		Case 5: • Variables unknown • Functional relationships unknown

AMBIGUITY REDUCTION

Figure 9–The uncertainty-ambiguity matrix

There are three parameters associated with the uncertainty-ambiguity matrix, namely (1) variables, (2) values of variables and (3) functional relationships of the variables. The level of ambiguity determines the variables and their functional relationships; while the level of uncertainty determines the values of the variables. In the case of high ambiguity (ambiguity level 2) and high uncertainty (case 5 from Figure 9), the problem solver makes a decision that both the nature of the problem and the structure of the problem are not clearly understood, i.e., the variables associated with the problems and their functional relationships among each other are unknown. On the other level, if the nature of the problem is understood but the structure of the problem is not clear, the problem solver can make a decision to frame the problem as high ambiguity (ambiguity level 1) and high uncertainty (case 4 from Figure 9) which indicates that the variables of the problem are known to the problem solvers but not the values of them and their functional relationships. In the case of high ambiguity (ambiguity level 1) and low uncertainty (case 3 from Figure 9), the problem solvers frame the problem in the way that the variables and their values are known but the functional relationships are unknown. On the other hand, in the case of low ambiguity and high uncertainty (case 2 from Figure 9), the structure of the model representing the problem is clear to the problem solver as the variables and their functional relationships are known; the only missing parameters are the appropriate values of the variables. Lastly, in the case of low ambiguity and low uncertainty (case 1 from Figure 9), all of the required parameter for model are known to the problem solver and the task for problem solving is merely to choose the right algorithm to apply and implement the model to the problem.

There are two notable challenges for applying the uncertainty-ambiguity matrix in the complex problem solving process according to the experimental workshop as shown by Carleton, Cockayne and Leifer [215]. Firstly, there is no instance that the problem has high ambiguity and low uncertainty together (case 3 from Figure 9) because the values of the variables cannot be finalized unless the functional relationships among each variable are known. Secondly, the level of ambiguity and the level of uncertainty are related to each other, albeit the claim of independency in determining the parameters for problem solving (i.e., ambiguity for variables and their functional relationships, uncertainty for values of variables) by Scharder, Riggs and Smith [27]. The relationship of ambiguity and uncertainty is time-dependent in the sense that ambiguity in problem solving always happens before uncertainty as shown in Figure 10 according to the suggestion of Carleton, Cockayne and Leifer [215] to extend the static uncertainty-ambiguity matrix into the dynamic spectrum of problem solving process. This two-step dynamic process – first ambiguity, then uncertainty – is also supported by Cockayne's earlier study [216].

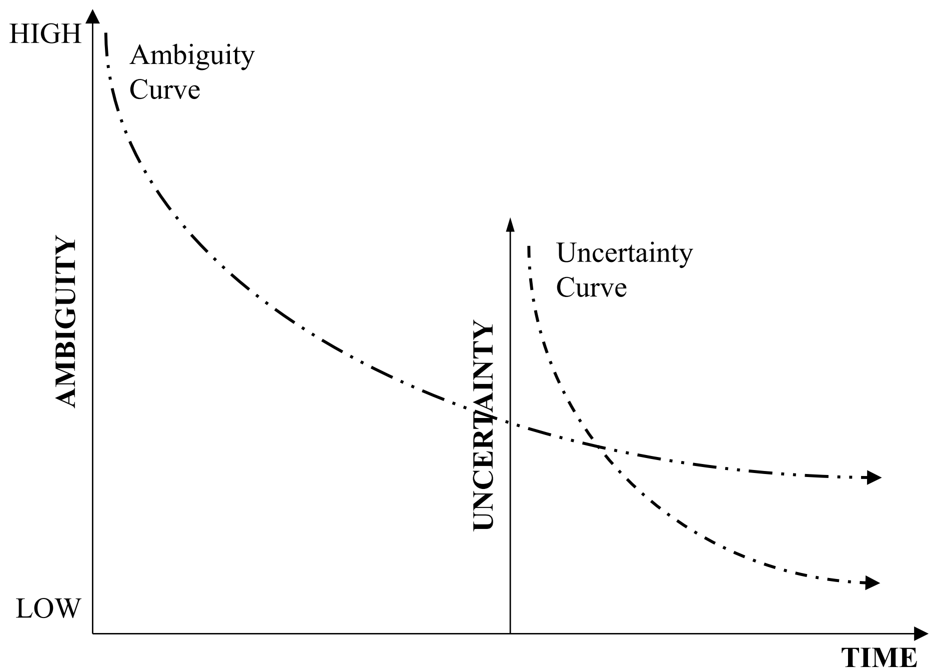

Figure 10–Dynamic spectrum of complex problem solving

Figure 10 can be explained as follows. Any kind of complex problem starts with high level of ambiguity without uncertainty (the situation of unknown unknowns). The level of ambiguity has to be reduced so that the problems become clearer from unknown variables to known variables, and then uncertainty (of the value of variables) emerges. As the levels of both ambiguity and uncertainty are decreasing, the functional relationships of variables become known to the problem solvers, following by the values of the variables. (It is highly unlikely that the problem solvers know the values of the variable before the functional relationships are known.) The levels of both ambiguity and uncertainty (once they occur) are decreasing over time along with the progress of the problem solving process and both ambiguity and uncertainty continue to exist throughout the life of the problem until the optimal or satisfying solution is found. Moreover, practically, the ambiguity curve and the uncertainty curve are not as smooth as shown in Figure 10 because multiple mini-iterations of problem solving process may occur along the path when smaller sub-problems arise and then get solved along the process. Table 53 summarizes the dynamic spectrum of complex problem solving process (from Figure 10) into four stages which are equivalent to four different cases of the uncertainty-ambiguity matrix (from Figure 9).

Table 53–Summary of stages of problem solving process

Time	Level of ambiguity	Level of uncertainty	Stages of problem solving process	Variables	Functional relationships of variables	Values of variables	Equivalent to uncertainty-ambiguity matrix
↓	High		Finding variables	Unknown	Unknown	Unknown	Case 5
	Medium	High	Defining relationships	Known	Unknown	Unknown	Case 4
	Low	Medium	Identifying values	Known	Known	Unknown	Case 2
	Low	Low	Satisfying solutions	Known	Known	Known	Case 1

This additional theory of temporal dynamic spectrum of complex problem solving process is still in agreement with Schrader, Riggs and Smith [27] on the deliberate choice in problem framing of problem solvers to focus on either ambiguity reduction or uncertainty reduction. However, it adds an insight on the occurrence of ambiguity (alone) without uncertainty (at the beginning stage of complex problem solving process) but no instance of uncertainty without ambiguity. Thus, the assumption of independency between uncertainty reduction and ambiguity reduction in problem framing as shown in research model (Figure 3) might not be true because there is a temporal relationship between ambiguity and uncertainty based on Figure 10 and Table 53. This might be the reason why the results from multiple regression analysis failed to accept Hypothesis3, Hypothesis 5, and Hypothesis 6.

Chapter 6

Conclusion

This chapter concludes the study by addressing all of the research questions and discussing the contribution of the research both in the academic domain and the practical domain. Then, the managerial implications of the results of the research along with the recommendations for best practice are presented. The limitations of the research are also discussed, along with the future research that could possibly be built upon this research.

6.1 Addressing Research Questions

From the results and discussion of this research as presented in Chapter 4 and Chapter 5, the research questions can be addressed as follows.

Research Question 1: What is the relationship between the social capital of intermediary agent and the choice in problem framing?

Social capital has both a positive and a negative relationship with the choice in choosing ambiguity reduction in problem framing as illustrated in Figure 7. Ease of reach, trust, and organization heterogeneity are positively related to ambiguity tolerance of the intermediary agents, while mutual understanding is negatively related to ambiguity tolerance. However, even though there is no explicit relationship between social capital and the choice in choosing uncertainty reduction in problem framing, the temporal relationship between ambiguity and uncertainty according to the dynamic spectrum of problem solving process suggests that uncertainty might not exist without ambiguity, thus social capital elements that have a relationship with ambiguity should also somehow have a relationship with uncertainty as well.

Research Question 2: What is the relationship between the choice in problem framing and the outcome of intermediation process?

The data from the research shows favorable results indicating that a higher level of ambiguity tolerance is associated with a higher proportion of innovativeness improvement outcome to efficiency improvement outcome. Similarly, the data also shows that a higher level of uncertainty tolerance is associated with a higher proportion of efficiency improvement outcome to innovativeness improvement outcome. The alternative view of temporal and dynamic relationship between ambiguity and uncertainty also indicates the interdependency between both problem framing variables which implies the existence of a relationship between the choice in problem framing and the outcome of intermediation process as indicated by the earlier results.

Research Question 3: What aspects of social capital are the enabling factors that improve the operational efficiency of the innovation intermediary and how to promote such factors for innovation intermediary organizations?

From Table 52, the aspects of social capital that have positive relationship with outcomes of the intermediation process can be identified as ease of reach, trust, and organization heterogeneity. Thus, these three parameters can be considered as the possible enabling factors for intermediary agents to achieve desired outcomes which in turn improve the operational efficiency. The managerial implications from the results (which are discussed in Section 6.3) provide the ways to promote such factors for the innovation intermediary organizations from the upper management perspective.

Research Question 4: What aspects of social capital are the inhibiting factors that prevent the innovation intermediary from improving the operational efficiency and how to eliminate or reduce such factors for innovation intermediary to achieve operational improvement?

In a similar manner to the enabling factors, Table 52 indicates the aspects of social capital that have a negative relationship with outcomes of the intermediation process which include mutual understanding and organization homogeneity. These two parameters can be considered as the inhibiting factors that prevent the intermediary agents to achieve the desired outcomes which in turn prevent the improvement of efficiency of the intermediation process. The implications from the results (as discussed in Section 6.3) provide the management of intermediary organizations with ways to eliminate or reduce such factors.

Figure 11 illustrates the simplified model for addressing the research questions. There are both positive and negative relationships between social capital and problem framing as indicated by solid line number 1 between social capital and problem framing

(Research Question 1). The positive and negative relationships between social capital and outcome of intermediation process are also shown as solid line number 2 between social capital and expected outcome (Research Question 3 and Research Question 4). Lastly, the relationships between problem framing and expected outcome are implied from the overall relationships between social capital and expected outcomes (Research Question 2). It should be noted that, in the problem framing process, uncertainty reduction may not exist without ambiguity reduction according to the alternative view of temporal and dynamic relationship between uncertainty and ambiguity. This is depicted as a box diagram of uncertainty inside a box diagram of ambiguity in Figure 11.

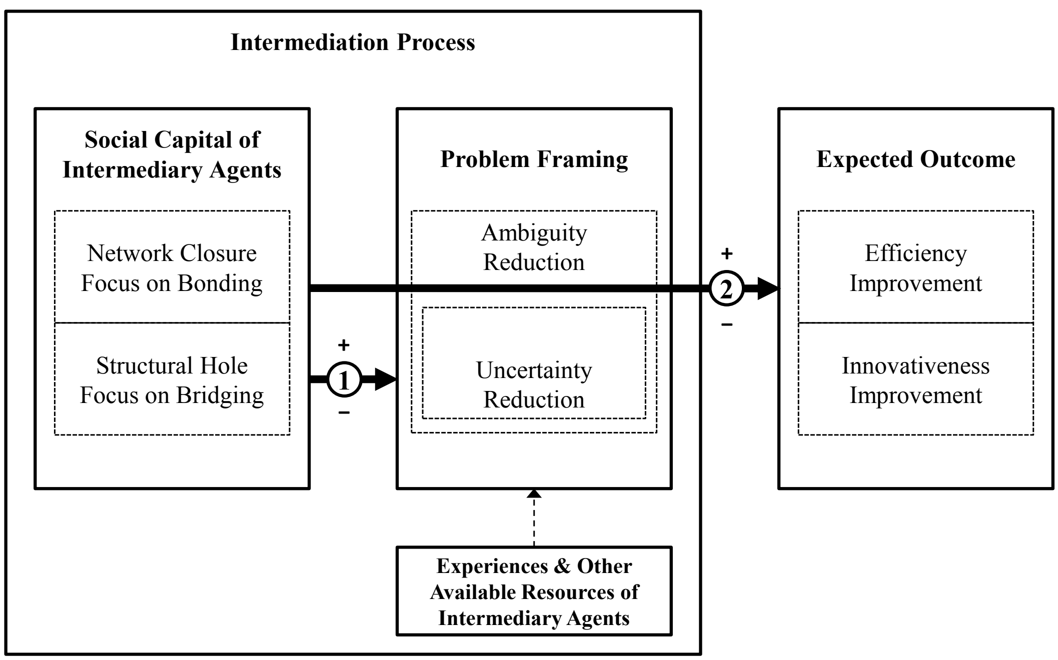

Figure 11–Simplified model for results of research

6.2 Contributions

This research contributes to the body of knowledge in engineering and technology management in several aspects both academically and practically. As for the academic contribution, the research combines three separate streams of research in technology management and other disciplines, i.e., innovation intermediary, problem solving process and social capital, into a unified framework. This includes the testing of the hypotheses based on the propositions set forth by Schrader, Riggs and Smith in their publication on choices over uncertainty and ambiguity in technical problem solving [27]. Even though the propositions cannot be statistically confirmed from the data in this research, the linkages between social capital, problem framing and outcomes of the intermediation process are presented with additional alternative views of the relationships that explained the results from the extensive analyses of the data. Moreover, the research provides empirical evidence for the impact of social capital on the innovation intermediation process as well as the problem solving process. Specifically, the impact of social capital of intermediary agents on their ambiguity tolerance is confirmed with several facets of social capital both positively and negatively related to the level of ambiguity tolerance. In addition, the impact of social capital on the outcome of the intermediation process is also confirmed with different aspects of social capital identified to have both positive and negative relationships with the outcomes.

As for the practical contribution, the results of the research lead to the implication on the appropriate strategy for an innovation intermediary to utilize social capital. This includes managerial implications for upper management level of intermediary organizations to develop appropriate procedures or guidelines for the intermediation process to achieve the desired outcomes (efficiency improvement, or innovation, or both). The management can also benefit from the result of the research by allocating the agents with appropriate focus on aspect of social capital, either bonding or bridging social capital, to the right project (for efficiency improvement or innovativeness improvement) besides the traditional way of putting the agents to work in the project by only considering the agents' area of expertise. Lastly, the results of the research also provide a guideline for potential clients (solution seekers) and experts (problem solvers) to better choose and operate with an innovation intermediary. The managerial implications of this research are discussed in detail in the next section.

6.3 Implications

The summary of results from regression models and additional analyses as shown in Table 52 indicates the facets of social capital that have different levels of impact to the outcomes of intermediation process. The upper management of the intermediary organization can implement the policy and recommend the working procedure in order to influence the desired outcomes of the intermediation process. The intermediary agents can also adapt their ways of building and maintaining an appropriate network of contacts to achieve the desired outcomes.

It is clear that ease of reach (the structural dimension of social capital) is the most influential dimension of social capital that has the highest relative impact on both outcomes with efficiency improvement and with innovativeness improvement. To ensure the higher perception of this structural dimension, the intermediary agents have to feel that they can easily make a contact with the experts both internally and externally. Various communication channels should be readily available for the agents to utilize; these include, but are not limited to, internet connection for electronic mail communication, landline telephone and mobile phone for voice communication, as well as transportation and flexibility in travelling for face-to-face communication with the experts. As a matter of fact, iTAP has already implemented the flexible office schedule for all ITAs by not requiring the ITAs to be present in the office regular working hours as long as they report directly to the manager of their meeting plans with clients and experts. Flexibility on the presence in the office as well as the time of wok is in agreement with the concept of time flexibility and locational flexibility as discussed by Gibson [217].

Trust (the relational dimension of social capital) also has an impact on the outcomes of intermediation process. It should be noted that the level of perception of trust that relates to the desired outcomes in this context is the benevolent-based trust (or the trust that the intermediary agents believe in the favor they will receive from the experts if they ask for help). The basic competent-based trust (or the trust that the intermediary agents believe in the capability of the experts) is assumed to be the prerequisite for intermediary agents to select and contact the experts in the first place. With that differentiation in mind, the upper management of intermediary organization can influence the higher level of perception of benevolent-based trust toward the experts of the intermediary agents by encouraging the bonding activities between the agents and the experts. The examples of the bonding activities with external experts include the formal seminars or workshop sessions between the experts and the intermediary agents, or the informal lunch/dinner business meetings, or the informal periodical contact to the experts, or the informal visit to the expert's workplace. As for the bonding activities with internal experts, the activities for external experts are still applicable with additional activities such as team-building exercises within the organization. This bonding activities in building trust are in agreement with the finding of Doney, Barry and Abratt [218] who indicate that (benevolent-based) trust building behaviors include frequent social interactions and open communications. Moreover, Cullen, Johnson and Sakano [219] also identify that trust building is a feedback loop that requires frequent interactions. Thus, the manager should encourage and allow the agents to frequently engage in bonding activities with their network of contacts both internally and externally.

Mutual understanding is a dimension of social capital that shows a negative relationship with ambiguity tolerance and efficiency improvement outcome. Moreover, organization homogeneity also has a negative relationship with innovation outcome. As discussed in Chapter 5, higher level of mutual understanding and organization homogeneity might lead to "groupthink" which prevents the generation and application of new ideas and alternatives, resulting in undesired outcomes. In order to lower or prevent groupthink, the manager of intermediary organizations should encourage the intermediary agents to explore more alternatives, find new experts either from within the organization or from outside, avoid making assumption of knowing the answers the experts would give before actually asking the particular experts. This recommendation follows the suggestion for preventing groupthink as suggested by Janis [201], [202].

As for the nature-of-network variables, there is a weak and counterintuitive evidence of the impact of relationship between similarity of expertise among the experts and innovative outcome. However, the relationship is questionable and might stem from the interaction effect among other variables. There is no evidence of a relationship between difference expertise and outcome of intermediation process. The nature of knowledge or expertise of the network of contacts of intermediary agents might not be significant as long as the agents can successfully match the right experts to the right problems. It is true that the knowledge in subject matter might help the agents in understanding the problems easier; however, the lack of knowledge can also help the agents to have a fresher look at the problems without a biased assumption.

As for the nature of affiliation of the experts, the agents with too many internal experts (high level of organization homogeneity) might suffer from groupthink (as explained earlier) along with the not-invented-here (NIH) syndrome and jeopardize the projects with innovativeness improvement. On the other hand, the agents with a variety of experts from different organizations enjoy the benefit of a higher level of ambiguity tolerance, which also relates to innovation outcome. This is in agreement with the significance of external sources of knowledge that can be helpful in the problem solving process as shown in boundary spanning literature [122]–[124] as well as the newer stream of research on broadcast search as illustrated by Lakhani [127] and Jeppesen and Lakhani [128]. (Chapter 2 provides an extensive literature review on these topics.)

Thus, if the intermediary organization focuses on the desired outcomes to be innovativeness improvement, the management can influence the intermediary agents to have more heterogeneous groups of experts from different organizations. This can be done by encouraging the agents to develop a "boundary spanning" attitude, for example, by attending both academic and trade conferences in different areas and building a wider network of contacts from different organizations. Moreover, by taking on an organizational perspective[8], the management can hire or recruit new intermediary agents with a broader or more generalized knowledge base (generalist) instead of specifically trained personnel (specialist) into the team; the generalist with high level of organization heterogeneity would have high ambiguity tolerance which is preferable for innovation outcome.

Lastly, it should be noted that in bridging and bonding perspective of social capital, both bridging and bonding activities are required for the intermediary agents to achieve the desired outcomes. The upper management should cultivate and nurture the agents with "T-shaped[9]" mindset who excel in both the "broadening" of the relationships to different experts (the horizontal part for expansion of network of contact) and the "deepening" of

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[8] The decision toward achieving higher organization heterogeneity in this case can be viewed as the use of the multiple perspectives concept as introduced by Linstone [220] which includes technical/analytic (T) perspective (i.e., the requirement for heterogeneous groups of experts), personal/individual (P) perspective (i.e., the personal development to expand network of contacts), and organizational/institutional (O) perspective (i.e., the appropriate recruitment of individuals for the job).

[9] The concept of the "T-shaped" person was first introduced in the context of knowledge management in 2001 by Hansen and von Oetinger [221]. In their original wok, Hansen and von Oetinger explained the concept of "T-shaped" management, which requires executives to share knowledge freely across their organization (the horizontal part of the "T"), while remaining fiercely committed to their individual business unit's performance (the vertical part), in response to the needs to capitalize on the wealth of expertise scattered across the organizations [221].

the relationships with the existing experts (the vertical part for reinforcement of the existing relationships). As long as groupthink and NIH syndrome are kept at the minimal level, the "T-shaped" agents who focus on both bridging and bonding social capital can deliver the desired outcomes (both efficiency improvement and innovativeness improvement) from the intermediation process.

6.4 Limitations and Future Research

This study did not explicitly differentiate between the internal aspect and the external aspect of social capital in all dimensions based on the organizational boundary of the intermediary agent (namely, internal connection versus external connection, trust among internal contacts versus trust among external contacts, and mutual understanding within organization versus mutual understanding with outsiders). The nature-of-network variables (organization/knowledge homogeneity/heterogeneity) only identified the similarity or difference of affiliation and expertise between the agents and their contacts. The importance of both the internal and the external aspect of social capital was assumed to be equal by the calculation of average rating scores for dimension of social capital variables from both internal and external contacts. This is so because, from the point of view of the individual intermediary agent, social capital that stemmed from the relationship within the intermediary organization (internal social capital) and social capital that stemmed from the relationship outside of the organization either with the clients or with the experts (external social capital) are equally valuable as both internal and external social capital can be used by the intermediary agents to fulfill their works. However, the values of internal social capital and external social capital might not be equal depending on different situations. Thus, the difference between internal and external social capital can be examined further in the future research.

The unit of study in this research is the individual intermediary agents who work in the same organization. The study focuses on the individual level of social capital, problem framing and outcomes of the intermediation process. There is a possibility to expand the study to cover the collective value of organizational social capital which may or may not be an additive value of individual social capital from the agents in the organization. Future research can identify this relationship.

This study assumes the static position of social capital in time, meaning that the level of social capital is assumed to be constant and has no significant difference or changes over the period of study. It is possible that the level of social capital can change over time depending on the interaction of the intermediary agents and their network. However, the dynamics and the change in the level of social capital (either increasing or decreasing) over time are not taken into account in this study. Future research can be extended to include the time dynamics of social capital and examine their impact on the operation of innovation intermediary.

Cultural issues might have an impact on social capital, for example, people from different cultures might consider different values in building bonding relationships and bridging structural holes, or people from different countries might have different levels of trust for various relationship levels. There are studies that show empirical evidence of the impact of cultural aspects on social capital, such as Xiao and Tsui [222] who investigate the network brokers in high-tech companies in China and find that the effect of structural holes in Chinese cultural context is different from the effect in Western cultural contexts. However, this research could not and does not attempt to investigate the impact of cultural aspects on social capital because the unit of study in this research (intermediary agents at iTAP) operates in a single cultural context. In addition, this research focuses on the usage of social capital, not the creation of social capital. Thus, there would not be significant differences in cultural issue as long as the data is acquired from a single cultural context. The cultural aspects of social capital as well as their impacts on the creation and maintenance of social capital can be investigated in further research.

Last but not least, this study focuses solely on the innovation intermediary agents and the innovation intermediary as an organization. As the innovation intermediation process involves both solution seekers (clients of innovation intermediary) and problem solvers (experts) and social capital of the intermediary agents include their networks of clients and experts, it is possible to include both the clients and the experts into the unit of study for future research to examine the full spectrum of the intermediation process from one end (the client) to the other end (the experts) and the impact of social capital from their perspectives. This might include the incorporation of the measurement of reciprocal trust and shared values between intermediary agents and their networks into the level of social capital.

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Appendix A

Questionnaire for Interviewing Industrial Technology Advisors at iTAP

This questionnaire is a part of a doctoral research in Engineering and Technology Management at Portland State University. The research studies the impact of social capital on innovation intermediaries, such as iTAP. We ask you to participate in your role as an industrial technology advisor at iTAP. Your responses will help us to better understand innovation intermediation and contribute to improve the operations of iTAP and similar organizations.

Name:____

Age:_______________

Gender:_______________

Educational Background

Highest degree received: ____

University/College:____

Mayor:____

Work Experience

Current position in iTAP:____

Years in this position:____

Years since joining iTAP:____

Is iTAP your first work-place? (Yes or No)

If the answer to the above question is "No", please also answer the following questions:

Last position before joining iTAP:

____

List of previous work-place(s) before joining iTAP:

____

Please provide the number of projects that you have been involved with since you started working at iTAP.

No. of projects: _________________________________

How many of these projects do you consider to be successful?

No. of successful projects: __________________________

How many of these successful projects do you think improving the efficiency of technologies that the clients have already used?

No. of successful projects with improvement from the same technology: _________

How many of these successful projects do you think providing the clients with innovations (or technologies that the clients have never used before)?

No. of successful projects with innovation from different technology: ___________

Please provide names of co-workers and experts (up to 10 names per category) that you have been in contact with within the past year (excluding administrative staff) along with their affiliation. Please also select whether the expertise of a person is similar, somewhat similar or different from your expertise. Please also rate the following statements on a scale from 1 to 10 (1 being strongly disagree and 10 being strongly agree):

Q1: It is easy to reach out to this person for help or information.

Q2: I trust that this person is willing to go the extra mile to help me.

Q3: I understand how this person thinks.

No.	Name	Affiliation	Expertise (Please select one)			Rating Score (From 1 to 10)		
			Similar	Somewhat Similar	Different	Q1	Q2	Q3
External Experts (from university or outside laboratory)								
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								

No.	Name	Affiliation	Expertise (Please select one)			Rating Score (From 1 to 10)		
			Similar	Somewhat Similar	Different	Q1	Q2	Q3
Co-workers (fellow ITAs or internal experts)								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								

Please state you opinion on the following statements.

Do you agree or disagree with the following statements?	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Q1: There is more than one right way to do anything.					
Q2: I like to play around with new ideas, even if they turn out later to be a total waste of time.					
Q3: Many of our most important decisions are based upon insufficient information.					
Q4: It is better to keep on with the present method of doing things than to take a way that which might lead to chaos.					
Q5: What we are used to is always preferable to what is unfamiliar.					
Q6: An expert who doesn't come up with a definite answer probably doesn't know too much.					

Note: Q4, Q5, and Q6 represent uncertainty tolerance value, the statements are reverse-coding (the more level of agreement to the statement translates to the less uncertainty tolerance level).

Appendix B

Models with High Multicollinearity Effect

In multiple linear regression analysis, multicollinearity occurs when any single independent variable is highly correlated with a set of other independent variables. Even though the predictive power of the regression model would not be affected by multicollinearity of the independent variables, the reliability and robustness of the model is questionable because a slight change in the model or the data may cause an erratic change in the regression coefficients of the variables with multicollinearity effect. The parameters that are generally used to detect multicollinearity are the variance inflation factor (VIF) and the tolerance. According to Pallant [168], the values of VIF should be less than 10 and the tolerance should be greater than 0.1 for the regression model to be robust and reliable.

The results of multiple linear regression model 1-collinear (Table 54), model 2-collinear (Table 55), model 3-collinear (Table 56), and model 4-collinear (Table 57) indicate extremely high values of VIF and extremely low values of tolerance for four variables from a set of nature-of-network variables, i.e., organization homogeneity, knowledge homogeneity, organization heterogeneity and knowledge heterogeneity. Thus, these four nature-of-network variables were excluded from the models. It should be noted that a single variable and some particular pairs of nature-of-network variables can be included in the models as long as they do not produce multicollinearity effect in the model.

Table 54–Regression model 1-collinear (not statistically significant)

Dependent variable:	Model 1-collinear Annual average of number of projects with efficiency improvement			
	Unstandardized coefficients (Standard error)	Standardized coefficients	Collinearity statistics	
			Tolerance	VIF
Intercept (Constant)	7.585 (7.3.98)			
Independent variables:				
1. Organization homogeneity	−3.427 (3.174)	−2.598	.004	269.208
2. Knowledge homogeneity	3.191 (3.186)	3.042	.002	428.901
3. Organization heterogeneity	−2.976 (3.246)	−1.895	.005	198.578
4. Knowledge heterogeneity	3.220 (3.237)	3.113	.002	455.595
5. Ease of reach	1.223 (1.025)	.253	.478	2.091
6. Trust	−.252 (.988)	−.056	.439	2.279
7. Mutual understanding	−1.123 (.679)	−.274	.745	1.343
R^2	.204			
Adjusted R^2	.054			
F	1.358			
Number of observations	45			

Notes: $^{\dagger}p < .1$; $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$

Table 55–Regression model 2-collinear (statistically significant)

Dependent variable:	Model 2-collinear Number of projects with innovativeness improvement			
	Unstandardized coefficients (Standard error)	Standardized coefficients	Collinearity statistics	
			Tolerance	VIF
Intercept (Constant)	−.875 (2.598)			
Independent variables:				
1. Organization homogeneity	−.461 (1.115)	−.901	.004	269.208
2. Knowledge homogeneity	.371 (1.119)	.911	.002	428.901
3. Organization heterogeneity	−.216 (1.140)	−.355	.005	198.578
4. Knowledge heterogeneity	.262 (1.137)	.653	.002	455.595
5. Ease of reach	.993** (.360)	.530**	.478	2.091
6. Trust	$-.603^{\dagger}$ (.347)	$-.349^{\dagger}$	.439	2.279
7. Mutual understanding	.041 (.245)	.026	.745	1.343
R^2	.347			
Adjusted R^2	.223			
F	2.809*			
Number of observations	45			

Notes: $^{\dagger}p < .1$; $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$

Table 56–Regression model 3-collinear (not statistically significant)

Dependent variable:	Model 3-collinear Attitude toward uncertainty tolerance			
	Unstandardized coefficients (Standard error)	Standardized coefficients	Collinearity statistics	
			Tolerance	VIF
Intercept (Constant)	3.916*** (1.059)			
Independent variables:				
1. Organization homogeneity	−.931* (.454)	−4.817*	.004	269.208
2. Knowledge homogeneity	.938* (.456)	6.101*	.002	428.901
3. Organization heterogeneity	−.979* (.465)	−4.253*	.005	198.578
4. Knowledge heterogeneity	.928† (.463)	6.124†	.002	455.595
5. Ease of reach	−.144 (.147)	−.203	.478	2.091
6. Trust	.271† (.142)	.415†	.439	2.279
7. Mutual understanding	−.127 (.100)	−.212	.745	1.343
R^2		.240		
Adjusted R^2		.097		
F		1.673		
Number of observations		45		

Notes: †$p < .1$; *$p < .05$; ** $p < .01$; *** $p < .001$

Table 57–Regression model 4-collinear (statistically significant)

Dependent variable:	Model 4-collinear Attitude toward ambiguity tolerance			
	Unstandardized coefficients (Standard error)	Standardized coefficients	Collinearity statistics	
			Tolerance	VIF
Intercept (Constant)	2.292* (.972)			
Independent variables:				
1. Organization homogeneity	−.410 (.417)	−2.269	.004	269.208
2. Knowledge homogeneity	.414 (.418)	2.877	.002	428.901
3. Organization heterogeneity	−.367 (.426)	−1.706	.005	198.578
4. Knowledge heterogeneity	.430 (.425)	3.037	.002	455.595
5. Ease of reach	.149 (.135)	.225	.478	2.091
6. Trust	.108 (.130)	.176	.439	2.279
7. Mutual understanding	−.176† (.092)	−.313†	.745	1.343
R^2		.269		
Adjusted R^2		.131		
F		1.944†		
Number of observations		45		

Notes: †$p < .1$; *$p < .05$; ** $p < .01$; *** $p < .001$

Appendix C

Scenario Analysis for the Set of Nature-of-network Variables

As indicated in Appendix B, four social capital variables representing nature-of-network have high multicollinearity and thus were excluded from the multiple linear regression models. However, there is a way to include the set of variables into the model by using a new variable that represents this set of variables. This follows a suggestion by Crown [223] that "another approach for dealing with multicollinearity is to create new variables that are some combinations of multicollinear ones" (page 75) [223][10]. Since these four variables are highly correlated with each other, the new variable can be operationalized as a linear combination of four nature-of-network variables. This new variable can act as a "scenario" variable where the weight of each nature-of-network variable indicates the level of importance of such variable in the intermediation process in different scenarios. By including different scenario variables in the regression models, the results of the models indicate whether each particular scenario generates statistically significant model and regression coefficient. The results also indicate how important these four different nature-of-network variables are to the intermediation process in different scenarios and thus can possibly provide an insightful policy implication for the top management to decide on which aspects of relationship between intermediary agents and the experts should be emphasized and fostered to achieve desired outcomes.

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[10] For extensive review on multicollinearity in regression analysis and the other recommendations to interpret and remedy the effect, see the classic work of Farrar and Glauber [224].

In this case, seven different scenarios were chosen to compare with baseline scenario where all of four different nature-of-network variables were excluded from the models. It should be noted that the summation of the weights of all variables in the linear combination equation for each scenario is equal to one, except for the baseline scenario which can be counted as a special case of scenario variable when all of the weights of all variables are zero. All of the scenarios and their associated equations for scenario variables are presented as follows:

- Baseline scenario: no nature-of-network variable.

$$S_0 = 0 \cdot SIM\_ORG + 0 \cdot SIM\_KNOW + 0 \cdot DIFF\_ORG + 0 \cdot DIFF\_KNOW \quad (1)$$

- Scenario 1: all nature-of-network variables are equally important.

$$S_1 = 0.25 \cdot SIM\_ORG + 0.25 \cdot SIM\_KNOW + 0.25 \cdot DIFF\_ORG + 0.25 \cdot DIFF\_KNOW \quad (2)$$

- Scenario 2: network homogeneity is more important.

$$S_2 = 0.4 \cdot SIM\_ORG + 0.4 \cdot SIM\_KNOW + 0.1 \cdot DIFF\_ORG + 0.1 \cdot DIFF\_KNOW \quad (3)$$

- Scenario 3: network heterogeneity is more important.

$$S_3 = 0.1 \cdot SIM\_ORG + 0.1 \cdot SIM\_KNOW + 0.4 \cdot DIFF\_ORG + 0.4 \cdot DIFF\_KNOW \quad (4)$$

- Scenario 4: organization homogeneity is the only important variable.

$$S_4 = 1 \cdot SIM\_ORG + 0 \cdot SIM\_KNOW + 0 \cdot DIFF\_ORG + 0 \cdot DIFF\_KNOW \quad (5)$$

- Scenario 5: knowledge homogeneity is the only important variable.

$$S_5 = 0 \cdot SIM\_ORG + 1 \cdot SIM\_KNOW + 0 \cdot DIFF\_ORG + 0 \cdot DIFF\_KNOW \quad (6)$$

- Scenario 6: organization heterogeneity is the only important variable.

$$S_6 = 0 \cdot SIM\_ORG + 0 \cdot SIM\_KNOW + 1 \cdot DIFF\_ORG + 0 \cdot DIFF\_KNOW \quad (7)$$

- Scenario 7: knowledge heterogeneity is the only important variable.

$$S_7 = 0 \cdot SIM\_ORG + 0 \cdot SIM\_KNOW + 0 \cdot DIFF\_ORG + 1 \cdot DIFF\_KNOW \quad (8)$$

Table 58 summarizes the results of multiple linear regression models for different scenarios. Each model is shown in detail from Table 59 to Table 90.

Table 58–Summary of results of regression models for different scenarios

Scenario	H1: Social capital & efficiency	H2: Social capital & innovation	H3: Social capital & uncertainty	H4: Social capital & ambiguity
Baseline scenario: No nature-of-network variable	Rejected	Accepted, $p < .05$ (*REACH*, positive, $p < .01$)	Rejected	Accepted, $p < .1$ (*MUTUAL*, negative, $p < .1$)
Scenario 1: Equally important	Rejected	Accepted, $p < .05$ (*REACH*, positive, $p < .01$)	Rejected	Accepted, $p < .05$ (*MUTUAL*, negative, $p < .05$)
Scenario 2: Homogeneity	Rejected	Accepted, $p < .05$ (*REACH*, positive, $p < .01$)	Rejected	Accepted, $p < .1$ (*MUTUAL*, negative, $p < .05$)
Scenario 3: Heterogeneity	Rejected	Accepted, $p < .05$ (*REACH*, positive, $p < .01$)	Rejected	Accepted, $p < .05$ (*MUTUAL*, negative, $p < .05$; S_3, positive, $p < .1$)
Scenario 4: *SIM_ORG*	Rejected	Accepted, $p < .01$ (*REACH*, positive, $p < .05$)	Rejected	Accepted, $p < .1$ (*MUTUAL*, negative, $p < .05$)
Scenario 5: *SIM_KNOW*	Rejected	Accepted, $p < .05$ (*REACH*, positive, $p < .01$)	Rejected	Accepted, $p < .1$ (*MUTUAL*, negative, $p < .1$)
Scenario 6: *DIFF_ORG*	Rejected	Accepted, $p < .05$ (*REACH*, positive, $p < .01$)	Rejected	Accepted, $p < .05$ (*MUTUAL*, negative, $p < .05$; *DIFF_ORG*, positive, $p < .1$)
Scenario 7: *DIFF_KNOW*	Rejected	Accepted, $p < .05$ (*REACH*, positive, $p < .01$)	Rejected	Accepted, $p < .05$ (*MUTUAL*, negative, $p < .1$)

Note: Underline words denote changes from baseline scenario.

From Table 58, it is clear that the results from different scenarios do not significantly differ in term of statistically significant independent variables from the baseline scenario where the nature-of-network variables were omitted. As a matter of fact, there is no change in statistically significant independent variables from the baseline scenario at all for model 1, model 2 and model 3. The changes in the statistically significant independent variables occur only in model 4 for scenario 3 and scenario 6. For scenario 3, the focus on network heterogeneity (different affiliation and different expertise) of the intermediary agent shows positive relationship with the level of ambiguity tolerance. As for scenario 6, organization heterogeneity has positive relationship with the level of ambiguity tolerance.

Even though the scenario analysis demonstrates some changes in the regression models, the changes are marginally small and have low to minimal level of statistical significance ($p < .1$). Thus, the changes are almost negligible. Moreover, the result of the scenario analysis is still in agreement with the result from Figure 7 where organization heterogeneity is the only nature-of-network variable that has a relationship with the level of ambiguity tolerance. Therefore, it can be concluded that various scenarios of nature-of-network variables do not significantly offer additional insight for the intermediation process in this case. On one hand, it is possible to disregard the nature-of-network variables based on this scenario analysis; however, on the other hand, there might possibly be a linear combination of nature-of-network variables that provides a specific scenario which results in significant effect on the intermediation process. This is one possibility for future research.

Table 59–Regression model 1 for baseline scenario (not statistically significant)

Dependent variable:	Model 1S0 Annual average number of projects with efficiency improvement			
	Unstandardized coefficients (Standard error)	Standardized coefficients	Collinearity statistics: Tolerance	Collinearity statistics: VIF
Intercept (Constant)	6.088 (6.973)			
Independent variables:				
1. Ease of reach	1.448 (.946)	.300	.550	1.819
2. Trust	−.106 (.923)	−.024	.493	2.030
3. Mutual understanding	$-1.311^{\dagger}$ (.655)	$-.320^{\dagger}$	.827	1.209
R^2		.136		
Adjusted R^2		.073		
F		2.153		
Number of observations		45		

Notes: $^{\dagger}p < .1$; $*p < .05$; $**\ p < .01$; $***\ p < .001$

Table 60-Regression model 2 for baseline scenario (statistically significant)

Dependent variable:	Model 2S0 Annual average number of projects with innovativeness improvement			
	Unstandardized coefficients (Standard error)	Standardized coefficients	Collinearity statistics: Tolerance	Collinearity statistics: VIF
Intercept (Constant)	−2.809 (2.558)			
Independent variables:				
1. Ease of reach	1.162** (.349)	.620**	.550	1.819
2. Trust	$-.601^{\dagger}$ (.341)	$-.348^{\dagger}$	.493	2.030
3. Mutual understanding	.035 (.242)	.022	.827	1.209
R^2		.216		
Adjusted R^2		.161		
F		3.810*		
Number of observations		45		

Notes: $^{\dagger}p < .1$; $*p < .05$; $**\ p < .01$; $***\ p < .001$

Table 61–Regression model 3 for baseline scenario (not statistically significant)

Dependent variable:	Model 3S0 Attitude toward uncertainty tolerance			
	Unstandardized coefficients (Standard error)	Standardized coefficients	Collinearity statistics	
			Tolerance	VIF
Intercept (Constant)	3.606** (1.036)			
Independent variables:				
1. Ease of reach	−.138 (.141)	−.196	.550	1.819
2. Trust	.270† (.138)	.413†	.493	2.030
3. Mutual understanding	−.147 (.098)	−.244	.827	1.209
R^2		.103		
Adjusted R^2		.037		
F		1.562		
Number of observations		45		

Notes: † $p < .1$; * $p < .05$; ** $p < .01$; *** $p < .001$

Table 62–Regression model 4 for baseline scenario (statistically significant)

Dependent variable:	Model 4S0 Attitude toward ambiguity tolerance			
	Unstandardized coefficients (Standard error)	Standardized coefficients	Collinearity statistics	
			Tolerance	VIF
Intercept (Constant)	2.614** (.931)			
Independent variables:				
1. Ease of reach	.101 (.127)	.152	.550	1.819
2. Trust	.187 (.124)	.305	.493	2.030
3. Mutual understanding	−.177† (.088)	−.315†	.827	1.209
R^2		.171		
Adjusted R^2		.111		
F		2.829†		
Number of observations		45		

Notes: † $p < .1$; * $p < .05$; ** $p < .01$; *** $p < .001$

Table 63–Regression model 1 for scenario 1 (not statistically significant)

Dependent variable:	Model 1S1 Annual average number of projects with efficiency improvement			
	Unstandardized coefficients (Standard error)	Standardized coefficients	Collinearity statistics	
			Tolerance	VIF
Intercept (Constant)	6.439 (7.198)			
Independent variables:				
1. Scenario 1 – equally important	−.064 (.292)	−.035	.837	1.194
2. Ease of reach	1.379 (1.007)	.285	.497	2.014
3. Trust	−.044 (.977)	−.010	.451	2.218
4. Mutual understanding	$-1.284^{\dagger}$ (.675)	$-.313^{\dagger}$	.798	1.253
R^2	.137			
Adjusted R^2	.051			
F	1.589			
Number of observations	45			

Notes: $^{\dagger}p < .1$; $*p < .05$; $** p < .01$; $*** p < .001$

Table 64-Regression model 2 for scenario 1 (statistically significant)

Dependent variable:	Model 2S1 Annual average number of projects with innovativeness improvement			
	Unstandardized coefficients (Standard error)	Standardized coefficients	Collinearity statistics	
			Tolerance	VIF
Intercept (Constant)	−2.307 (2.632)			
Independent variables:				
1. Scenario 1 – equally important	−.092 (.107)	−.130	.837	1.194
2. Ease of reach	1.063** (.368)	.568**	.497	2.014
3. Trust	−.512 (.357)	−.296	.451	2.218
4. Mutual understanding	.074 (.247)	.047	.798	1.253
R^2	.232			
Adjusted R^2	.155			
F	3.025*			
Number of observations	45			

Notes: $^{\dagger}p < .1$; $*p < .05$; $** p < .01$; $*** p < .001$

Table 65–Regression model 3 for scenario 1 (not statistically significant)

Dependent variable:	Model 3S1 Attitude toward uncertainty tolerance			
	Unstandardized coefficients (Standard error)	Standardized coefficients	Collinearity statistics	
			Tolerance	VIF
Intercept (Constant)	3.869** (1.059)			
Independent variables:				
1. Scenario 1 – equally important	−.048 (.043)	−.181	.837	1.194
2. Ease of reach	−.190 (.148)	−.269	.497	2.014
3. Trust	.317* (.144)	.484*	.451	2.218
4. Mutual understanding	−.126 (.099)	−.210	.798	1.253
R^2		.130		
Adjusted R^2		.043		
F		1.493		
Number of observations		45		

Notes: $^{\dagger}p < .1$; $*p < .05$; $** p < .01$; $*** p < .001$

Table 66–Regression model 4 for scenario 1 (statistically significant)

Dependent variable:	Model 4S1 Attitude toward ambiguity tolerance			
	Unstandardized coefficients (Standard error)	Standardized coefficients	Collinearity statistics	
			Tolerance	VIF
Intercept (Constant)	2.280* (.937)			
Independent variables:				
1. Scenario 1 – equally important	.061 (.038)	.246	.837	1.194
2. Ease of reach	.167 (.131)	.252	.497	2.014
3. Trust	.127 (.127)	.208	.451	2.218
4. Mutual understanding	−.204* (.088)	−.362*	.798	1.253
R^2		.222		
Adjusted R^2		.144		
F		2.855*		
Number of observations		45		

Notes: $^{\dagger}p < .1$; $*p < .05$; $** p < .01$; $*** p < .001$

Table 67–Regression model 1 for scenario 2 (not statistically significant)

Dependent variable:	Model 1S2 Annual average number of projects with efficiency improvement			
	Unstandardized coefficients (Standard error)	Standardized coefficients	Collinearity statistics	
			Tolerance	VIF
Intercept (Constant)	6.591 (7.072)			
Independent variables:				
1. Scenario 2 – network homogeneity	−.131 (.260)	−.083	.796	1.256
2. Ease of reach	1.276 (1.014)	.264	.488	2.049
3. Trust	.030 (.971)	.007	.454	2.203
4. Mutual understanding	−1.217† (.687)	−.297†	.766	1.306
R^2		.142		
Adjusted R^2		.056		
F		1.649		
Number of observations		45		

Notes: †$p < .1$; *$p < .05$; ** $p < .01$; *** $p < .001$

Table 68-Regression model 2 for scenario 2 (statistically significant)

Dependent variable:	Model 2S2 Annual average number of projects with innovativeness improvement			
	Unstandardized coefficients (Standard error)	Standardized coefficients	Collinearity statistics	
			Tolerance	VIF
Intercept (Constant)	−2.606 (2.606)			
Independent variables:				
1. Scenario 2 – network homogeneity	−.053 (.096)	−.086	.796	1.256
2. Ease of reach	1.093** (.374)	.583**	.488	2.049
3. Trust	−.546 (.358)	−.316	.454	2.203
4. Mutual understanding	.073 (.253)	.046	.766	1.306
R^2		.224		
Adjusted R^2		.146		
F		2.885*		
Number of observations		45		

Notes: †$p < .1$; *$p < .05$; ** $p < .01$; *** $p < .001$

Table 69–Regression model 3 for scenario 2 (not statistically significant)

Dependent variable:	Model 3S2 Attitude toward uncertainty tolerance			
	Unstandardized coefficients (Standard error)	Standardized coefficients	Collinearity statistics	
			Tolerance	VIF
Intercept (Constant)	3.679** (1.056)			
Independent variables:				
1. Scenario 2 – network homogeneity	−.019 (.039)	−.082	.796	1.256
2. Ease of reach	−.163 (.151)	−.230	.488	2.049
3. Trust	.290† (.145)	.443†	.454	2.203
4. Mutual understanding	−.133 (.103)	−.222	.766	1.306
R^2	.108			
Adjusted R^2	.019			
F	1.209			
Number of observations	45			

Notes: †$p < .1$; *$p < .05$; ** $p < .01$; *** $p < .001$

Table 70–Regression model 4 for scenario 2 (statistically significant)

Dependent variable:	Model 4S2 Attitude toward ambiguity tolerance			
	Unstandardized coefficients (Standard error)	Standardized coefficients	Collinearity statistics	
			Tolerance	VIF
Intercept (Constant)	2.487* (.941)			
Independent variables:				
1. Scenario 2 – network homogeneity	.033 (.035)	.152	.796	1.256
2. Ease of reach	.144 (.135)	.218	.488	2.049
3. Trust	.152 (.129)	.249	.454	2.203
4. Mutual understanding	−.201* (.091)	−.358*	.766	1.306
R^2	.190			
Adjusted R^2	.109			
F	2.346†			
Number of observations	45			

Notes: †$p < .1$; *$p < .05$; ** $p < .01$; *** $p < .001$

Table 71–Regression model 1 for scenario 3 (not statistically significant)

Dependent variable:	Model 1S3 Annual average number of projects with efficiency improvement			
	Unstandardized coefficients (Standard error)	Standardized coefficients	Collinearity statistics	
			Tolerance	VIF
Intercept (Constant)	5.893 (7.252)			
Independent variables:				
1. Scenario 3 – network heterogeneity	.028 (.255)	.016	.922	1.084
2. Ease of reach	1.471 (.982)	.304	.523	1.910
3. Trust	−.131 (.963)	−.029	.464	2.154
4. Mutual understanding	−1.315† (.664)	−.321†	.824	1.213
R^2	.136			
Adjusted R^2	.050			
F	1.579			
Number of observations	45			

Notes: †$p < .1$; *$p < .05$; ** $p < .01$; *** $p < .001$

Table 72–Regression model 2 for scenario 3 (statistically significant)

Dependent variable:	Model 2S3 Annual average number of projects with innovativeness improvement			
	Unstandardized coefficients (Standard error)	Standardized coefficients	Collinearity statistics	
			Tolerance	VIF
Intercept (Constant)	−2.172 (2.644)			
Independent variables:				
1. Scenario 3 – network heterogeneity	−.090 (.093)	−.139	.922	1.084
2. Ease of reach	1.087** (.358)	.580**	.523	1.910
3. Trust	−.520 (.351)	−.301	.464	2.154
4. Mutual understanding	.048 (.242)	.030	.824	1.213
R^2	.236			
Adjusted R^2	.159			
F	3.085*			
Number of observations	45			

Notes: †$p < .1$; *$p < .05$; ** $p < .01$; *** $p < .001$

Table 73–Regression model 3 for scenario 3 (not statistically significant)

Dependent variable:	Model 3S3 Attitude toward uncertainty tolerance			
	Unstandardized coefficients (Standard error)	Standardized coefficients	Collinearity statistics	
			Tolerance	VIF
Intercept (Constant)	4.000*** (1.054)			
Independent variables:				
1. Scenario 3 – network heterogeneity	−.055 (.037)	−.227	.922	1.084
2. Ease of reach	−.185 (.143)	−.262	.523	1.910
3. Trust	.320* (.140)	.489*	.464	2.154
4. Mutual understanding	−.139 (.097)	−.231	.824	1.213
R^2	.150			
Adjusted R^2	.065			
F	1.764			
Number of observations	45			

Notes: $^{\dagger}p < .1$; $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$

Table 74–Regression model 4 for scenario 3 (statistically significant)

Dependent variable:	Model 4S3 Attitude toward ambiguity tolerance			
	Unstandardized coefficients (Standard error)	Standardized coefficients	Collinearity statistics	
			Tolerance	VIF
Intercept (Constant)	2.175* (.933)			
Independent variables:				
1. Scenario 3 – network heterogeneity	$.062^{\dagger}$ (.033)	$.271^{\dagger}$	.922	1.084
2. Ease of reach	.153 (.126)	.231	.523	1.910
3. Trust	.131 (.124)	.213	.464	2.154
4. Mutual understanding	−.186* (.085)	−.331*	.824	1.213
R^2	.239			
Adjusted R^2	.163			
F	3.143*			
Number of observations	45			

Notes: $^{\dagger}p < .1$; $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$

Table 75–Regression model 1 for scenario 4 (not statistically significant)

Dependent variable:	Model 1S4 Annual average number of projects with efficiency improvement			
	Unstandardized coefficients (Standard error)	Standardized coefficients	Collinearity statistics	
			Tolerance	VIF
Intercept (Constant)	7.975 (7.146)			
Independent variables:				
1. Scenario 4 – organization homogeneity	−.223 (.208)	−.169	.843	1.186
2. Ease of reach	1.077 (1.006)	.223	.485	2.064
3. Trust	.104 (.942)	.023	.471	2.123
4. Mutual understanding	−1.161† (.669)	−.283†	.791	1.265
R^2	.160			
Adjusted R^2	.076			
F	1.906			
Number of observations	45			

Notes: †$p < .1$; *$p < .05$; ** $p < .01$; *** $p < .001$

Table 76–Regression model 2 for scenario 4 (statistically significant)

Dependent variable:	Model 2S4 Annual average number of projects with innovativeness improvement			
	Unstandardized coefficients (Standard error)	Standardized coefficients	Collinearity statistics	
			Tolerance	VIF
Intercept (Constant)	−1.642 (2.566)			
Independent variables:				
1. Scenario 4 – organization homogeneity	−.138† (.075)	−.269†	.843	1.186
2. Ease of reach	.933* (.361)	.498*	.485	2.064
3. Trust	−.471 (.338)	−.272	.471	2.123
4. Mutual understanding	.127 (.240)	.080	.791	1.265
R^2	.279			
Adjusted R^2	.207			
F	3.872**			
Number of observations	45			

Notes: †$p < .1$; *$p < .05$; ** $p < .01$; *** $p < .001$

Table 77–Regression model 3 for scenario 4 (not statistically significant)

Dependent variable:	Model 3S4 Attitude toward uncertainty tolerance			
	Unstandardized coefficients (Standard error)	Standardized coefficients	Collinearity statistics	
			Tolerance	VIF
Intercept (Constant)	3.765** (1.078)			
Independent variables:				
1. Scenario 4 – organization homogeneity	−.019 (.031)	−.097	.843	1.186
2. Ease of reach	−.170 (.152)	−.239	.485	2.064
3. Trust	.288† (.142)	.440†	.471	2.123
4. Mutual understanding	−.134 (.101)	−.223	.791	1.265
R^2		.110		
Adjusted R^2		.021		
F		1.241		
Number of observations		45		

Notes: † $p < .1$; * $p < .05$; ** $p < .01$; *** $p < .001$

Table 78–Regression model 4 for scenario 4 (statistically significant)

Dependent variable:	Model 4S4 Attitude toward ambiguity tolerance			
	Unstandardized coefficients (Standard error)	Standardized coefficients	Collinearity statistics	
			Tolerance	VIF
Intercept (Constant)	2.473* (.968)			
Independent variables:				
1. Scenario 4 – organization homogeneity	.017 (.028)	.092	.843	1.186
2. Ease of reach	.129 (.136)	.194	.485	2.064
3. Trust	.171 (.128)	.279	.471	2.123
4. Mutual understanding	−.189* (.091)	−.335*	.791	1.265
R^2		.179		
Adjusted R^2		.097		
F		2.175†		
Number of observations		45		

Notes: † $p < .1$; * $p < .05$; ** $p < .01$; *** $p < .001$

Table 79–Regression model 1 for scenario 5 (not statistically significant)

Dependent variable:	Model 1S5 Annual average number of projects with efficiency improvement			
	Unstandardized coefficients (Standard error)	Standardized coefficients	Collinearity statistics	
			Tolerance	VIF
Intercept (Constant)	6.053 (7.041)			
Independent variables:				
1. Scenario 5 – knowledge homogeneity	−.012 (.169)	−.011	.836	1.196
2. Ease of reach	1.433 (.981)	.296	.524	1.908
3. Trust	−.092 (.958)	−.021	.469	2.131
4. Mutual understanding	−1.298† (.690)	−.316†	.763	1.311
R^2	.136			
Adjusted R^2	.050			
F	1.577			
Number of observations	45			

Notes: †$p < .1$; *$p < .05$; ** $p < .01$; *** $p < .001$

Table 80‑Regression model 2 for scenario 5 (statistically significant)

Dependent variable:	Model 2S5 Annual average number of projects with innovativeness improvement			
	Unstandardized coefficients (Standard error)	Standardized coefficients	Collinearity statistics	
			Tolerance	VIF
Intercept (Constant)	−2.645 (2.571)			
Independent variables:				
1. Scenario 5 – knowledge homogeneity	.055 (.062)	.135	.836	1.196
2. Ease of reach	1.231** (.358)	.657**	.524	1.908
3. Trust	−.669† (.350)	−.387†	.469	2.131
4. Mutual understanding	−.028 (.252)	−.018	.763	1.311
R^2	.233			
Adjusted R^2	.157			
F	3.042*			
Number of observations	45			

Notes: †$p < .1$; *$p < .05$; ** $p < .01$; *** $p < .001$

Table 81–Regression model 3 for scenario 5 (not statistically significant)

Dependent variable:	Model 3S5 Attitude toward uncertainty tolerance			
	Unstandardized coefficients (Standard error)	Standardized coefficients	Collinearity statistics	
			Tolerance	VIF
Intercept (Constant)	3.627** (1.051)			
Independent variables:				
1. Scenario 5 – knowledge homogeneity	.007 (.025)	.045	.836	1.196
2. Ease of reach	−.130 (.146)	−.183	.524	1.908
3. Trust	.261† (.143)	.400†	.469	2.131
4. Mutual understanding	−.155 (.103)	−.257	.763	1.311
R^2		.104		
Adjusted R^2		.015		
F		1.164		
Number of observations		45		

Notes: †$p < .1$; *$p < .05$; ** $p < .01$; *** $p < .001$

Table 82–Regression model 4 for scenario 5 (statistically significant)

Dependent variable:	Model 4S5 Attitude toward ambiguity tolerance			
	Unstandardized coefficients (Standard error)	Standardized coefficients	Collinearity statistics	
			Tolerance	VIF
Intercept (Constant)	2.639** (.943)			
Independent variables:				
1. Scenario 5 – knowledge homogeneity	.008 (.023)	.057	.836	1.196
2. Ease of reach	.111 (.131)	.168	.524	1.908
3. Trust	.176 (.128)	.289	.469	2.131
4. Mutual understanding	−.187† (.093)	−.332†	.763	1.311
R^2		.174		
Adjusted R^2		.092		
F		2.110†		
Number of observations		45		

Notes: †$p < .1$; *$p < .05$; ** $p < .01$; *** $p < .001$

Table 83–Regression model 1 for scenario 6 (not statistically significant)

Dependent variable:	Model 1S6 Annual average number of projects with efficiency improvement			
	Unstandardized coefficients (Standard error)	Standardized coefficients	Collinearity statistics	
			Tolerance	VIF
Intercept (Constant)	5.604 (6.993)			
Independent variables:				
1. Scenario 6 – organization heterogeneity	.193 (.240)	.123	.907	1.102
2. Ease of reach	1.540 (.957)	.319	.542	1.845
3. Trust	−.296 (.957)	−.066	.463	2.162
4. Mutual understanding	−1.350* (.660)	−.329*	.823	1.216
R^2	.150			
Adjusted R^2	.065			
F	1.762			
Number of observations	45			

Notes: $^{\dagger}p < .1$; $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$

Table 84‑Regression model 2 for scenario 6 (statistically significant)

Dependent variable:	Model 2S6 Annual average number of projects with innovativeness improvement			
	Unstandardized coefficients (Standard error)	Standardized coefficients	Collinearity statistics	
			Tolerance	VIF
Intercept (Constant)	−2.937 (2.589)			
Independent variables:				
1. Scenario 6 – organization heterogeneity	.051 (.089)	.084	.907	1.102
2. Ease of reach	1.187** (.354)	.633**	.542	1.845
3. Trust	$-.652^{\dagger}$ (.354)	$-.377^{\dagger}$	.463	2.162
4. Mutual understanding	.025 (.244)	.015	.823	1.216
R^2	.224			
Adjusted R^2	.147			
F	2.893*			
Number of observations	45			

Notes: $^{\dagger}p < .1$; $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$

Table 85–Regression model 3 for scenario 6 (not statistically significant)

Dependent variable:	Model 3S6 Attitude toward uncertainty tolerance			
	Unstandardized coefficients (Standard error)	Standardized coefficients	Collinearity statistics	
			Tolerance	VIF
Intercept (Constant)	3.718** (1.033)			
Independent variables:				
1. Scenario 6 – organization heterogeneity	−.045 (.036)	−.194	.907	1.102
2. Ease of reach	−.160 (.141)	−.226	.542	1.845
3. Trust	.314* (.141)	.480*	.463	2.162
4. Mutual understanding	−.138 (.097)	−.229	.823	1.216
R^2		.137		
Adjusted R^2		.050		
F		1.584		
Number of observations		45		

Notes: $^{\dagger}p < .1$; $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$

Table 86–Regression model 4 for scenario 6 (statistically significant)

Dependent variable:	Model 4S6 Attitude toward ambiguity tolerance			
	Unstandardized coefficients (Standard error)	Standardized coefficients	Collinearity statistics	
			Tolerance	VIF
Intercept (Constant)	2.461** (.903)			
Independent variables:				
1. Scenario 6 – organization heterogeneity	.061† (.031)	.285†	.907	1.102
2. Ease of reach	.130 (.124)	.197	.542	1.845
3. Trust	.126 (.124)	.207	.463	2.162
4. Mutual understanding	−.190* (.085)	−.337*	.823	1.216
R^2		.245		
Adjusted R^2		.169		
F		3.245*		
Number of observations		45		

Notes: $^{\dagger}p < .1$; $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$

Table 87–Regression model 1 for scenario 7 (not statistically significant)

Dependent variable:	Model 1S7 Annual average number of projects with efficiency improvement			
	Unstandardized coefficients (Standard error)	Standardized coefficients	Collinearity statistics	
			Tolerance	VIF
Intercept (Constant)	6.376 (7.338)			
Independent variables:				
1. Scenario 7 – knowledge heterogeneity	−.021 (.154)	−.020	.975	1.025
2. Ease of reach	1.429 (.968)	.296	.539	1.857
3. Trust	−.091 (.941)	−.020	.485	2.060
4. Mutual understanding	−1.317[†] (.664)	−.321[†]	.823	1.215
R^2	.136			
Adjusted R^2	.050			
F	1.581			
Number of observations	45			

Notes: [†]$p < .1$; *$p < .05$; ** $p < .01$; *** $p < .001$

Table 88–Regression model 2 for scenario 7 (statistically significant)

Dependent variable:	Model 2S7 Annual average number of projects with innovativeness improvement			
	Unstandardized coefficients (Standard error)	Standardized coefficients	Collinearity statistics	
			Tolerance	VIF
Intercept (Constant)	−1.490 (2.610)			
Independent variables:				
1. Scenario 7 – knowledge heterogeneity	−.095[†] (.055)	−.238[†]	.975	1.025
2. Ease of reach	1.077** (.344)	.575**	.539	1.857
3. Trust	−.531 (.335)	−.307	.485	2.060
4. Mutual understanding	.007 (.236)	.004	.823	1.215
R^2	.273			
Adjusted R^2	.200			
F	3.757*			
Number of observations	45			

Notes: [†]$p < .1$; *$p < .05$; ** $p < .01$; *** $p < .001$

Table 89–Regression model 3 for scenario 7 (not statistically significant)

Dependent variable:	Model 3S7 Attitude toward uncertainty tolerance			
	Unstandardized coefficients (Standard error)	Standardized coefficients	Collinearity statistics	
			Tolerance	VIF
Intercept (Constant)	4.040** (1.070)			
Independent variables:				
1. Scenario 7 – knowledge heterogeneity	−.031 (.022)	−.207	.975	1.025
2. Ease of reach	−.167 (.141)	−.235	.539	1.857
3. Trust	.293* (.137)	.448*	.485	2.060
4. Mutual understanding	−.156 (.097)	−.259	.823	1.215
R^2		.144		
Adjusted R^2		.059		
F		1.685		
Number of observations		45		

Notes: $^{\dagger}p < .1$; $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$

Table 90–Regression model 4 for scenario 7 (statistically significant)

Dependent variable:	Model 4S7 Attitude toward ambiguity tolerance			
	Unstandardized coefficients (Standard error)	Standardized coefficients	Collinearity statistics	
			Tolerance	VIF
Intercept (Constant)	2.232* (.963)			
Independent variables:				
1. Scenario 7 – knowledge heterogeneity	.028 (.020)	.195	.975	1.025
2. Ease of reach	.126 (.127)	.190	.539	1.857
3. Trust	.166 (.124)	.272	.485	2.060
4. Mutual understanding	$-.169^{\dagger}$ (.087)	$-.301^{\dagger}$	.823	1.215
R^2		.208		
Adjusted R^2		.129		
F		2.634*		
Number of observations		45		

Notes: $^{\dagger}p < .1$; $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$

Appendix D

Full Data Set

Table 91 shows the full data set used in this research.

Table 91–Full data set

No.	Agent	SIM_ORG	SIM_KNOW	DIFF_ORG	DIFF_KNOW	REACH	TRUST	MUTUAL	Q1	Q2	Q3	AMBIGUITY	Q4	Q5	Q6	UNCERTAINTY	ANN_EFF	ANN_INN
1	ITA01	6.00	3.50	4.00	6.50	8.80	8.30	9.50	5	4	2	3.67	4	3	2	3.00	4.40	1.89
2	ITA02	10.00	3.00	10.00	17.00	8.15	8.00	8.30	4	4	3	3.67	3	4	2	3.00	3.50	1.50
3	ITA03	10.00	5.00	10.00	15.00	8.35	9.40	6.85	5	4	5	4.67	4	4	4	4.00	8.40	2.10
4	ITA04	10.00	7.00	10.00	13.00	8.90	8.70	6.75	5	4	4	4.33	5	4	5	4.67	14.40	3.60
5	ITA05	10.00	8.00	10.00	12.00	10.00	10.00	10.00	5	4	2	3.67	5	5	2	4.00	11.52	2.88
6	ITA06	10.00	8.50	10.00	11.50	9.00	8.85	8.40	4	4	2	3.33	4	4	2	3.33	16.00	4.00
7	ITA07	10.00	5.50	10.00	14.50	9.70	9.25	9.05	4	4	1	3.00	4	4	4	4.00	2.00	1.00
8	ITA08	10.00	5.00	10.00	15.00	10.00	9.30	8.50	5	4	5	4.67	4	3	2	3.00	7.60	0.40
9	ITA09	6.00	1.50	10.00	14.50	7.94	7.69	6.94	5	4	4	4.33	4	4	4	4.00	15.75	1.75
10	ITA10	10.00	3.00	10.00	17.00	9.00	9.05	7.85	5	4	4	4.33	3	4	4	3.67	3.13	1.04
11	ITA11	5.00	7.00	10.00	8.00	8.53	8.73	8.80	5	5	4	4.67	4	4	2	3.33	8.91	2.23
12	ITA12	3.00	3.00	10.00	10.00	9.08	8.00	6.92	5	2	2	3.00	4	4	2	3.33	12.00	8.00
13	ITA13	3.00	3.00	5.00	5.00	8.00	8.25	8.13	4	3	2	3.00	2	4	3	3.00	2.15	2.15
14	ITA14	3.00	0.00	3.00	6.00	10.00	8.00	6.83	5	5	3	4.33	2	4	4	3.33	15.20	3.80
15	ITA15	2.00	1.00	10.00	11.00	10.00	10.00	5.00	5	4	3	4.00	2	4	3	3.00	13.60	3.40

No.	Agent	*SIM_ORG*	*SIM_KNOW*	*DIFF_ORG*	*DIFF_KNOW*	*REACH*	*TRUST*	*MUTUAL*	Q1	Q2	Q3	*AMBIGUITY*	Q4	Q5	Q6	*UNCERTAINTY*	*ANN_EFF*	*ANN_INN*
16	ITA16	1.00	1.50	5.00	4.50	9.67	9.33	7.67	5	5	1	3.67	4	4	4	4.00	6.30	2.70
17	ITA17	1.00	1.00	6.00	6.00	8.14	8.71	7.57	5	4	2	3.67	4	5	5	4.67	3.80	0.20
18	ITA18	1.00	4.00	10.00	7.00	10.00	10.00	10.00	4	4	2	3.33	4	4	4	4.00	14.50	6.21
19	ITA19	9.00	9.00	10.00	10.00	8.26	8.47	8.16	5	4	3	4.00	4	4	3	3.67	2.57	0.29
20	ITA20	3.00	5.00	10.00	8.00	8.38	8.92	9.23	5	4	4	4.33	4	4	4	4.00	2.50	2.50
21	ITA21	10.00	3.50	5.00	11.50	7.80	8.07	7.67	4	2	1	2.33	4	5	3	4.00	8.00	2.00
22	ITA22	10.00	3.50	5.00	11.50	8.13	7.93	8.13	5	3	1	3.00	4	3	3	3.33	5.40	3.60
23	ITA24	6.00	8.00	9.00	7.00	8.60	8.27	8.80	4	2	2	2.67	4	4	2	3.33	8.40	5.60
24	ITA25	2.00	3.00	4.00	3.00	8.67	5.67	7.00	4	4	2	3.33	3	4	4	3.67	8.40	5.60
25	ITA26	10.00	8.00	10.00	12.00	10.00	9.30	8.70	5	4	4	4.33	4	4	2	3.33	4.00	4.00
26	ITA27	5.00	2.00	12.00	15.00	8.94	8.29	8.35	5	4	2	3.67	4	2	2	2.67	11.52	1.28
27	ITA28	4.00	4.00	8.00	8.00	8.08	6.75	6.08	4	4	3	3.67	4	4	4	4.00	4.80	1.20
28	ITA29	7.00	9.50	10.00	7.50	8.47	7.82	8.18	5	3	2	3.33	2	2	1	1.67	3.73	1.60
29	ITA30	10.00	18.00	10.00	2.00	7.85	8.00	8.30	4	5	2	3.67	4	4	2	3.33	13.09	3.27
30	ITA31	10.00	4.50	6.00	11.50	8.19	8.50	7.38	5	5	3	4.33	4	4	3	3.67	6.40	1.60
31	ITA32	8.00	6.00	8.00	10.00	7.81	7.13	8.31	4	4	1	3.00	2	4	2	2.67	4.73	1.58

No.	Agent	SIM_ORG	SIM_KNOW	DIFF_ORG	DIFF_KNOW	REACH	TRUST	MUTUAL	Q1	Q2	Q3	AMBIGUITY	Q4	Q5	Q6	UNCERTAINTY	ANN_EFF	ANN_INN
32	ITA33	10.00	9.50	10.00	10.50	7.55	8.70	9.10	5	2	2	3.00	5	4	2	3.67	4.90	2.10
33	ITA34	10.00	9.50	10.00	10.50	8.55	9.10	9.45	5	4	2	3.67	2	4	2	2.67	5.60	2.40
34	ITA35	10.00	0.00	10.00	19.00	7.95	7.58	8.58	4	3	2	3.00	2	2	2	2.00	2.58	1.11
35	ITA36	10.00	18.50	10.00	1.50	9.85	9.80	8.85	5	4	2	3.67	3	4	5	4.00	2.50	2.50
36	ITA37	8.00	6.50	10.00	11.50	8.56	9.50	8.61	4	4	2	3.33	4	4	4	4.00	6.08	0.68
37	ITA38	10.00	6.00	10.00	14.00	7.45	7.75	7.45	5	4	4	4.33	4	4	2	3.33	7.20	1.80
38	ITA39	10.00	11.00	10.00	9.00	9.00	8.95	8.45	4	5	2	3.67	4	5	5	4.67	7.84	3.36
39	ITA40	10.00	11.00	10.00	9.00	7.00	7.90	6.45	5	2	4	3.67	2	4	4	3.33	3.43	1.14
40	ITA41	10.00	4.00	10.00	16.00	6.20	5.75	6.55	4	4	2	3.33	4	4	4	4.00	6.63	0.23
41	ITA42	10.00	9.00	4.00	5.00	8.00	8.50	7.93	4	3	1	2.67	4	4	4	4.00	5.00	0.20
42	ITA43	10.00	3.00	3.00	10.00	8.92	8.62	8.31	4	4	2	3.33	4	4	3	3.67	1.91	1.27
43	ITA44	10.00	5.00	5.00	9.00	8.86	8.29	7.79	4	4	2	3.33	2	3	4	3.00	3.73	1.60
44	ITA45	6.00	2.00	1.00	5.00	7.43	7.86	7.29	4	4	2	3.33	4	4	4	4.00	11.05	1.95
45	ITA46	10.00	10.50	10.00	9.50	9.45	9.30	8.85	5	4	4	4.33	2	4	4	3.33	3.00	3.00

Note: ITA23 refused to complete the questionnaire rendering the missing data point, thus ITA23 was excluded from the data set.

Appendix E

Calculation of Required Minimum Sample Size

Noble et al. [193] demonstrates the mathematical formula for calculating the minimum requirement of sample size for studying the small populations. In the case of small and finite populations where the samples make up as a significant proportion of the population size, the minimum sample size requirement cannot be determined using the normal approximation to the binomial distribution as in the case of large population (which is the general case of survey research where the sample size is small comparing to the entire population). Instead, the normal approximation to the hypergeometric distribution is used to calculate the sample size for small populations. The formula for calculating the necessary sample size (n) is given as:

$$n = \frac{Z_{1-\alpha/2}^2 p(1-p)N}{Z_{1-\alpha/2}^2 p(1-p)+E^2(N-1)} \qquad (9)$$

where N denotes the population size, p denotes the population proportion that possesses the characteristic of interest, E denotes the user-specified value for accuracy of the population proportion or the margin of error, and $Z_{1-\alpha/2}$ is the cut-point on the standard normal curve dictated by the confidence level (for example, for $\alpha = 0.05$ or at 95% confidence level, $Z_{1-\alpha/2} = Z_{0.975} = 1.96$).

In the case of iTAP in this research context, the full population size of ITAs is 50 ($N = 50$) which is considered to be small and finite population. The value of population proportion (p) can vary from zero to one; while the value of 0.5 provides the maximum value of the possible minimum sample size (as it provides the highest level of constraint to the number of sample size). Thus, the value of 50% population proportion ($p = 0.5$) is selected to ensure the upper limit of the number of sample size. As for the accuracy of the sample proportion, it is acceptable for the margin of error to be ±5% ($E = 0.05$). Lastly, for the confidence level, the de facto standard is at 95% confidence level or $\alpha = 0.05$ ($Z_{1-\alpha/2} = Z_{0.975} = 1.96$). By using Equation 9 and the value of variables as specified above, the necessary sample size in this research is calculated to be 45 ($n = 45$) which exactly matches the number of usable data point in this research as shown in Appendix D. If the confidence level increases to 99% (or $\alpha = 0.01$ which renders the value of $Z_{1-\alpha/2} = Z_{0.995} = 2.58$) and the minimum sample size is hold to be constant at 45, the margin of error will have to increase to be ±6.5% (E = 0.065). On the other hand, if the confidence level is relaxed and decreases to 90% (or $\alpha = 0.10$ which renders the value of $Z_{1-\alpha/2} = Z_{0.950} = 1.645$) with the margin of error to be ±5% ($E = 0.05$), the necessary minimum sample size decreases to be 43. In this latter case of 90% confidence level, if the sample size is 45, the margin of error will decrease from ±5% to be ±4% ($E = 0.04$). Table 92 illustrates the relationship among variables required for the calculation of minimum sample size for small populations according to Equation 9.

Table 92–Relationship of variables in minimum sample size calculation for small populations

Confidence level (α)	Population proportion (p)	Accuracy (E)	Minimum sample size (n)
90% ($\alpha = 0.10$)	0.5	±5.0% ($E = 0.050$)	43
90% ($\alpha = 0.10$)	0.5	±4.0% ($E = 0.040$)	45
95% ($\alpha = 0.05$)	0.5	±5.0% ($E = 0.050$)	45
99% ($\alpha = 0.01$)	0.5	±6.5% ($E = 0.065$)	45

From Table 92, it is clear that data set used in this research for multiple linear regression analysis is justifiable by the sample size formula for small populations as given above. For the confidence level ranging from the more relaxing value at 90% to the more strict value at 99%, the accuracy or margin of error of the population proportion representing by the result of regression analysis from the sample of 45 out of 50 ranges between ±4.0% to ±6.5% which is acceptable in this case.

Appendix F

Type I Error and Type II Error

In statistical testing, there are two possible types of error, i.e., Type I error and Type II error. According to Hair et al. [179], Type I error is defined as the probability of rejecting the null hypothesis when it is actually true, or in other words, the chance of the test showing statistical significance when it is actually not. This is the case of "false positive" which in the context of this research is the case of identifying the existing of the relationship that does not really exist. Type I error is specified by alpha (α) value. Hair et al. [179] defined Type II error as the act of failing to reject the null hypothesis when it is actually false. This is the case of "false negative" which in the context of this research is the case of identifying the nonexistence of the relationship that actually exists. Type II error is specified by beta (β) value. Statistical power is the probability of correctly rejecting the false null hypothesis, or in other words, power is the probability that statistical significance will be indicated if it is present. Power is specified by the value of $1 - \beta$. The relationship of these two types of error in statistical decision is shown in Table 93 (adapted from Aberson [225]).

Table 93–Reality versus statistical decision

		Reality	
		Null hypothesis is true	Null hypothesis is false
Statistical decision	Fail to reject null hypothesis	Correct failure to reject null Probability = $1 - \alpha$	Type II error Probability = β
	Reject null hypothesis	Type I error Probability = α	Correct rejection of null Probability = $1 - \beta$ (Power)

In this research setting, alpha value specifies the level of acceptable statistical significance, while the level of power indicates the probability of success in identifying the relationship if the relationship actually exists. It should be noted that Type I error and Type II error are negatively related, reducing one would increase the other. In other words, reducing Type I error (by selecting more restrictive value of alpha) will increase Type II error, resulting in the decrease in the statistical power.

Appendix G

Power Analysis

Cohen and Cohen [194] demonstrate the tactics in power analysis by showing that there are interrelationships among four statistical parameters, i.e., statistical power (β), significant level (α), sample size (n), and effect size (f^2 in the case of multiple regression analysis). Mathematically, any one of these parameters can be determined by the other three [194]. In the case of Table 49, since the value of statistical power and the number of sample size are fixed, the value of effect size can be calculated as a function of the level of significance. The value of effect size obtained this way is called the "detectable" effect sized by Cohen and Cohen [194] in the sense that it is "the population f^2 one can expect to detect using the significance criterion α, with probability given by the specified power desired, in a sample of *n* case" (page 154) [194].

Cohen and Cohen [194] use the *L* tables which are provided in the appendix of their book for calculating the desired effect size. The value from *L* tables can be looked up by specifying the significant criterion α (0.01 or 0.05), the level of statistical power (0.10, 0.30, 0.50, 0.60, 0.70, 0.75, 0.80, 0.85, 0.90, 0.95, and 0.99), and the number of degree of freedom which is equal to the number of independent variables (represented by the variable *k*) in the case of multiple regression analysis. The value of *L* is generated from the complex mathematical formulation involving the calculation of noncentral F-distribution cumulative distribution function by using Gauss error function and regularized lower incomplete beta function. The *L* tables from Cohen and Cohen [194] are adapted from the power tables provided by Cohen [192]. Upon successfully identifying the value of L from the appropriate table (α = 0.01 or 0.05) at the given row (k) and column (specified power), the value of detectable effect size can be calculated from the following formula:

$$f^2 = \frac{L}{n-k-1} \tag{10}$$

where n denotes the number of sample size and k denotes the number of independent variables in the multiple regression model. Then, the value of R^2 can be calculated from the value of f^2 by using the following equation:

$$R^2 = \frac{f^2}{f^2+1} \tag{11}$$

It should be noted that the method provided by Cohen and Cohen [194] to calculate the detectable effect size is limited to two possible values of significant criterion (α = 0.01 or 0.05) which is deemed to be the acceptable de facto standard values for the significant level. However, in the case that the significant criterion is relaxed (the confidence level is allowed to decrease), e.g., α = 0.10 (90% confidence level), there is no available L tables. Thus, the value of L has to be calculated from the complex mathematical functions as listed above. These complex calculations can be done by a statistical power analysis computer program such as G*Power 3 by Faul et al. [226], an add-on package for R statistical programing language called pwr developed by Champely [227] or an online software tool such as Statistics Calculators by Soper [228]. All the values of f^2 and R^2 in Table 49 are generated by these computer programs.