BRUNEL UNIVERSITY, LONDON

Relational versus Structural Embeddedness: The Roles of Uncertainty in Information Technology Outsourcing

A Thesis Submitted for Degree of
Doctor of Philosophy
by

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Declaration

I declare that the thesis is written by me and its contents, in full or in parts, have not been submitted to any other institute or university for the award of any degree or diploma.

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Jaeyoun Oh

Table of Contents

Declaration........ i
Table of Contents ii
List of Figures... vi
List of Tables.... viii
List of Acronyms ix
Publications...... x
Abstract............ 1
CHAPTER 1 INTRODUCTION 3
1.1 Introduction 3
1.2 Research Background 3
1.3 Research Gap and Question 5
1.4 Research Aim and Objectives 7
1.5 Research Scope 8
1.6 Research Approach and Methods 8
1.7 Contributions 11
1.8 Thesis Structure 13
CHAPTER 2 LITERATURE REVIEW 15
2.1 Introduction 15
2.2 Literature Review Papers on ITO Studies 15
2.2.1 ITO Stage Model 17
2.2.2 Strategic Management Framework of ITO 18
2.2.3 Classification Dimension for Research Topics 19
2.2.4 Descriptive Models of Findings on ITO Decisions and Outcomes 20
2.2.5 Current ITO Research Trends 21
2.3 Opportunistic Behaviour and Risks in ITO 22
2.3.1 Opportunistic Behaviour 22
2.3.2 Risks in ITO 28
2.4 Relational and Structural Embeddedness 31
2.4.1 Concepts and Theoretical Backgrounds 33
2.4.2 Relational Embeddedness 34

2.4.3 Structural Embeddedness 37
2.4.4 Comparison between Relational and Structural embeddedness 39
2.5 Roles of Two Types of Embeddedness in ITO 42
2.5.1 Roles of Relational Embeddedness in ITO 43
2.5.2 Roles of Structural Embeddedness in ITO 49
2.6 Limitations of Prior Literature 53
2.7 Chapter Conclusion 55
CHAPTER 3 RESEARCH APPROACH AND METHODS 57
3.1 Introduction 57
3.2 Simulation in Management Studies 57
3.3 Research Approach 61
3.3.1 Step 1: Begin with research question and simple theory 62
3.3.2 Step 2: Choose simulation method 63
3.3.3 Step 3: Create Computational Representation 65
3.3.4 Step 4: Verify Computational Representation 68
3.3.5 Step 5: Experiment to Build Novel Theory 68
3.3.6 Step 6: Validate with Empirical Data 69
3.4 Chapter Conclusion 70
CHAPTER 4 SIMULATION MODEL 71
4.1 Introduction 71
4.2 Simulation Procedure 72
4.3 Vendors in ITO Network 74
4.4 Two Uncertainties Imposed on ITO Business Environments 78
4.4.1 Technological Unpredictability 78
4.4.2 Measurement Difficulty 80
4.5 Coordinator’s Decision-Making 82
4.5.1 Whether to Become Coordinator 83
4.5.2 Publication of Call-for-Bids (CFB) 83
4.5.3 Relational vs. Structural Strategy 84
4.6 Partner’s Decision-Making 86
4.7 Profits 89
4.7.1 Actual Investment 90
4.7.2 Payoff 92

4.7.3 Profit ... 94
4.8 Information Update and Transfer ... 95
4.8.1 Cumulative Profit Matrix ... 96
4.8.2 Relationship Matrix ... 97
4.8.3 Perceived Behavioural Tendency Matrix ... 97
4.9 Measurements ... 99
4.9.1 Cumulative Profit for Coordination Abilities ... 99
4.9.2 Cumulative Number of Ties ... 100
4.9.3 Average Strength of Ties ... 101
4.9.4 Average Proportion of Opportunistic Partners ... 101
4.9.5 Average Proportion of Requested Partners ... 102
4.10 Chapter Conclusion ... 103
CHAPTER 5 Simulation Experiments and Results ... 106
5.1 Introduction ... 106
5.2 Design of Experiments ... 107
5.3 Basic Test Results ... 111
5.4 Complete Test Results ... 117
5.4.1 Low Level of TU and Low Level of MD ... 118
5.4.2 High Level of TU and High Level of MD ... 121
5.4.3 High Level of TU and Low Level of MD ... 126
5.5 Chapter Conclusion ... 130
CHAPTER 6 Discussions ... 134
6.1 Introduction ... 134
6.2 Discussion of Findings ... 134
6.3 Theoretical Implication ... 139
6.3.1 IT Outsourcing ... 140
6.3.2 Network Dynamics ... 142
6.3.3 Environmental Adaptation ... 143
6.4 Practical Implication ... 144
6.5 Chapter Conclusion ... 145
CHAPTER 7 Conclusions ... 146
7.1 Introduction ... 146
7.2 Research Summary ... 146

7.3 Research Limitation 148
7.4 Further Research Directions 149
References.. 150
Appendix A: Notations 166
Appendix B: Initial Values of Parameters 171
Appendix C: Source Codes 172

List of Figures

Figure 1-1 Classification of Approaches in ITO Studies 9
Figure 2-1 Stage Model of Information Systems Outsourcing 17
Figure 2-2 Strategic Management Framework of ITO 18
Figure 2-3 Classification Dimension for Research Topics 19
Figure 2-4 Forms of Opportunism 23
Figure 2-5 Empirical Findings on Features of Opportunistic Behaviour 28
Figure 2-6 Risks faced by Client in ITO 29
Figure 2-7 Three Dimensions of Uncertainty in ITO 31
Figure 2-8 Classification of Uncertainty in R&D Alliances 31
Figure 2-9 Advantages of Relational Embeddedness 35
Figure 2-10 Moderating Effects of Structural Properties 38
Figure 2-11 ITO Partnership Quality Model 44
Figure 2-12 Three Alternative Models of ITO Partnership 44
Figure 2-13 Integrated ITO Relationship Model 46
Figure 2-14 Source of Partners 50
Figure 3-1 Roles of Simulation Research in Management Studies 59
Figure 3-2 Roadmap and Research Approach 61
Figure 4-1 Simulation Procedures 72
Figure 4-2 Vendors and Characteristics in ITO network 76
Figure 4-3 Coordinator's Decision-Makings 82
Figure 4-4 Partner's Decision-Making 87
Figure 5-1 Full Factorial Design with Two factors and Two Levels 107
Figure 5-2 Full Factorial Design Applied to Research 110
Figure 5-3 Average Proportion of Requested Partners at Low TU & High MD 112
Figure 5-4 Average Proportion of Opportunistic Partners at Low TU & High MD 113
Figure 5-5 Cumulative Number of Ties at Low TU & High MD 114
Figure 5-6 Average Strength of Ties at Low TU & High MD 114
Figure 5-7 Cumulative Profit at Low TU & High MD 116
Figure 5-8 Average Proportion of Requested Partners at Low TU & Low MD 118
Figure 5-9 Average Proportion of Opportunistic Partners at Low TU & Low MD 119
Figure 5-10 Cumulative Number of Ties at Low TU & Low MD 119

Figure 5-11 Average Strength of Ties at Low TU & Low MD 120
Figure 5-12 Cumulative Profit at Low TU & Low MD 120
Figure 5-13 Average Proportion of Requested Partners at High TU & High MD 122
Figure 5-14 Average Proportion of Opportunistic Partners at High TU & High MD 123
Figure 5-15 Cumulative Number of Ties at High TU & High MD 124
Figure 5-16 Average Strength of Ties at High TU & High MD 124
Figure 5-17 Cumulative Profit at High TU & High MD 125
Figure 5-19 Average Proportion of Opportunistic Partners at High TU & Low MD .. 127
Figure 5-20 Cumulative Number of Ties at High TU & Low MD 128
Figure 5-21 Average Strength of Ties at High TU & Low MD 128
Figure 5-22 Cumulative Profit at High TU & Low MD 129
Figure 5-23 Interaction Effects of TU & MD 132
Figure 6-1 Conceptual Framework of Relational and Structural Embeddedness 139
Figure 6-2 Guideline for Establishment of ITO Consortia 144

List of Tables

Table 2-1 Classification Dimensions 16
Table 2-2 Independent and Dependent Variables in Empirical ITO Studies 20
Table 2-3 Empirical Studies on Opportunistic Behaviour 24
Table 2-4 Risks in ITO 29
Table 2-5 Comparison between Relational and Structural Embeddedness 42
Table 2-6 Relational and Structural Embeddedness in ITO 51
Table 3-1 Simulation Method 63
Table 4-1 Profits for Four Cases 90
Table 4-2 Actual Investment in Coordination Abilities 90
Table 4-3 Actual Investment in Resources under C1 91
Table 4-4 Actual Investment in Resources under C2 91
Table 4-5 Payoff under C1 93
Table 4-6 Payoff under C2 93
Table 4-7 Profit under C1 94
Table 4-8 Profit under C2 95
Table 5-1 Observed Performance 108
Table 5-2 Main and Interaction Effects 109
Table 5-3 Numerical Results at Low TU & High MD 117
Table 5-4 Numerical Results at Low TU& Low MD 121
Table 5-5 Numerical Results at High TU & High MD 126
Table 5-6 Numerical Results at High TU & Low MD 129
Table 5-6 Continued 130
Table 5-7 ANOVA for Interaction Effect on Cumulative Profit for Group 1 131
Table 5-8 ANOVA for Interaction Effect on Cumulative Profit for Group 2 131
Table 5-9 T-Test for Comparing Cumulative Profits for Group 1 and 2 132
Table 6-1 Conditional Superiority of Relational and Structural Embeddedness 135
Table 6-2 EU FP 7 ICT Programme 141

List of Acronyms

Acronym	Expansion
ITO	Information Technology Outsourcing
RFP	Request-for-Proposals
CFB	Call-for-Bids
TU	Uncertainty from the unpredictability of technological requirements
MD	Uncertainty from the difficulty in measuring performance

Publications

Contributions to Conference Proceedings

Oh, J., Lee, H. and Tsohou, A. (2013) Governance of IT Service Procurement: Relationship vs Network based Approach. in *Proceedings of the 17th Pacific Asia Conference on Information Systems*, Jeju Island, S. Korea, Paper 55.

Oh, J., and Lee, H. (2012) Relational and Structural Embeddedness in IT Outsourcing Networks. in *Proceedings of the Post-ICIS 2012 LG CNS/KrAIS Workshp*, Orlando, Florida, Paper 22.

Oh, J., Lee, H., Ali, M. and Weerakkody, V. (2011) The Role of Structural Embeddedness in an IT Outsourcing Network. in *Proceedings of the 8th European, Mediterranean and Middle Eastern Conference on Information Systems*, Athens, Greece, Paper TTM7.

Best Paper Award

Structural Embeddedness and Opportunistic Behaviour in an IT Outsourcing Network: Best Year Two Paper at 2011 Brunel Business School Doctoral Symposium

Abstract

In response to uncertainty imposed on ITO business environments, it is reported that relational and structural embeddedness play an important role in safeguarding against opportunistic behaviour and improving long-term performance. A firm can outsource its IT services to a partner who is believed to be reliable and competent among existing parties for whom it has the outsourcing histories in the perspective of relational embeddedness. In contrast, from the viewpoint of structural embeddedness, a firm can collect information on multiple alternative candidates through the observation of their network linkages and the information transmission via third parties although it has no outsourcing histories for them. Also, based on this information, it can outsource its IT services to a new partner who could make better performance as well as who is considered reliable. However, the building and maintenance of new outsourcing relationships require resources which could be better used for the refinement of existing outsourcing relationships. Therefore, a firm faces the tension between the two types of embeddedness.

Prior studies addressing relational and structural embeddedness in the context of ITO are mainly based on relational exchange theory and social capital theory respectively. They also provide a body of empirical evidence rooted in these theories. However, each ITO research stream on relational or structural embeddedness has mainly focused on its own advantages in response to uncertainty. That is, the conditional superiority of each type of embeddedness has not been investigated in ITO studies. Furthermore, although they have been compared in other research contexts, the main research focus has been on which is preferred at the high level of uncertainty rather than which leads to better performance according to the type and level of uncertainty. Therefore, this research aims at answering the following research question in the context of ITO: which of the two types of embeddedness is more appropriate in improving long-term performance in the presence of uncertainty of which the type and level are not uniform across a wide range of outsourced IT services?

In particular, the following uncertainties from two different sources are introduced for the comparison between the two types of embeddedness: the uncertainty stemming from the unpredictability of technological requirements and the uncertainty originating in the difficulty in measuring performance. In this research, they are called “technological unpredictability” and “measurement difficulty” respectively. It is widely accepted that the two uncertainties discovered from transaction cost theory and agency theory increase the possibility of opportunism and threaten performance. Therefore, the different levels of technological unpredictability and measurement difficulty can create an ideal platform to investigate the conditional superiority of relational or structural embeddedness.

In order to address the research question, an ITO network is simulated. Firms in this network perform the role of a coordinator or a partner in establishing ITO consortia to

respond to outsourcing opportunities with the different levels of the two uncertainties. As coordinators, firms take the partner selection and control strategy based on relational or structural embeddedness, which is called "the relational strategy" or "the structural strategy" in this research. They also compete with each other to maximise their long-term profits. As partners, firms behave cooperatively or opportunistically. Their decision-makings and payoffs are modelled through a game-theoretic method. In addition, a full factorial design of experiments is applied for efficient simulation experiments and systematic analyses.

Consequently, the simulation results show that the superiority of each type of embeddedness is different according the type and level of uncertainty. The research on relational embeddedness emphasises the advantage of trust and commitment generated by the repetition or long-term maintenance of outsourcing relationships with reliable partners as shown in the literature on long-term cooperative ITO relationships. The findings in this research support this argument when measurement difficulty is at the high level and technological unpredictability is at the low level. On the other hand, the study on structural embeddedness focuses on the use of (potential) partners' network positions and information transmitters as revealed in the literature on network-based ITO relationships. The simulation results support this claim when technological unpredictability is at the high level regardless of the level of measurement difficulty. Especially, at the high levels of both uncertainties, structural embeddedness enables better performance.

This research contributes to the literature in three research areas: (1) IT outsourcing, (2) network dynamics and (3) environmental adaptation. Firstly, this research examines the conditional superiority of each type of embeddedness at the different levels of technological unpredictability and measurement difficulty. Therefore, the findings resolve the tension between the two types of embeddedness in ITO studies. Especially, this resolution can provide possible theoretical answers to why an ITO partnership based on relational embeddedness fails in spite of its popularity in the industry and academia, and in which condition structural embeddedness is preferred in ITO business environments. Secondly, the simulation results reveal that some coordinators preferring relational embeddedness consolidate their existing network ties while others favouring structural embeddedness increase the number of network ties. Therefore, this research improves an understanding of how the strength and structure of network ties at the egocentric level can be changed by the type and level of uncertainty. Thirdly, the relational and structural strategy in this research focus on the utilisation of present partners and the search for alternative partners respectively. Therefore, the concepts underlying the two types of embeddedness are in line with those underlying exploitation and exploration. The examination on the relative advantage of each type of embeddedness can extend the general argument that more resources should be invested in exploration than in exploitation to adapt to uncertain business settings.

CHAPTER 1 INTRODUCTION

1.1 Introduction

Chapter 1 provides an overview of the research. Firstly, the research background is described. In sequence, the research gap and question are identified. Then, based on these, the research aim and objectives are suggested along with the research scope. Next, the research approach and methods are explained which are appropriate to address the research question. Finally, this chapter concludes with the contributions and thesis structure.

1.2 Research Background

Opportunistic behaviour causes undesirable outcomes including cost escalation and service debasement in information technology outsourcing (ITO) (Aubert *et al.*, 1998). The prevention of this behaviour is, therefore, one of the critical research topics for the improvement of ITO performance. This issue is also gaining its importance as the research focus of ITO has shifted from “why and what” to “how and outcomes” (Dibbern *et al.*, 2004). Furthermore, “relationship characteristics” has been deeply investigated during recent decades (Lacity *et al.*, 2010).

It is commonly recognised that formal mechanisms such as a competitive tender and formal contract are fundamental to select a suitable partner and control its behaviour in ITO business environments (Kobayashi-Hillary, 2004; Poppo and Zenger, 2002). A client can choose an appropriate vendor by designing elaborate tender procedures which can reveal hidden information on bidders. A competitive tender generally includes the following procedures in the context of ITO: request-for-information, site visits, request-for-proposal and negotiation (Kobayashi-Hillary, 2004). Through these procedures, a firm attempts to identify a partner who is suitable for meeting needs as well as who is reliable. In the meantime, a client can manage a provider’s behaviour by developing more complex and customised contract clauses which clearly stipulate obligations and responsibilities. The empirical study of Chen and Bharadwaj (2009) shows how an ITO formal contract is structuralised. The authors propose that it usually includes four major provisions: monitoring, dispute resolution, property rights protection and contingency planning. It is especially suggested that strict monitoring and thorough contingency planning can prevent cost escalation and service debasement caused by opportunistic behaviour.

However, several critical risks imposed on ITO business environments tend to attenuate the functions of formal mechanisms (Balaji and Brown, 2010; Lee and Kim, 1999). In response, it is reported that relational and structural embeddedness play an important role in preventing opportunism and enhancing long-term performance in the context of ITO (Poppo and Zenger, 2002; Ravindran *et al.*, 2009). Relational embeddedness is defined as "the kind of personal relationships people have developed with each other through a history of interactions" while structural embeddedness "the impersonal configuration of linkages between people or units" respectively (Nahapiet and Ghoshal, 1998, p.244).

A firm can outsource its IT services to a partner who is believed to be reliable and competent among existing parties for whom it has the outsourcing histories in the perspective of relational embeddedness. Alternatively, from the viewpoint of structural embeddedness, a firm can collect information on multiple alternative candidates through the observation of their network linkages and the information transmission via third parties although it has no outsourcing histories for them. Also, based on this information, it can outsource its IT services to a new partner who could make better performance as well as who is considered trustworthy. However, the building and maintenance of new outsourcing relationships require resources which could be better used for improving outcomes through the refinement of existing outsourcing relationships. As a result, a firm face the tension between relational and structural embeddedness.

1.3 Research Gap and Question

Prior studies addressing relational and structural embeddedness in ITO business environments are mainly based on relational exchange theory and social capital theory respectively. They also provide a body of empirical evidence rooted in these theoretical backgrounds.

Relational exchange theory supports the research on long-term cooperative outsourcing relationships based on relational embeddedness. Trust and commitment are manifested and developed in the process of the repetition or long-term maintenance of an outsourcing relationship between specific parties in the perspective of relational exchange (Poppo and Zenger, 2002). These relational factors can serve as effective ways to safeguard against opportunistic behaviour (Brown *et al.*, 2004; Uzzi, 1996). Furthermore, a client can reduce the considerable transaction costs involved in finding and managing a new vendor by repeating or sustaining its current outsourcing relationship (Goo *et al.*, 2007; Gopal *et al.*, 2003). Therefore, a firm can improve its outcomes with a relationally embedded outsourcing partner. Rooted in these theoretical backgrounds, many empirical studies have been conducted on the advantages of long-term cooperative outsourcing relationships (Balaji and Brown, 2010; Flemming and Low, 2007; Henderson, 1990; Kim *et al.*, 2003; Kim and Chung, 2003; Lee and Kim, 1999; 2005; Poppo and Zenger, 2002).

Social capital theory provides the theoretical foundations of studies on network-based outsourcing relationships rooted in structural embeddedness. A network is a source of information on past exchanges and acts as a “prism” through which this information is provided for third parties (Podolny, 2001). Therefore, a firm can gain information on the reliability and competence of multiple alternative candidates through the observation of their network linkages to connote this information and the transmission of this information via third parties (Gulati, 1995; Ravindran *et al.*, 2009). Then, it can enhance performance by selecting an outsourcing partner who is considered more suitable for a given business opportunity because diverse experts could provide more potential profits than fixed partners (Kandori, 1992). Furthermore, the selected partner would refrain from behaving opportunistically to prevent the loss of its reputation (Ravindran *et al.*, 2009). These theoretical backgrounds are reflected in a few empirical studies on the benefits of network-based outsourcing relationships (Drath and Wayman, 2010; Heng *et al.*, 2009; Ravindran *et al.*, 2009).

However, each ITO research stream on relational or structural embeddedness has mainly focused on its own advantages in response to several critical risks as revealed in the literature on long-term cooperative ITO relationships (Balaji and Brown, 2010; Flemming and Low, 2007; Goo *et al.*, 2007; Lee and Kim, 2005) or on network-based ITO relationships (Drath and Wayman, 2010; Ravindran *et al.*, 2009). That is, the conditional superiority of each type of embeddedness has not been investigated in ITO business environments. In the theoretical perspective, this one-sided emphasis may lead to the puzzling conclusion that both types of embeddedness could be universally optimal for any given risk. From the practical viewpoint, an improper prescription derived from this confusing conclusion may be given to a firm facing the tension between relational and structural embeddedness. Furthermore, although the two types of embeddedness have been compared in other research contexts (Beckman *et al.*, 2004; DiMaggio and Louch, 1998; Gulati, 1995), the main research focus has been on which is preferred at the high level of risk rather than which leads better performance according to the type and level of risk.

Based on this reasoning, this research attempts to answer the following specific question in the context of ITO.

- Which of the two types of embeddedness is more appropriate in improving long-term performance in the presence of risk imposed on ITO business environments?

In particular, the following uncertainties from two different sources are introduced as criteria to compare relational and structural embeddedness: the uncertainty originating in the unpredictability of technological requirements and the uncertainty stemming from the difficulty in measuring performance. They are respectively called “technological unpredictability" and "measurement difficulty" in this study. It is widely accepted that the two uncertainties discovered from transaction cost theory and agency theory tend to increase the possibility of opportunism and threaten long-term performance in ITO business environments (Aubert *et al.*, 1999; Bahli and Rivard, 2003). Therefore, the different levels of technological unpredictability and measurement difficulty can create an ideal environment for investigating the conditional superiority of relational or structural embeddedness.

1.4 Research Aim and Objectives

This research aims to reveal the relative advantage of each type of embeddedness in enhancing long-term performance in the presence of technological unpredictability and measurement difficulty imposed on ITO business environments. In order to achieve this aim, an ITO network is simulated. Firms in this network perform the role of a coordinator or a partner in establishing ITO consortia in response to outsourcing opportunities with the different levels of the two uncertainties. As coordinators, firms take the partner selection and control strategy based on relational or structural embeddedness, which is called "the relational strategy" or "the structural strategy" in this research. They also compete with each other to maximise their long-term profits. As partners, firms behave cooperatively or opportunistically. Their decision-makings and profits are modelled through a game-theoretic method. Furthermore, a full factorial design of experiments is used for efficient simulation tests and systematic analyses.

Accordingly, the research objectives are as follows.

- To review uncertainty which can increase the possibility of opportunism and threaten long-term performance
- To investigate the roles of relational or structural embeddedness
- To develop a simulation model for the examination of which of the two types of embeddedness operates more successfully

- To conduct simulation tests applying a full factorial design of experiments
- To suggest theoretical and practical implications based on simulation results

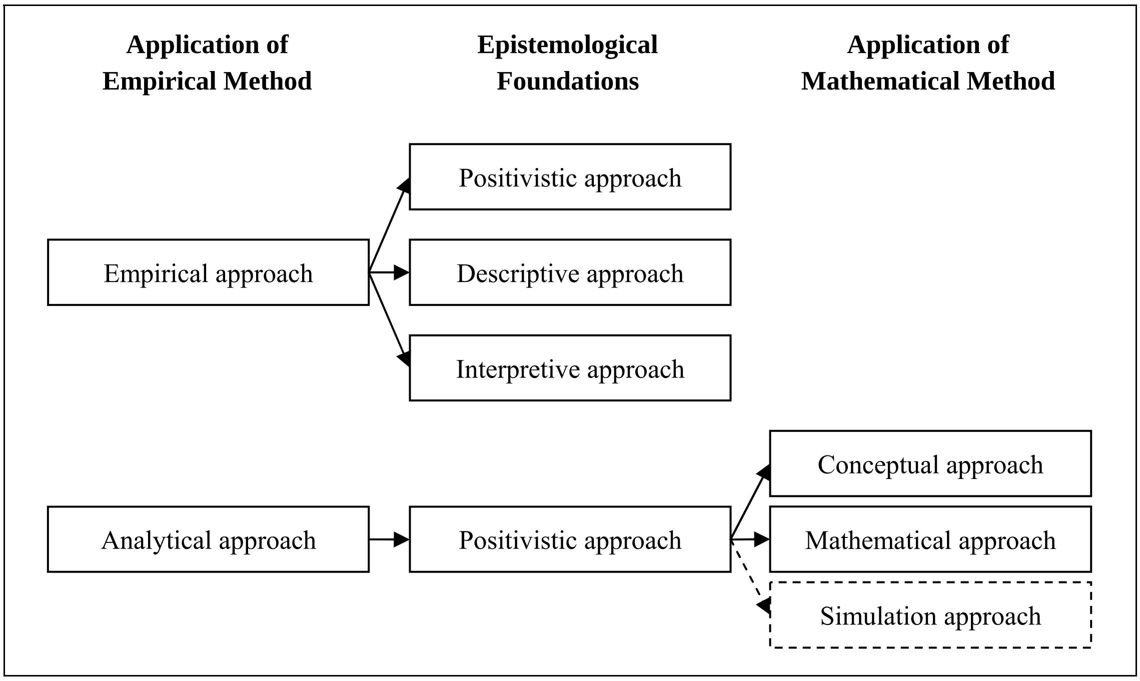
1.5 Research Scope

In this research, the ITO market is viewed as a network where firms build consortia in response to outsourcing opportunities with the different levels of technological unpredictability and measurement difficulty. Then, this ITO network is simulated for the comparison between relational and structural embeddedness based on several theories which are widely applied to organisational studies. Firstly, the two uncertainties are discovered from transaction cost theory and agency theory. Secondly, the relational or structural strategy taken by coordinators is on the theoretical basis of relational exchange theory or social capital theory. Also, partners' opportunistic behaviour (i.e. adverse selection and moral hazard) is supported by agency theory. Finally, game theory provides the theoretical foundations for firms' decision-makings and long-term profits. As a result, the theoretical research scope includes the exploration of these theories. In addition, based on the theoretical grounds, this research investigates optimal strategies in the presence of the two uncertainties imposed on ITO business environments. The practical research range contains the provision of a guideline for firms who agonise over the tension between relational and structural embeddedness in an ITO network due to the scarcity of resources.

1.6 Research Approach and Methods

The comprehensive literature review of Dibbern *et al*. (2004) illustrates several research approaches which are frequently used in ITO studies. In this review, approaches are distinguished from methods as follows: "approaches are a generic or overarching way of going about research, while methods are more narrowly focused techniques and procedures for conducting research" (p.20). The authors also classify research approaches according to the application of empirical methods, the epistemological foundations and the application of mathematical methods as shown in Figure 1-1.

[1]*Figure 1-1 Classification of Approaches in ITO Studies*



(Source: Dibbern *et al*., 2004)

In particular, the authors suggest that a mathematical approach based on a set of strict assumptions is appropriate to investigate the minimisation of costs or the maximisation of profits through the so-called "ceteris paribus restrictions" indicating that key parameters are varied while others are fixed. Moreover, it is proposed that this approach is naturally related to positivism in terms of epistemology.

The simulation approach used in this study is close to a mathematical approach. The decision-makings and long-term profits of firms in an ITO network are mathematically modelled through a game-theoretic method. Furthermore, the levels of the two uncertainties are varied while the values of the other parameters are fixed in full factorial simulation experiments. However, the two types of embeddedness are compared through numerical data generated from simulation tests rather than through mathematical derivations. In this sense, the simulation approach composed of a game-theoretic method and a full factorial design of experiments is not purely mathematical.

[1] The original classification proposed in the literature review of Dibbern *et al.* (2004) does not include the dimension of a simulation approach because there is no study applying this approach among the papers reviewed by the authors.

The dimension of a simulation approach, therefore, needs to be added to the original classification proposed in the literature review of Dibbern *et al.* (2004). In the meantime, the research approach (i.e. "a generic or overarching way of going about research") applied to this research follows "the roadmap for developing theory with simulations" proposed by Davis *et al.* (2007). Its details are described in Section 4.2 Research Approach.

A simulation approach is useful for dealing with the research question in this study because it can appropriately demonstrate the behaviour of actors who compose a network and affect one another through their interactions, and the performance which is the consequence of their behaviour (Harrison *et al.*, 2007). In addition, this approach is especially proper in case of challenging to obtain sufficient empirical data at the different levels of the two uncertainties in the long term (Davis *et al.*, 2007). Therefore, a simulation approach can be an effective substitute for an empirical approach in this research. In the meantime, the discussions of a simulation approach in management studies propose that this approach has both deductive and inductive characteristics (Harrison *et al.*, 2007). The process of deriving a simulation model from existing theories and assumptions is deductive. On the other hand, the process of eliciting new findings from simulation experiments and establishing new theories is inductive.

A game-theoretic method is widely adopted in organisational studies. The game models developed by Shapiro and Stiglitz (1984) and Kandori (1992) are especially suitable for this research. The former illustrates decision-makings and payoffs in repeated transactions between a specific employer and employee. However, particular outsourcing parties may not iteratively transact with each other for each business opportunity in the context of ITO (Ravindran *et al.*, 2009). The latter relieves the condition of the repeatedness by showing the substitutable effects of the observation of labels, the collection of information via third parties and the sharing of social norms. Therefore, a modified game model based on a mixture of the two studies can analytically reveal the decision-makings and outcomes of firms in an ITO network where repeated or non-repeated interactions occur.

A full factorial design of experiments is applied for efficient experiments and systematic analyses. An experimental design has two or more factors and each of them has discrete possible values, which are called levels. The combinations of levels are also called experimental points. Then, the tests at all of the possible experimental points are conducted in a full factorial design of experiments. In this research, there are two key factors involved in uncertainty imposed on ITO business environments: technological unpredictability and measurement difficulty. Each factor has two levels: high and low.

1.7 Contributions

This research contributes to the literature in three research areas: (1) IT outsourcing, (2) network dynamics and (3) environmental adaptation.

Firstly, as shown in the literature on long-term cooperative outsourcing relationships (Balaji and Brown, 2010; Flemming and Low, 2007; Goo *et al.*, 2007; Lee and Kim, 2005) or on network-based outsourcing relationships (Drath and Wayman, 2010; Ravindran *et al.*, 2009), each ITO research stream on relational or structural embeddedness has mainly focused on its own advantages in response to uncertainty. Furthermore, although there are several prior studies comparing the two types of embeddedness in other research contexts (Beckman *et al.*, 2004; DiMaggio and Louch, 1998; Gulati, 1995), they mainly emphasise which is preferred at the high level of uncertainty rather than which leads to better performance according to the type and level of uncertainty. This research intends to examine which of the two types of embeddedness leads to better performance at the different levels of technological unpredictability and measurement difficulty. The findings, therefore, resolve the tension between the two types of embeddedness in the presence of the two uncertainties which are considered critical in ITO studies. Especially, this resolution can provide possible theoretical answers to why an ITO partnership based on relational embeddedness fails in spite of its popularity in the industry and academia, and in which condition structural embeddedness is preferred in ITO business environments.

Secondly, a network is viewed as antecedents or consequences in various research settings (Borgatti and Foster, 2003). A body of research especially at the egocentric level has investigated the effects of an actor's network position on its performance in the perspective of antecedents. For example, much attention has been paid to the correlations between network positions and a variety of significant outcomes such as "power, leadership, mobility, employment, individual performance, individual creativity, entrepreneurship and team performance" (Borgatti and Foster, 2003, p.993). On the other hand, it has been studied why and how network ties are consolidated or generated from the viewpoint of consequences. For instance, the strength of network ties is reinforced in the presence of the uncertainty regarding service and product quality or partners' performance because organisations or individuals tend to select their existing partners to suppress the uncertainty (DiMaggio and Louch, 1998; Kraatz, 1998; Podolny, 1994). In addition to the literature in the research area of network dynamics, this study attempts to illustrate how the strength and structure of network ties at the egocentric level can be changed by the different levels of technological unpredictability and measurement difficulty.

Thirdly, the relational and structural strategy in this research emphasise the utilisation of present partners and the search for alternative partners respectively. Therefore, the ideas underlying the two strategies are in line with those underlying exploitation and exploration. It is generally argued that more resources should be invested in exploration than in exploitation in uncertain business settings (Lant *et al.*, 1992). This research tries to extend this common claim by examining the conditional superiority of each type of embeddedness according to the type and level of uncertainty.

Finally, this research intends to provide a guideline for ITO managers who agonise over the choice between existing partners who are strongly connected and reputational partners who occupy prominent network positions.

1.8 Thesis Structure

This research includes the following seven chapters along with references and appendices.

Chapter 1 Introduction

Chapter 1 provides an overview of this research.

Chapter 2 Literature Review

Chapter 2 reviews a body of existing literature related to this research and discusses their limitations. First, several literature review papers on ITO studies are introduced. The next section focuses on opportunistic behaviour and risks in the research area of ITO based on transaction cost theory and agency theory. In the following section, the research on relational and structural embeddedness is explored on the theoretical basis of relational exchange theory and social capital theory. The fifth section mainly reviews the empirical literature on long-term cooperative outsourcing relationships based on relational embeddedness and on network-based outsourcing relationships rooted in structural embeddedness. Finally, the limitations of prior studies are discussed, and the research gap and question are more clearly understood.

Chapter 3 Research Approach and Methods

Chapter 3 discusses the approach and methods applied to the research. The simulation approach including a game-theoretic method and a full factorial design of experiments is explained.

Chapter 4 Simulation Model

In Chapter 4, a simulation model is developed which includes the following elements.

- ITO opportunities with the different levels of technological unpredictability and measurement difficulty
- Relational strategy vs. structural strategy
- Opportunistic behaviour vs. cooperative behaviour
- Decision-makings and payoffs
- Information updating and transferring through network ties

Chapter 5 Simulation Experiments and Results

Chapter 5 describes simulation experiments and analyses simulation results. The following two-step tests are conducted: the basic test on the selected experimental point and the complete tests on all the experimental points. First, the basic test verifies the developed simulation model by examining the consistency between its results and the related existing studies. Next, the complete tests are implemented to examine the conditional superiority of relational or structural embeddedness at the different levels of technological unpredictability and measurement difficulty.

Chapter 6: Discussions

In Chapter 6, the conditional superiority of each type of embeddedness is discussed in accordance with the results of the complete tests. This chapter also discusses the theoretical and practical implications of the research.

Chapter 7: Conclusions

Chapter 7 summarises the results. The limitations of the research are also discussed. Finally, several future research directions are proposed.

CHAPTER 2 LITERATURE REVIEW

2.1 Introduction

The research question is which of the two types of embeddedness is more appropriate in improving long-term performance according to the type and level of uncertainty imposed on ITO business environments? In order to answer this question, Chapter 2 reviews a body of literature related with this question.

Chapter 2 involves the following sections: Literature Review Papers on ITO Studies, Opportunistic Behaviour and Risks in ITO, Relational and Structural Embeddedness, and Roles of Two Types of Embeddedness in ITO. This chapter begins by introducing several literature review papers on ITO studies, which help to comprehensively understand ITO research streams. The next section reviews opportunistic behaviour and risks in the context of ITO on the theoretical basis of transaction cost theory and agency theory. This review provides knowledge to interpret why risks can increase the possibility of opportunism and how they can threaten outcomes in ITO business environments. In the following section, the literature on relational and structural embeddedness is explored based on relational exchange theory and social capital theory. This review illustrates the roles of the two types of embeddedness in suppressing uncertainty which can enhance the likelihood of opportunism and hamper the improvement of long-term performance. The fifth section mainly reviews the empirical research on long-term cooperative ITO relationships based on relational embeddedness and network-based ITO relationships rooted in structural embeddedness. Finally, based on the above reviews, this chapter discusses the limitations of prior studies. Also, the research gap and question are more clearly understood.

2.2 Literature Review Papers on ITO Studies

Since Kodak's historic decision to outsource its information systems to IBM, DEC and Business Land, an enormous and diverse body of research has been theoretically and empirically conducted in the research area of ITO (Dibbern *et al.*, 2004). Accordingly, several classification frameworks with multi-dimensions are provided to systematically organise existing studies and to clearly show future research directions. This section introduces the following literature review papers with a focus on the dimension related to ITO research topics.

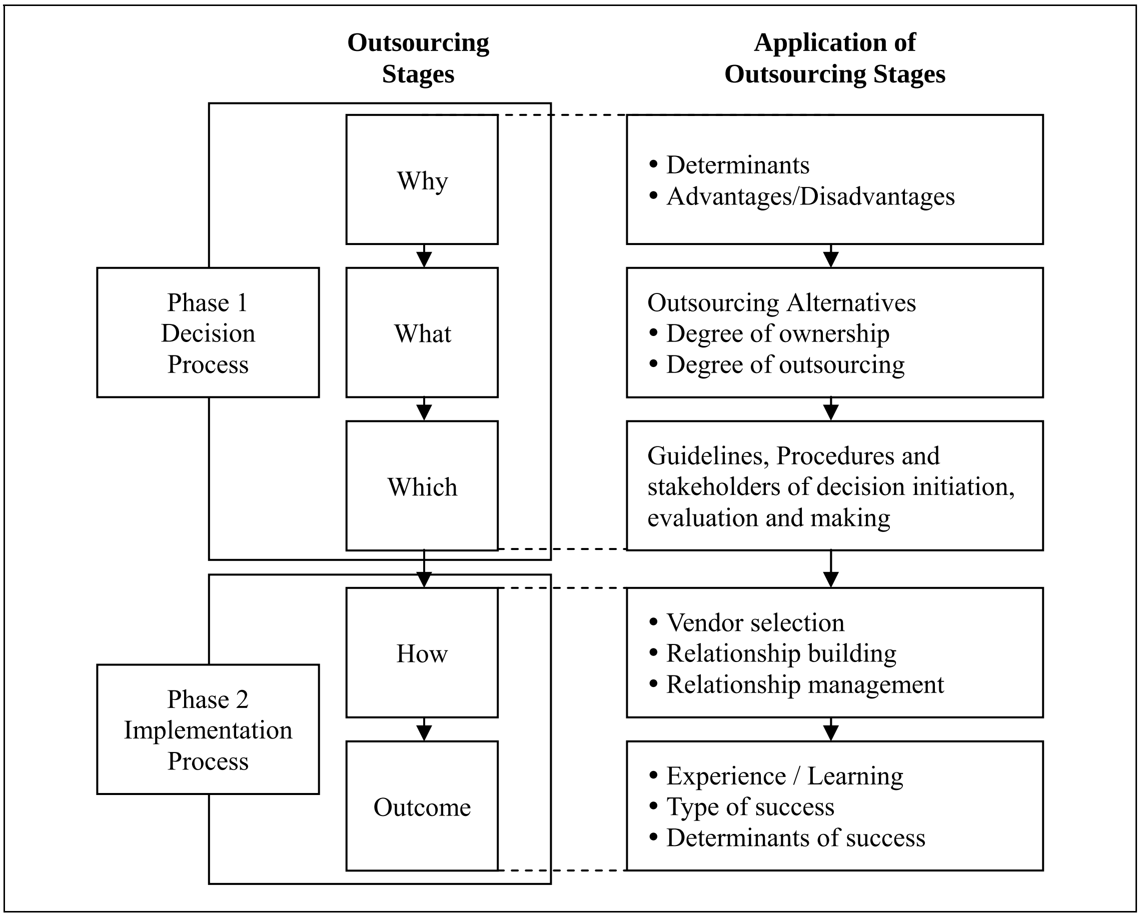
Table 2-1 Classification Dimensions

Authors	Classification Dimensions
Dibbern *et al*. (2004)	• **ITO stages** - Why, What, Which, How and Outcomes • **Research approaches** - Empirical and Analytical approaches • **Reference theories** - Strategic, Economic and Social/organisational theories • **Analysis levels** - Macro and Micro levels
Fjermestad and Saitta (2005)	• **Components for ITO success** - Alignment to business strategy, Contracts, Infrastructure and technology, Culture, Strategic partnership, Management support, Governance committees, Economics
Gonzalez *et al*. (2006)	• **Research methodologies** - Theoretical and Empirical methodologies • **Topics** - Client, Provider, Relationship, Economic theory perspective • **Scopes** - General IS, S/W development, Applications and E-commerce
Lacity *et al*. (2010)	• **Effects on ITO decisions** - Motivations to outsource, Transaction attributes, Client firm characteristics, Influence source • **Effects on ITO outcomes** - Transaction attributes, Client firm characteristics, Client firm capabilities, Contractual governance, Relationship characteristics, ITO decision, Decision characteristics

2.2.1 ITO Stage Model

The comprehensive literature review of Dibbern *et al*. (2004) includes definitions, concepts, modes, stages, theoretical foundations, approaches and literature analyses. The main dimension applied for the categorisation of existing studies is based on the ITO stage model in Figure 2-1.

Figure 2-1 Stage Model of Information Systems Outsourcing



(Source: Dibbern *et al*., 2004)

An ITO process is classified into five stages: why, what, which, how and outcomes. The applications of each stage represent research topics. Especially, the authors propose that "how" is closely related to "outcomes" and deconstruct its applications as follows.

- Vendor selection: vendor types, selection criteria, selection procedures

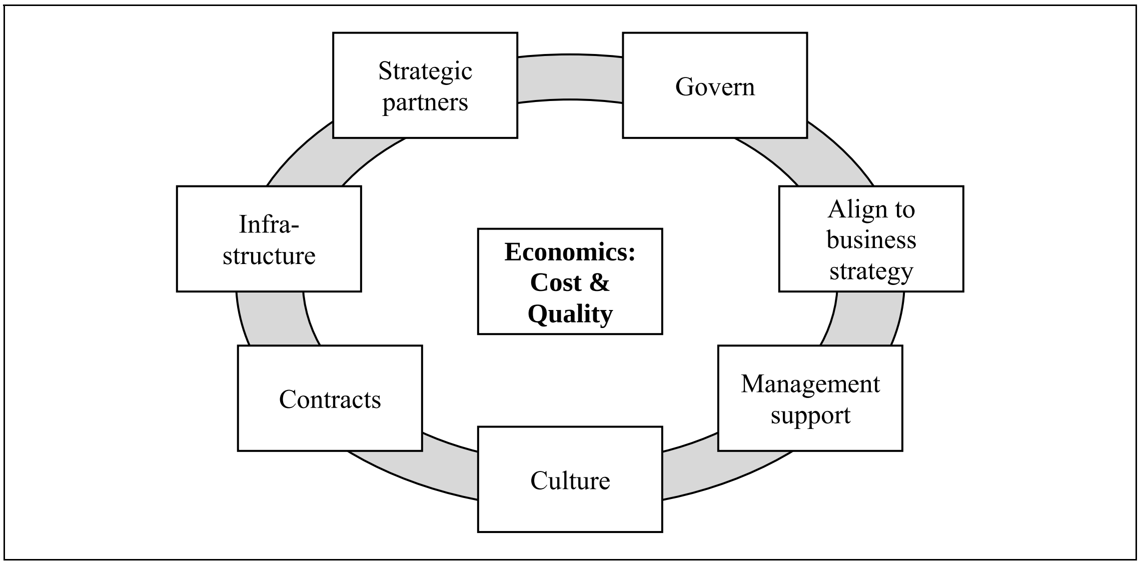
- Relationship building: attributes and determinants of relationships
- Relationship management: management techniques and procedures

Furthermore, it is emphasised that the research focus of ITO has shifted from "why and what" to "how and outcomes".

2.2.2 Strategic Management Framework of ITO

The research of Fjermestad and Saitta (2005) proposes the strategic management framework which integrates several critical components for ITO success as shown in Figure 2-2.

Figure 2-2 Strategic Management Framework of ITO



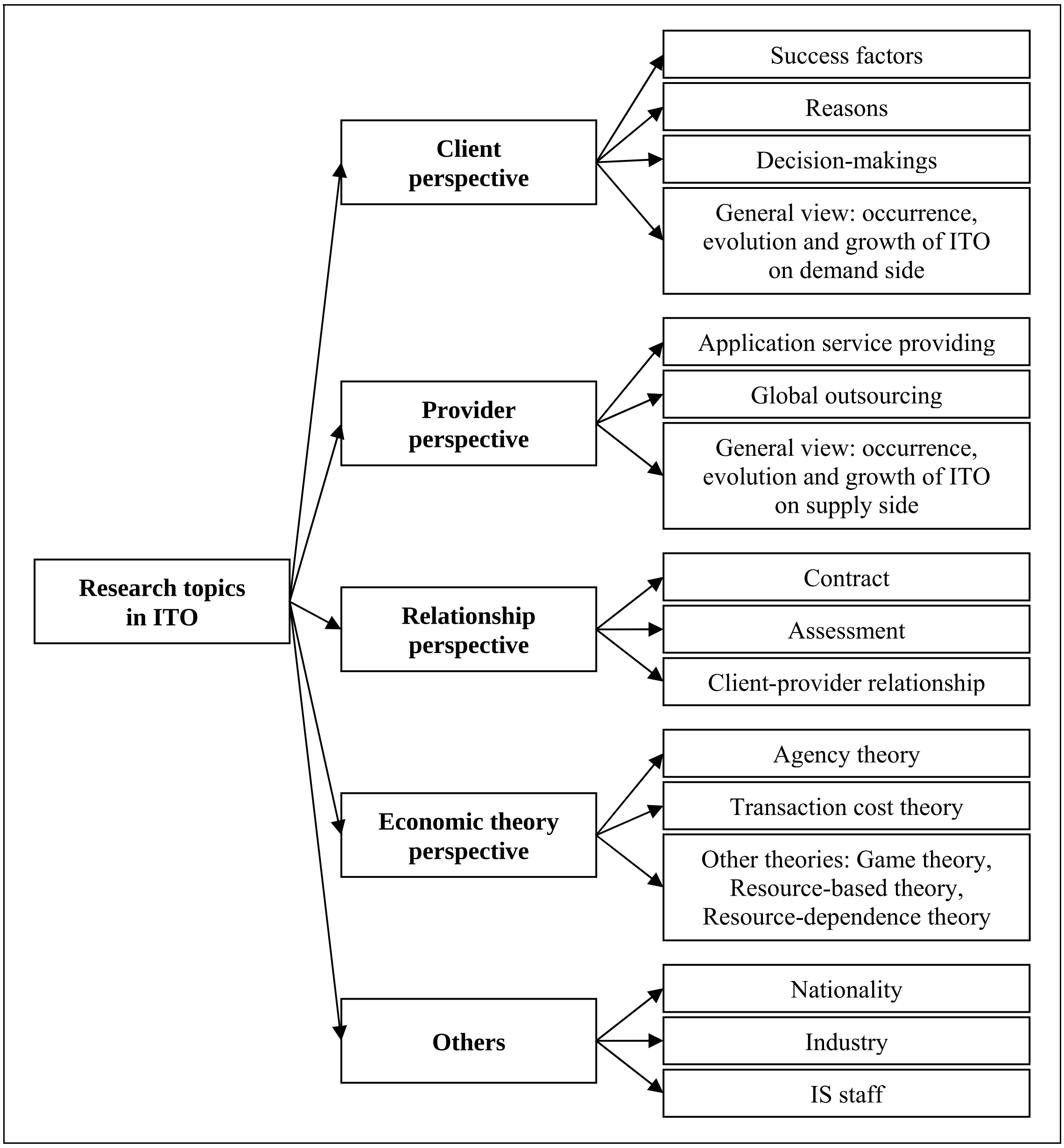
(Source: Fjermestad and Saitta, 2005)

ITO studies are categorised based on these significant components which represent research topics. This framework provides ITO managers with an integrated insight into the successful management of ITO. However, the authors suggest that each component could be implemented in varying degrees in accordance with complex and dynamic business settings, which can be addressed in future empirical studies.

2.2.3 Classification Dimension for Research Topics

The literature review of Gonzalez *et al*. (2006) involves the following multi-dimensions for the classification of ITO studies: research methodologies, topics, scopes, authors and countries. Especially, Figure 2-3 shows the classification dimensions in terms of research topics.

Figure 2-3 Classification Dimension for Research Topics



(Source: Gonzalez *et al*., 2006)

Existing ITO studies are classified according to the above research topics and the following publication periods: until 1995, 1996 ~ 2000 and since 2001. This categorisation shows that since 2001, increasing attention has been paid to “global outsourcing” and “client-provider relationships”. In particular, the growing amount of literature on “client-provider relationships” is also found in the literature analysis of Dibbern *et al*. (2004) indicating that the ITO research focus has shifted to “how”.

2.2.4 Descriptive Models of Findings on ITO Decisions and Outcomes

The recent literature review of Lacity *et al*. (2010) on empirical ITO studies identifies various kinds of independent and dependent variables which are frequently examined and are statistically significant. The identified independent and dependent variables are classified into thirteen and two categories respectively through several rigorous classification procedures. Table 2-2 is derived from the descriptive model of findings proposed in this review paper. It shows a wide range of ITO research topics. Especially, the authors indicate that the broad category of “relationship characteristics” has been frequently investigated during the past two decades.

Table 2-2 Independent and Dependent Variables in Empirical ITO Studies

Broad Categories of Independent Variables	Frequently Examined & Statistically Significant Independent Variables	Dependent Variables
Motivation to outsource	Cost reduction, Focus on core capabilities, Access to skills/expertise, Business/process improvements, Technical reasons, Political reasons, Concern for security, Fear of losing control	ITO Decisions
Transaction attributes	Uncertainty, Critical role of IS transaction, Transaction costs, Business risk	
Client firm characteristics	Prior IS department performance	
Influence sources	Mimetic	

Table 2-2 Continued

Broad Categories of Independent Variables	Frequently Examined & Statistically Significant Independent Variables	Dependent Variables
Transaction attributes	Uncertainty, Measurement difficulty	ITO Outcomes
Client firm characteristics	Client experience with outsourcing	
Client firm capabilities	Supplier management capability, Contract negotiation capability, IS technical and methodological capability, Cultural distance management capability, Risk management capability	
Supplier firm capabilities	IS human resource management capability, IS technical and methodological capability, Domain understanding	
Contractual governance	Contract detail, Contract size, Contract type, Control mechanisms	
Relationship characteristics	Effective knowledge sharing, Trust, Communication, Partnership view, Prior client/supplier working relationship, Relationship quality, Cultural distance	
ITO decision	Outsourcing decision	
Decision characteristics	Top management commitment/support, Evaluation process	

(Source: Lacity *et al*., 2010)

2.2.5 Current ITO Research Trends

The investigation into these literature review papers with a focus on research topics provides a better understanding of the current research trends and issues in the context of ITO. The initial discussions on whether to outsource and what to outsource have evolved into the recent debates on how to outsource and how to measure and increase outcomes. Also, multidisciplinary theories from economic, strategic and relational views are applied to explain complex and dynamic interactions between ITO parties.

Especially, the volume of literature based on relational views has increased over recent decades in accordance with the current research trend with a focus on how to initiate and maintain ITO relationships.

2.3 Opportunistic Behaviour and Risks in ITO

This section reviews opportunistic behaviour and risks on the theoretical basis of transaction cost theory and agency theory. They have been deeply investigated in the context of ITO because they tend to hamper the formation of cooperative outsourcing relationships and decrease their efficiency (Aubert *et al.*, 1998).

2.3.1 Opportunistic Behaviour

In transaction cost theory, opportunistic behaviour is generally defined as "self-interest seeking with guile" (Williamson, 1975, p.6), which is supplemented with the following examples: "lying, stealing, cheating, and calculated efforts to mislead, distort, disguise, obfuscate, or otherwise confuse" (Williamson, 1985, p.47). Based on these fundamental definition and examples, a body of literature has attempted to conceptualise and measure this behaviour. For instance, opportunistic behaviour is classified into four forms in selling environments: "misrepresenting information, activities or efforts, distorting results, misrepresenting intentions and misrepresenting selling costs" (Anderson, 1988, p.248). Several examples of self-interest seeking with guile are also provided in retail business settings: "taking shortcuts, breaking promises, masking inadequate or poor quality work and generally being dishonest in order to gain an advantage" (Provan and Skinner, 1989, p.203). Also, the recent study of Liu *et al*. (2010) measures a buyer's opportunistic behaviour with five items in a buyer-supplier relationship: a buyer "takes advantage of holes in contracts, breaches informal agreements, breaks promises, uses unexpected events to extract concessions, and lies to maximize its own benefits" (p.848). In the research area of ITO, three types of opportunistic behaviour are proposed: "withholding or distorting of information, failing to fulfil promises and delivery of substandard products and services" (Goo *et al.*, 2007, p.2113). The research of Wathne and Heide (2000), however, points out that there is a paucity of literature on a systematic conceptualisation of opportunistic behaviour. Presenting a wide range of examples in the real world, the authors classify this behaviour into four forms such as evasion, refusal to adapt, violation and forced renegotiation in accordance with “how active or passive opportunism manifest themselves under existing or new circumstances” (p.41) as shown in Figure 2-5.

Figure 2-4 Forms of Opportunism

		Circumstances	
		Existing	**New**
Behaviour	**Passive**	Evasion	Refusal to adapt
	Active	Violation	Forced renegotiation

Oh

(Source: Wathne and Heide, 2000)

This theory also predicts that opportunistic behaviour is likely to occur when the routinisation of transactions to overcome bounded rationality and market uncertainty causes the problems of asset specificity and small-number conditions (Provan, 1993).

Agency theory suggests two types of opportunistic behaviour: adverse selection and moral hazard, which are respectively defined as “the mispresentation of ability by the agent” and “the lack of effort on the part of the agent” (Eisenhardt, 1989, p.61). This theory also predicts that each type of opportunistic behaviour is caused due to information asymmetry derived from the fact that the principal cannot observe the characteristic or behaviour of the agent (Aubert *et al.*, 1998). The following description simply and explicitly explains why the two types of this behaviour occur (Eisenhardt, 1989, p.61).

> *"... the agent may simply not put forth the agreed-upon effort. ... For example, moral hazard occurs when a research scientist works on a personal research project on company time, but the research is so complex that corporate management cannot detect what the scientist is actually doing. ... the agent may claim to have certain skills or abilities when he or she is hired. Adverse selection arises because the principal cannot completely verify these skills or abilities either at the time of hiring or while the agent is working. For example, adverse selection occurs when a research scientist claims to have experience in a scientific specialty and the employer cannot judge whether this is the case."*

The empirical research on opportunistic behaviour has been deeply conducted in various research settings. Table 2-3 shows the statistical test results on this behaviour which is viewed as an independent variable (i.e. what are the outcomes caused by opportunistic behaviour?) and a dependent variable (i.e. what are the determinants of the possibility of opportunistic behaviour?). In this table, A(+)B or A(−)B indicates that A has a positive or negative effect on B. Also, A*B(+)C or A*B(−)C means that A's effect on C is positively or negatively moderated by B.

Table 2-3 Empirical Studies on Opportunistic Behaviour

Author	**Industry / Relationship**	**Constructs / Empirical Test Results**
John (1984)	Oil / Retail dealer (RD) & Supplier (S)	• Constructs - Bureaucratic structure (A) - Coercive influence attributions (B) - Reward influence attributions (C) - Attitudinal orientation (D) - RD's Opportunism (E) • Empirical test results - Supported: C(+)E, D(−)E, - Rejected: A(+)E, B(+)E

Table 2-3 Continued

Author	**Industry / Relationship**	**Constructs / Empirical Test Results**
Anderson (1988)	Electronic components / Sales people (SP) & Sales manager (SM)	• Constructs - SP's transaction-specific assets (A) - Integration (B) - Difficulty of evaluation (C) - Goal congruence (D) - SP's Opportunism (E) • Empirical test results - Supported: A(+)E, B(−)E, C(+)E, D(−)E
Provan & Skinner (1989)	Farm equipment / Retail dealer (RD) & Supplier (S)	• Constructs - RD's dependence on S (A) - S's control over RD's decisions (B) - RD's Opportunism (C) • Empirical test results - Supported: A(−)C, B(+)C
Mohr & Sohi (1995)	Computer / Retail dealer (RD) & Manufacturer (M)	• Constructs - Communication formality (A) - RD's Opportunism (B) • Empirical test results - Supported: A(−)B
Joshi & Arnold (1997)	Microchip / Buyer (BU) & Supplier (S)	• Constructs - BU's Dependence on S (A) - Relational norm (B) - BU's Opportunism (C) • Empirical test results - Supported: A*B(−)C
Lee (1998)	International alliance / Exporter (EX) & Importer (IM)	• Constructs - EX's decision-making uncertainty (A) - EX's opportunism (B) - Relational strength (C) • Empirical test results - Supported: A(+)B, B(−)C

Table 2-3 Continued

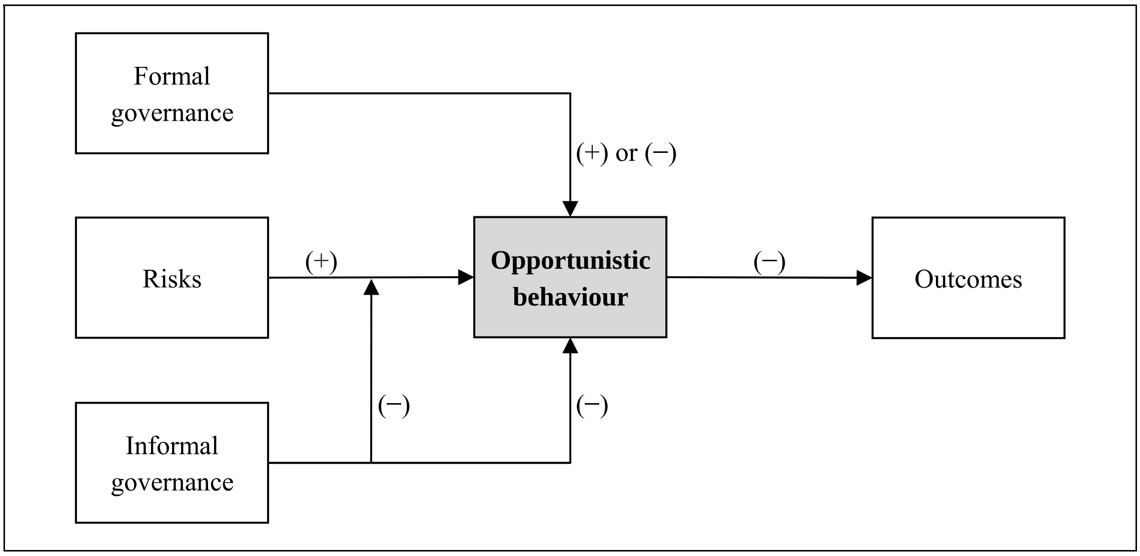
Author	Industry / Relationship	Constructs / Empirical Test Results
Dahlstrom & Nygaard (1999)	Oil / Franchisor (FO) & Franchisee (FE)	• Constructs - Interfirm cooperation (A) - Formalisation (B) - FO's Opportunism (C) - FE's Bargaining costs (D) - FE's Monitoring costs (E) - FE's Maladaption costs (F) • Empirical test results - Supported: A(−)C, B(−)C, C(+)D, C(+)E, C(+)F
Brown *et al.* (2000)	Hotel / Hotel (H) & Brand headquarter (BH)	• Constructs - BH's ownership (A) - H's investment in transaction-specific assets (B) - H's Perception level of relational exchange (C) - H's Opportunism (D) • Empirical test results - Supported: B(−)D, C(−)D, B*C(−)D - Rejected: A(−)D, A*C(−)D
Rokkan & Buvik (2003)	Voluntary retail / Retailer (R) & Retail headquarter (RH)	• Constructs - Group size (A) - Goal conflict (B) - RH's Monitoring (C) - R's opportunism (D) • Empirical test results - Supported: A(+)D, B(+)D, C(−)D
Rokkan *et al.* (2003)	Building material / Manufacturer (M) & Distributer (DI)	• Constructs - DI's specific investment (A) - Extendedness (B) - Solidarity (C) - M's Opportunism (D) • Empirical test results - Supported: A*B(−)D, A*C(−)D

Table 2-3 Continued

Author	**Industry / Relationship**	**Constructs / Empirical Test Results**
Goo *et al*. (2007)	IT outsourcing / Vendor (VE) & Client (CL)	• Constructs - VE's opportunism (A) - Relationship duration (B) • Empirical test results - Rejected: A(−)B
Liu *et al*. (2010)	Household appliances / Buyer (BU) & Supplier (S)	• Constructs - S's calculative commitment (A) - S's loyalty commitment (B) - Competitiveness (C) - Environmental uncertainty (D) - BU's Opportunism (E) • Empirical test results - Supported: A(+)E, B(−)E, C(+)E, D(+)E
Legend • A(+)B: A has a positive effect on B • A(−)B: A has a negative effect on B • A*B(+)C: A's effect on C is positively moderated by B • A*B(−)C: A's effect on C is negatively moderated by B		

The review of empirical literature on opportunistic behaviour provides several findings on its nature. Initially, the research viewing self-interest seeking with guile as an independent variable proposes that opportunistic behaviour causes the inefficiency of transaction relationships and hampers their maturity. Secondly, as a dependent variable, the possibility of opportunistic behaviour is increased by transaction risks and formal governance. On the other hand, its possibility is decreased by formal and informal governance. The third finding is derived from that of the second. That is, there is inconsistency in the effects of formal governance on opportunistic behaviour. This governance can safeguard against self-interest seeking with guile. However, its strictness may act as a signal of distrust, which can increase the possibility of opportunistic behaviour (Rokkan and Buvik, 2003). A clear example is found in the process of designing and enforcing a rigorous formal contract (Poppo and Zenger, 2002). When a formal contract includes more complex and customised clauses and the implementation of them is strictly monitored, exchange parties tend to behave opportunistically in response to what cannot be specified and monitored (Bernheim and Whinston, 1998). Fourthly, the effects of transaction risks on opportunistic behaviour are moderated by informal governance. These empirical findings on the characteristics of opportunistic behaviour in various research settings are graphically summarised in Figure 2-5.

Figure 2-5 Empirical Findings on Features of Opportunistic Behaviour



In addition to these findings, it needs to be noted that the essence of opportunistic behaviour is guile and hence self-interest seeking with guile is differentiated from normal self-interest seeking such as "hard bargaining, intense and frequent disagreements, and similar conflictual behaviors" (John, 1984, p.278).

2.3.2 Risks in ITO

This subsection reviews ITO literature addressing risks which can facilitate outsourcing parties' opportunistic behaviour and threaten their outcomes. In ITO business environments, a wide range of risks are identified in accordance with their sources such as a client, vendor and transaction as shown in Table 2-4 (Aubert *et al.*, 1999; Aubert *et al.*, 1998; Bahli and Rivard, 2003).

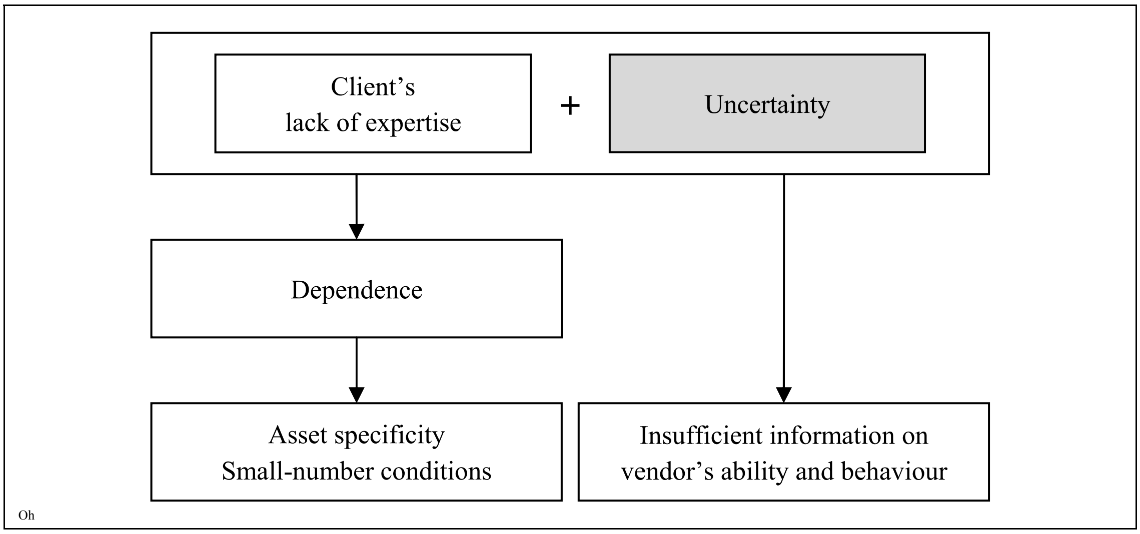
Table 2-4 Risks in ITO

Risk Sources	Risks
Client	• Lack of expertise with IT operation • Lack of expertise with IT outsourcing
Vendor	• Lack of expertise with IT operation • Lack of expertise with IT outsourcing
Transaction	• Uncertainty • Dependence • Asset specificity • Small-number conditions

(Source: Aubert *et al.*, 1999; Aubert *et al.*, 1998; Bahli and Rivard, 2003)

Based on the arguments in transaction cost theory and agency theory, the identified risks stemming from a client and transaction can be reorganised as shown in Figure 2-6.

Figure 2-6 Risks faced by Client in ITO



At first, following the arguments of transaction cost theory (Provan, 1993), a client attempts to repeat or maintain its current ITO relationship to overcome the risks of its lack of expertise and uncertainty. However, the attempt increases the dependence on its existing vendor. In sequence, the heightened dependence paradoxically results in the other risks of asset specificity and small-number conditions. In the end, the possibility of the current vendor's opportunistic behaviour is enhanced. Secondly, following the claims of agency theory (Eisenhardt, 1989), a client cannot collect sufficient information on a (potential) vendor's characteristic and behaviour due to its lack of expertise and uncertainty. Therefore, the vendor may exploit information asymmetry and is likely to behave opportunistically.

Among various kinds of risks faced by a client in ITO business environments, the uncertainties from two different sources are regarded as the fundamental and critical determinants of ITO success: the uncertainty stemming from the unpredictability of technological requirements and the uncertainty originating in the difficulty in measuring performance (Lacity *et al.*, 2010). Basically, transaction relationships are initiated and maintained in the presence of a certain level of uncertainty (Alchian and Demsetz, 1972). Their efficiency is considerably affected by measurement difficulty (Barzel, 1982). Also, the research of Kim and Chung (2003) proposes three types of uncertainty which have been intensively investigated in the context of ITO: technological, measurement and demand uncertainty as shown in Figure 2-7. Moreover, the study of Robertson and Gatignon (1998) provides a well-organised classification of uncertainty according to its source in R&D alliances. That is, uncertainty is categorised into two dimensions: external and internal uncertainty. The former stems from demand uncertainty and technology uncertainty while the latter originates in a firm's ability to measure performance and a firm's level of experience with alliances as shown in Figure 2-8. Therefore, this research focuses on the two uncertainties emanating from the unpredictability of technological requirements and the difficulty in measuring performance. For the convenience of the description, they are respectively called "technological unpredictability or TU" and "measurement difficulty or MD" in this study.

Figure 2-7 Three Dimensions of Uncertainty in ITO

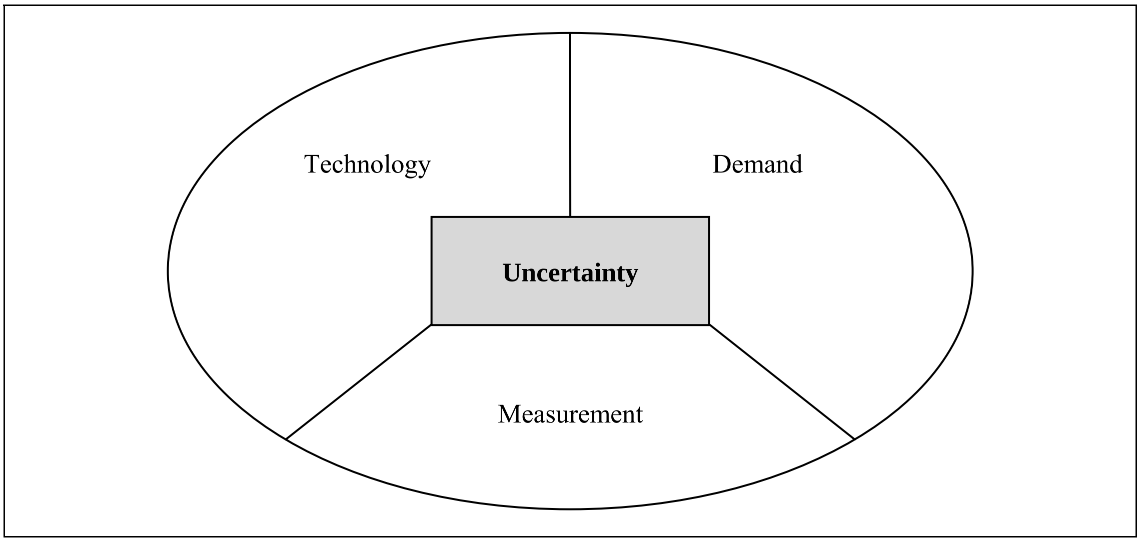
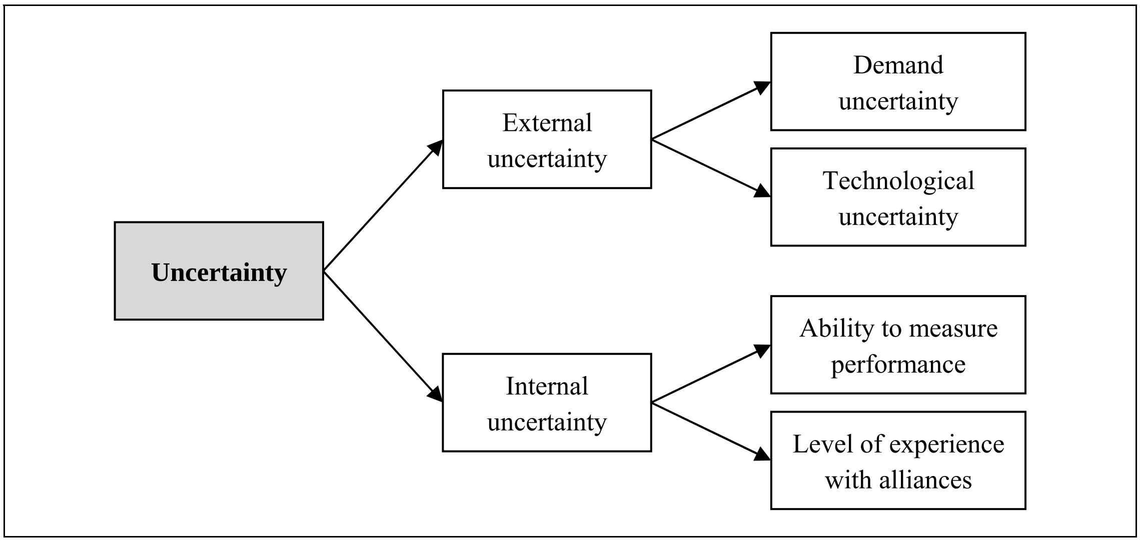


Figure 2-8 Classification of Uncertainty in R&D Alliances



2.4 Relational and Structural Embeddedness

Opportunistic behaviour is inherent in any transaction between firms (Williamson, 1975; 1985). However, it reduces the efficiency of exchange relationships by amplifying the transaction costs involved in selecting and managing suitable partners, and hampers the maturity of cooperative transaction relationships by degrading the satisfaction of exchange parties (Dahlstrom and Nygaard, 1999; Gassenheimer *et al.*, 1996). This behaviour occurs due to the following various causes: ambiguous and incomplete contracting, asset specificity, interdependence, market dynamics and information asymmetry (Achrol and Gundlach, 1999; Anderson, 1988; Brown *et al.*, 2000; Jap and Ganesan, 2000; John, 1984; Rokkan and Buvik, 2003; Söllner, 1999).

From the traditional economic viewpoint, the best strategy to prevent opportunistic behaviour is having multiple alternative candidates in the market and transacting with the most competitive partner in terms of price or quality for each given business opportunity. However, the effects of the market-based strategy on this behaviour are attenuated when risks are at the high level and competitions are limited (John, 1984). What is worse, this strategy exposes (potential) partners to the following undesirable situations: the difficulty in predicting future demands, the limitation on innovative attempts due to strict contract clauses, the investment for short-term profits and the search for other business opportunities (Cousins, 2002).

Transaction cost theory suggests that vertical integration is efficient when risks considerably increase the transaction costs of choosing and controlling exchange partners (Hill, 1990). This governance can remove uncertainty in the market and control opportunistic behaviour by internalising transactions. Also, agency theory proposes that opportunistic behaviour can be managed by elaborate bidding procedures, explicit contract clauses specifying tasks, strict monitoring of them and objective incentives according to performance (Kobayashi-Hillary, 2004; Kwon, 2007). However, it is sometimes reported that these formal mechanisms incur considerable hidden costs, increase opportunistic behaviour and lead to unsatisfactory outcomes (Barzel, 1982; Ghoshal and Moran, 1996; Nam *et al.*, 1996). For example, the research of John (1984) reports the negative effects of a bureaucratic structure which includes the formalisation of operational procedures, the centralisation of authority, and the enforcement and surveillance of rules. It is shown that the strictness of this structure may dispossess a counterparty of its self-control and autonomy, and hence lead to its disaffection and less commitment.

In ITO business environments, scholars have also observed that uncertainty tends to attenuate the effects of formal mechanisms on the prevention of opportunistic behaviour and the improvement of long-term performance (Balaji and Brown, 2010; Lee and Kim, 1999). In response, it is reported that relational and structural embeddedness can serve as complements to formal mechanisms (Poppo and Zenger, 2002; Ravindran *et al.*, 2009). This section explores the literature surrounding the two types of embeddedness based on relational exchange theory and social capital theory.

2.4.1 Concepts and Theoretical Backgrounds

Embeddedness is defined as "the contextualization of economic activity in on-going patterns of social relations" (Dacin *et al.*, 1999, p.319). Therefore, it can help to understand how economic behaviour is implanted in business settings including relational structures as well as economic structures (Granovetter, 1985; Zukin and DiMaggio, 1990).

The origin of embeddedness is found in the pioneering research of Granovetter (1985), which argues that embeddedness is useful to explain economic phenomena occurring between organisations as well as individuals because "most behaviour is closely embedded in networks of interpersonal relations" (p.504). This seminal study classifies embeddedness into two dimensions: "concrete personal relations and structures (or networks) of such relations" (p.490). In the following research, it is again emphasised that "economic actions and outcomes are affected by actors' dyadic (pair wise) relations and by the structure of the overall network of relations" (Granovetter, 1992, p.33). The author uses the terms "relational and structural embeddedness" to distinguish the unique effects of the two viewpoints. Based on these original conceptualisations, the more specific definitions of relational and structural embeddedness are respectively provided: "the kind of personal relationships people have developed with each other through a history of interactions" and "the impersonal configuration of linkages between people or units" (Nahapiet and Ghoshal, 1998, p.244).

The roles of relational and structural embeddedness in transaction relationships are scrutinised mainly based on relational exchange theory and social capital theory. First, relational exchange theory is frequently used to address issues related to relational exchange which is regarded as a dynamic process evolving through consecutive transactions between particular partners (Poppo and Zenger, 2002). Therefore, this theory is suitable for explaining a situation where a firm taking the relational strategy attempts to repeat or maintain its outsourcing relationships with existing partners for whom it has the outsourcing histories. Second, social capital theory mainly deals with the value of connections (Borgatti and Foster, 2003). The most common conceptualisation of social capital is considered structural embeddedness although it involves the relational and structural dimension of embeddedness (Moran, 2005). Furthermore, a body of literature on networks' structural properties is rooted in this theory (Brass *et al.*, 2004). Therefore, this theory is helpful to explain a situation where a firm taking the structural strategy tries to exchange with reputational partners who occupy prominent network positions although it has no outsourcing histories for them.

Based on these theoretical backgrounds, the investigation on relational embeddedness addresses the quality and contents of network ties such as "interpersonal trust and trustworthiness, overlapping identities and feelings of closeness or interpersonal solidarity" while the examination on structural embeddedness deals with the structures of network ties such as "the presence or absence of network ties between actors, along with other structural features like connectivity, centrality and hierarchy" (Moran, 2005, p.1132). The following subsections more specifically review the roles of relational and structural embeddedness.

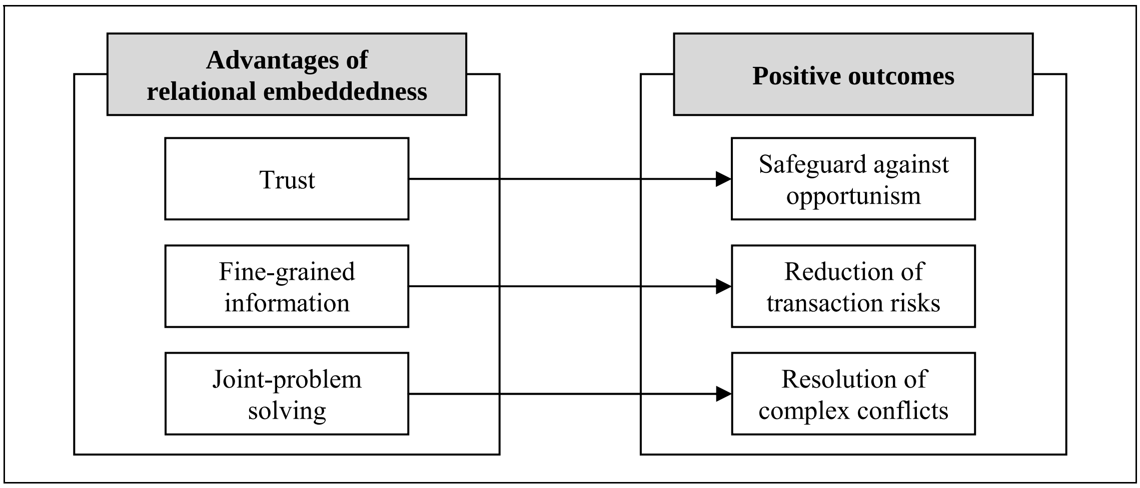
2.4.2 Relational Embeddedness

It has been observed that firms in the automobile and electronics industries are neither involved in market-based transaction relationships nor are vertically integrated (Cousins, 2002; Frazier *et al.*, 1988; Helper, 1991). Rather, they attempt to sustain long-term cooperative exchange relationships (Uzzi, 1999; Walker and Poppo, 1991). Relational exchange theory is frequently applied to explain these relationships which are differentiated from arm's-length relationships in classical or neoclassical economics (DiMaggio and Louch, 1998; Fowler *et al.*, 2004; Uzzi, 1999).

It is argued that relational exchange is distinguished from discrete exchange (Macneil, 1980). Discrete exchange is regarded as a one-time interaction between anonymous parties, who mainly focus on the maximisation of their own short-term economic efficiency (Ring and Van de Ven, 1992). Therefore, the identities and relational aspects between them are likely to be ignored in this exchange (Kim and Chung, 2003). On the other hand, relational exchange is not viewed as a separate event but rather as a dynamic process evolving through successive interactions between specific partners (Poppo and Zenger, 2002). Therefore, they decide whether to maintain an exchange relationship and anticipate outcomes based on the history of their past transactions (Dwyer *et al.*, 1987; Levinthal and Fichman, 1988). A premium is also placed on non-economic values such as trust and commitment generated by the iteration or long-term maintenance of a transaction relationship (Brown *et al.*, 2004).

Various advantages can be enjoyed by exchange parties who are coupled through relationally embedded ties. Firstly, the research of Uzzi (1997) argues that they can benefit from trust, fine-grained information and joint problem-solving as shown in Figure 2-9. Opportunistic behaviour is effectively controlled in a transaction relationship based on trust. The sharing of fine-grained information dramatically reduces exchange risks which threaten outcomes. Complex problems and conflicts are smoothly resolved by the joint efforts to solve problems.

Figure 2-9 Advantages of Relational Embeddedness



In line with this research, it is also claimed that transaction risks are noticeably decreased by flexibility, solidarity and information sharing between relationally embedded firms (Poppo and Zenger, 2002). Flexibility enables them to effectively respond to unpredictable events. Solidarity encourages their joint problem-solving activities. Information sharing facilitates the flexible response to unpredictability and the joint problem solving through solidarity. Secondly, as transaction relationships evolve over time, relationally embedded partners deeply understand each other's business, harmoniously resolve conflicts and share benefits and risks. Therefore, the differences in their strategic goals are minimised, which facilitates the successful establishment of partnerships (Lee and Kim, 1999; 2005). Thirdly, in the perspective of cost-effectiveness, firms can cut the considerable transaction costs of finding and managing new partners by repeating or maintaining their current transaction relationships (Goo *et al.*, 2007).

Contrary to these arguments, the research of Cousins (2002) claims that partnerships do not exist and organisations only make an effort to manage transaction risks. In particular, this study emphasises that interfirm relationships should not be developed with a focus on "a utopian ideal of working better together" but on "a sound business case" such as the minimisation of costs to survive and compete in the market (p.72). Furthermore, it is pointed out that the term "trust" is misleading in commercial contexts which are fundamentally calculative (Williamson, 1996).

Nevertheless, transaction relationships are not well developed when they are too much calculative (Kumar *et al.*, 1995). The research of Liu *et al*. (2010) identifies two forms of attitudinal commitment: calculative commitment (i.e. "instrumental realization of the benefits of staying and the costs of leaving") and loyalty commitment (i.e. "sentiment of allegiance and faithfulness") (p.844), which exist together in exchange relationships (Gilliland and Bello, 2002). According to this study, calculative commitment is negatively related to loyalty commitment and is positively associated with opportunistic behaviour.

2.4.3 Structural Embeddedness

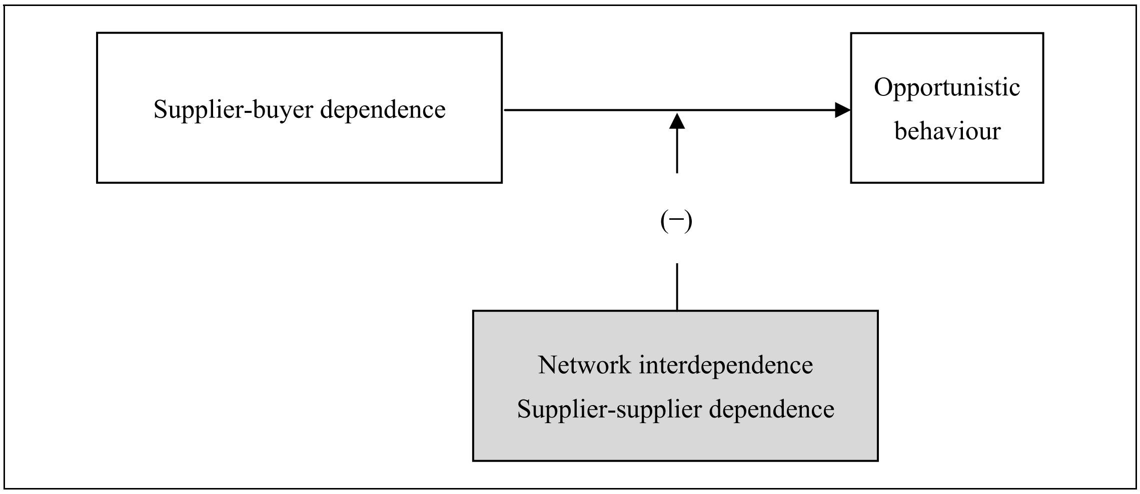
The research of Provan (1993) shows that a body of literature on various forms of long-term cooperative transaction relationships is mainly based on dyadic exchange relationships (Dwyer *et al.*, 1987; Frazier *et al.*, 1988; Heide and John, 1988; Hill, 1990). However, scholars in favour of social capital theory have paid attention to the fact that particular partners may not repeatedly transact with each other or maintain their long-term exchange relationships. In particular, it is argued that the existence of firms related with multiple exchange partners in a network can be proof that relational exchange theory is likely to be incomplete to explain the building and maintenance of transaction relationships (Ravindran *et al.*, 2009). Over recent decades, the analysis level of a relationship has shifted from dyads to egocentric and complete networks, and studies at the level of a network have successfully investigated complex and interrelated exchange relationships (Cousins, 2002; Provan *et al.*, 2007). According to this research stream, the volume of literature on structural embeddedness has dramatically increased (Borgatti and Foster, 2003).

Social capital is defined as “resources embedded in a social structure which are accessed and/or mobilized in purposive actions” and hence its concept includes “three elements intersecting structure and action: the structural embeddedness, opportunity accessibility and action-oriented use aspects” (Lin, 1999, p.35). Especially, the most common conceptualisation of social capital is regarded as structural embeddedness (Moran, 2005).

Following this conceptualisation, social capital research has been conducted under the general agreement that its value emanates from the access to resources through social relationships (Adler and Kwon, 2002; Granovetter, 1992). Therefore, a body of literature based on this theory addresses the values of linkages and their structures. In particular, they have investigated the relationships between network positions and a variety of significant outcomes such as “power, leadership, mobility, employment, individual performance, individual creativity, entrepreneurship and team performance” (Borgatti and Foster, 2003, p.993). Also, a (potential) partner’s network position represents its reputation which is an indicator of past performance and a predictor of future behaviour (Gopal *et al.*, 2003; Heng *et al.*, 2009; Malik and Bouguettaya, 2009). This valuable information can be gained through the observation of a network position or the information transmission via indirect ties with little cost (Hansen, 1999; Ravindran *et al.*, 2009). Therefore, a firm can collect information on multiple alternative candidates, have an opportunity to compare them and flexibly respond to a given business opportunity by transacting with a more suitable partner. In fact, it is reported that project managers place a premium on reputation rather than cost and consider the roles of a third party important to find a competent partner in uncertain situations (Drath and Wayman, 2010; Gopal *et al.*, 2003). Moreover, a firm's reputation is regarded as a collective measure of reliability rooted in the evaluation of counterparties and as an intangible asset (Jøsang *et al.*, 2007; Lee and Roh, 2012). It is also described that a network is "a nonhierarchical contracting relation in which reputation effects are quickly and accurately communicated" (Williamson, 1991, p.290). Therefore, a reputational partner would refrain from behaving opportunistically because the damage of its reputation caused by this behaviour is the loss of its capital (Kandori, 1992).

The research of Provan (1993) provides a conceptual framework on how opportunistic behaviour can be affected by a network's structural properties as shown in Figure 2-10.

Figure 2-10 Moderating Effects of Structural Properties



In this study, the following two features of a network are proposed: interconnectedness which indicates that members are interconnected and hence a certain member's success or failure influences others' outcomes in a network, and low information impactedness which means that uncodified information diffuses across a network. The interactions between the two features can increase the incentive for information sharing (Axelrod, 1984) and impede the restoration of damaged reputation (Granovetter, 1985). Therefore, the author argues that the following network structural properties stemming from interconnectedness and low information impactedness play an important role in safeguarding against opportunistic behaviour: overall network interdependence and supplier-supplier dependence. That is, it is shown that the effects of buyer-supplier dependence on opportunistic behaviour are moderated by the two structural properties in a buyer-dominant network.

2.4.4 Comparison between Relational and Structural embeddedness

Relational and structural embeddedness have been compared under alternative labels such as direct ties vs. indirect ties (Gulati, 1995), within-network embeddedness vs. search embeddedness (DiMaggio and Louch, 1998), strong ties vs. weak ties (Hansen, 1999; Kraatz, 1998; Schneider *et al.*, 1997) and reinforcing vs. broadening (Beckman *et al.*, 2004). This subsection more specifically reviews these studies on the comparison between the two types of embeddedness in other research contexts.

Information on (potential) partners enables firms to discover multiple alternative candidates and to improve trust in their counterparties. A network can serve as a conduit of this information because direct and indirect ties composing it emerge and evolve through the accumulation of transaction experience (Podolny, 2001). The research of Gulati (1995) investigates the roles of direct and indirect ties in selecting alliance partners. In this study, it is shown that information asymmetry between alliance parties can be resolved through direct and indirect ties as follows. Firstly, alliance parties can resolve information asymmetry by repeating or maintaining their current alliance relationships. Secondly, firms can access information on multiple alternative alliance candidates through indirect ties which increase the amount and diversity of information.

As a result, it is suggested that the number of past alliances between two specific alliance parties is positively related to the possibility of their establishing new alliances. Furthermore, this study proposes that the number of common indirect ties between two particular firms increases the possibility of their building new alliances when they are not directly connected.

The study of DiMaggio and Louch (1998) shows the preference for within-network embeddedness or search embeddedness at the high level of uncertainty. In this research, the two forms of embeddedness respectively represent directly and indirectly connected relationships which are used to evaluate potential partners' reliability. Firstly, it is suggested that search embeddedness can suppress uncertainty by increasing the amount of information with little cost. In fact, this form of embeddedness is frequently used to purchase products or services with higher quality at lower cost when uncertainty is at the high level (Brown and Reingen, 1987; Powell, 1990). Secondly, it is proposed that within-network embeddedness can overcome uncertainty by resolving information asymmetry through repeated transactions and by imposing reciprocal obligations which may not exist in search embeddedness. Moreover, this research argues that competitive quality or price derived from search embeddedness can be balanced by reliability underlying within-network embeddedness. Consequently, it is revealed that buyers tend to prefer within-network embeddedness when uncertainty is at the high level.

In the meantime, weak ties are considered more beneficial in searching information because exchange parties maintaining weak ties can rapidly and flexibly explore information beyond their existing relationships (Brass *et al.*, 2004). Conversely, the amount and diversity of information accessed by transaction parties coupled through strong ties are limited because they tend to stay within their existing relationships (Boorman, 1975; Gargiulo and Benassi, 2000; Henderson and Clark, 1990). The research of Schneider *et al*. (1997) investigates the roles of weak ties in collecting information on public goods of which the quality is multidimensional and is difficult to exactly evaluate. Weak ties can considerably contribute to the dissemination and diversity of information (Kogut, 2000; Oliver, 2001). Therefore, the author reveals that they play an important role in gaining information on public goods.

However, the study of Hansen (1999) asks whether tacit information is correctly transferred through weak ties although they are more useful in finding the location of knowledge in a network. Therefore, it is examined how the effectiveness of strong and weak ties is affected by the tacitness of knowledge in this research. Social network research typically assumes that information is well shared among actors in a network and hence it takes little additional effort to transfer it (Burt, 1992). In contrast to this assumption, it is difficult to transfer tacit knowledge which is neither documented nor independent (Zander and Kogut, 1995). Accordingly, the author shows that reciprocity and commitment between a sender and receiver are needed to correctly transmit tacit information and that strong ties are more advantageous in transferring this knowledge. In addition, the research of Kraatz (1998) points out that strong ties play an important role in adapting to environmental change. This study argues that strong ties characterised by frequent interactions, extended histories and intimacy can facilitate cooperative interactions and provide reliable information for the imitation of successful practices. Therefore, it is shown that organisations attempt to respond to environmental change through the interactions with others who are strongly connected and the imitation of their practices.

The study of Beckman *et al*. (2004) examines the preference for broadening or reinforcing network ties in the presence of two types of uncertainty: firm-specific uncertainty which is peculiar and is internal to a firm, and market uncertainty which is external and is experienced across the market. The examples for each type of uncertainty are provided as follows: firm-specific uncertainty stems from the entrance of a new market, the acquisition of another firm and the turnover of top management while market uncertainty originates in competitive uncertainty, demand uncertainty and input cost uncertainty. Then, this research suggests that firms can control firm-specific uncertainty by help of diverse information gained through heterogeneous and temporary relationships. On the other hand, it is proposed that market uncertainty beyond firms' control can be managed by the repetition or long-term maintenance of existing relationships. As a result, it is shown that firms tend to choose broadening both at the high level of firm-specific uncertainty and at the low level of market uncertainty while they are apt to select reinforcing at the high level of market uncertainty.

Table 2-5 summarises the literature on the comparison between relational and structural embeddedness in other research contexts.

Table 2-5 Comparison between Relational and Structural Embeddedness

Author	Findings
Gulati (1995)	• **Direct ties vs. Indirect ties** • The number of past alliances between two specific firms is positively related to the possibility of their establishing new alliances. • The number of common indirect ties between two particular firms has a positive relationship with the possibility of their new alliances when they are not directly connected
DiMaggio and Louch (1998)	• **Within-network embeddedness vs. Search embeddedness** • Buyers tend to apply within-network embeddedness when uncertainty is at the high level.
Schneider *et al*. (1997)	• **Strong ties vs. Weak ties** • Weak ties are more beneficial in collecting information on public goods.
Kraatz (1998)	• **Strong ties vs. Weak ties** • Organisations attempt to respond to environmental change through the interactions with others who are strongly connected and the imitation of their practices.
Hansen (1999)	• **Strong ties vs. Weak ties** • Strong and weak ties are more advantageous in transferring tacit and explicit knowledge respectively.
Beckman *et al*. (2004)	• **Reinforcing vs. Broadening** • Firms tend to choose broadening both at the high level of firm-specific uncertainty and at the low level of market uncertainty • Firms are apt to select reinforcing at the high level of market uncertainty.

2.5 Roles of Two Types of Embeddedness in ITO

A body of research has been conducted on the roles of relational and structural embeddedness in the context of ITO. The former has examined long-term cooperative outsourcing relationships mainly based on relational exchange theory while the latter has investigated network-based outsourcing relationships primarily rooted in social capital theory. This section reviews the empirical literature on the roles of the two types of embeddedness in ITO business environments.

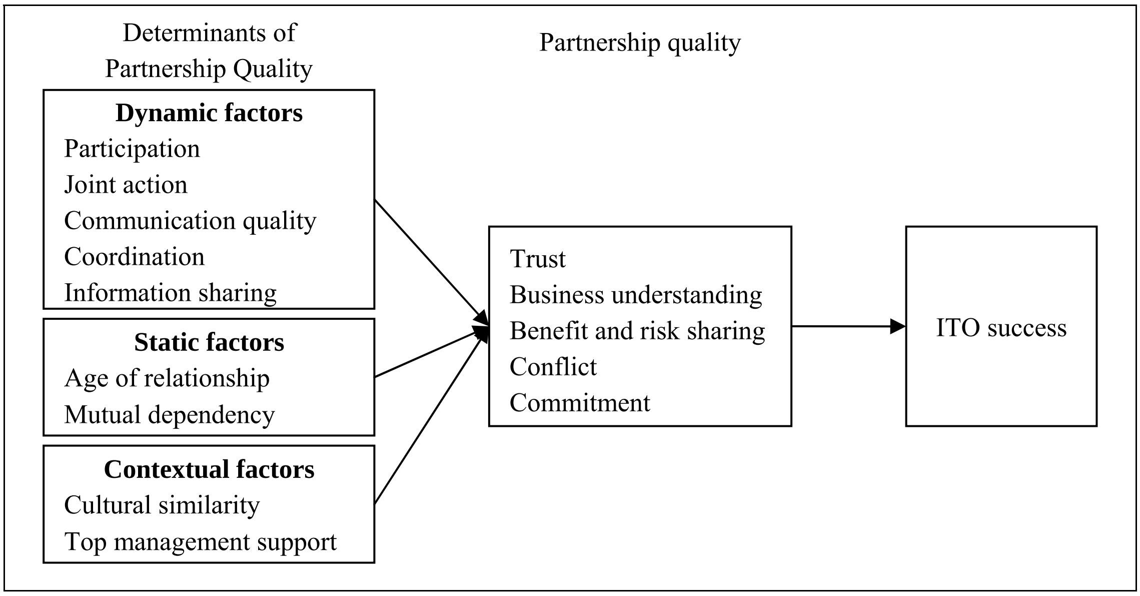
2.5.1 Roles of Relational Embeddedness in ITO

As shown in Section 2.2 Literature Review Papers on ITO Studies, increasing attention has been focused on how to initiate and maintain ITO relationships over recent decades. In particular, a body of literature has deeply investigated long-term cooperative ITO relationships (i.e. partnerships) based on relational embeddedness.

The research of Henderson (1990) investigates the concept of an ITO partnership. First, an ITO partnership is classified into two dimensions: partnership in action (i.e. "what are the factors or elements of this relationship that contribute to its effective execution on a day-to-day, week to week basis?") and partnership in context (i.e. "what are the factors or elements of this relationship that lead you to believe that it will be sustained over time?") (p.9). Next, several critical components of each dimension are identified. That is, the former includes shared knowledge, distinctive competency and resources, and organisational linkage while the latter involves mutual benefits, commitment and predisposition. As a result, an ITO partnership model composed of the six elements is established and is validated through interviews with executives.

The study of Lee and Kim (1999) points out that the components and determinants of ITO partnership quality are not clearly distinguished in existing studies. Therefore, the authors propose an ITO partnership quality model mainly based on power-political theory and relational exchange theory as shown in Figure 2-11. Their following research argues that the causalities between the determinants and components are not theoretically justified although they are statistically supported (Lee and Kim, 2005). Three alternative models are established as shown in Figure 2-12 and are compared through structural equation modelling. Finally, it is found that the first model based on behavioural-attitudinal theory can more closely represent the reality of ITO partnerships.

Figure 2-11 ITO Partnership Quality Model



(Source: Lee and Kim, 1999)

Figure 2-12 Three Alternative Models of ITO Partnership

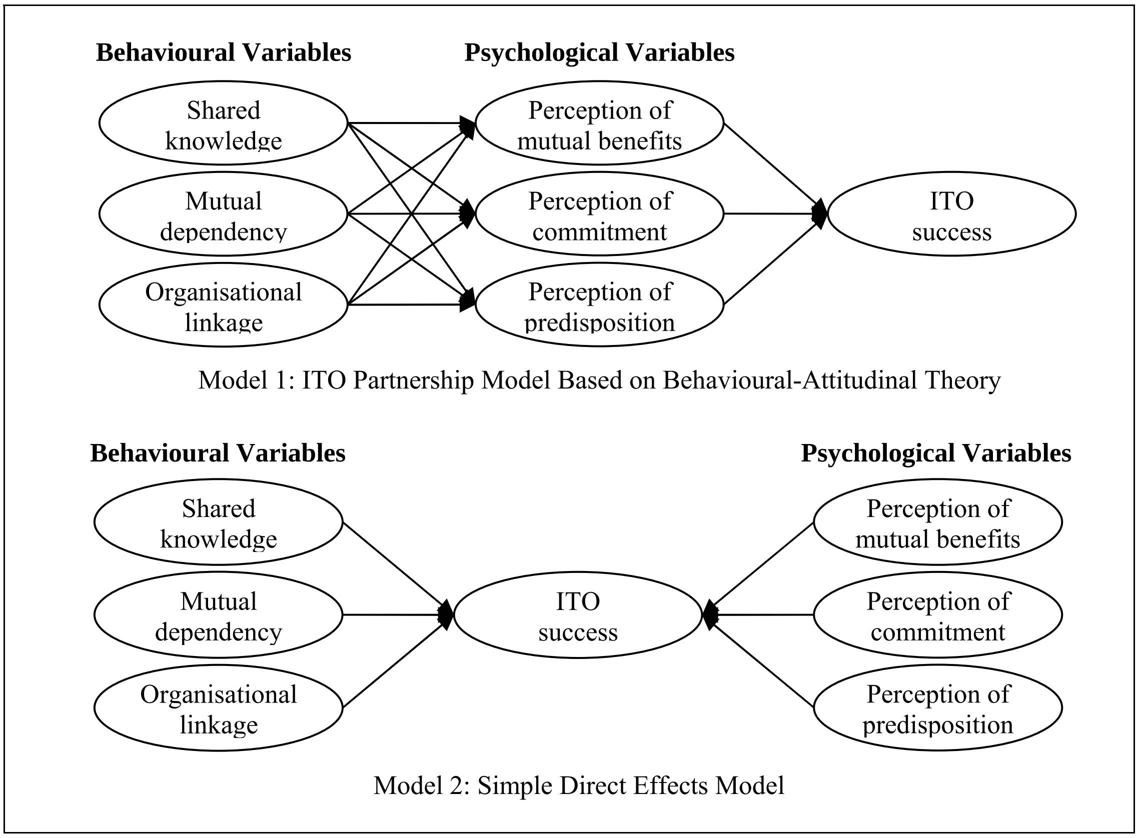
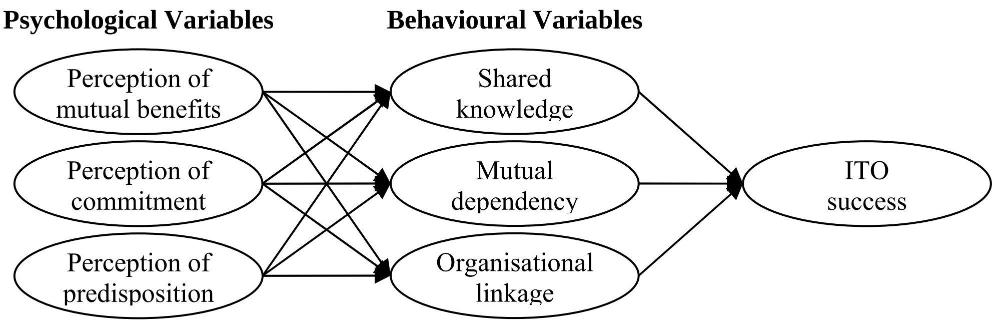


Figure 2-12 Continued



Model 3: ITO Partnership Model Based on Theory of Reasoned Action

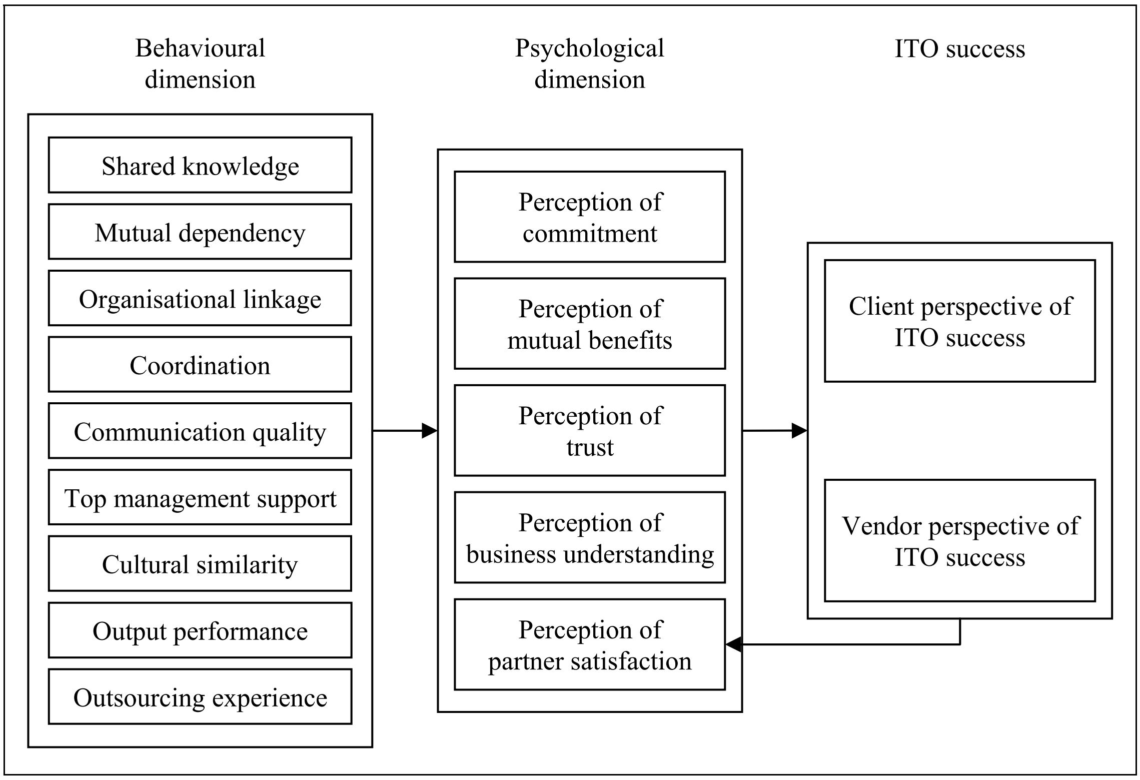
(Source: Lee and Kim, 2005)

The study of Kim *et al*. (2003) deals with the determinants of the satisfaction of various customer groups related to ITO. In this research, customer groups are classified into project directors, users and operators. Then, it is found that each group's satisfaction is differently affected by the following three dimensions: transaction relationships (including personnel participation, past experience, transaction period and business group effect), partnerships (including task understanding, risk sharing, technical level and responsiveness) and outcomes (including IT-related performance and task-related performance). More specifically, it is shown that transaction relationships and partnerships are more significant for the satisfaction of project directors while outcomes are more important for that of users and operators.

The research of Kim and Chung (2003) examines the effects of relational and task characteristics on ITO success. At first, ITO success is categorised into satisfaction levels and perceived economic and non-economic benefits. Next, solidarity, continuity expectation, role integrity, flexibility and monitoring are identified as relational characteristics based on relational exchange theory while uncertainty and asset specificity are identified as task characteristics based on transaction cost theory. In this study, it is interesting that uncertainty is not significantly related to ITO success, which is different from the prediction. The authors propose a possible explanation that the utilisation of less firm-specific assets in the presence of uncertainty may counteract the effects of uncertainty in ITO business environments.

The above reviewed literature explicitly or implicitly indicates that the establishment of long-term cooperative outsourcing relationships is critical for ITO success in the presence of uncertainty. Based on these studies, the research of Flemming and Low (2007) points out that the existing models of ITO partnerships need to be more systematically integrated in the perspective of both clients and vendors. Therefore, an integrated model of ITO relationships is proposed as shown in Figure 2-13 and is validated through interviews with professionals.

Figure 2-13 Integrated ITO Relationship Model



(Source: Flemming and Low, 2007)

In the meantime, clients attempt to switch their current vendors for various reasons. However, this attempt tends to incur the considerable transaction costs involved in finding and managing new vendors. Therefore, the repetition or long-term maintenance of ITO relationships is beneficial in terms of cost-benefits. In this sense, the study of Goo *et al*. (2007) argues that it is necessary to examine the duration of ITO relationships unlike the literature which mainly focuses on satisfaction levels and perceived benefits.

The authors identify the determinants of the duration in the strategic, economic and social perspectives. At first, two determinants are identified in the strategic perspective: knowledge acquisition and strategic importance of IT activities. Next, the economic viewpoint proposes three determinants: relationship-specific investment, demand uncertainty and extent of substitution. Finally, the determinants like opportunism and satisfaction with output quality are derived from the social perspective. In this research, it is interesting that opportunism is not significantly associated with the duration of ITO relationships, which is unlike the prediction. The authors provide a possible explanation that the effects of opportunism may be mitigated by the impacts of relationship-specific investment. That is, it is explained that opportunism may no longer play an important role in an ITO relationship where outsourcing parties behave cooperatively because they believe that opportunism is harmful to their trust-based relationship for overcoming uncertainty at the high level of asset specificity.

Several studies illustrate that various forms of governance structures can complement each other in the context of ITO. The research of Poppo and Zenger (2002) demonstrates that formal contracting and relational governance act as complements rather than substitutes in ITO business environments. It is sometimes argued that relational governance can be a substitute of formal contracting since the former incurs less transaction costs while the latter serves as a signal of distrust and increases the possibility of opportunistic behaviour (Liu *et al.*, 2010; Rokkan and Buvik, 2003). However, this study suggests that well-specified formal contract terms can reduce risks and this reduction can again improve trust and cooperation between outsourcing parties. In addition, it is proposed that continuity and reciprocity underlying relational governance can decrease risks which are not likely to be controlled by formal contracting. As a result, the authors show that managers tend to prefer less customised contracting in response to uncertainty and are apt to supplement its incompleteness with relational governance.

The study of Choudhury and Sabherwal (2003) investigates several control modes for the management of vendors in the context of information systems development (ISD) outsourcing. In this research, ISD is viewed as complex, intensive and dynamic activities which are organised based on cooperation among various stakeholders. The authors argue, therefore, that the selection of an appropriate control mode can promote the effective integration of these activities. Two types of control modes are identified: formal mode including outcome control and behaviour control, and informal mode involving clan control and self control. It is also shown that the former affects vendors' behaviour through assessment and reward while the latter reduces the difference of goals between clients and vendors. As a result, this research observes that clients employ a mixture of the four control modes according to task characteristics, participants' project-related knowledge and role expectations, and the portfolio of the modes evolves over time.

The research of Balaji and Brown (2010) claims that outsourcing parties need to invest in various forms of governance structures because uncertainty cannot be completely managed only by contractual specifications although they are generally perceived to be fundamental to ITO success. Therefore, the following four governance structures are examined: contractual, structural, extra-contractual and relational governance. Furthermore, this study introduces the multidimensional ITO outcomes composed of business, functional and economic benefits, and execution-level effectiveness. Consequently, it is revealed that relational trust serves as a positive mediator between the various governance structures and the multidimensional ITO outcomes.

In the meantime, increasing attention has been paid to relational embeddedness in the context of international outsourcing. Earlier studies have mainly focused on clients' economic advantages in terms of cost-benefits or their abilities to evaluate vendors for the removal of opportunism and the facilitation of cooperation (Berggren *et al.*, 2001; Lacity *et al.*, 1994). However, the research of Harried and Ramamurthy (2009) argues that clients' economic profits cannot capture all the dimensions of offshoring success and they may behave opportunistically. Therefore, the essential components of key relationship dimensions and relational success dimensions are identified in the context of international outsourcing. The former includes information exchange, legal bonds, mutual obligations, relationship-specific adaptations and intellectual competence while the latter involves trust, commitment and conflict. Finally, it is revealed how key relationship dimensions affect relational success dimensions in offshoring business environments.

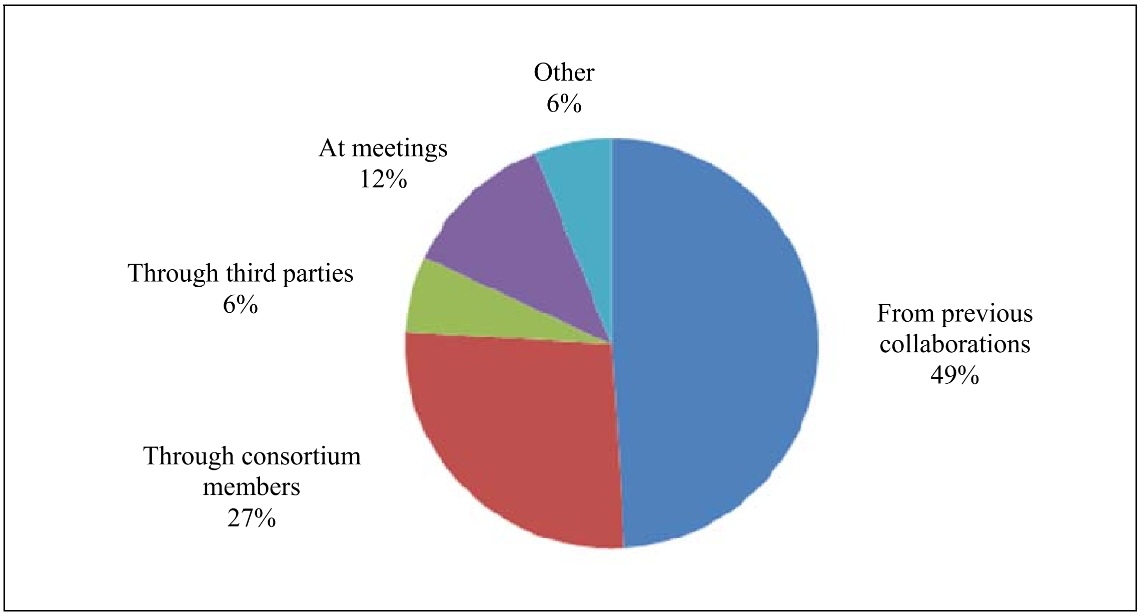
2.5.2 Roles of Structural Embeddedness in ITO

Interestingly, although the roles of structural embeddedness have been intensively investigated in other research areas (Borgatti and Foster, 2003), there are just a few studies addressing them in the context of ITO. As described in the research of Ravindran *et al*. (2009), their study is likely to be the first empirical attempt to examine the effects of structural embeddedness in ITO business environments. The authors point out that the existing ITO literature on the control of uncertainty has mainly focused on formal contracting and relational governance. They argue, however, that another type of governance needs to be investigated to supplement the incompleteness of formal contracting and to explain the existence of multiple alternative partners in an ITO network. A network position is introduced as a new form of governance in this research. It is shown that a client occupying a prominent network position can access diverse information on vendors and their services or products, and a vendor's reputational network position represents its good performance or its ability to fulfil duties. As a result, this research shows that the higher network positions of a client and vendor are associated with the shorter and longer duration of an ITO contract respectively.

The research model established by Heng *et al*. (2009) includes the construct of referencing power related with structural embeddedness. ITO contracts are terminated due to various reasons such as unsatisfactory performance, multiple alternative vendors and competence loss (Whitten and Leidner, 2006). The authors point out, however, that these reasons are significant only from a client's perspective and hence it is necessary to understand what factors can affect the suspension of ITO contracts from a vendor's viewpoint. Referencing power represents "the ability of clients to positively promote or negatively tarnish vendors' reputation" (p.6). Consequently, it is shown that a client's positive referencing power is negatively associated with a vendor's terminating intention since vendors are not likely to terminate ITO relationships with clients who tend to transfer positive information on their services or products to potential clients in an ITO network.

The survey report of Drath and Wayman (2010) shows how coordinators select their partners for the establishment of information and communication technologies (ICT) consortia. As shown in Figure 2-14, about fifty percent of the coordinators select members based on previous collaborations. However, around thirty-five percent of them choose partners recommended by other consortium members or third parties. This proportion indicates that coordinators sometimes build ICT consortia with partners for whom they have no transaction histories. From this practical report, it is inferred that ITO relationships can be established through structural embeddedness as well as relational embeddedness.

Figure 2-14 Source of Partners



(Source: Drath and Wayman, 2010)

Finally, the reviewed studies on the roles of relational and structural embeddedness in this section are organised in Table 2-6.

Table 2-6 Relational and Structural Embeddedness in ITO

Author	Findings
Henderson (1990)	• **Conceptualising ITO Partnership** • Two dimensions of an ITO partnership are identified: (PIA) and partnership in context (PIC). • PIA is related to the components that contribute to the effective implementation of an ITO partnership and includes shared knowledge, distinctive competency and resources, and organisational linkage. • PIC is associated with the components that strengthen outsourcing parties' belief in the maintenance of an ITO partnership and involves mutual benefits, commitment and predisposition.
Lee and Kim (1999)	• **Establishing ITO Partnership Quality Model** • The components and determinants of ITO partnership quality are clearly distinguished. • The determinants include the dynamic factors (participation, joint action, communication quality, coordination and information sharing), the static factors (age of relationship and mutual dependency) and the contextual factors (culture similarity and top management support). • The components involve trust, business understanding, benefit and risk sharing, conflict and commitment.
Lee and Kim (2005)	• **Comparing Three Alternative ITO Partnership Models** - Model based on behavioural-attitudinal theory - Simple direct effects model - Model based on theory of reasoned action • The model based on behavioural-attitudinal theory can more closely represent the reality of ITO partnerships.
Kim *et al*. (2003)	• **Identifying Determinants of ITO Satisfaction of Different Groups** • Transaction relationships and partnerships are more significant for the ITO satisfaction of project directors while outcomes are more important for that of users and operators.
Kim and Chung (2003)	• **Investigating Effects of Relational and Task Features on ITO Success** • Vendor capability, solidarity, continuity expectation, flexibility and monitoring are positively associated with ITO success while role integrity and asset specificity are negatively related to ITO success.

Table 2-6 Continued

Author	Findings
Flemming and Low (2007)	• **Integrating Existing ITO Partnership Models** • An integrated ITO partnership model is proposed which includes the behavioural and psychological dimensions from the viewpoint of both clients and vendors.
Harried and Ramamurthy (2009)	• **Investigating Relational Success in Offshoring** • The relationship between the key relationship dimensions and the relational success is examined in the context of international outsourcing.
Goo *et al*. (2007)	• **Scrutinizing Determinants of ITO Contract Duration** • Knowledge acquisition, relationship-specific investment and extent of substation are positively related to contract duration. • Requirement uncertainty is negatively associated with contract duration. • Strategic importance of IT activities, opportunistic behaviour and satisfaction with output quality have no significant impact on contract duration.
Poppo and Zenger (2002)	• **Examining Roles of Formal Contracting and Relational Governance** • Less customised formal contracts tend to be used in the context of ITO where it is difficult to measure performance and the pace of technological change is unpredictable and hence relational governance can supplement the incompleteness of them.
Choudhury and Sabherwal (2003)	• **Investigating Different Control Modes for ITO relationships** • Clients employ the mixture of outcome, behaviour, clan and self control mode according to task characteristics, participants' project-related knowledge and role expectations, and the portfolio of the modes evolves as time passes.
Balaji and Brown (2010)	• **Scrutinizing Mediating Effects of Trust between Different Forms of Governance Structures and Multidimensional ITO Outcomes** • Relational trust mediates the impacts of contractual, extra-contractual and relational governance on business, functional and economic benefits, and execution-level effectiveness.
Ravindran *et al*. (2009)	• **Examining Effects of Network Positions on ITO Contract Duration** • The higher network positions of clients and vendors are associated with the shorter and longer duration of ITO contracts respectively.

Table 2-6 Continued

Author	Findings
Heng *et al*. (2009)	• **Investigating Effects of Referencing Power on Terminating Intention** • A client's positive referencing power is negatively related to a vendor's ITO contract terminating intention.
Drath and Wayman (2010)	• **Survey Source of Partners for ICT Consortia** • Coordinators find partners through the recommendation of other consortium members and third parties as well as from previous collaborations.

2.6 Limitations of Prior Literature

A body of literature has deeply investigated the roles of relational and structural embeddedness in the context of ITO. However, the literature does not clearly answer the following research question in this study: which of the two types of embeddedness is more appropriate in enhancing long-term performance at the different levels of technological unpredictability and measurement difficulty imposed on ITO business environments?

First of all, existing ITO studies have not compared the two types of embeddedness. The comparisons between them have been conducted in other research contexts such as organisational learning (Hansen, 1999), environmental adaptation (Kraatz, 1998), alliances (Beckman *et al.*, 2004; Gulati, 1995) and buyer-seller relationships (DiMaggio and Louch, 1998). In ITO business environments, however, each research stream on relational or structural embeddedness has mainly focused on its own advantages as shown in the literature on long-term cooperative outsourcing relationships or on network-based outsourcing relationships. Therefore, there is a lack of understanding the conditional superiority of each type of embeddedness in the context of ITO.

Secondly, the two types of embeddedness have not been compared at the different levels of technological unpredictability and measurement difficulty even in other research contexts. The study of Robertson and Gatignon (1998) argues that the efficiency of an exchange relationship can be considerably affected by the selection of a proper governance structure in response to the type of uncertainty. The authors suggest two types of uncertainty: internal uncertainty stemming from measurement difficulty and lack of experience, and external uncertainty originating in technological and demand uncertainty. In ITO studies, technological unpredictability and measurement difficulty have been frequently and significantly addressed (Kim and Chung, 2003; Lacity *et al.*, 2010). Therefore, relational and structural embeddedness need to be compared in the presence of these two uncertainties imposed on ITO business environments.

Thirdly, the comparisons between the two types of embeddedness in other research contexts mainly emphasise which is preferred at the high level of uncertainty rather than which leads to better performance according to the type and level of uncertainty. It is proposed that organisations prefer partners for whom they have the transaction histories when the uncertainty of service or product quality is at the high level (Podolny, 1994). It is also suggested that the uncertainty regarding the performance of partners tends to encourage individuals to utilise within-network embeddedness (DiMaggio and Louch, 1998). Furthermore, the research of Beckman *et al*. (2004) reveals a firm's preference for reinforcing or broadening according to the type of uncertainty. These existing studies could provide a partial answer to the research question in this study. However, the preference for relational or structural embeddedness is distinguished from the performance led by each type of embeddedness. Therefore, it needs to be examined how each type of embeddedness affects long-term performance in the context of ITO.

To sum up, ITO studies have hardly investigated the conditional superiority of relational or structural embeddedness at the different levels of technological unpredictability and measurement difficulty. In other research contexts, only the preference for each type of embeddedness has been examined at the high level of uncertainty. It needs to be understood, therefore, which of the two types of embeddedness is more appropriate in improving long-term performance at the different levels of the two uncertainties imposed on ITO business environments.

In fact, the choice between the utilisation of something present and the search for something alternative has been considered one of the fundamental and critical problems for adapting to uncertain business environments (Lee *et al.*, 2003b). A possible theoretical answer to this choice problem can be found by examining the conditional superiority of each type of embeddedness in the presence of the two uncertainties which promote opportunism and threaten long-term performance in the context of ITO. Also, from the practical viewpoint, the comparison between the two types of embeddedness can provide ITO managers with a guideline for the choice between existing partners who are connected through strong network ties and reputational partners who are located in prominent network positions.

2.7 Chapter Conclusion

This chapter reviewed several literature review papers, opportunistic behaviour and risks, relational and structural embeddedness which are related to the research question in this study. The limitations of prior studies were more clearly identified through this review.

Several literature review papers provided a better understanding of the current research trends and issues in the research area of ITO. The early discussions on “why and what” have shifted into the recent debates on “how and outcomes”. In particular, there has been a dramatic increase in the volume of literature on how to initiate and maintain ITO relationships over the recent two decades. Moreover, according to these trends, much attention has been paid to relational exchange theory and social capital theory.

Among various kinds of risks drawn from transaction cost theory and agency theory, the two uncertainties (i.e. technological unpredictability and measurement difficulty) have been frequently and significantly addressed in ITO studies because they can increase the possibility of opportunistic behaviour and threaten long-term performance. Therefore, a body of literature has investigated the roles of relational and structural embeddedness in controlling these uncertainties on the theoretical basis of relational exchange theory and social capital theory.

However, each ITO research stream on relational or structural embeddedness has focused on its own advantages. This one-sided emphasis may lead to the puzzling conclusion that both types of embeddedness could be universally optimal regardless of the type and level of uncertainty. What is worse, an improper prescription derived from this confusing conclusion may be given to a firm facing the tension between the two types of embeddedness. Furthermore, existing studies in other research contexts have mainly investigated the preference for relational or structural embeddedness at the high level of uncertainty rather than the performance led by each type of embeddedness at the different type and level of uncertainty.

As a result, there is a paucity of literature on the conditional superiority of each type of embeddedness in the context of ITO. This research attempts to fill this research gap by answering the following specific question.

- Which of the two types of embeddedness is more appropriate in improving long-term performance at the different levels of technological unpredictability and measurement difficulty imposed on ITO business environments?

The next chapter discusses how this research proceeds to address this question. That is, the simulation approach including a game-theoretic method and a full factorial design of experiments is explained.

CHAPTER 3 RESEARCH APPROACH AND METHODS

3.1 Introduction

Chapter 3 describes the research approach and methods used in this study. As described in Section 1.6 Research Approach and Methods, approaches are differentiated from methods as follows: "approaches are a generic or overarching way of going about research, while methods are more narrowly focused techniques and procedures for conducting research" (Dibbern *et al.*, 2004, p.20). This research takes a simulation approach, which includes a game-theoretic method and a full factorial design of experiments to examine the conditional superiority of each type of embeddedness according to the type and level of uncertainty in the long-term perspective.

This chapter includes the following two sections: Simulation in Management Studies and Research Approach. Firstly, it is described why a simulation approach is applied. This section provides, therefore, a better understanding of the novelty of a simulation approach in management studies. The next section explains "the roadmap for developing theories with simulations" developed by Davis *et al*. (2007). This roadmap is used as a guideline for the research approach in this study. It is also demonstrated how this research proceeds to address the research question.

3.2 Simulation in Management Studies

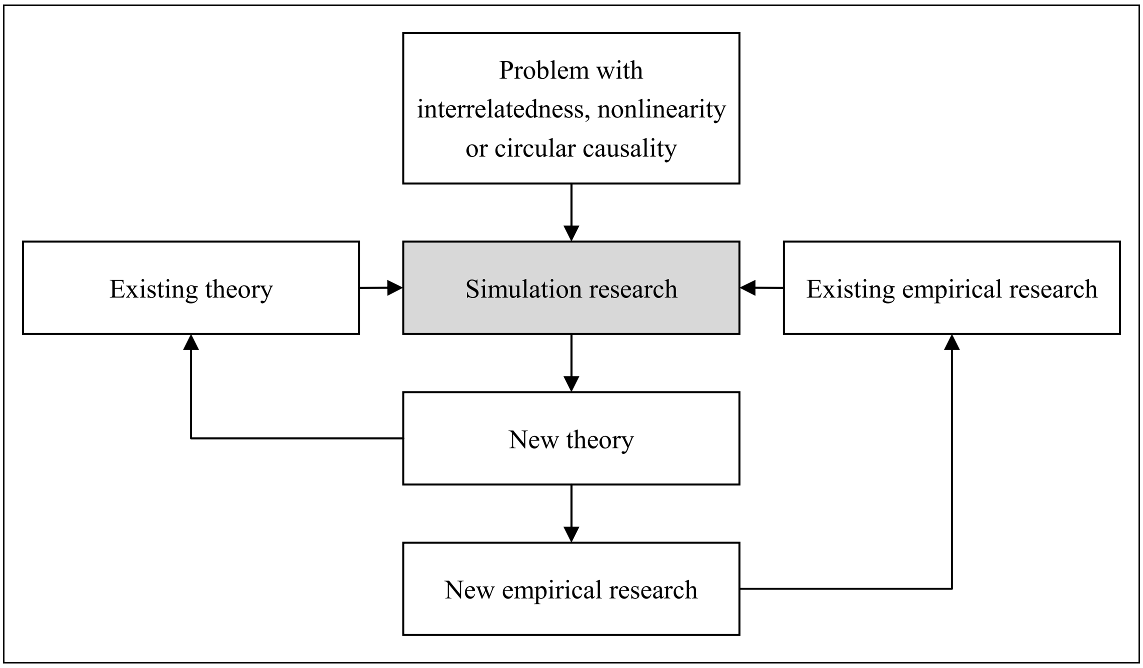
A simulation approach has become more important in organisational and strategic studies (Axelrod, 1997b; Harrison *et al.*, 2007; Repenning, 2003; Zott, 2003). This computer-based approach creates computational representations for constructs derived from existing literature, theoretical logics establishing relationships among them and assumptions defining research boundary conditions (Davis *et al.*, 2007). Therefore, a theory developed or extended through a simulation approach includes constructs, theoretical logics and assumptions which are necessary to be qualified for a well-made theory (Sutton and Staw, 1995; Whetten, 1989).

Research has been traditionally conducted through two main approaches: "theoretical analysis or deduction, and empirical analysis or induction" (Harrison *et al.*, 2007, p.1230). A deductive study draws conclusions from a set of strict assumptions while an inductive research infers consequences from observed data (Hammersley, 1960). Furthermore, a modified version of an inductive approach has been widely employed to confirm hypotheses developed in a study applying a deductive approach (Harrison *et al.*, 2007). However, each research approach has its own shortcomings: the former sometimes makes assumptions which are far distant from the real world for their usefulness itself, and the latter sometimes faces the problem of data availability (Harrison *et al.*, 2007). A simulation approach can cope with these problems by making more realistic assumptions and generating virtual data. In this sense, this approach has both deductive and inductive characteristics (Axelrod, 1997a). It is deductive in the perspective that a simulation model is derived from existing theories and assumptions. On the other hand, it is inductive from the viewpoint that new findings are from simulation experiments. These two features, therefore, lead to the usefulness of a simulation approach. That is, based on computational representations with high internal validity from the exact specification of constructs, theoretical logics and assumptions, a wide range of experiments can be conducted to gain sufficient data by modifying computer codes (Berends and Romme, 1999; Davis *et al.*, 2007).

A simulation approach is beneficial when multiple processes are interconnected, nonlinear and circular causal phenomena are addressed, and it is challenging to obtain empirical data (Repenning, 2003; Zott, 2003). Multiple processes can be individually well understood. However, as the processes continuously interact with each other, their behaviours and/or outcomes could become more interrelated. The interrelatedness also tends to increase the nonlinearity and circular causality of the behaviours and/or outcomes over time. When investigating this situation, some researchers using a deductive approach may make unrealistic assumptions and others employing an inductive approach may experience difficulty in collecting sufficient empirical data. In such a case, a simulation approach can act as an effective substitute for the two traditional approaches. In the meantime, the majority of simulation studies do not usually provide hypotheses because the interrelatedness, nonlinearity and circular causality hamper the establishment of clear and logical relationships among the behaviours and/or outcomes (Harrison *et al.*, 2007).

Figure 3-1 shows the roles of a simulation study in management studies.

Figure 3-1 Roles of Simulation Research in Management Studies



As described above, a simulation approach is considered more appropriate for dealing with a research problem with interconnectedness, nonlinearity or circular causality. It is worthwhile, therefore, to apply a simulation approach if a given problem includes the whole or part of these complex features. Next, a simulation study is conducted based on existing theories and empirical studies which provide theoretical foundations and empirical evidences for internal and external validity. Then, a new theory is established or an existing theory is extended by analysing simulation experiment results. Moreover, this newly developed or extended theory serves as a basis for further empirical research.

Finally, the research of Davis *et al*. (2007) proposes that a simulation study is evaluated based on the contribution to literature and the strictness of an approach.

Contribution to Theory

- Is the research question derived from its related existing studies and theories to maintain its theoretical consistency with them?

- Is the focus of simulation experiments on the development of a new theory or on the extension of an existing theory?

Strictness of Approach

- Does the simulation approach clearly define computational representations for constructs, theoretical logics and assumptions?

- Does the simulation approach explicitly verify computational representations to confirm internal validity and correct coding?

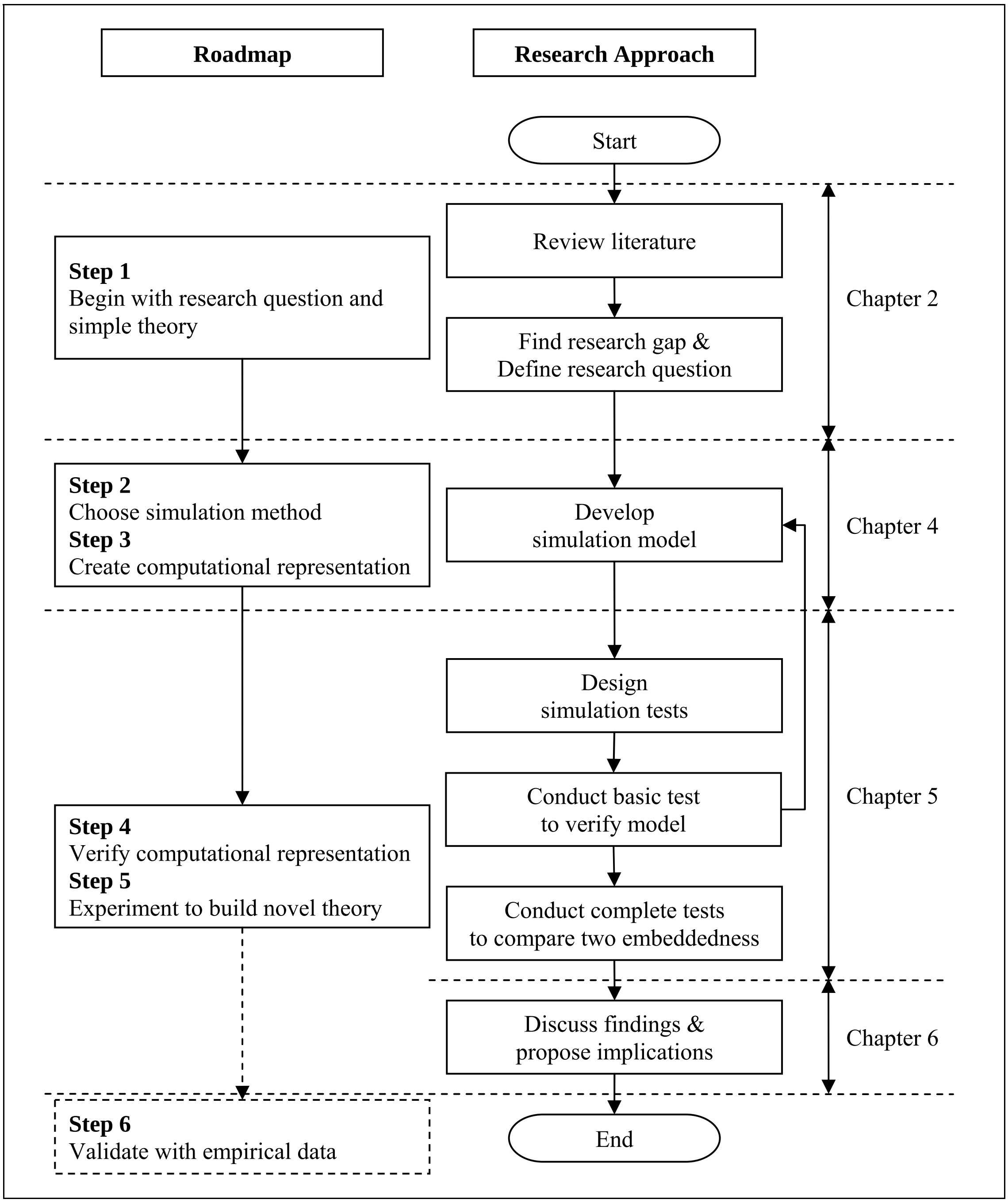
- Does the simulation approach apply the proper design of simulation tests?

This study examines the conditional superiority of relational or structural embeddedness in the following research setting. There are multiple vendors in an ITO network. They establish ITO consortia in response to given outsourcing opportunities with the different levels of technological unpredictability and measurement difficulty. The consortium formation is viewed as an interaction between the vendors to gain their profits. Then, as they continuously interact with one another, ITO ties are generated and reinforced, and their behaviours and/or outcomes become more interrelated. Therefore, this research includes the behaviour of vendors who compose a network and affect one another through their interactions, and the performance which is the consequence of their behaviour. Furthermore, the two types of embeddedness are compared at the different levels of the two uncertainties in the long-term perspective. As a result, a simulation approach is appropriate for this study.

3.3 Research Approach

The research approach (i.e. "a generic or overarching way of going about research") in this study is on the basis of "the roadmap for developing theories with simulations" (Davis *et al.*, 2007). Figure 3-1 shows how this research proceeds based on the roadmap.

Figure 3-2 Roadmap and Research Approach



3.3.1 Step 1: Begin with research question and simple theory

A simulation study theoretically disconnected from extant literature is apt to emphasise only the side of computational representations. Therefore, similar to studies with other approaches, the roadmap recommends that a study using a simulation approach should start from the clear and concrete definition of a research question which is derived from the intensive review of existing literature and which is involved in theoretical issues.

It is also emphasised that the development of a new theory or the extension of an existing theory through a simulation approach is based on a "simple theory" which serves as a platform for discovering new findings. A simple theory is regarded as an immature theory which is restricted due to "weak conceptualisation, few propositions, and/or rough underlying theoretical logic" (Davis *et al*., 2007, p.484). However, it does not always refer to a less developed theory. That is, the roadmap suggests that a well-established theory can perform the role of a simple theory when a research question is associated with competitions, conflicts, tensions and trade-offs among concepts or processes drawn from this mature theory.

Chapter 2 reviewed the existing literature concerning the concepts and roles of relational and structural embeddedness to respond to uncertainty in the context of ITO. In addition to this review, the chapter explored the comparison between the two types of embeddedness in other research contexts. Through this comprehensive literature review, the following research question was clearly defined: which of the two types of embeddedness is more suitable for improving long-term performance at the different levels of technological unpredictability and measurement difficulty imposed on ITO business environments? The two uncertainties are discovered from transaction cost theory and agency theory. Also, the notions of relational and structural embeddedness are supported by relational exchange theory and social capital theory respectively. As a result, this research attempts to resolve the tension between the two types of embeddedness in the presence of the two uncertainties based on the above simple theories through a simulation approach. Furthermore, this approach is appropriate for addressing the research question in this study as described in the previous section.

3.3.2 Step 2: Choose simulation method

The roadmap proposes the following five simulation methods: systems dynamics, NK fitness landscape, genetic algorithms, cellular automata and stochastic processes. Table 3-1 shows the comparison of the methods, which is extracted from the table in the research of Davis *et al*. (2007, p.486).

Table 3-1 Simulation Method

Method	Focus
Systems dynamics	Behaviour of a system with complex causality and timing
NK fitness landscape	Speed and effectiveness of adaptation of modular systems with tight vs. loose coupling to an optimal point
Genetic algorithms	Adaptation of a population of agents via simple learning to an optimal agent form
Cellular automata	Emergence of macro patterns from micro interactions via spatial processes in a population of agents
Stochastic processes	Flexible method to a wide variety of research questions, assumptions and theoretical logics
Method	**Common Research Questions**
Systems dynamics	What conditions create system instability?
NK fitness landscape	How long does it take to find an optimal point? What is the performance of an optimal point?
Genetic algorithms	What affects the rate of adaptation? When does an optimal form emerge?
Cellular automata	How does a pattern emerge and change? How fast does a pattern emerge?
Stochastic processes	No specific research questions beyond asking what the effects of varying stochastic sources are?
Method	**Key Assumptions**
Systems dynamics	System with intersecting and circular causal loops Flows that specify rates within system

Table 3-1 Continued

Method	Key Assumptions
NK fitness landscape	System of N nodes and K coupling Fitness landscape that maps the performance of all combinations Adaptation via incremental moves and long jumps
Genetic algorithms	Population of agents with genes / Evolutionary adaptation / Variation via mutation and crossover / Retention via copying selected agents
Cellular automata	Population of spatially arrayed and semi-intelligent agents Neighbourhood of agents where local rules apply
Stochastic processes	One or more processes by which system operates One or more stochastic sources Probabilistic distributions for each stochastic source
Method	**Common Experiments**
Systems dynamics	Add causal loops / Change mean of flow rates / Change variance of flow rates
NK fitness landscape	Vary N and K / Change adaptation moves / Add a map of the landscape / Create an environmental jolt
Genetic algorithms	Vary mutation probability / Vary crossover probability / Vary length of evolution time / Create an environmental jolt
Cellular automata	Change rules / Change neighbourhood size
Stochastic processes	Change stochastic sources / Vary levels of stochasticity / Unpack constructs / Change pieces of theoretical logic

(Source: Davis *et al*., 2007)

The first four methods are standardised methods which have their own applicable research questions, assumptions and common experiments. On the other hand, stochastic processes are just an alternative name for a set of simulation methods which are customised to specific domains and include probabilistic sources. Therefore, this method is recommended when research questions, assumptions and common experiments in a certain simulation study do not match those in the four standardised methods. The roadmap also suggests that a study applying stochastic processes is suitable to examine how the different levels of stochastic sources can affect outcomes. For this examination, several interesting sources of probability are varied while others are fixed.

The research question in this study does not lie in the categories of the first four methods. Furthermore, the levels of the two uncertainties are varied while the values of other parameters are fixed in full factorial simulation experiments. Therefore, this study employs stochastic processes, which are customised to investigate the conditional superiority of each type of embeddedness at the different levels of technological unpredictability and measurement difficulty.

3.3.3 Step 3: Create Computational Representation

The roadmap demonstrates that creating computational representations includes three activities: operationalising theoretical constructs, building algorithms and specifying assumptions. It is also illustrated that the activities are simultaneously performed since constructs, algorithms and assumptions are highly correlated.

Operationalising Theoretical Constructs

During the activity of operationalising theoretical constructs, the measures for them are computationally defined. The roadmap describes that this operationalisation in a simulation study is roughly similar to the development of measures to gauge constructs in an empirical research. It is argued, therefore, that constructs in a simulation study should be based on existing literature for the theoretical consistency with extant studies and their computational measures should be rigorously formulated for the correctness of analyses.

Building Algorithms

Theoretical logics, constructs and assumptions are embodied in a computer programme during the activity of building algorithms. The roadmap argues that the adjustment of the tension between parsimony and accuracy is one of the most important issues in building algorithms and depends on the complexity of theoretical logics, constructs and assumptions. It is pointed out, however, that a simulation study frequently emphasises the side of parsimony because a simple algorithm is intuitively understood and hence is used as a basis for extracting more complex implications (Repenning, 2003).

Specifying Assumptions

The research range is limited by the specification of assumptions. Furthermore, the roadmap claims that this specification itself is a way of adjusting the tension between parsimony and accuracy because assumptions can exclude several logics and constructs which are not essential to address a research question.

In Chapter 4, a simulation model is developed which includes theoretical logics, constructs and assumptions. An ITO network is modelled where vendors build consortia to maximise their long-term profits in response to given outsourcing opportunities. At first, vendors in this network are provided with ITO opportunities with the different levels of technological unpredictability and measurement difficulty. Then, they act as a coordinator or a partner in establishing ITO consortia. As coordinators, they take the relational or structural strategy. As partners, they behave cooperatively or opportunistically. Also, the winning consortium members gain their profits in accordance with the assessment result of a delivered IT service. Their decision-makings and profits are formulated through a game-theoretic method.

The following key constructs are operationalised to embody this simulation model.

- Partner selection and control strategy based on relational embeddedness, which is called “relational strategy”
- Partner selection and control strategy based on structural embeddedness, which is called “structural strategy”
- Cooperative behaviour
- Opportunistic behaviour including adverse selection and moral hazard

- Uncertainty stemming from the unpredictability of technological requirements, which is called “technological unpredictability”
- Uncertainty originating in the difficulty in measuring performance, which is called “measurement difficulty”

Next, the following measures are developed for the comparison between relational and structural embeddedness.

- Cumulative profit for coordination abilities
- Cumulative number of ties
- Average strength of ties
- Average proportion of opportunistic partners
- Average proportion of existing or reputational partners

Finally, the following key assumptions are made in this research.

- Technological unpredictability and measurement difficulty exist together in ITO business environments.
- Existing partners for the coordinators taking the relational strategy can be controlled with lower hidden costs than reputational partners for the coordinators taking the structural strategy.
- Vendors can update and transfer information on others’ tendencies to behave cooperatively or opportunistically through network ties.
- Vendors share a norm such that a vendor is deprived of its further outsourcing opportunities when its opportunistic behaviour is detected.

3.3.4 Step 4: Verify Computational Representation

The roadmap argues that the step of verifying computational representations is very critical in a simulation approach. Verification is a procedure for confirming internal validity (Davis *et al*., 2007, p.482). That is, this activity confirms whether computational representations correctly reflect theoretical logics, constructs and assumptions, and provides high internal validity. In the roadmap, several ways are proposed to verify computational representations. Above all, it is most significant to compare the simulation results derived from the implementation of a simulation model with the existing propositions of simple theories. Theoretical logics, constructs and assumptions are likely to be correctly embodied when the results maintain the consistency with the propositions. In addition, the completeness and correctness of coding need to be verified through monitoring the values of key variables at each step of a simulation model.

In Chapter 5, full factorial experiments are designed. Then, the basic test for verifying the developed simulation model is conducted at the low level of technological unpredictability and the high level of measurement difficulty. The results at this experimental point are compared with the existing studies addressing the advantages of relational embeddedness when it is difficult to measure performance. This comparison confirms whether the model is consistent with extant theories. At the same time, the source codes are checked through tracking the values of key variables at each procedure of the model.

3.3.5 Step 5: Experiment to Build Novel Theory

The roadmap describes that a new theory is established or an existing theory is extended through effective and appropriate simulation experiments. The following four types of simulation experiments are proposed: varying values of constructs, unpacking constructs, varying assumptions and adding new features. The first type is common in the case where new findings can be discovered by varying the values of constructs which are fixed in simple theories. Next, if a multidimensional construct can be divided into several subconstructs which have their own unique effects, unpacking constructs is helpful. The third type is applicable when there are alternative processes and the assumptions for them are different. Finally, adding new features to original computational representations can provide a better understanding of complex interactions among processes which individually exist.

In Chapter 5, the complete tests for comparing the two types of embeddedness are conducted at all the experimental points. The levels of the two uncertainties are varied while the values of the other parameters are fixed. Also, the following measures are gauged at each test point: (1) the average proportion of existing or reputational partners, (2) the average proportion of opportunistic partners, (3) the average strength of ties, (4) the cumulative number of ties and (5) the cumulative profit for coordination abilities. Then, the analysis results reveal the conditional superiority of each type of embeddedness at the different levels of technological unpredictability and measurement difficulty.

3.3.6 Step 6: Validate with Empirical Data

The final step is to validate a simulation model. Validation is a procedure for strengthening external validity (Davis et al., 2007, p.482). New findings in a simulation study can be validated through the collection and analysis of additional empirical data related to them. However, the developers of the roadmap state that the significance of validating a simulation model is controversial. They take a contingent view and argue that the importance is subject to the extent to which simple theories are supported by empirical evidences. That is, the validation is a less significant issue in a simulation study applying simple theories which have evolved based on a lot of empirical literature. Conversely, its importance is emphasised when a simulation research employs simple theories which are mainly based on analytical arguments.

Considerable empirical evidence supports the simple theories applied to this research (i.e. relational exchange theory, social capital theory, transaction cost theory and agency theory). Therefore, the new findings derived from the simulation results can attain a certain level of their external validity. As a result, the validation issue is less important and this final step is not addressed in this research.

3.4 Chapter Conclusion

There is no study applying a simulation approach among the papers explored in several literature reviews on ITO (Dibbern *et al*., 2004; Fjermestad and Saitta, 2005; Gonzalez *et al*., 2006; Lacity *et al*., 2010). A simulation study is rarely found in the research area of ITO in spite of its usefulness. Therefore, this chapter specifically explained why and how a simulation approach was applied to this research.

Firstly, the roles of a simulation approach in management studies were explained. It was shown that a theory developed or extended through a simulation approach can be qualified for a well-made theory. Next, this approach was compared with a deductive and inductive approach. This comparison provided a better understanding of the usefulness of a simulation approach. In addition to the comparison, several research settings were identified where this approach is applicable. Finally, this section illustrated the roles of a simulation approach in developing a new theory or extending an existing theory, and the two evaluation criteria for a simulation study.

Secondly, it was described how this research proceeds based on “the roadmap for developing theories with simulations”. The simulation steps to address the research question in this study include (1) beginning with a research question and simple theory, (2) choosing a simulation method, (3) creating computational representations, (4) verifying computation representations and (5) experimenting to build a novel theory. The final step of validating with empirical data was excluded.

In the next chapter, a simulation model is developed based on existing theories and empirical studies to compare relational and structural embeddedness at the different levels of technological unpredictability and measurement difficulty.

CHAPTER 4 SIMULATION MODEL

4.1 Introduction

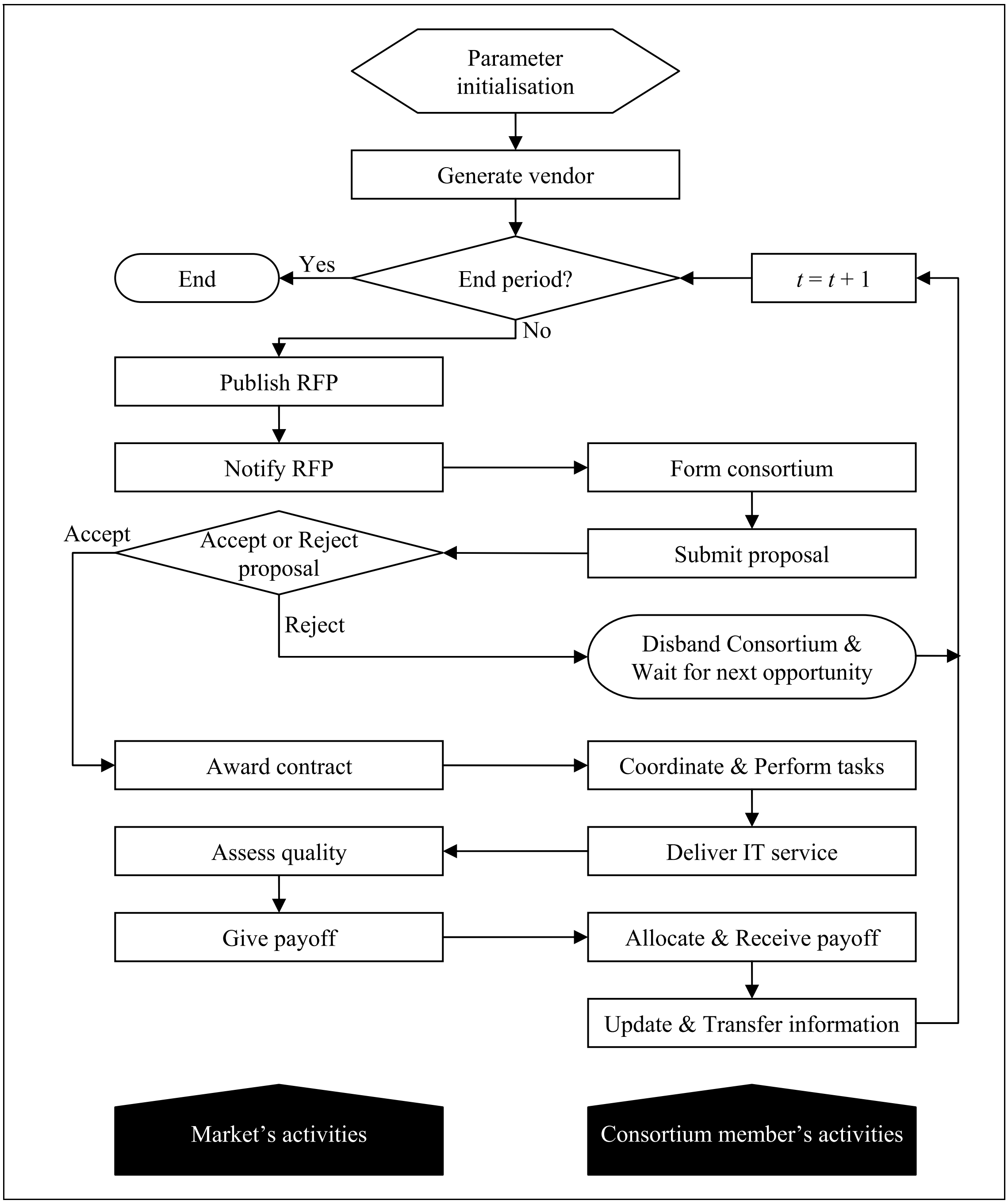
Chapter 4 aims at describing a simulation model which can examine the conditional superiority of each type of embeddedness according to the type and level of uncertainty based on several theories. At first, transaction cost theory and agency theory propose the two uncertainties (i.e. technological unpredictability and measurement difficulty) which are significantly addressed in ITO studies (Bahli and Rivard, 2003; Kim and Chung, 2003; Robertson and Gatignon, 1998). In the simulation model, the market offers ITO business opportunities with the different levels of the two uncertainties. Next, the establishment of ITO consortia is simulated in response to these opportunities. Vendors in an ITO network perform the role of either a coordinator or a partner. As coordinators, they take the partner selection and control strategy based on relational or structural embeddedness (i.e. the relational or structural strategy). The advantages of each strategy are derived from relational exchange theory and social capital theory respectively (Poppo and Zenger, 2002; Ravindran *et al.*, 2009). As partners, they behave cooperatively or opportunistically. Two types of opportunistic behaviour drawn from agency theory are manifested in the simulation model: adverse selection and moral hazard (Eisenhardt, 1989). Finally, the decision-makings and payoffs of ITO consortium members are modelled based on the game models developed by Shapiro and Stiglitz (1984) and Kandori (1992).

This chapter includes the following sections. Firstly, it is overviewed how the simulation proceeds. The next section describes several characteristics of vendors in an ITO network. Thirdly, it is explained how ITO opportunities with the different levels of the two uncertainties are generated. In sequence, the decision-makings of coordinators and (potential) partners are illustrated. Thereafter, consortium members' profits are formulated. It is also demonstrated how vendors update and transfer information on others through ITO network ties. Finally, several measures are illustrated to compare relational and structural embeddedness.

4.2 Simulation Procedure

This research simulates an ITO network where vendors establish consortia in response to outsourcing opportunities given by the market. Figure 4-1 schematically shows how the simulation proceeds.

Figure 4-1 Simulation Procedures



Initially, the market generates an ITO business opportunity with certain levels of technological unpredictability and measurement difficulty. The details of this opportunity are defined in a request-for-proposals (RFP). Then, the RFP is notified to vendors in an ITO network.

Thereafter, several vendors qualified to be coordinators establish their ITO consortia. A coordinator has an option to take the relational or structural strategy. A coordinator employing the relational strategy prefers an existing partner who is strongly connected while one using the structural strategy favours a reputational partner who is located in a prominent network position. In the meantime, a cooperative potential partner attempts to participate in an ITO consortium only if it has enough resources to cover a technological requirement in the RFP while an opportunistic one tries to become a consortium member exaggerating its current resource availability.

After several ITO consortia are established, the coordinators submit their proposals to the market. When receiving the proposals, the market selects the one with the highest level of coordination abilities and awards a contract in accordance with the RFP to the winning consortium. The other consortia except for the winner are disbanded and their members wait for the next opportunity.

The winning consortium coordinator manages its partners by using coordination abilities. When the coordinator takes the relational strategy, an existing partner can be controlled with lower hidden costs because they are coupled through a strong tie. On the other hand, when the coordinator employs the structural strategy, a reputational partner is likely to be more suitable for a given technological requirement. However, it should bear higher hidden costs because the outsourcing parties are not completely committed to each other. In the meantime, the partners perform their tasks by inputting their resources to cover the technological requirements in the contract. A cooperative partner invests as many resources as required while an opportunistic one inputs no resources for its own interests.

When the tasks are completed, the coordinator delivers the IT service. Then, the market assesses the quality of the delivered IT service and gives the payoff according to the assessment result. Thereafter, the coordinator allocates the payoff to its consortium partners. More specifically, if the quality is evaluated as satisfactory, the coordinator believes that all the members behaved cooperatively (i.e. they invested as many resources as required). Therefore, it allocates the payoff to them in proportion to the amounts of resources required in the RFP. On the other hand, if the quality is assessed as unsatisfactory and opportunistic partners are detected, the coordinator allocates the payoff to its partners according to the amounts of resources which were actually invested by them. That is, a cooperative partner receives the payoff which is the same with the amount of resources which it inputted while an opportunistic partner receives nothing. Finally, the members update and transfer information on one another through ITO network ties.

The simulation model mainly includes three parts: market’s activities, coordinator’s activities and partner’s activities. More specifically, the market's activities are involved in publishing a RFP, selecting the winning consortium, assessing the quality of a delivered IT service and awarding payoff. The coordinator’s activities consist of identifying the types and quantities of resources for technological requirements in a RFP, selecting partners according to the identified resource set, coordinating members, allocating payoff and updating information. The partner’s activities include applying for a consortium member, performing a given task through the investment of its resources and updating information. The computational representations of each party are provided in the following sections.

4.3 Vendors in ITO Network

In an ITO network, there exist vendors who play the role of either a coordinator or a partner in establishing ITO consortia to respond to given outsourcing opportunities with the different levels of technological unpredictability and measurement difficulty.

As coordinators, vendors take the relational or structural strategy, which affects their decision-makings on how to select and control consortium members. A coordinator taking the relational strategy attempts to select existing partners who are strongly connected through the experience of participating in ITO consortia together. The coordinator has the outsourcing histories for these partners in the perspective of relational embeddedness (Nahapiet and Ghoshal, 1998). In this case, the level of uncertainty can be noticeably decreased by flexibility, solidarity and information sharing which emerge and evolve through the repetition or long-term maintenance of outsourcing relationships (Poppo and Zenger, 2002). Furthermore, the coordinator can reduce the cost of measuring the partners' outcomes because the outsourcing parties believe that their temporary inequities will be eventually compensated for by their long-term joint success and hence the need for the precise measurement of performance is decreased (Kronman, 1985). Therefore, it can control their behaviour with lower hidden costs (Barthelemy, 2001).

On the other hand, a coordinator taking the structural strategy tries to choose reputational partners who occupy prominent network positions although it has no outsourcing histories for them from the viewpoint of structural embeddedness (Nahapiet and Ghoshal, 1998). The partners are likely to be more competent for given outsourcing opportunities because a network position is an indicator of past performance and a predictor of future behaviour (Gopal *et al.*, 2003; Malik and Bouguettaya, 2009). Furthermore, the coordinator actively uses information on potential partners which is transferred by third parties (Drath and Wayman, 2010). Therefore, it can flexibly respond to the fast and unstable pace of technological change by collecting information on multiple alternative candidates through the observation of their network positions and the information transmission via third parties, and by selecting the most suitable partners. However, in this case, the coordinator bears the higher hidden costs of managing the partners' behaviour since they are not completely committed to each other.

As partners, vendors behave cooperatively or opportunistically. Two types of opportunistic behaviour are manifested in the simulation model: adverse selection and moral hazard (Eisenhardt, 1989). That is, an opportunistic vendor attempts to attend an

ITO consortium by exaggerating its current resource availability although the amount of its resources is smaller than that is required (i.e. adverse selection). Also, when selected as a partner, it invests no resources for its own interests (i.e. moral hazard). These types of behaviour induce a coordinator to select an unqualified partner and decrease the quality of a delivered IT service (Aubert *et al.*, 1998).

Besides the key assumptions in Section 3.3.3 Create Computational Representation, the following assumptions related to vendors are additionally made for the parsimony of the developed simulation model.

- As a coordinator, a vendor takes either of the two divergent strategies (i.e. the relational or structural strategy), and selects one partner for each type of technology in the establishment of its ITO consortium.

- As a partner, a vendor has either of the two contradictory behavioural tendencies (i.e. the tendency to behave cooperatively or opportunistically), and has resources for one type of technology.

Figure 4-2 graphically shows vendors and their characteristics in an ITO network.

Figure 4-2 Vendors and Characteristics in ITO network

1st type technology	2nd type technology	…	*i* th type technology	…	*m* th type technology
$v_{1,1}$	$v_{2,1}$	…	v_{i1}	…	v_{m1}
$v_{1,2}$	$v_{2,2}$	…	v_{i2}	…	v_{m2}
⋮	⋮	⋮	⋮	⋮	⋮
v_{1j}	v_{2j}	…	v_{ij}	…	v_{mj}
⋮	⋮	⋮	⋮	⋮	⋮
v_{1n}	v_{2n}	…	v_{in}	…	v_{mn}

v_{ij} represents the j th vendor who has resources for the i th type of technology. Then, it has $r_{ij}(t)$ and b_{ij} to act as a partner and, at the same time, $a_{ij}(t)$ and s_{ij} to serve as a coordinator in the establishment of an ITO consortium. More specifically, let us suppose that following vendors exist in an ITO network.

$$v_{i1}, v_{i2}, \cdots, v_{ij}, \cdots, v_{in} \text{ for } i = 1, 2, \cdots, m, \quad (4\text{-}1)$$

where m denotes the number of technology types. Also, n and v_{ij} represent the number of vendors who has resources for the i th type of technology and the j th among those vendors. Also, it is assumed that n is an even number.

Then, v_{ij} has the following features to serve as a partner.

$$r_{ij}(t) \text{ for } t = 0, 1, \cdots, T \text{ and } b_{ij},$$

where $r_{ij}(t)$ and b_{ij} represent the amount of resources which v_{ij} has for the i th type of technology at the period of t and the behavioural propensity which v_{ij} has. At the initial period of $t = 0$, $r_{ij}(0)$ is generated to follow the uniform distribution over the range $[r_{\min}(0), r_{\max}(0)]$. In the meantime, let n_c or n_o be the number of cooperative or opportunistic vendors for each type of technology. Then, $n = n_c + n_o$. Also, +1 or −1 is randomly given to b_{ij} so that $n_c = n_o$, where each value means that v_{ij} behaves cooperatively or opportunistically.

At the same time, v_{ij} has the following characteristics to play a coordinator role.

$$a_{ij}(t) \text{ for } t = 0, 1, \cdots, T \text{ and } s_{ij},$$

where $a_{ij}(t)$ and s_{ij} indicate the level of coordination abilities which v_{ij} has at the period of t and the strategy which v_{ij} takes. At the initial period of $t = 0$, $a_{ij}(0)$ is generated to follow the uniform distribution over the range $[a_{\min}(0), a_{\max}(0)]$. In the meantime, let n_r or n_s be the number of vendors taking the relational or structural strategy for each type of technology. Then, $n = n_r + n_s$. Also, +1 or −1 is randomly given to s_{ij}, so that $n_r = n_s$, where each value means that v_{ij} takes the relational or structural strategy.

4.4 Two Uncertainties Imposed on ITO Business Environments

This research simulates the uncertainties stemming from the unpredictability of technological requirements and the difficulty in measuring outcomes. Basically, transaction relationships are initiated and maintained at a certain level of uncertainty and their performance is seriously affected by measurement difficulty (Alchian and Demsetz, 1972; Barzel, 1982). Also, the selection of a suitable governance structure in response to the type and level of uncertainty is one of the important determinants of successful transactions (Beckman *et al.*, 2004; Robertson and Gatignon, 1998). In ITO studies, the two uncertainties have been frequently and significantly addressed (Kim and Chung, 2003; Lacity *et al.*, 2010) since they increase the possibility of opportunistic behaviour and threaten long-term performance (Auber et al. 1998, 1999). Therefore, the different levels of technological unpredictability and measurement difficulty create an ideal platform for the comparison between relational and structural embeddedness in ITO business environments.

4.4.1 Technological Unpredictability

In the simulation model, a request-for-proposals (RFP) is denoted by a combination of types and quantities of coordination abilities and resources which are necessary to cover technological requirements for the delivery of an outsourced IT service. Therefore, the RFP published at the period of t is indicated by

$$\mathbf{RFP}(t) = [pa(t), pr_1(t), pr_2(t), \cdots, pr_x(t), \cdots, pr_m(t)],$$

where $pa(t)$ and $pr_x(t)$ denote the level of coordination abilities and the amount of resources for the x th type of technology required in $\mathbf{RFP}(t)$.

In the meantime, uncertainty is defined as "the degree of unpredictability or volatility of future states as it relates to the definition of IS requirements, emerging technologies, and/or environmental factors" (Lacity *et al.*, 2010, p.411). Following this definition, technological unpredictability in the simulation model is represented as the extent to which technological requirements in a RFP are unpredictable. More specifically, this uncertainty can be considered from two viewpoints: how fast technological requirements increase and how unstably they fluctuate as time passes. Their rapid incline and unsteady variation can hinder vendors from responding to future outsourcing opportunities. On the other hand, vendors can keep up with the pace of change in technological requirements when they increase slowly and their fluctuation range is narrow.

In order to simulate this situation, $pa(t)$ and $pr_x(t)$ are generated to follow the normal distribution with $\mu_a(t)$, $\sigma_a(t)$ and $\mu_r(t)$, $\sigma_r(t)$, where

$$\mu_a(t) = \alpha \times \frac{\sum_{i=1}^{m}\sum_{j=1}^{n_i} a_{ij}(t)}{\sum_{i=1}^{m} n_i},\ \ \sigma_a(t) = \alpha \times \sqrt{\frac{\sum_{i=1}^{m}\sum_{j=1}^{n_i}\left[a_{ij}(t)-\mu_a(t)\right]^2}{\left(\sum_{i=1}^{m} n_i\right)-1}} \text{ and}$$

$$\mu_r(t) = \alpha \times \frac{\sum_{i=1}^{m}\sum_{j=1}^{n_i} r_{ij}(t)}{\sum_{i=1}^{m} n_i},\ \ \sigma_r(t) = \alpha \times \sqrt{\frac{\sum_{i=1}^{m}\sum_{j=1}^{n_i}\left[r_{ij}(t)-\mu_r(t)\right]^2}{\left(\sum_{i=1}^{m} n_i\right)-1}}\ . \quad (4\text{-}2)$$

Also, $pa(t)$ or $pr_x(t)$ with a negative value is generated again. Then, α can indicate the increasing rate and instability of coordination abilities and resources required in **RFP**(t). That is, as the value of α is higher, $pa(t)$ and $pr_x(t)$ are likely to increase more steeply and their fluctuation range seems to become larger over time.

In the simulation model, technological unpredictability is associated with the use of elaborate tender procedures and rigorous contract clauses. When the change of technological requirements is too rapid and unstable, existing or reputational partners for a coordinator taking the relational or structural strategy may not cover them. In this case, new consortium members should be found and controlled with elaborate tender procedures and rigorous contract clauses. However, these formal mechanisms incur the considerable hidden costs involved in selecting and managing new partners (Barthelemy, 2001).

4.4.2 Measurement Difficulty

The quality of a delivered IT service is one of the critical indicators to measure ITO performance (Dibbern *et al.*, 2004) and is evaluated in the perspective of "fitness of use", that is, whether a customer's requirements are satisfied (Garvin, 1988). Let $I(t)$ and $R(t)$ be the sum of coordination abilities and resources which are actually invested by the winning consortium members at the period of t, and the sum of coordination abilities and resources which are necessary to cover the technological requirements in **RFP**(t). Then, the quality of an IT service can be assessed with respect to the following proportion.

$$Prop(t) = I(t) / R(t) \quad (4\text{-}3)$$

since the proportion can represents the extent to which the technological requirements in the RFP have been achieved. For example, the extreme case that $Prop(t) = 1$ indicates the winning consortium members inputted all the coordination abilities and resources required in **RFP**(t) and hence all the requirements have been achieved. In the meantime, this proportion is decided by the number of opportunistic partners in the winning consortium because they invest no resources for their own interests. The higher the number, the lower the proportion and vice versa.

However, it is almost impossible to exactly measure this proportion due to measurement difficulty, which is defined as "the degree of difficulty in measuring performance of exchange partners under circumstances of joint effort, soft outcomes, and/or ambiguous links between effort and performance" (Lacity *et al.*, 2010, p.411). This uncertainty stems from various sources according to the types of IT activities, for example, high in the comprehensive type of ITO such as "application development, systems conversion and integration, consulting services and disaster recovery" and low in the commodity type of ITO such as "network maintenance, data center operations, systems maintenance and PC maintenance" (Goo *et al.*, 2007, p.2116). Therefore, the type of an outsourced IT service makes a difference in the extent to which *Prop*(t) can be exactly measured.

In order to simulate this situation, a cut-off value (β) between 0 and 1 is given to an outsourced IT service, which refers to the degree to which the technological requirements in **RFP**(t) can be verified. Then, the quality of a delivered IT service is evaluated as

$$\textit{satisfactory if } \beta \leq Prop(t) \textit{ or unsatisfactory if } \beta > Prop(t). \quad (4\text{-}4)$$

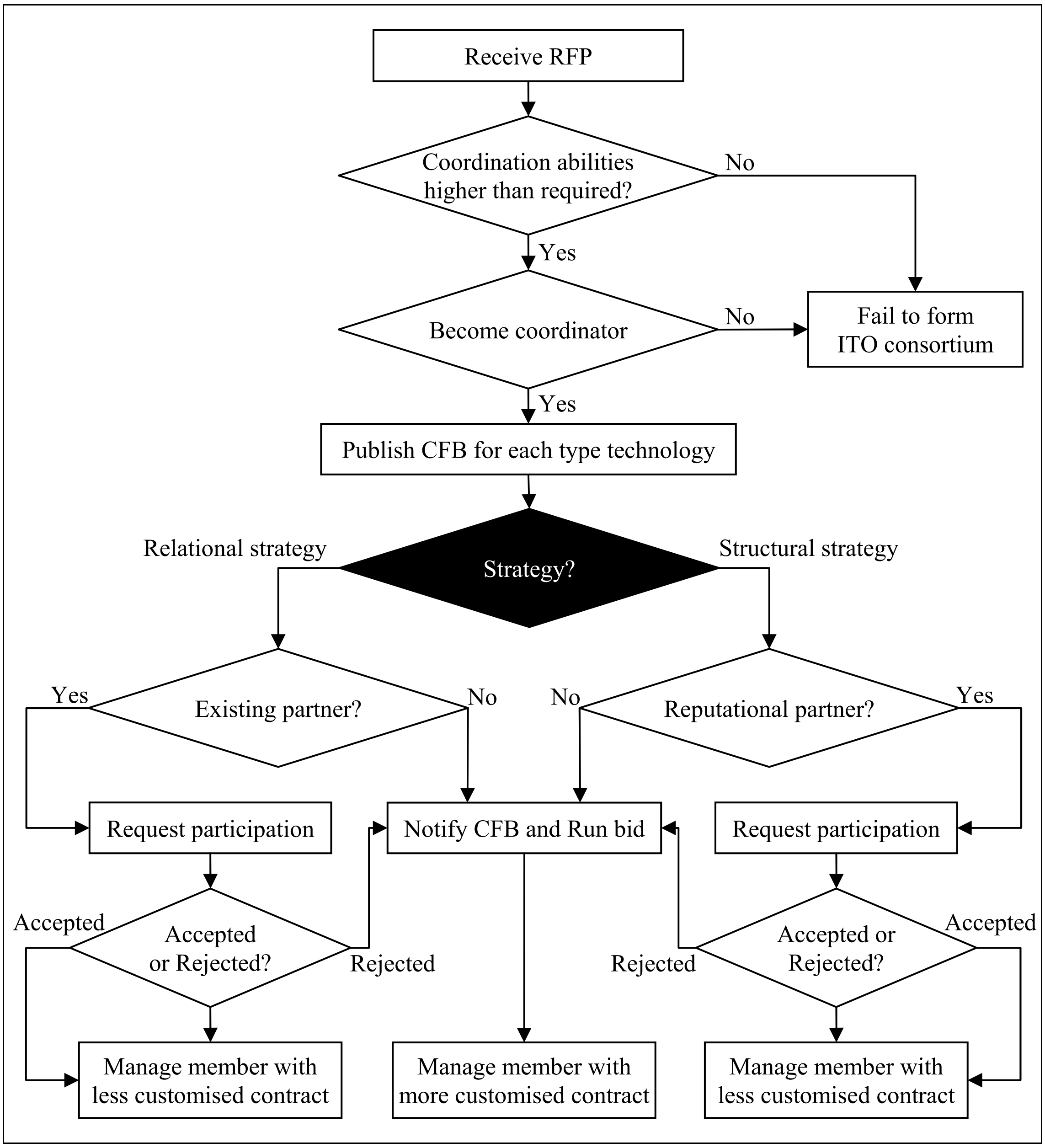
For example, let us suppose that $\beta = 0.7$ and $Prop(t) = 0.8$. In this case, seventy percent of the technological requirements in **RFP**(t) can be verified. Also, eighty percent of them have been achieved although this proportion cannot be exactly measured. Then, the quality is evaluated as satisfactory. An IT service with the high value of β is involved in the commodity type of ITO. In contrast, the comprehensive type of ITO includes an IT service with the low value of β.

The randomness for measurement difficulty originates in a combination of *Prop*(t) and β. Above all, a coordinator cannot always select cooperative partners. Therefore, *Prop*(t) has a wide range of values between 0 and 1 according to the number of opportunistic partners in the winning ITO consortium. Furthermore, it is difficult to exactly measure this proportion. Therefore, the quality evaluation result is subject to *Prop*(t) and β. For example, although *Prop*(t) is low, the quality is assessed as satisfactory if β is lower than *Prop*(t). On the contrary, it is evaluated as unsatisfactory if β is higher than *Prop*(t).

In the simulation model, measurement difficulty is related to the correctness of information on (potential) partners. At the high level of measurement difficulty, the quality of a delivered IT service may be evaluated as satisfactory although its actual quality is low. In this case, consortium members' opportunistic behaviour is not detected and hence incorrect information on them is distributed across an ITO network. Moreover, coordinators need to use more coordination abilities to control their partners' behaviour and to exactly measure their performance when it is difficult to measure outcomes (Barthelemy, 2001).

4.5 Coordinator's Decision-Making

Figure 4-3 Coordinator's Decision-Makings



The central issue in this research is the tension between relational and structural embeddedness in selecting and controlling ITO consortium members. A coordinator taking the relational or structural strategy attempts to form an ITO consortium with existing partners who are coupled through strong ties or reputational partners who occupy prominent network positions. Furthermore, the type of its strategy makes a difference in the hidden costs of managing members (Barthelemy, 2001; Gopal *et al.*, 2003; Poppo and Zenger, 2002). With a focus on the relational and structural strategy, this section explains a coordinator's decision-makings, which are schematically shown in Figure 4-3.

4.5.1 Whether to Become Coordinator

When receiving **RFP**(t), a vendor (v_{ij}) can be qualified for a coordinator if

$$a_{ij}(t) \geq pa(t),$$

which means that the level of its coordination abilities is higher than that is required in the RFP. However, in order to prevent too many coordinators from forming their ITO consortia in the simulation, p_1 percent of the vendors satisfying this condition are randomly selected as coordinators.

4.5.2 Publication of Call-for-Bids (CFB)

A coordinator publishes CFBs to secure resources which are necessary to cover the technological requirements in the RFP. Again, let v_{ij} be a coordinator. Then, this coordinator does not need to find a partner to provide resources for the i th type of technology if

$$r_{ij}(t) \geq pr_i(t)$$

because it has enough resources for this type of technology. On the other hand, v_{ij} needs to additionally secure resources which are necessary to cover the requirement for the i th type of technology if

$$r_{ij}(t) < pr_i(t)$$

since the amount of its resources is smaller than that is required in the RFP.

For the convenience of the description, let $r_{ij}(t) \geq pr_i(t)$ and $r_{ij}(t) < pr_i(t)$ be the condition 1 (C1) and condition 2 (C2) respectively. Also, let $CFB_{ijx}(t)$ be the CFB which v_{ij} publishes to secure resources for the x th type of technology required in **RFP**(t). Then, v_{ij} publishes the following CFBs to secure resources under C1.

$$CFB_{ij1}(t), CFB_{ij2}(t), \cdots, CFB_{i,j,i\text{-}1}(t), CFB_{i,j,i+1}(t), \cdots, CFB_{ijm}(t),$$

where $CFB_{ijx}(t) = [br_{ijx}(t)]$ and $br_{ijx}(t) = pr_x(t)$ $(x \neq i)$. Under this condition, v_{ij} has enough resources for the i th type of technology. Therefore, it can cover this technological requirement for itself. On the other hand, the coordinator additionally publishes the following CFB to compensate for the lack of resources for the i th type of technology under C2.

$$CFB_{iji}(t),$$

where $\text{CFB}_{iji}(t) = [br_{iji}(t)]$ and $br_{iji}(t) = pr_i(t) - r_{ij}(t)$.

4.5.3 Relational vs. Structural Strategy

A coordinator taking the relational strategy prefers an existing partner who is strongly connected through prior working experience. Let

$$p_{ij\leftrightarrow xy}(t) \quad (4\text{-}5)$$

be v_{ij}'s cumulative profit gained through the join in ITO consortia together with v_{xy} until the period of $t - 1$. Then, this indicator can denote the strength of the tie between v_{ij} and v_{xy} (Uzzi, 1996).

Let $v_{ij\leftrightarrow x,p\max}(t)$ be the vendor with the maximum value of $p_{ij\leftrightarrow xy}(t)$. Then, v_{ij} such as s_{ij} = +1 (i.e. taking the relational strategy) requests

$$v_{ij\leftrightarrow x,p\max}(t)$$

to attend its ITO consortium for the x th type of technology.

Alternatively, a coordinator employing the structural strategy favours a reputational partner who occupies a prominent network position. Let $c_{xy}(t)$ be v_{xy}'s degree centrality at the period of t. Then, this measurement can indicate the extent to which v_{xy} is prominent in an ITO network (Wasserman and Faust, 1994) and is calculated as follows.

$$c_{xy}(t) = \frac{\sum_{v=1}^{m}\sum_{u=1}^{n_u} r_{uv\leftrightarrow xy}(t)}{\sum_{v=1}^{m} n_v}, \quad (4\text{-}6)$$

where $r_{uv\leftrightarrow xy}(t)$ = +1 if v_{uv} has the experience of participating in ITO consortia together with v_{xy} between the period of 1 and $t-1$, or 0 if it has no experience. In addition to information gained through the observation of network positions, the coordinator actively uses information transferred through indirect ties. That is, although v_{ij} has no experience of joining ITO consortia together with v_{xy}, the coordinator can know about this potential partner's behavioural tendency through the information transmission via third parties. Therefore, in the case where v_{ij} receives information on v_{xy}'s tendency to behave opportunistically, the coordinator does not request this candidate to participate in its ITO consortium although $c_{xy}(t)$ is high.

Let $v_{ij\leftrightarrow x,c\max}(t)$ be the vendor with the maximum value of $c_{xy}(t)$ among candidates who are perceived to be cooperative by v_{ij}. Then, v_{ij} such as $s_{ij} = -1$ (i.e. taking the structural strategy) asks

$$v_{ij\leftrightarrow x,c\max}(t)$$

to participate in its ITO consortium for the x th type of technology.

In the meantime, when there is no such existing or reputational partner or when $v_{ij\leftrightarrow x,p\max}(t)$ or $v_{ij\leftrightarrow x,c\max}(t)$ rejects the request to join, v_{ij} notifies $CFB_{ijx}(t)$ to vendors who have resources for the x type of technology and unavoidably uses a competitive tender to find its member. However, it incurs the substantial hidden costs involved in running a bid, which is denoted by bc in the simulation model.

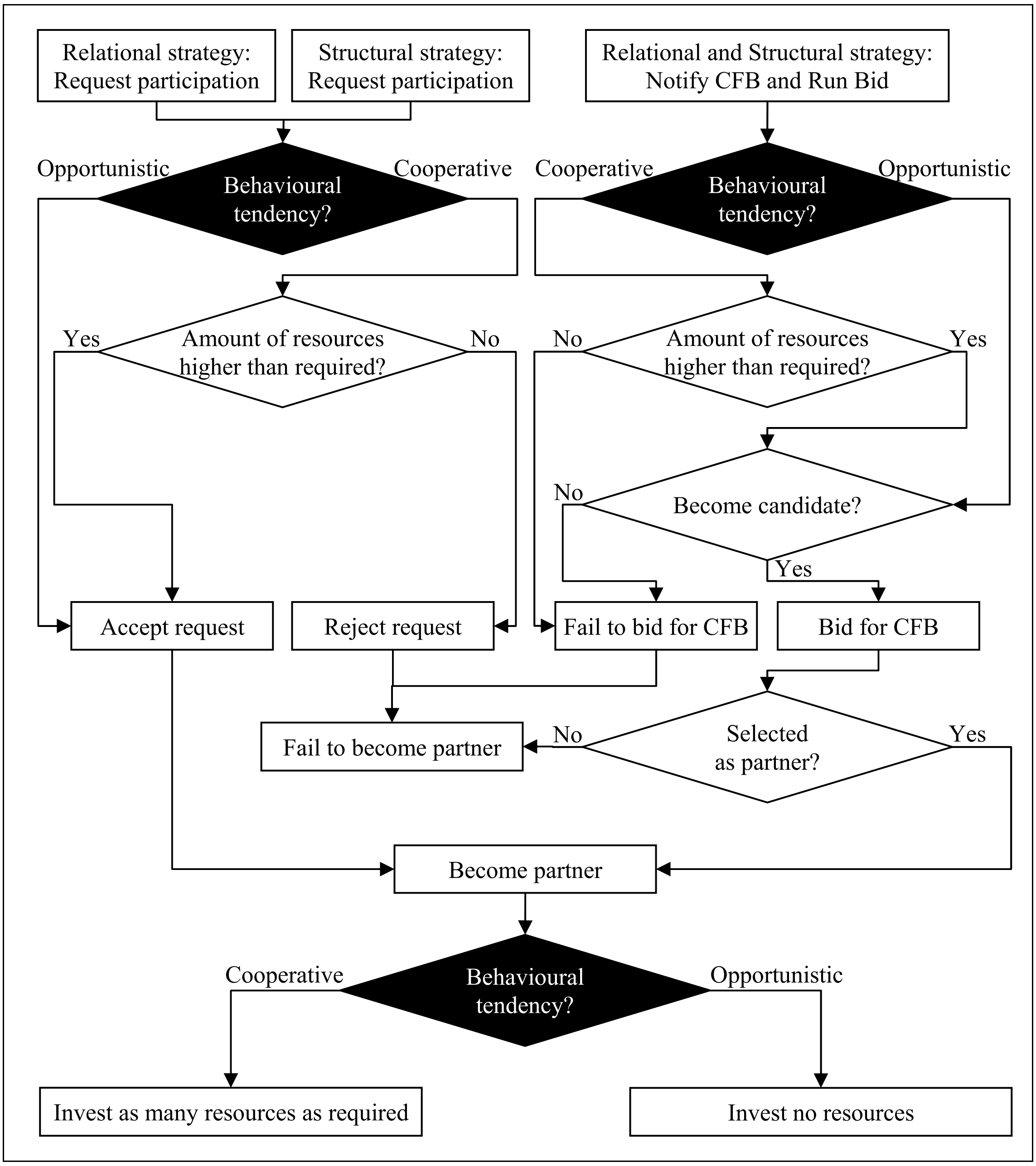
Next, let us suppose that an ITO consortium is selected as the winner. When the winning consortium coordinator takes the relational strategy, an existing partner who is connected through a strong tie can be managed with lower hidden costs, which is represented by rc in the model. Alternatively, when the coordinator employs the structural strategy, a reputational partner who occupies a prominent network position is likely to be more suitable for a given technological requirement. However, the coordinator should bear the higher hidden costs of controlling this partner because they are not completely committed to each other. In the simulation model, the hidden costs of managing a reputational member are represented by sc. Finally, when a partner is selected via a competitive tender, the coordinator needs to design more customised contract clauses and to more strictly enforce them. In this case, these formal mechanisms incur considerable hidden costs, which are indicated by cc in the model. Also, based on this reasoning, the simulation model makes the following assumption on the hidden costs involved in selecting and controlling a partner.

$$rc < sc < bc + cc. \quad (4\text{-}7)$$

4.6 Partner's Decision-Making

A cooperative (potential) partner attempts to participate in an ITO consortium only when it has enough resources to cover a technological requirement, and invests as many resources as required. However, an opportunistic one tries to become a consortium member by exaggerating its current resource availability (i.e. adverse selection) and inputs no resources for its own interests (i.e. moral hazard) (Eisenhardt, 1989; Kandori, 1992; Shapiro and Stiglitz, 1984). Figure 4-4 schematically illustrates the decision-makings of a (potential) partner.

Figure 4-4 Partner's Decision-Making



When a vendor is requested to participate in an ITO consortium by a coordinator taking the relational or structural strategy, it decides whether to accept this asking. Let

$v_{ij\leftrightarrow x,p\max}(t)$ or $v_{ij\leftrightarrow x,c\max}(t)$ be v_{xy} again. Then, v_{xy} such as b_{xy} = +1 (i.e. behaving cooperatively) agrees to the request and become a partner only if it satisfies

$$r_{xy}(t) \geq br_{ijx}(t),$$

which means that the amount of its resources is higher than that is required.

In contrast, v_{xy} such as b_{xy} = −1 (i.e. behaving opportunistically) accepts the request

regardless of its current resource availability.

That is, although the vendor cannot cover the requirement for the x th type of technology, it agrees to this asking and becomes a partner. This deceit may induce the coordinator to select an unqualified partner (Aubert *et al.*, 1998).

When a CFB is notified for a competitive tender, the behaviour of a bidder is similar to that of a vendor requested to attend an ITO consortium. A cooperative bidder decides to apply to become a consortium member only if it can cover the technological requirement. On the contrary, an opportunistic candidate unconditionally bids for the CFB. This deception may also induce the coordinator to choose an incompetent partner (Aubert *et al.*, 1998). In the meantime, in order to prevent too many vendors from bidding, p_2 percent of the cooperative vendors satisfying the above condition and the opportunistic vendors are randomly selected as bidders. Let v_{xy} be a bidder in case of the notification of CFB_{ijx}(t). Then, v_{xy} such as b_{xy} = +1 (i.e. behaving cooperatively) submits a bid which represents that the amount of its resources is

$$r_{xy}(t).$$

On the other hand, v_{xy} such as b_{xy} = −1 (i.e. behaving opportunistically) submits a bid which indicates that the quantity of its resources is

$$r_{xy}(t) \text{ if } r_{xy}(t) \geq br_{ijx}(t) \text{ or } br_{ijx}(t) \text{ if } r_{xy}(t) < br_{ijx}(t).$$

Then, the coordinator selects the candidate submitting the bid with the largest amount of resources as a partner.

Next, let us suppose that v_{xy} becomes a partner for the x th type of technology and the ITO consortium which it belongs to is selected as the winner by the market. Then, v_{xy} such as $b_{xy} = +1$ (i.e. behaving cooperatively) invests as many resources as the coordinator requires while v_{xy} such as $b_{xy} = -1$ (i.e. behaving opportunistically) spends no resources for its own interests. This breach may decrease the quality of an IT service (Aubert *et al.*, 1998).

4.7 Profits

The decision-makings and profits of ITO consortium members follow a modified game model based on a mixture of the following two game models. The game model developed by Shapiro and Stiglitz (1984) describes the repetition of transactions between a specific employer and employee. The authors show that this iteration can serve as a mechanism to safeguard against opportunism and improve long-term outcomes. However, particular members may not repeatedly build their consortium for each outsourcing opportunity in the context of ITO (Ravindran *et al.*, 2009). The game model developed by Kandori (1992) reveals that the roles of the repeatedness can be substituted with the direct observation of various labels (e.g. reputation, membership and license) or the indirect collection of this information through third parties. In addition, the author suggests that a norm such that an opportunistic member is permanently expelled from a community can serve as an alternative to the repeatedness. Following the results, the simulation model assumes that vendors in an ITO network can update and transfer information on others' tendencies to behave cooperatively or opportunistically through the observation of network positions and the information transmission via indirect ties. It is also assumed that they share a norm such that a vendor is deprived of its further outsourcing opportunities when its opportunistic behaviour is detected. Then, the sharing of this information and norm can promote a partner's cooperation even in a one-time outsourcing relationship. Therefore, a combination of the two game models enables the analyses of the decision-makings and profits for both cases of the relational and structural strategy in the simulation model.

The profits of the winning consortium members are calculated for four cases according to the assessment result of a delivered IT service and the sufficiency of the winning consortium coordinator's resources as shown in Table 4-1.

Table 4-1 Profits for Four Cases

Case	C1 such as $r_{ij}(t) \geq pr_i(t)$	C2 such as $r_{ij}(t) < pr_i(t)$
Unsatisfactory quality and Opportunism detected	• Profit of coordinator such as $s_{ij} = +1$ or -1 • Profit of partner such as $b_{ij} = +1$ or -1	• Profit of coordinator such as $s_{ij} = +1$ or -1 • Profit of partner such as $b_{ij} = +1$ or -1
Satisfactory quality	• Profit of coordinator such as $s_{ij} = +1$ or -1 • Profit of partner such as $b_{ij} = +1$ or -1	• Profit of coordinator such as $s_{ij} = +1$ or -1 • Profit of partner such as $b_{ij} = +1$ or -1

4.7.1 Actual Investment

Let v_{ij} and $caa(t)$ be the winning consortium coordinator and the level of coordination abilities which are actually used by this coordinator. Also, let u, v and w be the number of existing partners for the relational strategy, the number of reputational partners for the structural strategy and the number of partners selected via bidding. Then, Table 4-2 shows the level of coordination abilities which v_{ij} actually uses.

Table 4-2 Level of Coordination Abilities Actually Used by Coordinator

Coordinator	**Actual Investment in Coordination Abilities**
v_{ij} if $s_{ij} = +1$ (Relational)	$caa(t) = pa(t) + u \times rc + w \times (bc + cc)$
v_{ij} if $s_{ij} = -1$ (Structural)	$caa(t) = pa(t) + v \times sc + w \times (bc + cc)$

In Equation (4-7), *rc* and *sc* indicates the hidden costs of managing an existing partner for the relational strategy and a reputational partner for the structural strategy respectively. Also, *bc* + *cc* represent the hidden costs of selecting and managing a partner through elaborate tender procedures, and more customised and complex contract clauses when there is no existing or reputational partner.

In the meantime, let $car(t)$ be the amount of resources which v_{ij} actually invests in the i th type of technology. Also, let v_{xy} and $par_x(t)$ be the partner for the x th type of technology and the quantity of resources which this partner actually invests in this type of technology. Then, Table 3-2 and 3-3 illustrate the amounts of resources which v_{ij} and v_{xy} invest under C1 and C2 respectively.

Table 4-3 Amount of Resources Actually Invested by Coordinator & Partner under C1

Member		**Actual Investment in Resources**
Coordinator	v_{ij} if $s_{ij} = +1$ (Relational)	$car(t) = pr_i(t)$
	v_{ij} if $s_{ij} = -1$ (Structural)	
Partner	v_{xy} if $b_{xy} = +1$ (Cooperative)	$par_x(t) = pr_x(t)$ for $x \neq i$
	v_{xy} if $b_{xy} = -1$ (Opportunistic)	$par_x(t) = 0$ for $x \neq i$

Under C1, the coordinator has enough resources for the i th type of technology. Therefore, it covers this technological requirement for itself. Also, a cooperative partner invests as many resources as required while an opportunistic one inputs no resources for its own interests.

Table 4-4 Amount of Resources Actually Invested by Coordinator & Partner under C2

Member		**Actual Investment in Resources**
Coordinator	v_{ij} if $s_{ij} = +1$ (Relational)	$car(t) = r_{ij}(t)$
	v_{ij} if $s_{ij} = -1$ (Structural)	

Table 4-4 Continued

Member		Actual Investment in Resources
Partner	v_{xy} if $b_{xy} = +1$ (Cooperative)	$par_x(t) = pr_x(t)$ for $x \neq i$ or $par_x(t) = pr_i(t) - r_{ij}(t)$ for $x = i$
	v_{xy} if $b_{xy} = -1$ (Opportunistic)	$par_x(t) = 0$

Under C2, the coordinator itself cannot cover the requirement for the i th type of technology. Therefore, a cooperative partner for this technological requirement provides resources of which the amount is $pr_i(t) - r_{ij}(t)$.

4.7.2 Payoff

The payoff awarded by the market is different according to the quality assessment of a delivered IT service. When the quality is unsatisfactory and hence the opportunistic partners for the technology type f, ···, g are detected, the market gives the following payoff to the contracted consortium.

$$PO_u(t) = R(t) - [pr_f(t) + \cdots + pr_g(t)],$$

where $R(t)$ denotes the sum of coordination abilities and resources which are necessary to cover the technological requirements in **RFP**(t) in Equation (4-3). Also, $R(t) = pa + pr_1(t) + \cdots + pr_m(t)$. Then, the coordinator allocates this payoff to its partners. A cooperative partner receives as much payoff as it invests. Conversely, an opportunistic one receives nothing. Furthermore, the consortium members punish this partner by transferring its negative information to other vendors. The vendors receiving the information will not select it as a member in their future ITO consortium establishment.

When the quality is evaluated as satisfactory, the market rewards the cooperation of the consortium with the following payoff.

$$PO_s(t) = (1 + r) \times R(t),$$

where r indicates the profit rate. Then, the coordinator allocates this payoff to its partners in proportion to their investments.

More specifically, let $cpoa(t)$, $cpor(t)$ and $ppor_x(t)$ be the payoffs which are allocated to the coordinator and partner. Then, $PO_u(t)$ if unsatisfactory or $PO_s(t)$ if satisfactory is allocated to the winning consortium members as shown in Table 4-5 under C1 and Table 4-6 under C2 respectively.

Table 4-5 Payoff under C1

Case	Member		Payoff
Unsatisfactory Quality and Opportunism Detected	Coordinator	v_{ij} if $s_{ij} = +1$	$cpoa(t) = pa(t)$ and $cpor(t) = pr_i(t)$
		v_{ij} if $s_{ij} = -1$	
	Partner	v_{xy} if $b_{xy} = +1$	$ppor_x(t) = pr_x(t)$ for $x \neq i$
		v_{xy} if $b_{xy} = -1$	$ppor_x(t) = 0$ for $x \neq i$
Satisfactory Quality	Coordinator	v_{ij} if $s_{ij} = +1$	$cpoa(t) = (1 + r) \times pa(t)$ and $cpor(t) = (1 + r) \times pr_i(t)$
		v_{ij} if $s_{ij} = -1$	
	Partner	v_{xy} if $b_{xy} = +1$	$ppor_x(t) = (1 + r) \times pr_x(t)$ for $x \neq i$
		v_{xy} if $b_{xy} = -1$	

Table 4-6 Payoff under C2

Case	Member		Payoff
Unsatisfactory Quality and Opportunism Detected	Coordinator	v_{ij} if $s_{ij} = +1$	$cpoa(t) = pa(t)$ and $cpor(t) = r_{ij}(t)$
		v_{ij} if $s_{ij} = -1$	
	Partner	v_{xy} if $b_{xy} = +1$	$ppor_x(t) = pr_x(t)$ for $x \neq i$ or $ppor_x(t) = pr_i(t) - r_{ij}(t)$ for $x = i$
		v_{xy} if $b_{xy} = -1$	$ppor_x(t) = 0$

Table 4-6 Continued

Case	Member		Payoff
Satisfactory Quality	Coordinator	v_{ij} if s_{ij} = +1	$cpoa(t) = (1 + r) \times pa(t)$ and $cpor(t) = (1 + r) \times r_{ij}(t)$
		v_{ij} if s_{ij} = −1	
	Partner	v_{xy} if b_{xy} = +1	$ppor_x(t) = (1 + r) \times pr_x(t)$ for $x \neq i$ or $ppor_x(t) = (1 + r) \times [pr_x(t) - r_{ij}(t)]$ for $x = i$
		v_{xy} if b_{xy} = −1	

4.7.3 Profit

The profit can be obtained by subtracting the actual investment from the payoff. Let $cpa(t)$, $cpr(t)$ and $ppr_x(t)$ be the profits which the coordinator and partner gain. Then, their profits are shown in Table 4-7 under C1 and Table 4-8 under C2.

Table 4-7 Profit under C1

Case	Member		Profit
Unsatisfactory Quality and Opportunism Detected	Coordinator	v_{ij} if s_{ij} = +1	$cpa(t) = -u \times rc - w \times (bc + cc)$ and $cpr(t) = 0$
		v_{ij} if s_{ij} = −1	$cpa(t) = -v \times sc - w \times (bc + cc)$ and $cpr(t) = 0$
	Partner	v_{xy} if b_{xy} = +1	$ppr_x(t) = 0$ for $x \neq i$
		v_{xy} if b_{xy} = −1	
Satisfactory Quality	Coordinator	v_{ij} if s_{ij} = +1	$cpa(t) = r \times pa(t) - u \times rc - w \times (bc + cc)$ and $cpr(t) = r \times pr_i(t)$
		v_{ij} if s_{ij} = −1	$cpa(t) = r \times pa(t) - v \times sc - w \times (bc + cc)$ and $cpr(t) = r \times pr_i(t)$
	Partner	v_{xy} if b_{xy} = +1	$ppr_x(t) = r \times pr_x(t)$ for $x \neq i$
		v_{xy} if b_{xy} = −1	$ppr_x(t) = (1 + r) \times pr_x(t)$ for $x \neq i$

Table 4-8 Profit under C2

Case	Member		Profit
Unsatisfactory Quality and Opportunism Detected	Coordinator	v_{ij} if $s_{ij} = +1$	$cpa(t) = -u \times rc - w \times (bc + cc)$ and $cpr(t) = 0$
		v_{ij} if $s_{ij} = -1$	$cpa(t) = -v \times sc - w \times (bc + cc)$ and $cpr(t) = 0$
	Partner	v_{xy} if $b_{xy} = +1$	$ppr_x(t) = 0$
		v_{xy} if $b_{xy} = -1$	
Satisfactory Quality	Coordinator	v_{ij} if $s_{ij} = +1$	$cpa(t) = r \times pa(t) - u \times rc - w \times (bc + cc)$ and $cpr(t) = r \times r_{ij}(t)$
		v_{ij} if $s_{ij} = -1$	$cpa(t) = r \times pa(t) - v \times sc - w \times (bc + cc)$ and $cpr(t) = r \times r_{ij}(t)$
	Partner	v_{xy} if $b_{xy} = +1$	$ppr_x(t) = r \times pr_x(t)$ for $x \neq i$ or $ppr_x(t) = r \times [pr_i(t) - r_{ij}(t)]$ for $x = i$
		v_{xy} if $b_{xy} = -1$	$ppr_x(t) = (1 + r) \times pr_x(t)$ for $x \neq i$ or $ppr_x(t) = (1 + r) \times [pr_i(t) - r_{ij}(t)]$ for $x = i$

4.8 Information Update and Transfer

The winning consortium members update and transfer information on one another for further outsourcing opportunities after the allocation of the payoff has been completed. Let us suppose that (1) v_{ab} and v_{cd} are two members who belong to the winning ITO consortium at the period of t (2) v_{cd}'s behavioural tendency is opportunistic (3) v_{ab} has the experience of joining ITO consortia together with v_{pq} between the period of 1 and $t - 1$ and (4) v_{pq}'s behavioural tendency was perceived to be cooperative by v_{ab}. Then, v_{ab} updates information on v_{cd}' behavioural tendency according to the quality assessment result and transfers this information to v_{pq} for further outsourcing opportunities. Moreover, in accordance with the update and transfer of the information, the matrices of the cumulative profit, relationship and perceived behavioural tendency are revised in the simulation model.

4.8.1 Cumulative Profit Matrix

In Equation (4-5), $p_{ab\leftrightarrow cd}(t)$ represents v_{ab}'s cumulative profit gained through joining ITO consortia together with v_{cd} until the period of $t - 1$. Therefore, if v_{ab} and v_{cd} are the coordinator and partner for the c th type of technology, $p_{ab\leftrightarrow cd}(t)$ and $p_{cd\leftrightarrow ab}(t)$ are revised to $p_{ab\leftrightarrow cd}(t + 1)$ and $p_{cd\leftrightarrow ab}(t + 1)$ as follows.

$$p_{ab\leftrightarrow cd}(t + 1) = p_{ab\leftrightarrow cd}(t) + [cpa(t) + cpr(t)] \text{ and}$$
$$p_{cd\leftrightarrow ab}(t + 1) = p_{cd\leftrightarrow ab}(t) + ppr_c(t).$$

Cumulative Profit at Period of $t - 1$					
Vendor	⋯	v_{ab}	⋯	v_{cd}	⋯
⋮	⋮	⋮	⋮	⋮	⋮
v_{ab}	⋯	*itself*	⋯	$p_{ab\leftrightarrow cd}(t)$	⋯
⋮	⋮	⋮	⋮	⋮	⋮
v_{cd}	⋯	$p_{cd\leftrightarrow ab}(t)$	⋯	*itself*	⋯
⋮	⋮	⋮	⋮	⋮	⋮

↓

Cumulative Profit at Period of t					
Vendor	⋯	v_{ab}	⋯	v_{cd}	⋯
⋮	⋮	⋮	⋮	⋮	⋮
v_{ab}	⋯	*itself*	⋯	$p_{ab\leftrightarrow cd}(t+1)$	⋯
⋮	⋮	⋮	⋮	⋮	⋮
v_{cd}	⋯	$p_{cd\leftrightarrow ab}(t+1)$	⋯	*itself*	⋯
⋮	⋮	⋮	⋮	⋮	⋮

4.8.2 Relationship Matrix

In Equation (4-6), $r_{ab\leftrightarrow cd}(t)$ indicates whether v_{ab} has the experience of participating in ITO consortia together with v_{cd} between the period of 1 and $t - 1$. Therefore, $r_{ab\leftrightarrow cd}(t)$ is revised to $r_{ab\leftrightarrow cd}(t + 1)$ as follows.

$$r_{ab\leftrightarrow cd}(t + 1) = +1.$$

Relationship between Period of 1 and $t - 1$			
Vendor	$\cdots$	v_{cd}	$\cdots$
$\vdots$	$\vdots$	$\vdots$	$\vdots$
v_{ab}	$\cdots$	$r_{ab\leftrightarrow cd}(t)$	$\cdots$
$\vdots$	$\vdots$	$\vdots$	$\vdots$

→

Relationship between Period of 1 and t			
Vendor	$\cdots$	v_{cd}	$\cdots$
$\vdots$	$\vdots$	$\vdots$	$\vdots$
v_{ab}	$\cdots$	$r_{ab\leftrightarrow pq}(t+1)$	$\cdots$
$\vdots$	$\vdots$	$\vdots$	$\vdots$

4.8.3 Perceived Behavioural Tendency Matrix

Let $pb_{ab\leftrightarrow cd}(t)$ be v_{cd}'s behavioural tendency perceived by v_{ab} at the period of $t - 1$. When the quality is evaluated as unsatisfactory and v_{cd}'s opportunistic behaviour is detected at the period of t, v_{cd}'s behavioural tendency is perceived to be opportunistic by v_{ab}. Therefore,

$$pb_{ab\leftrightarrow cd}(t + 1) = -1.$$

Alternatively, when the quality is assessed as satisfactory at this period, v_{ab} perceives that v_{cd} is cooperative although its actual behavioural tendency is opportunistic. Then,

$$pb_{ab\leftrightarrow cd}(t + 1) = +1.$$

Also, according to the assumption that v_{ab} has the experience of participating in ITO consortia with v_{pq} between the period of 1 to $t-1$ and v_{pq}'s behavioural tendency is perceived to be cooperative by v_{ab},

$$r_{ab\leftrightarrow pq}(t) = +1 \text{ and } pb_{ab\leftrightarrow pq}(t) = +1.$$

Then, v_{ab} transfers information on v_{cd}'s behavioural tendency to v_{pq} with the probability of pt. Therefore,

$$pb_{pq\leftrightarrow cd}(t+1) = pb_{ab\leftrightarrow cd}(t+1) \text{ with the probability of } pt$$
$$\text{if } r_{ab\leftrightarrow pq}(t) = +1 \text{ and } pb_{ab\leftrightarrow pq}(t) = +1.$$

Perceived Behavioural Tendency at Period of $t-1$					
Vendor	⋯	v_{cd}	⋯	v_{pq}	⋯
⋮	⋮	⋮	⋮	⋮	⋮
v_{ab}	⋯	$pb_{ab\leftrightarrow cd}(t)$	⋯	$pb_{ab\leftrightarrow pq}(t)$	⋯
⋮	⋮	⋮	⋮	⋮	⋮
v_{pq}	⋯	$pb_{pq\leftrightarrow cd}(t)$	⋯	*itself*	⋯
⋮	⋮	⋮	⋮	⋮	⋮

↓

Perceived Behavioural Tendency at Period of t					
Vendor	⋯	v_{cd}	⋯	v_{pq}	⋯
⋮	⋮	⋮	⋮	⋮	⋮
v_{ab}	⋯	$pb_{ab\leftrightarrow cd}(t+1)$	⋯	$pb_{ab\leftrightarrow pq}(t+1)$	⋯
⋮	⋮	⋮	⋮	⋮	⋮
v_{pq}	⋯	$pb_{pq\leftrightarrow cd}(t+1)$	⋯	*itself*	⋯
⋮	⋮	⋮	⋮	⋮	⋮

4.9 Measurements

In this research, the notion of relational or structural embeddedness is reflected in the relational or structural strategy which is taken by a coordinator. Moreover, the conditional superiority of each type of embeddedness is examined in managing members as well as in selecting partners. Therefore, five measures associated with the winning consortium coordinator are observed at the end of each period: (1) the profit for coordination abilities, (2) the number of ties, (3) the strength of ties, (4) the proportion of opportunistic partners and (5) the proportion of existing or reputational partners. In the meantime, the winning consortium coordinators are categorised into two groups to compare the two types of embeddedness: Group 1 using the relational strategy and Group 2 employing the structural strategy. Then, the following quantities for each group are calculated based on the above five measures,

4.9.1 Cumulative Profit for Coordination Abilities

Let v_{ij} be the winning consortium coordinator at the period of t. Then, its profit for coordination abilities is represented by $cpa(t)$ as shown in Table 4-7 and 4-8. Also, let $cpa_r(t)$ and $cpa_s(t)$ be the profit for Group 1 and 2 at this period. Then,

$$cpa_r(t) = \begin{cases} cpa(t) \text{ if } s_{ij} = +1 \\ 0 \text{ if } s_{ij} = -1 \end{cases} \text{ and } cpa_s(t) = \begin{cases} 0 \text{ if } s_{ij} = +1 \\ cpa(t) \text{ if } s_{ij} = -1 \end{cases}.$$

Finally, let $CPA_r(T)$ and $CPA_s(T)$ be the cumulative profit for Group 1 and 2 at the period of T. Then,

$$CPA_r(T) = \sum_{t=1}^{T} cpa_r(t) \text{ and } CPA_s(T) = \sum_{t=1}^{T} cpa_s(t).$$

4.9.2 Cumulative Number of Ties

Let v_{xy} be the partner for the x th type of technology in the winning consortium at the period of t ($x \neq i$ under C1). Also, let $nt_{ij\leftrightarrow xy}(t)$ be equal to +1 if the tie between v_{ij} and v_{xy} is newly created at this period or 0 if the tie between them was established before this period. That is,

$$nt_{ij\leftrightarrow xy}(t) = \begin{cases} +1 \text{ if } r_{ij\leftrightarrow xy}(t) = 0 \\ 0 \text{ if } r_{ij\leftrightarrow xy}(t) = +1 \end{cases}.$$

In the meantime, let $nt(t)$ be the number of ties newly built by the winning consortium coordinator at the period of t. Then,

$$nt(t) = \sum_{x=1}^{m} nt_{ij\leftrightarrow xy}(t).$$

Also, let $nt_r(t)$ and nt_s(t) be the number of new ties for Group 1 and 2 at this period. Then,

$$nt_r(t) = \begin{cases} nt(t) \text{ if } s_{ij} = +1 \\ 0 \text{ if } s_{ij} = -1 \end{cases} \text{ and } nt_s(t) = \begin{cases} 0 \text{ if } s_{ij} = +1 \\ nt(t) \text{ if } s_{ij} = -1 \end{cases}.$$

Finally, let $CNT_r(t)$ and $CNT_s(t)$ be the cumulative number of ties for Group 1 and 2 at the period of T. Then,

$$CNT_r(T) = \sum_{t=1}^{T} nt_r(t) \text{ and } CNT_s(T) = \sum_{t=1}^{T} nt_s(t).$$

In the meantime, from Equation (4.1), the total number of vendors is

$$m \times n.$$

Therefore, the maximum number of ties for each vendor is bounded by

$$m \times n - 1.$$

Also, the maximum number of possible ties for all the vendors is bounded by

$$\frac{(m \times n) \times (m \times n - 1)}{2}.$$

4.9.3 Average Strength of Ties

The average strength of ties can be obtained by dividing the cumulative profit by the cumulative number of ties. Let $AST_r(T)$ and $AST_s(T)$ be the average strength of ties for Group 1 and 2 at the period of T.

$$AST_r(T) = \begin{cases} CPA_r(T) / CNT_r(T) & \text{if } CNT_r(T) \neq 0 \\ 0 & \text{if } CNT_r(T) = 0 \end{cases} \quad \text{and}$$

$$AST_s(T) = \begin{cases} CPA_s(T) / CNT_s(T) & \text{if } CNT_s(T) \neq 0 \\ 0 & \text{if } CNT_s(T) = 0 \end{cases}.$$

4.9.4 Average Proportion of Opportunistic Partners

Let $n(t)$, $no(t)$ and $po(t)$ be the number of partners, the number of opportunistic partners and the proportion of opportunistic partners in the winning consortium at the period of t. Then,

$$po(t) = no(t) / n(t).$$

Also, let $po_r(t)$ and $po_s(t)$ be the proportion of opportunistic partners for Group 1 and 2 at this period. Then,

$$po_r(t) = \begin{cases} po(t) \text{ if } s_{ij} = +1 \\ 0 \text{ if } s_{ij} = -1 \end{cases} \text{ and } po_s(t) = \begin{cases} 0 \text{ if } s_{ij} = +1 \\ po(t) \text{ if } s_{ij} = -1 \end{cases}.$$

In the meantime, let $NW_r(T)$ and $NW_s(T)$ be the cumulative number of winning contracts for Group 1 and 2 at the period of T. Also, let $APO_r(T)$ and $APO_s(t)$ be the average proportion of opportunistic partners for Group 1 and 2 at this period. Then,

$$APO_r(T) = \begin{cases} \sum_{t=1}^{T} po_r(t) / NW_r(T) \text{ if } NW_r(T) \neq 0 \\ impossible\ \ to\ \ measure \text{ if } NW_r(T) = 0 \end{cases} \text{ and}$$

$$APO_s(T) = \begin{cases} \sum_{t=1}^{T} po_s(t) / NW_s(T) \text{ if } NW_s(T) \neq 0 \\ impossible\ \ to\ \ measure \text{ if } NW_s(T) = 0 \end{cases}.$$

In the case where $NW_r(T) = 0$, the coordinators belonging to Group 1 have won no contracts until the period of T. Therefore, it is impossible to measure the average proportion of opportunistic partners in the winning consortium, which is also the case if $NW_s(T) = 0$ for Group 2.

4.9.5 Average Proportion of Requested Partners

In contrast to a partner selected via bidding, an existing partner for Group 1 and a reputational partner for Group 2 are together called a requested partner in this research. Let $nrp(t)$ and $prp(t)$ be the number and proportion of requested partners in the winning consortium at the period of t. Then,

$$prp(t) = nrp(t) / n(t).$$

Also, let $prp_r(t)$ and $prp_s(t)$ be the proportion of requested partners for Group 1 and 2 at this period (i.e. the proportion of existing partners for Group 1 and the proportion of reputational partners for Group 2). Then,

$$prp_r(t) = \begin{cases} prp(t) \text{ if } s_{ij} = +1 \\ 0 \text{ if } s_{ij} = -1 \end{cases} \text{ and } prp_s(t) = \begin{cases} 0 \text{ if } s_{ij} = +1 \\ prp(t) \text{ if } s_{ij} = -1 \end{cases}.$$

Finally, let $APR_r(T)$ and $APR_s(t)$ be the average proportion of requested partners for Group 1 and 2 at the period of T. Then,

$$APR_r(T) = \begin{cases} \sum_{t=1}^{T} prp_r(t) / NW_r(T) \text{ if } NW_r(T) \neq 0 \\ impossible\ \ to\ \ measure \text{ if } NW_r(T) = 0 \end{cases} \text{ and}$$

$$APR_s(T) = \begin{cases} \sum_{t=1}^{T} prp_s(t) / NW_s(T) \text{ if } NW_s(T) \neq 0 \\ impossible\ \ to\ \ measure \text{ if } NW_s(T) = 0 \end{cases}.$$

As with the proportion of opportunistic partners, it is impossible to measure the average proportion of requested partners in the winning consortium in the case where $NW_r(T) = 0$ and $NW_s(T) = 0$.

4.10 Chapter Conclusion

This chapter explained the simulation model to compare relational and structural embeddedness at the different levels of technological unpredictability and measurement difficulty imposed on ITO business environments. This model included the two uncertainties, the decision-makings of coordinators and partners, the profits according to the features of consortium members, and the update and transfer of information.

Firstly, the two uncertainties were modelled as the increasing rate and instability of coordination abilities and resources necessary to cover technological requirements in a RFP and the extent to which these requirements can be verified. Also, technological unpredictability is associated with the use of elaborate tender procedures and rigorous contract clauses, and measurement difficulty is related to the correctness of information on (potential) partners' behavioural tendencies.

Secondly, the simulation model involved vendors who perform the role of either a coordinator or a partner in the establishment of ITO consortia to respond to outsourcing opportunities with the different levels of the two uncertainties. The coordinators taking the relational strategy prefer existing partners who are connected through strong ties in the perspective of relational embeddedness. Those employing the structural strategy favour reputational partners who are located in prominent network positions. They also actively utilise information transferred through third parties. Furthermore, the difference in the hidden costs between the two strategies was reflected in the simulation model. In case of partners, two types of opportunistic behaviour were modelled: adverse selection and moral hazard. That is, opportunistic (potential) partners attempt to become a consortium member by exaggerating their current resource availability (i.e. adverse selection) and input no resources for their own interests (i.e. moral hazard). This self-interest seeking with guile may induce a coordinator to select an unqualified partner and decrease the quality of a delivered IT service.

Thirdly, the profits according to the features of the winning consortium members were modelled through a modified game model. This model analytically revealed the profits of the coordinators taking the relational or structural strategy and those of the partners behaving cooperatively or opportunistically.

Fourthly, it was described how consortium members update and transfer information on one another. They revise information on other members' behavioural tendencies according to the assessment result of a delivered IT service. They also punished opportunistic members by transferring negative information to other vendors through ITO network ties.

Finally, the following measures are illustrated to compare relational and structural embeddedness: (1) the cumulative profit for coordination abilities, (2) the cumulative number of ties, (3) the average strength of ties, (4) the average proportion of opportunistic partners and (5) the average proportion of requested partners.

The simulation model is embodied in Microsoft Excel 2007 Visual Basic for Applications. Also, the implementation of simulation experiments and the analysis of results are described in the next chapter.

CHAPTER 5 Simulation Experiments and Results

5.1 Introduction

Chapter 5 provides the graphical and numerical analyses of the simulation results and includes four sections: Design of Experiments, Basic Test Results, Complete Test Results, and Interaction Effect and Comparison at End Period.

At first, simulation tests are planned with a full factorial design of experiments for efficient simulation tests and systematic analyses. This study identified the two uncertainties which exist together in ITO business environments: the uncertainty stemming from the unpredictability of technological requirements and the uncertainty originating in the difficulty in measuring performance. They are used as two factors in this experimental design.

Then, the two step simulation strategy is employed: the basic test at the selected experimental point to verify the developed simulation model and the complete tests at all the experimental points to compare relational and structural embeddedness. That is, the developed simulation model is verified through examining the consistency between the results from the basic test and those in existing studies. Next, the cumulative profits for relational and structural embeddedness are compared through analysing the results from the complete tests with this confirmed model. For this comparison, the following measures are additionally analysed: the average proportion of requested partners, the average proportion of opportunistic partners, the average strength of ties and the cumulative number of ties.

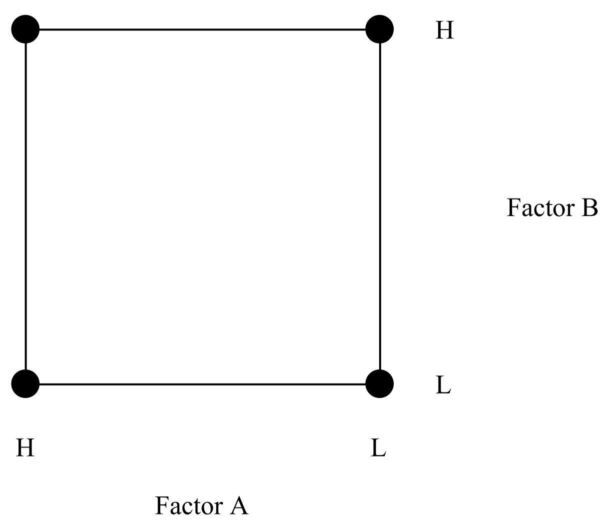
Finally, this chapter concludes with the examination of the interaction effect of the two uncertainties on the cumulative profits for the two types of embeddedness at the end period, and the comparison between them at the end period of each test point. Then, it is explicitly shown which of relational and structural embeddedness is more appropriate at the different levels of the two uncertainties in the long-term perspective.

5.2 Design of Experiments

This research adopts a full factorial design of experiments for efficient simulation tests and systematic analyses. An experimental design has two or more factors and each of them has discrete possible values, which are called levels. The combinations of levels are also called experimental points. Then, the tests at all of the possible experimental points are conducted in a full factorial design. Therefore, this experimental design is beneficial when the interaction effects of two or more factors on outcomes are investigated. Furthermore, a full factorial design including factors especially with two levels is widely used in research work because the results drawn from this fundamental design perform the role of a basis of other designs with a variety of practical levels (Montgomery, 2009).

At first, this section explains a full factorial design of experiments with two factors and two levels. Let us suppose that the effects of two factors (i.e. A and B) on the outcomes of two strategies (i.e. S1 and S2) are compared. Then, as shown in Figure 5-1, the full factorial experiments are designed in the case where each of the factors has two levels: low and high (i.e. L and H).

Figure 5-1 Full Factorial Design with Two factors and Two Levels



Let n be the number of replicates at each test point. Then, the following results are obtained after all the experiments have been completed.

Table 5-1 Observed Performance

Factor A	**Factor B**	**Strategy**	**Replicate**				**Total**
			1	2	···	n	
Low	Low	S1	$p1_{L,L,1}$	$p1_{L,L,2}$	···	$p1_{L,L,n}$	$T1_{L,L} = \sum_{k=1}^{n} p1_{L,L,k}$
		S2	$p2_{L,L,1}$	$p2_{L,L,2}$	···	$p2_{L,L,n}$	$T2_{L,L} = \sum_{k=1}^{n} p1_{L,L,k}$
	High	S1	$p1_{L,H,1}$	$p1_{L,H,2}$	···	$p1_{L,H,n}$	$T1_{L,H} = \sum_{k=1}^{n} p1_{L,H,k}$
		S2	$p2_{L,H,1}$	$p2_{L,H,2}$	···	$p2_{L,H,n}$	$T2_{L,H} = \sum_{k=1}^{n} p2_{L,H,k}$
High	Low	S1	$p1_{H,L,1}$	$p1_{H,L,2}$	···	$p1_{H,L,n}$	$T1_{H,L} = \sum_{k=1}^{n} p1_{H,L,k}$
		S2	$p2_{H,L,1}$	$p2_{H,L,2}$	···	$p2_{H,L,n}$	$T2_{H,L} = \sum_{k=1}^{n} p2_{H,L,k}$
	High	S1	$p1_{H,H,1}$	$p1_{H,H,2}$	···	$p1_{H,H,n}$	$T1_{H,H} = \sum_{k=1}^{n} p1_{H,H,k}$
		S2	$p2_{H,H,1}$	$p2_{H,H,2}$	···	$p2_{H,H,n}$	$T2_{H,H} = \sum_{k=1}^{n} p2_{H,H,k}$

In Table 5-1, $p1_{ijk}$ and $p2_{ijk}$ represent the observed outcomes of S1 and S2 respectively when A is at the i th level (for i = L, H) and B is at the j th level (for j = L, H) for the k th replicate (for $k = 1, 2, \cdots, n$).

Based on these observations, the main and interaction effects of A and B on the outcomes of S1 and S2 are calculated as follows.

Table 5-2 Main and Interaction Effects

Effect	Calculation
Main effect of A on S1	$MA_{S1} = \frac{[(T1_{H,L} + T1_{H,H}) - (T1_{L,L} + T1_{L,H})]}{2n}$
Main effect of B on S1	$MB_{S1} = \frac{[(T1_{L,H} + T1_{H,H}) - (T1_{L,L} + T1_{H,L})]}{2n}$
Main effect of A on S2	$MA_{S2} = \frac{[(T2_{H,L} + T2_{H,H}) - (T2_{L,L} + T2_{L,H})]}{2n}$
Main effect of B on S2	$MB_{S2} = \frac{[(T2_{L,H} + T2_{H,H}) - (T2_{L,L} + T2_{H,L})]}{2n}$
Interaction effect of A and B on S1	$IAB_{S1} = \frac{[(T1_{L,L} + T1_{H,H}) - (T1_{L,H} + T1_{H,L})]}{2n}$
Interaction effect of A and B on S2	$IAB_{S2} = \frac{[(T2_{L,L} + T2_{H,H}) - (T2_{L,H} + T2_{H,L})]}{2n}$

Factor A has a positive or negative effect on the performance of S1 if MA_{S1} > or < 0. Also, its statistical significance is tested with an ANOVA. This is the same for MB_{S1}, MA_{S2}, MB_{S2}, IAB_{S1} and IAB_{S2}.

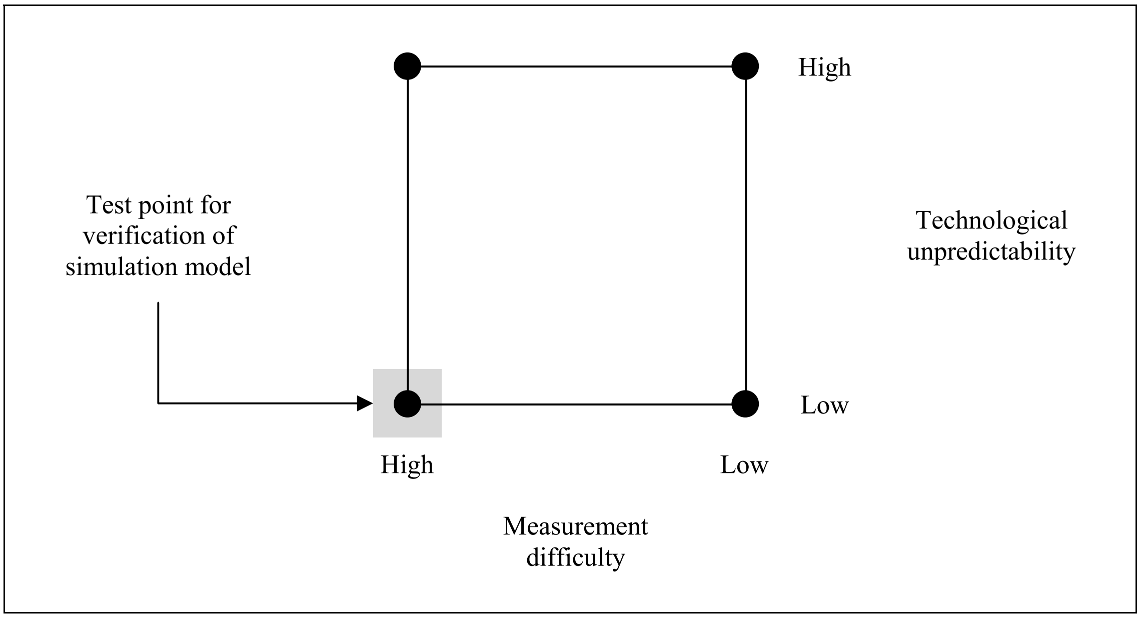
Furthermore, a T-test examines the statistical difference between the outcomes of S1 and S2 at each test point. For example,

$$\frac{T1_{L,L}}{n} \text{ and } \frac{T2_{L,L}}{n}$$

are statistically compared with a T-test at the low level of both A and B.

Turning to this research, there are two key factors involved in uncertainty imposed on ITO business environments: technological unpredictability and measurement difficulty. Each factor has two levels: low and high. Therefore, the following simulation experiments are planned with a full factorial design.

Figure 5-2 Full Factorial Design Applied to Research



In Equation (4-2) and (4-4), the two uncertainties are represented as α (i.e. the increasing rate and instability of coordination abilities and resources) and β (i.e. the degree to which technological requirements can be verified). Therefore, when technological unpredictability is at the low and high level, the value of α is set up as 0.3 and 0.7 respectively. Also, when measurement difficulty is at the low and high level, the value of β is set up as 0.7 and 0.3 respectively.

Then, the two step simulation strategy is applied: the basic test at the highlighted experimental point and the complete tests at the three remaining experimental points. Firstly, the developed simulation model is verified through the implementation of the basic test where technological unpredictability is fixed at the low level and measurement difficulty is fixed at the high level. A set of the other parameters are chosen so that they produce the results which are in line with the existing studies favouring relational embeddedness when it is difficult to measure ITO outcomes. Secondly, the complete tests based on the selected parameter set are conducted where the levels of the two uncertainties are varied simultaneously. The results from these experiments enable the investigation of the conditional superiority of relational or structural embeddedness in the presence of both uncertainties.

The experiment from the period of 1 to 150 is replicated 50 times at each test point. Also, as described earlier, the winning consortium coordinators are classified into two groups: Group 1 taking the relational strategy and Group 2 taking the structural strategy. Then, the following five measures for each group are gauged: (1) the average proportion of requested partners, (2) the average proportion of opportunistic partners, (3) the average strength of ties, (4) the cumulative number of ties and (5) the cumulative profit for coordination abilities. The first four measures are used to explain the change of the cumulative profit for each group over time. Finally, an ANOVA is employed to examine the interaction effect of the two uncertainties on the cumulative profit for each group at the end period of 150. A T-test is applied to compare the cumulative profits for the two groups at the end period at each test point. However, the main effects of the two uncertainties are not addressed in this research due to the assumption that they exist together in ITO business environments.

Finally, the two uncertainties of technological unpredictability and measurement difficulty are denoted by TU and MD respectively in the following sections for the convenience of the description. Also, the simulation experiments were conducted on a Viglen desktop computer with an Intel® Core™ i5-2320 CPU @ 3.00 GHz processor and 4.00 GB RAM.

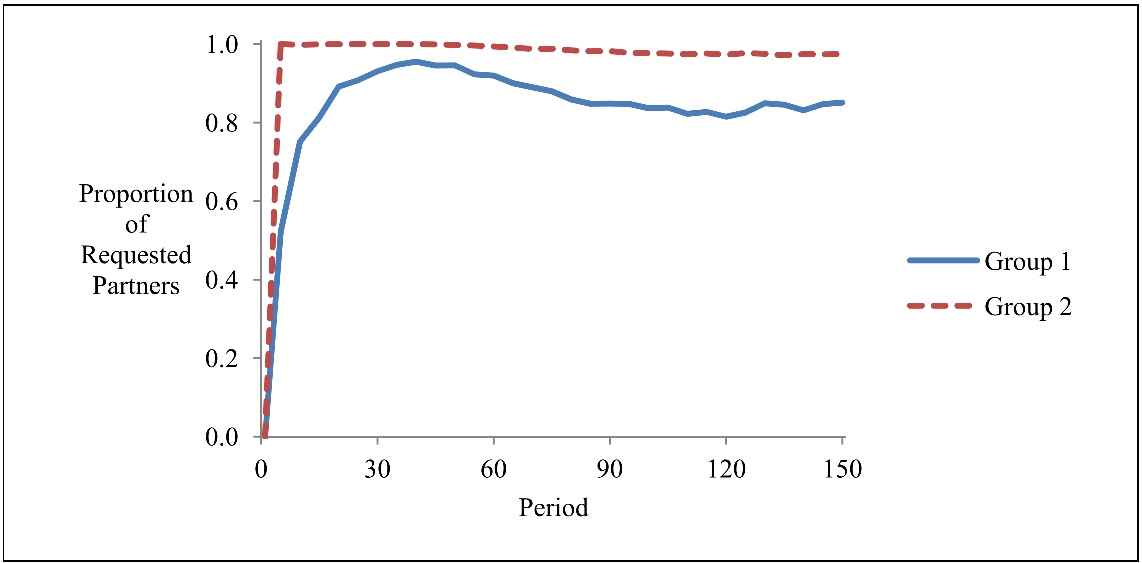
5.3 Basic Test Results

This section verifies the developed simulation model through the basic test where TU and MD are fixed at the low and high level respectively. A set of the other parameters are also selected so that they lead to the results which maintain the consistency with the existing studies preferring relational embeddedness at the high level of MD. In the meantime, the basic test results are partial in the sense that the two key factors, TU and MD, are not varied.

At the low level of TU, the amounts of resources necessary to cover technological requirements increase slowly and stably. In this case, it seems that a competitive tender is hardly used to find appropriate ITO consortium members because both existing partners for the coordinators taking the relational strategy and reputational partners for the coordinators employing the structural strategy are likely to have enough resources to respond to the slow and stable pace of change in technological requirements.

This prediction is supported by Figure 5-3 which illustrates the average proportion of requested partners (i.e. existing or reputational partners) in the winning ITO consortia. The proportion for Group 1 increases steeply until the period of about 30 and then shows a flat trend with around 0.85. On the other hand, the proportion for Group 2 stays at about 0.95 throughout the period. The high proportions for the two groups indicate that technological requirements are covered by existing partners for Group 1 and reputational partners for Group 2 respectively. Therefore, the coordinators hardly employ bidding which incurs the considerable hidden costs involved in finding proper members at the low level of TU. In the meantime, existing partners connected via strong ties can be managed with lower hidden costs although it is difficult to exactly measure ITO performance. Therefore, the relational strategy is superior in cost-effectiveness to the structural strategy.

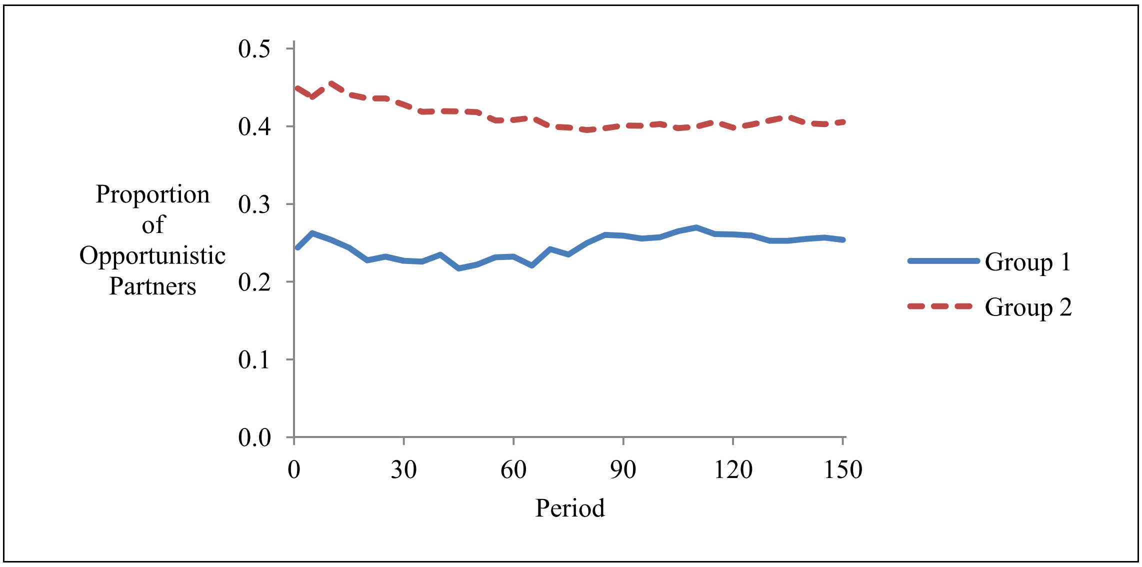
Figure 5-3 Average Proportion of Requested Partners at Low TU & High MD



In the meantime, the coordinators taking the relational strategy need time to accumulate information on potential partners because they can gain this information through the direct approach such as the participation in ITO consortia. As demonstrated in Figure 5-3, the proportion for Group 1 starts to stay at around 0.85 from the period of about 30. This means that the coordinators employing the relational strategy gather information on candidates during the period of 1 to around 30. Thereafter, based on this collected information, they establish ITO consortia mainly with existing partners who are strongly connected. On the other hand, the coordinators taking the structural strategy can easily and quickly access information on potential partners through the indirect approach such as the observation of network positions and the information transmission via third parties without joining ITO consortia. Therefore, the proportion for Group 2 shows a flat trend with about 0.95 from the initial period.

However, it is remarkable that the accessibility to this information is not in line with its accuracy. Figure 5-4 shows the average proportion of opportunistic partners in the winning ITO consortia and represents the correctness of information on members which is collected through the relational and structural strategy.

Figure 5-4 Average Proportion of Opportunistic Partners at Low TU & High MD



The proportion for each group stays at around 0.25 or 0.4 throughout the period. At the high level of MD, it is difficult to exactly measure performance and hence to detect opportunistic behaviour. Therefore, incorrect information on partners is likely to diffuse across an ITO network. In this case, the coordinators taking the relational strategy enjoy more advantages in acquiring accurate information on partners.

Figure 5-5 Cumulative Number of Ties at Low TU & High MD

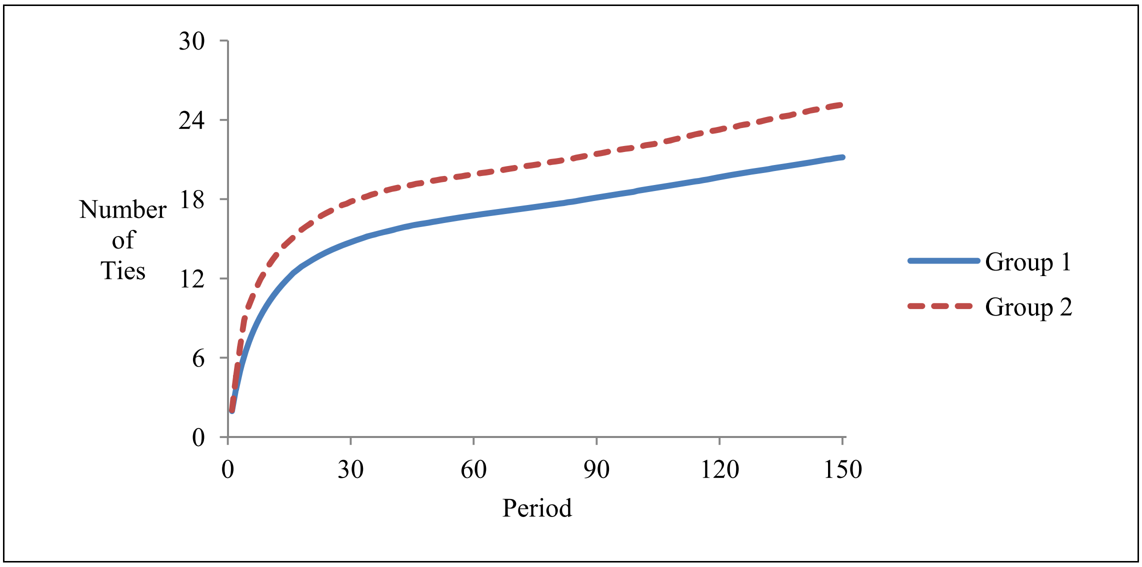


Figure 5-6 Average Strength of Ties at Low TU & High MD

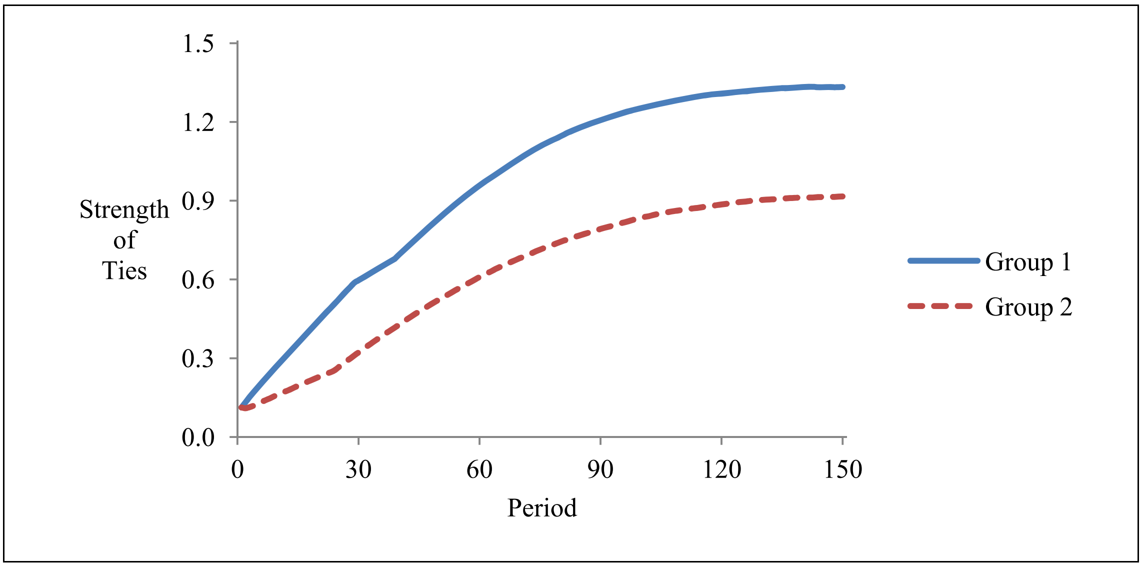


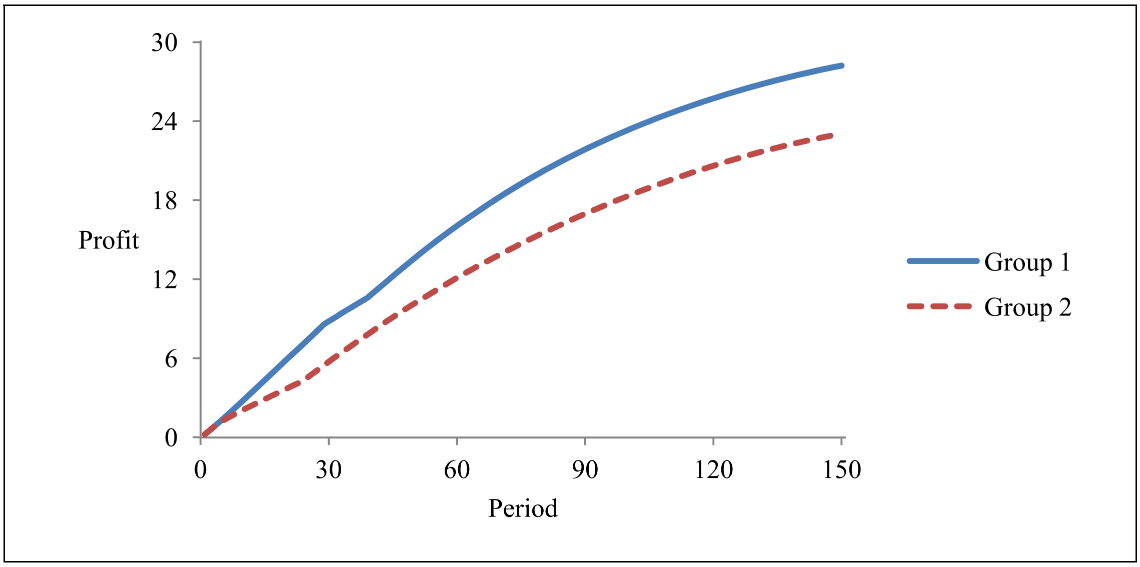
Figure 5-5 and 5-6 illustrate the cumulative number and average strength of ties of the coordinators in the winning ITO consortia respectively. As explained previously, the coordinators taking the relational strategy collect information on candidates through the participation in ITO consortia during the period of 1 to about 30. ITO ties are created during the process of this participation and hence the cumulative number for Group 1 increases steeply until this period. After that, based on this collected information, these coordinators form ITO consortia mainly with existing partners who are strongly coupled and hence just a few new ITO ties are generated. As a result, the cumulative number goes up gently and the average strength becomes higher as time passes as demonstrated in Figure 5-5 and 5-6.

On the other hand, the network positions of potential partners denote their capabilities to cover technological requirements. At the low level of TU, the higher network positions of several candidates at the initial period act as a signal indicating that they can continue to effectively deal with the slow and stable pace of change in technological requirements. Therefore, the coordinators taking the structural strategy build ITO consortia mainly with these candidates. However, the access to information on multiple alternative candidates and the replacement of partners based on this information are easier for Group 2. Therefore, if there are any potential partners with higher network positions, these coordinators build ITO consortia with them. As a result, Group 2 maintains a little large number of weak ITO ties as shown in Figure 5-5 and 5-6.

The analysis of the above results enables the prediction of ITO outcomes at the low level of TU and the high level of MD. The research of Hansen (1999) addresses the roles of weak and strong network ties in searching and transferring tacit knowledge. It is argued that weak ties are more advantageous to search the location of this knowledge in a network while strong ties are more beneficial to send and receive this knowledge. Turning to this research, the tacitness of information on potential partners is likely to be high when it is difficult to exactly measure ITO performance. In this case, the relational strategy to maintain strong ties is superior in information correctness to the structural strategy to sustain weak ties. Also, the coordinators taking the relational strategy do not need to search multiple alternative candidates because existing partners connected through strong ties can sufficiently respond to the low level of TU. Furthermore, these partners can be managed with lower hidden costs although it is difficult to measure ITO performance. Therefore, Group 1 can perform better performance than Group 2.

Figure 5-7 demonstrates the cumulative profit of the coordinators in the winning ITO consortia. At the initial period, there is little difference between the cumulative profits for Group 1 and 2. However, Group 1 gains more profits than Group 2 as time passes.

Figure 5-7 Cumulative Profit at Low TU & High MD



These results from the basic test are supported by relational exchange theory and empirical ITO research. In the relational exchange perspective, a present transaction between specific partners is not regarded as a one-time occasion but rather as a bridge which links their past and future transactions. They are willing, therefore, to bear short-term inequities because they believe that the inequities will be compensated for by their long-term joint success, and this shared belief can reduce the costs involved in the precise measurement of performance (Kronman, 1985). In addition, the costs of switching or managing a partner can be saved through the repetition or long-term maintenance of their current outsourcing relationship (Gopal *et al.*, 2003; Hill, 1990). In fact, it is empirically shown that ITO outcomes are enhanced by the experience of working together, the duration of an outsourcing relationship and the expectation of continuity (Kim *et al.*, 2003; Kim and Chung, 2003; Lee and Kim, 1999). Several studies also reveal that measurement difficulty and opportunism are not significantly related to the outcomes of an ITO relationship between relationally embedded partners (Goo *et al.*, 2007; Kim and Chung, 2003).

Finally, Table 5-3 shows the numerical results at the basic test point at the low level of TU and the high level of MD.

Table 5-3 Numerical Results at Low TU & High MD

Period		**1**	**30**	**60**	**90**	**120**	**150**
Proportion of requested partners	Group 1	0.00	0.93	0.92	0.85	0.82	0.85
	Group 2	0.00	1.00	0.99	0.98	0.97	0.97
Proportion of opportunistic partners	Group 1	0.24	0.23	0.23	0.26	0.26	0.25
	Group 2	0.45	0.43	0.41	0.40	0.40	0.41
Cumulative number of ties	Group 1	2	15	17	18	20	21
	Group 2	2	18	20	21	23	25
Average strength of ties	Group 1	0.11	0.60	0.96	1.21	1.31	1.33
	Group 2	0.11	0.32	0.61	0.79	0.89	0.92
Cumulative profit	Group 1	0.22	8.80	16.05	21.86	25.73	28.22
	Group 2	0.23	5.74	12.11	16.98	20.61	23.06

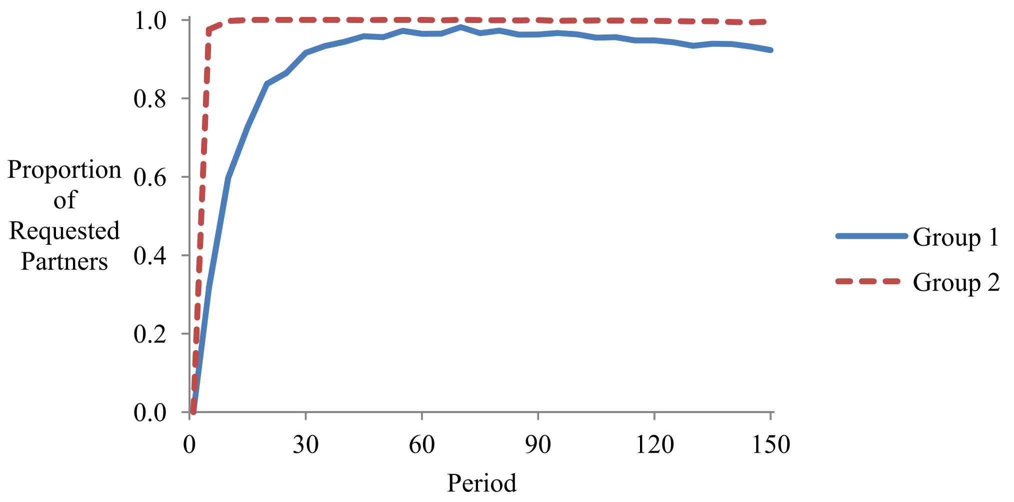
5.4 Complete Test Results

In the previous section, the developed simulation model was verified through examining the consistency between the results and those in existing studies. This section addresses the main research question with this confirmed model: which of the two types of embeddedness is more appropriate for improving long-term performance at the different levels of the two uncertainties? In order to answer this question, the two key factors, technological unpredictability (TU) and measurement difficulty (MD), are varied from the low level to the high level while the values of the other parameters are fixed as determined in the basic test.

5.4.1 Low Level of TU and Low Level of MD

The results at the experimental point of the low level of TU and the low level of MD are similar with those at the basic test point of the low level of TU and the high level of MD. At first, Figure 5-8 shows the average proportion of requested partners.

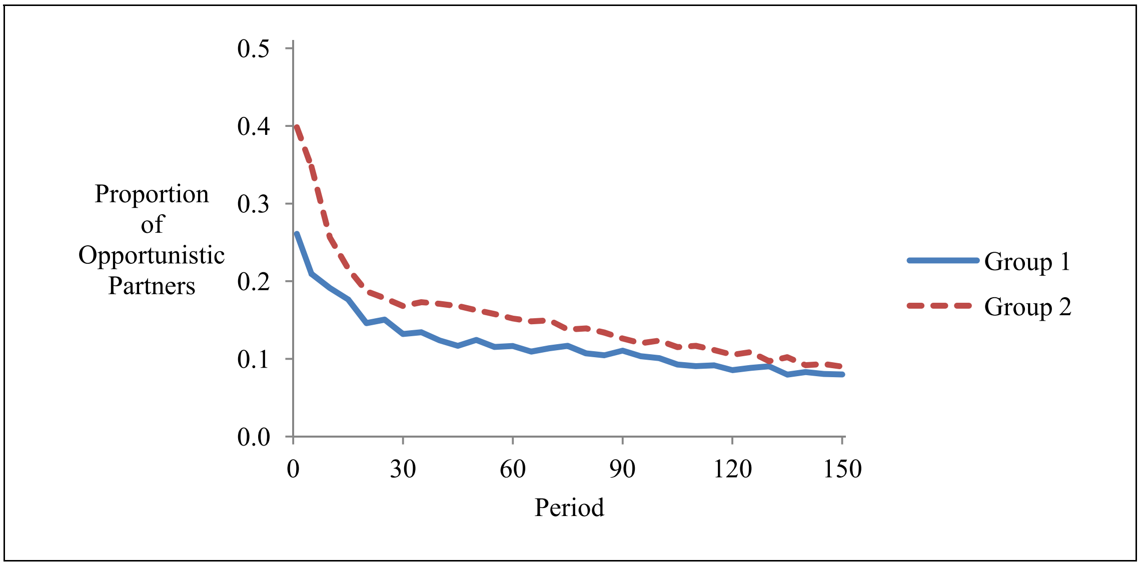
Figure 5-8 Average Proportion of Requested Partners at Low TU & Low MD



The high proportion for each group indicates that the coordinators taking the relational or structural strategy build ITO consortia mainly with existing partners who are strongly connected or reputational partners who occupy prominent network positions. Also, even at the low level of MD, the hidden costs of managing existing partners for Group 1 is lower than those of controlling reputational partners for Group 2. Therefore, the relational strategy is superior in cost-effectiveness to the structural strategy. In the meantime, the proportions for Group 1 and 2 start to stay at the high level from the period of around 30 and from the initial period respectively. Therefore, the structural strategy is more advantageous in information accessibility than the relational strategy.

Figure 5-9 illustrates that the coordinators taking the relational strategy enjoy a little more advantages in information correctness than those employing the structural strategy.

Figure 5-9 Average Proportion of Opportunistic Partners at Low TU & Low MD



It is interesting that the proportions for both groups generally decrease over time at this experimental point because MD is at the low level.

Figure 5-10 and 5-11 demonstrate the cumulative number and average strength of ties respectively. As with the basic test results, Group 1 maintains a small number of strong ties while Group 2 sustains a somewhat large number of weak ties.

Figure 5-10 Cumulative Number of Ties at Low TU & Low MD

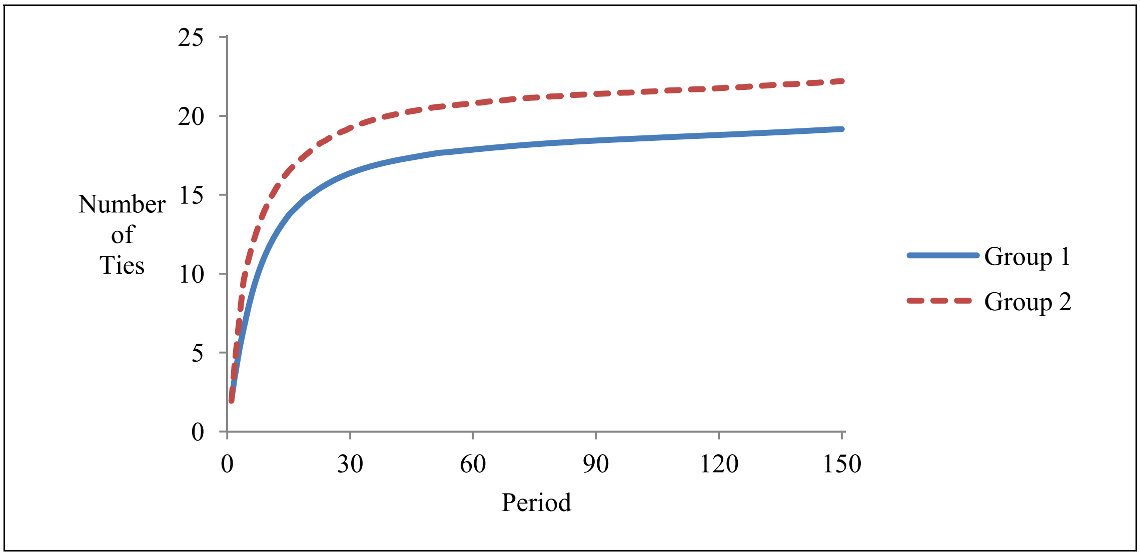
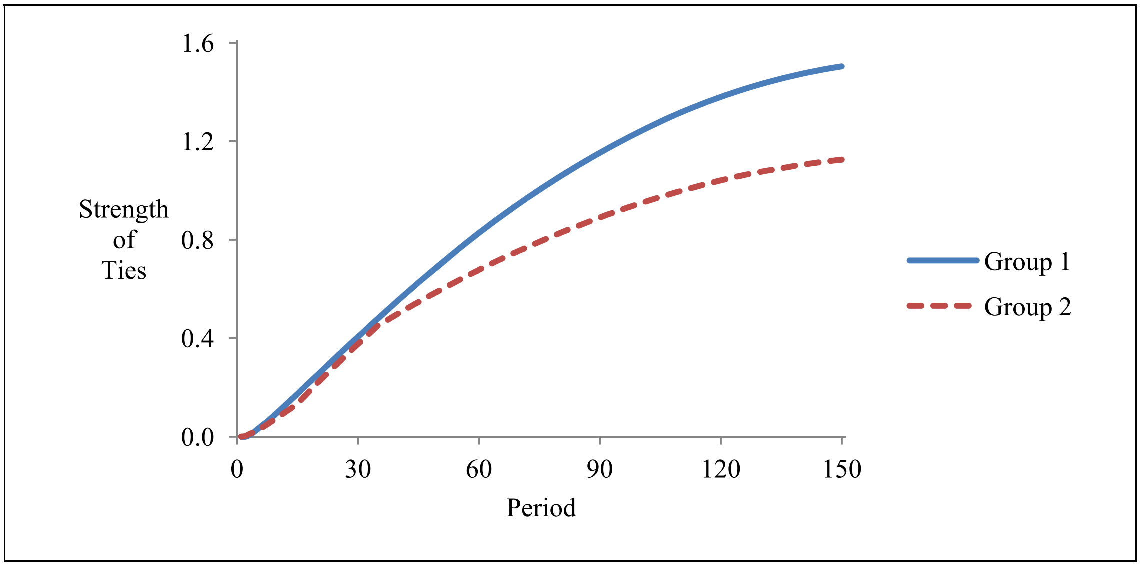


Figure 5-11 Average Strength of Ties at Low TU & Low MD



The coordinators taking the relational strategy can gather more accurate information on partners than those employing the structural strategy. Also, they can sufficiently respond to the low level of TU mainly with existing partners who are coupled via strong ties. Moreover, these partners can be controlled with the lower hidden costs even at the low level of MD. Therefore, the relational strategy is likely to be more appropriate than the structural strategy at the low level of TU and the low level of MD.

Figure 5-12 Cumulative Profit at Low TU & Low MD

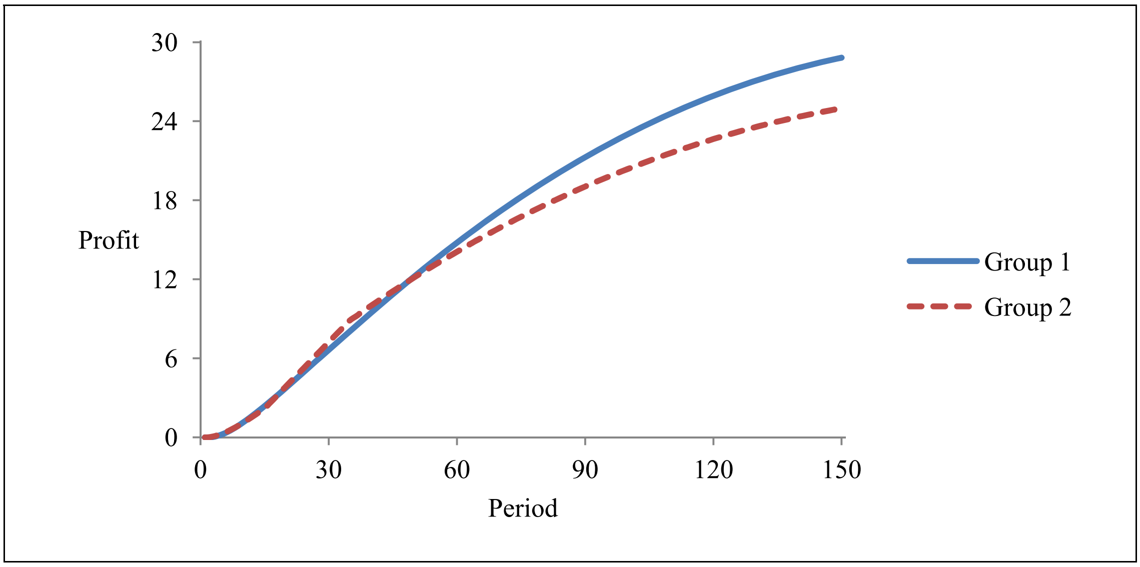


Figure 5-12 shows the cumulative profit. At the initial period, the cumulative profits for Group 1 and 2 increase similarly. However, Group 1 gains more profit than Group 2 over time.

Finally, Table 5-4 illustrates the numerical results at the experimental point of the low level of TU and the low level of MD.

Table 5-4 Numerical Results at Low TU& Low MD

Period		**1**	**30**	**60**	**90**	**120**	**150**
Proportion of requested partners	Group 1	0.00	0.93	0.96	0.96	0.95	0.92
	Group 2	0.00	1.00	1.00	1.00	1.00	1.00
Proportion of opportunistic partners	Group 1	0.26	0.13	0.12	0.11	0.09	0.08
	Group 2	0.40	0.17	0.15	0.13	0.11	0.09
Cumulative number of ties	Group 1	2	16	18	18	19	19
	Group 2	2	19	21	21	22	22
Average strength of ties	Group 1	0	0.41	0.83	1.15	1.38	1.50
	Group 2	0	0.38	0.68	0.89	1.04	1.13
Cumulative profit	Group 1	0	6.64	14.79	21.26	25.92	28.82
	Group 2	0	7.24	14.09	19.05	22.65	24.99

5.4.2 High Level of TU and High Level of MD

The results at this experimental point provide an answer to the most interesting question in this research: which of the two types of embeddedness is more appropriate at the high level of both TU and MD. At the high level of TU, the amounts of resources necessary to cover technological requirements increase fast and unstably. In this case, it seems that the coordinators taking the relational strategy need to use a competitive tender to find proper partners because they may not be able to flexibly respond to the high level of TU with only existing partners and may face the problem of overembeddedness (Gargiulo and Benassi, 2000; Gulati and Westphal, 1999). On the other hand, it seems that the coordinators employing the structural strategy can effectively deal with the high level of TU by collecting information on multiple alternative candidates through the observation of network positions and the information transmission via third parties, and by selecting more competent partners based on this information.

Figure 5-13 Average Proportion of Requested Partners at High TU & High MD

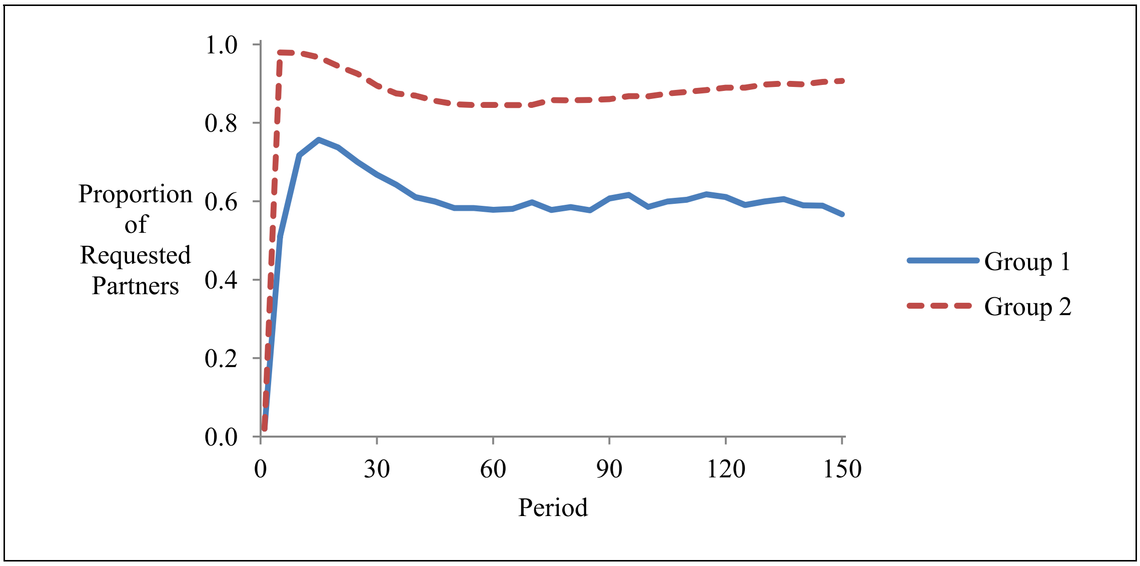


Figure 5-13 demonstrates the average proportion of requested partners. The proportion for Group 1 increases steeply until the period of around 30 and then shows a flat trend with around 0.6. On the other hand, the proportion for Group 2 stays at about 0.9 throughout the period. It is worthwhile to note that the proportion for Group 1 at this experimental point is generally lower than those at the two previous test points. The low proportion indicates that the coordinators taking the relational strategy unavoidably employ a competitive tender to choose competent members who can respond to the high level of TU. Moreover, the partners selected via bidding need to be managed by more rigorous formal contracting at the high level of MD. Therefore, the coordinators in Group 1 should bear the considerable hidden costs involved in selecting and controlling partners. On the other hand, there is little difference between the proportions for Group 2 at this experimental point and at the two previous test points. Therefore, the structural strategy is superior in cost-effectiveness to the relational strategy. In the meantime, the high proportion for Group 2 from the initial period indicates that the structural strategy is more advantageous in information accessibility than the relational strategy.

Figure 5-14 demonstrates the average proportion of opportunistic partners. It is notable that there is little difference between the proportions for Group 1 and 2. As shown in Figure 5-13, around forty percent of the members in the winning ITO consortia built by Group 1 are selected via a competitive tender. The correctness of information on partners collected through bidding is not likely to be higher than that of this information shared through strong ties. Therefore, the accuracy for Group 1 becomes lower and is not much higher than that for Group 2, which is different from the results at the previous two test points.

Figure 5-14 Average Proportion of Opportunistic Partners at High TU & High MD

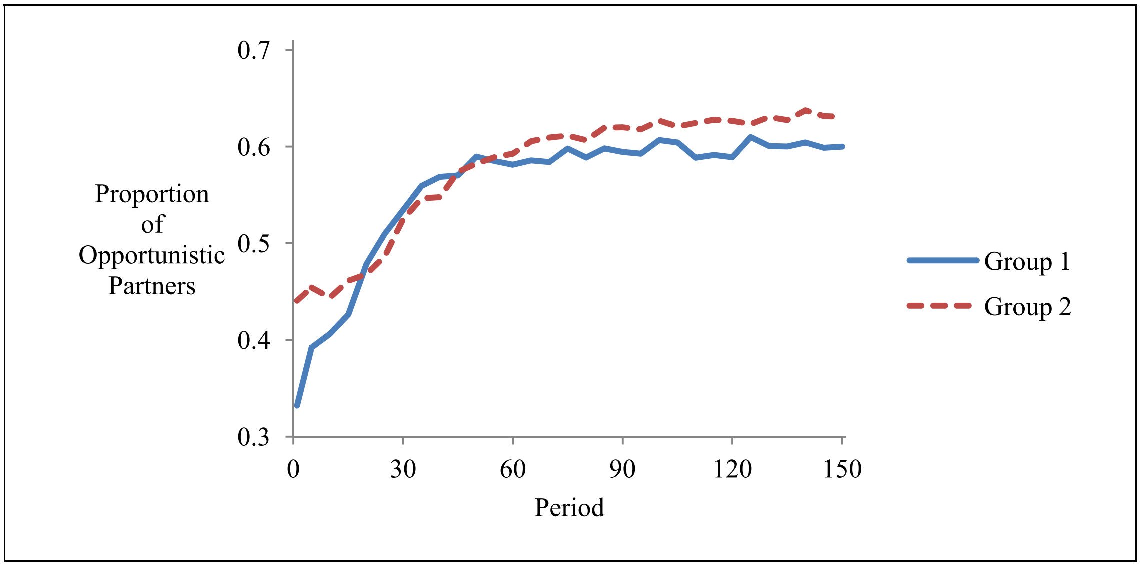


Figure 5-15 shows the cumulative number of ties. At the high level of TU, the fast and unstable pace of change in technological requirements is likely to be beyond the coverage of existing partners for Group 1. Therefore, the coordinators taking the relational strategy select new members who can respond to the high level of TU via bidding as shown in Figure 5-13. As a result, the cumulative number of ties for Group 1 increases constantly until the end period. A similar trend is found in the cumulative number of ties for Group 2. The coordinators taking the structural strategy easily and quickly access information on multiple alternative candidates through the observation of network positions and the information transmission via third parties, and establish ITO consortia with new partners who can respond to the high level of TU.

Figure 5-15 Cumulative Number of Ties at High TU & High MD

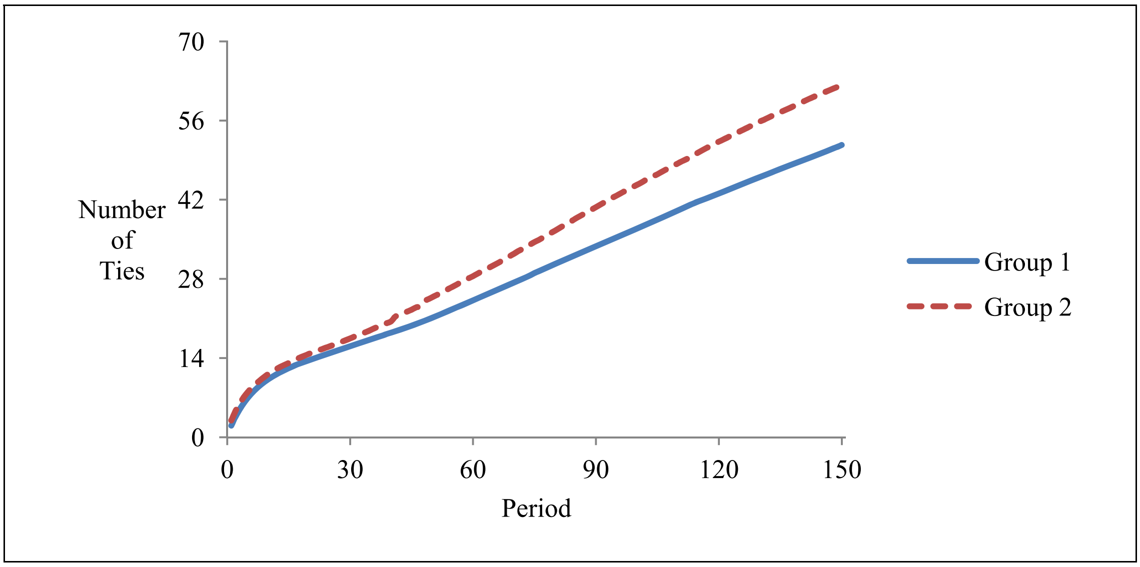


Figure 5-16 Average Strength of Ties at High TU & High MD

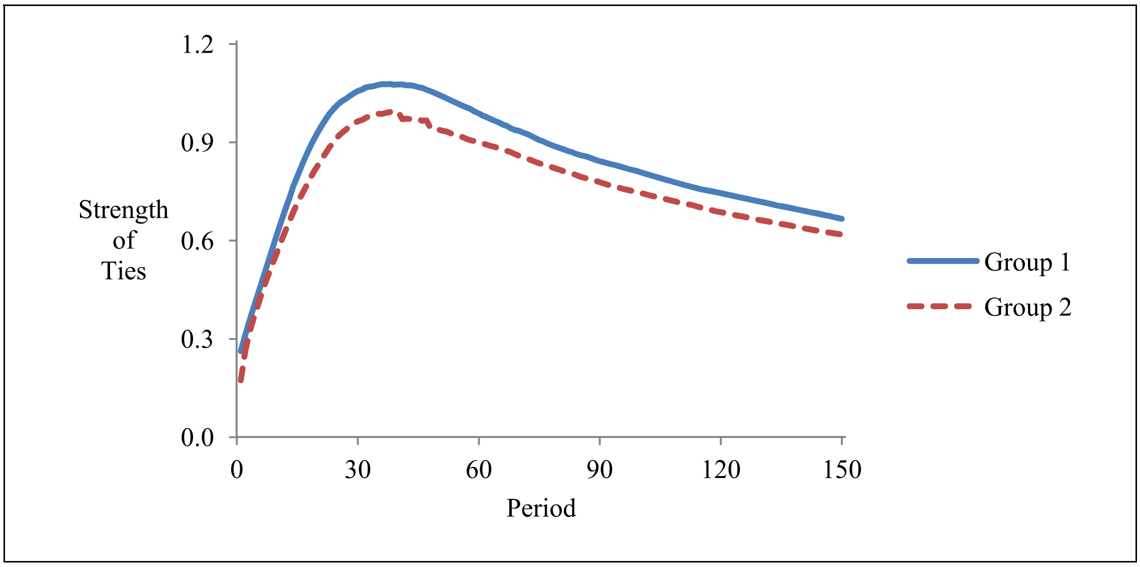


Figure 5-16 shows the average strength of ties. The cumulative numbers for both groups at this experimental point go up more steeply and continuously until the end period than those at the two previous test points. The steep and continuous increase in the numbers makes a difference between the curve shapes of the average strength at this experimental point and at the two previous test points. The strength for each group increases steeply at first and then starts to decrease slowly from the period of about 30. Also, that for Group 1 is not much higher than that for Group 2.

In the case where existing partners coupled via strong ties cannot respond to the high level of TU, the coordinators taking the relational strategy should select new members through elaborate bidding procedures. Also, the correctness of information on the new partners selected via bidding is not higher. Moreover, they should be managed via more rigorous formal contracting at the high level of MD. These formal mechanisms incur the considerable hidden costs involved in selecting and controlling partners. On the other hand, the coordinators employing the structural strategy can flexibly respond to the high level of TU without using a competitive tender. Furthermore, the hidden costs of managing reputational partners who occupy prominent network positions are less than those of controlling members who are selected via bidding at the high level of MD. Therefore, Group 2 can make better performance than Group 1.

Figure 5-17 Cumulative Profit at High TU & High MD

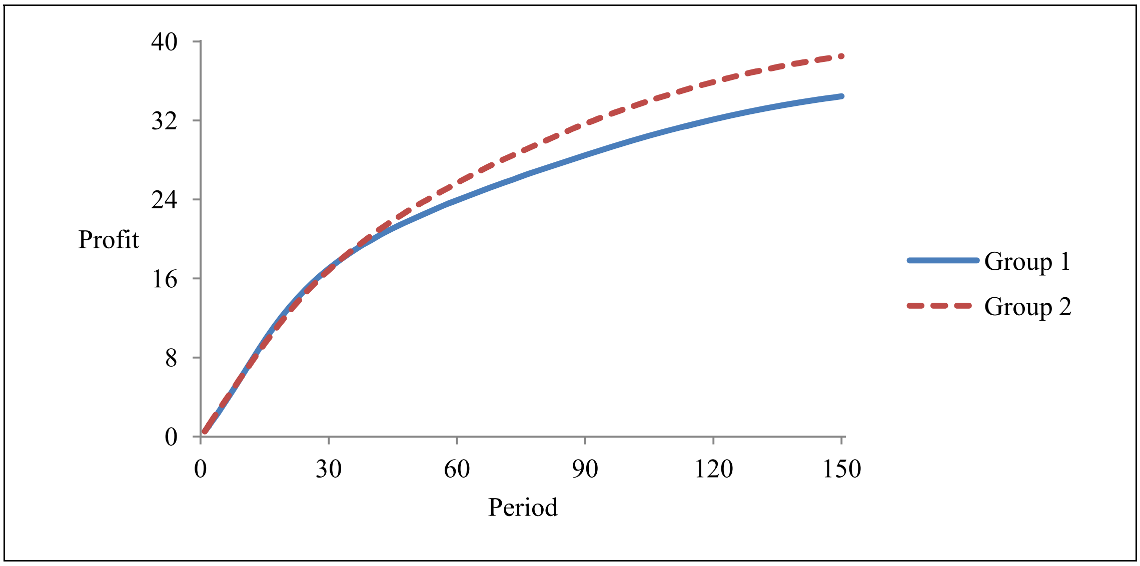


Figure 5-17 shows the cumulative profit. The two groups compete with each other until the period of around 30 and then Group 2 gains more profit than Group 1 as predicted.

Finally, Table 5-5 demonstrates the numerical results at the experimental point of the high level of TU and the high level of MD.

Table 5-5 Numerical Results at High TU & High MD

Period		**1**	**30**	**60**	**90**	**120**	**150**
Proportion of requested partners	Group 1	0.00	0.67	0.58	0.61	0.61	0.57
	Group 2	0.00	0.89	0.85	0.86	0.89	0.91
Proportion of opportunistic partners	Group 1	0.33	0.53	0.58	0.59	0.59	0.61
	Group 2	0.44	0.52	0.59	0.62	0.63	0.63
Cumulative number of ties	Group 1	2	16	24	34	43	52
	Group 2	3	17	28	40	52	62
Average strength of ties	Group 1	0.26	1.06	0.99	0.84	0.74	0.67
	Group 2	0.17	0.96	0.90	0.78	0.69	0.62
Cumulative profit	Group 1	0.54	17.00	23.92	28.47	32.09	34.44
	Group 2	0.51	16.85	25.54	31.66	35.89	38.51

5.4.3 High Level of TU and Low Level of MD

The results at the experimental point of the high level of TU and low level of MD are similar with those at the previous test point of the high level of TU and the high level of MD. Figure 5-18 shows the average proportion of requested partners. The proportion of about 0.7 for Group 1 indicates that around thirty percent of the members in the winning ITO consortia built by the coordinators taking the relational strategy are selected via a competitive tender. On the other hand, the high proportion for Group 2 means that the winning ITO consortia established by the coordinator employing the structural strategy mainly include reputational partners who occupy prominent network positions. Therefore, the structural strategy is superior in cost-effectiveness to the relational strategy. In the meantime, the proportions for Group 1 and 2 start to show a flat trend from the period of around 30 and from the initial period respectively. Therefore, Group 2 enjoys more advantages in information accessibility than Group 1.

Figure 5-18 Average Proportion of Requested Partners at High TU & Low MD

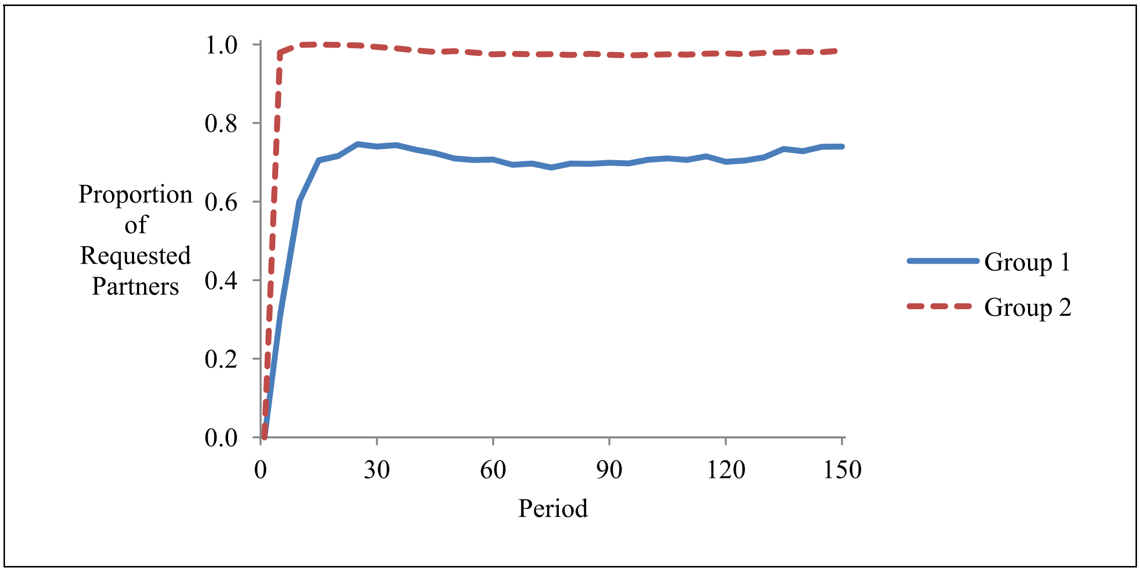


Figure 5-19 Average Proportion of Opportunistic Partners at High TU & Low MD

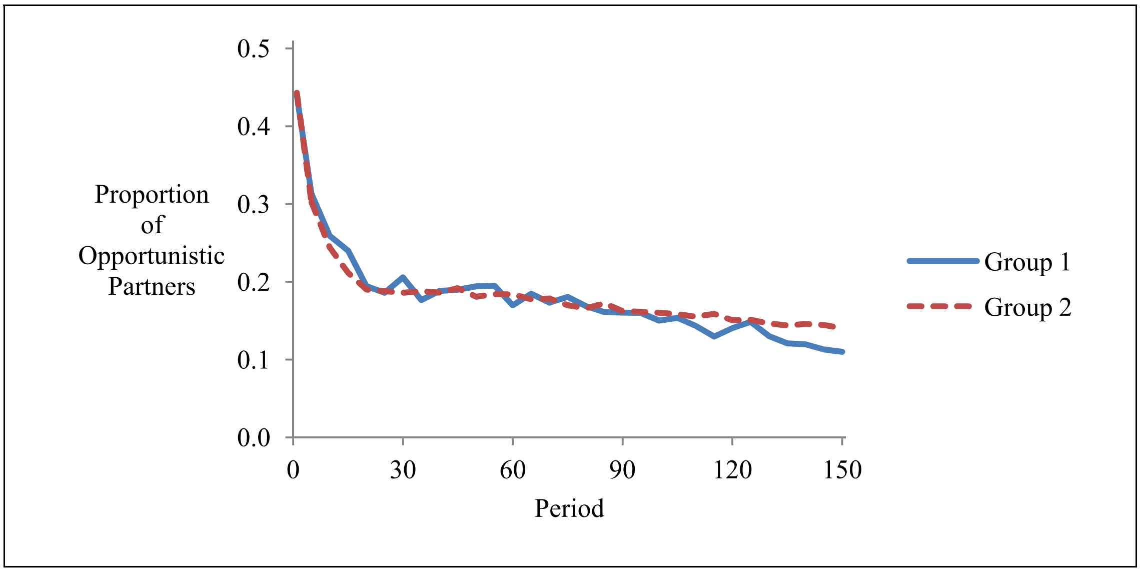


Figure 5-19 demonstrates the average proportion of opportunistic partners. As with the results at the previous test point, there is little difference between the two proportions. That is, Group 1 cannot enjoy more advantages in information correctness than Group 2.

Figure 5-20 Cumulative Number of Ties at High TU & Low MD

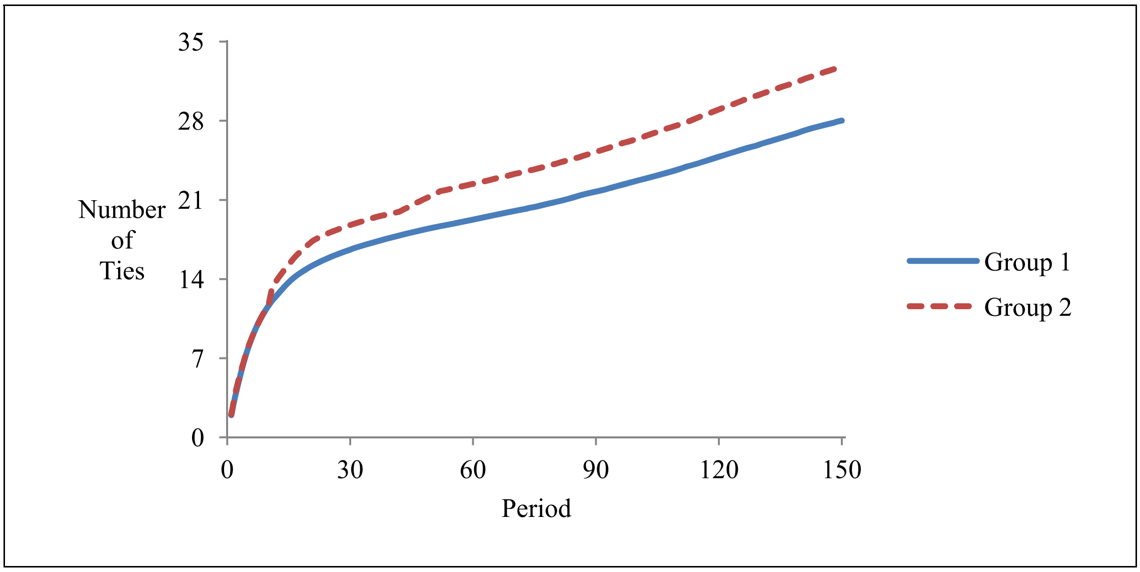


Figure 5-21 Average Strength of Ties at High TU & Low MD

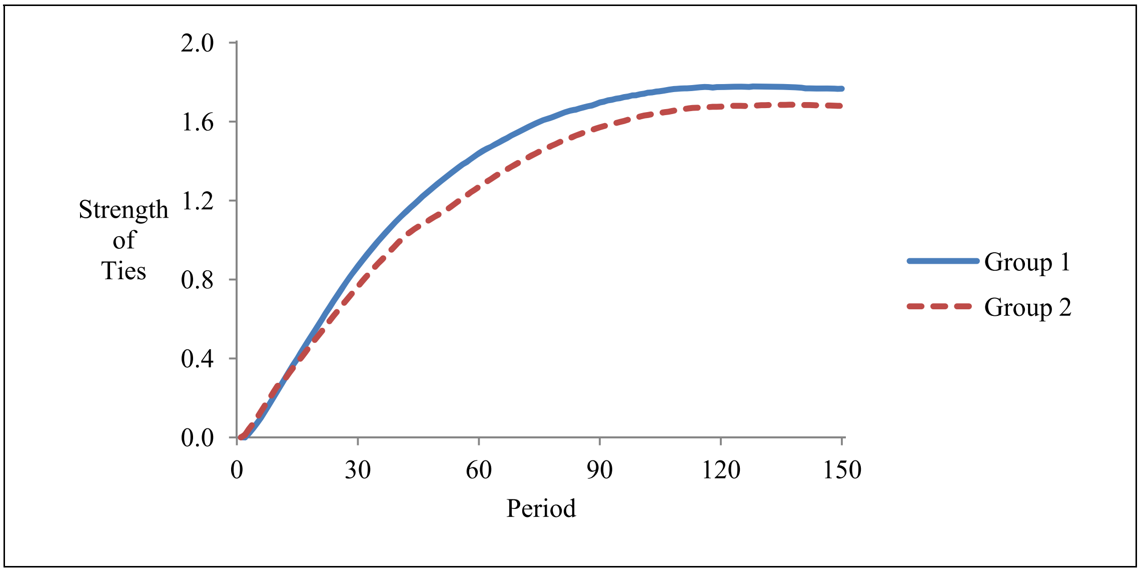
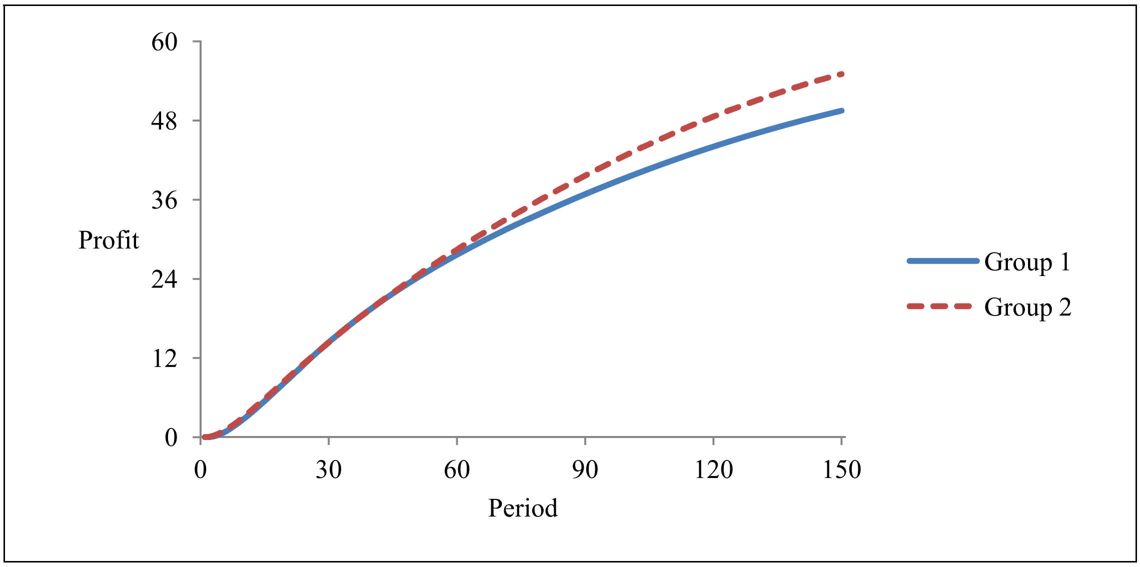


Figure 5-20 and 5-21 show the cumulative number and average strength of ties respectively. The cumulative numbers for both groups go up incrementally until the end period. Also, Group 1 maintains a small number of strong ties while Group 2 sustains a large number of weak ties.

The correctness of information on partners for Group 1 is not much higher than that for Group 2. Also, the coordinators taking the relational strategy cannot flexibly respond to the high level of TU only with existing partners who are connected via strong ties. Therefore, they select new members via a competitive tender. Furthermore, the new partners selected via bidding can be controlled with the higher hidden costs involved in designing and enforcing more rigorous formal contracting even at the low level of MD. Consequently, the structural strategy can be more appropriate than the relational strategy at the high level of TU and the low level of MD.

Figure 5-22 shows the cumulative profit. The cumulative profits for Group 1 and 2 increase similarly at the initial period. However, Group 2 gains more profit than Group 1 as time passes.

Figure 5-22 Cumulative Profit at High TU & Low MD



Finally, Table 5-6 demonstrates the numerical results at the experimental point of the high level of TU and the low level of MD.

Table 5-6 Numerical Results at High TU & Low MD

Period		**1**	**30**	**60**	**90**	**120**	**150**
Proportion of requested partners	Group 1	0	0.74	0.71	0.70	0.70	0.74
	Group 2	0	0.99	0.97	0.97	0.98	0.98

Table 5-7 Continued

Period		1	30	60	90	120	150
Proportion of opportunistic partners	Group 1	0.44	0.21	0.17	0.16	0.14	0.11
	Group 2	0.44	0.19	0.18	0.16	0.15	0.14
Cumulative Number of ties	Group 1	2	17	19	22	24	28
	Group 2	2	19	22	25	29	33
Strength of ties	Group 1	0.11	1.04	1.72	2.07	2.24	2.20
	Group 2	0.02	0.80	1.49	1.89	2.11	2.11
Cumulative profit	Group 1	0.00	14.39	27.69	36.85	44.05	49.49
	Group 2	0.00	14.37	28.44	39.65	48.59	55.05

5.5 Chapter Conclusion

The chapter conclusion summarises the conditional superiority of relational or structural embeddedness at the different levels of TU and MD in the long-term perspective. As described earlier, the experiment from the period of 1 to 150 was replicated 50 times at each experimental point. Then, the investigation into the cumulative profit for each group at the end period provides a better understanding of how the two uncertainties affect the long-term profit for the coordinators taking the relational or structural strategy.

At first, the interaction effect of the two uncertainties is calculated. Thereafter, its statistical significance is tested with an ANOVA. Let $T1_{i,j}$ or $T2_{i,j}$ be the sum of the cumulative profit for Group 1 or 2 at the end period of the experimental point of the i th level of TU and the j th level of MD. Also, let I_{G1} or I_{G2} be the interaction effect of TU and MD on the cumulative profit for Group 1 or 2 at the end period. Then, as shown in Section 5.2 Design of Experiments, they are calculated as follows.

$$I_{\mathrm{G1}} = \frac{[T1_{\mathrm{L,L}} + T1_{\mathrm{H,H}}] - [T1_{\mathrm{L,H}} + T1_{\mathrm{H,L}}]}{2n} = -7.22 \text{ and}$$

$$I_{G2} = \frac{[T2_{L,L} + T2_{H,H}] - [T2_{L,H} + T2_{H,L}]}{2n} = -7.31.$$

Furthermore, the following ANOVA tables show the statistical significance of each interaction effect.

Table 5-8 ANOVA for Interaction Effect on Cumulative Profit for Group 1

Source	DF	SS	MS	F	P
Interaction	1	2607.600	2607.600	771.810	0.000
Error	196	662.200	3.380		

S = 1.838, R^2 = 95.69%, R^2 (Adj.) = 95.63%

Table 5-9 ANOVA for Interaction Effect on Cumulative Profit for Group 2

Source	DF	SS	MS	F	P
Interaction	1	2670.000	2670.00	1239.70	0.000
Error	196	422.100	2.200		

S = 1.468 R^2 = 98.73%, R^2 (Adj.) = 98.71%

Therefore, the interaction of TU and MD has a negative effect on the cumulative profits for Group 1 and 2. Also, the cumulative profit for Group 2 is a little bit more sensitive to the interaction of the two uncertainties than that for Group 1 because

$$|I_{G1}| = 7.22 < 7.31 = |I_{G2}|.$$

Figure 5-23 graphically demonstrates the interaction effects of TU and MD on the cumulative profits for Group 1 and 2. In line with the above numerical comparison (i.e. $|I_{G1}| < |I_{G2}|$), the slope of the surface for Group 2 is steeper than that for Group 1.

Figure 5-23 Interaction Effects of TU & MD

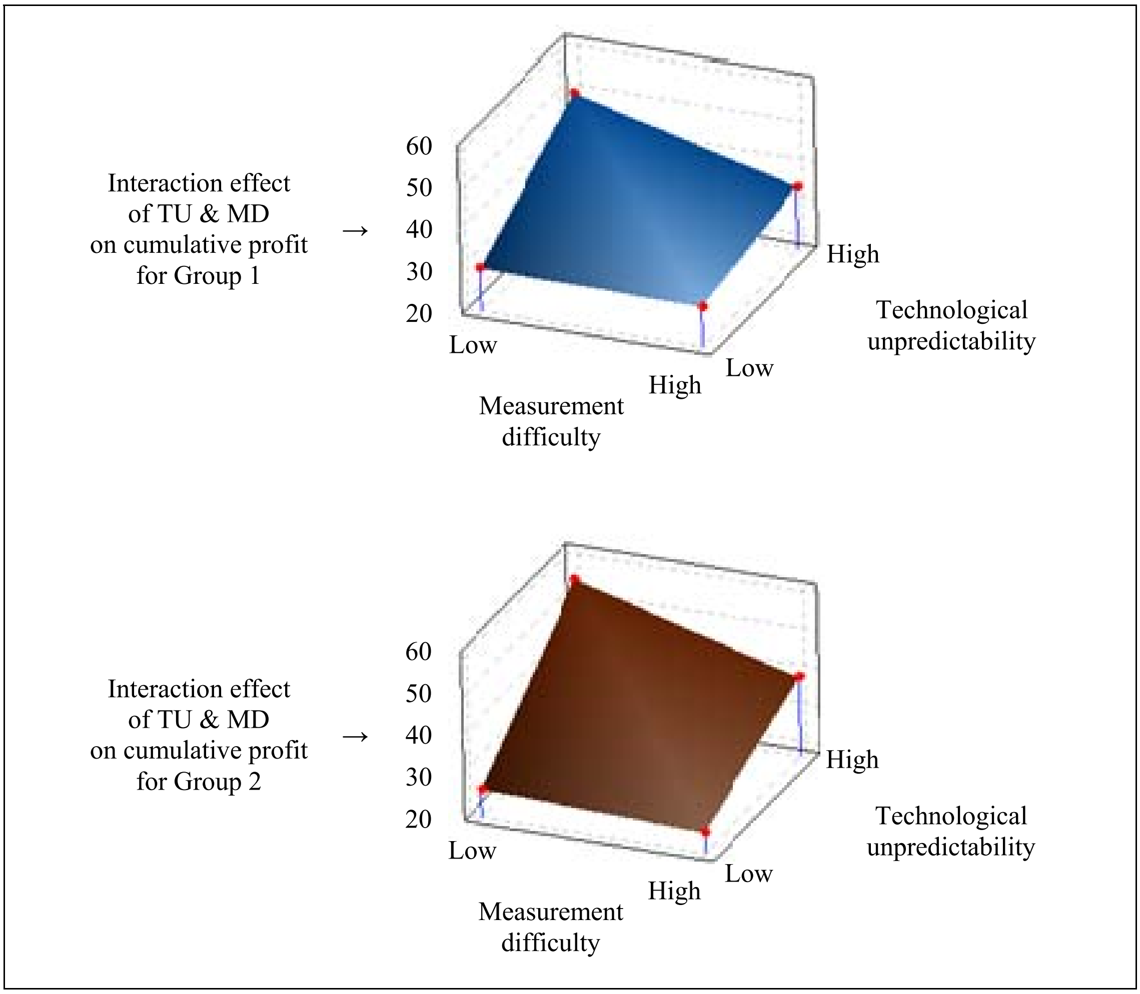


Table 5-10 T-Test for Comparing Cumulative Profits for Group 1 and 2

Uncertainty		Measurement Difficulty	
		Low	High
Technological Unpredictability	Low	Group 1 > Group 2 (p-value: 0.00)	Group 1 > Group 2 (p-value: 0.00)
	High	Group 1 < Group 2 (p-value: 0.00)	Group 1 < Group 2 (p-value: 0.00)

Next, the difference between the cumulative profits for the two groups is examined at the end period of each test point. Table 5-9 shows the T-test results for the statistical comparison between them. As a result, no matter how difficult it is to measure ITO performance, Group 1 gains more profits as long as the pace of change in technological requirements is slow and stable. On the contrary, when technological requirements change fast and unstably, Group 2 gains more profits regardless of the level of MD.

CHAPTER 6 Discussions

6.1 Introduction

This research aims to reveal the conditional superiority of relational or structural embeddedness in enhancing long-term performance in the presence of technological unpredictability and measurement difficulty imposed on ITO business environments. In order to achieve this aim, a simulation model was developed based on several theories which have been frequently used to explain complex and dynamic interactions between ITO parties. Moreover, a full factorial design was applied for efficient and systematic simulation experiments. The basic test was conducted to verify the developed simulation model through the comparison with existing studies. Thereafter, with this confirmed model, the complete tests were implemented to compare the two types of embeddedness at the different levels of the two uncertainties. In particular, the investigation into the cumulative profit at the end period provided a better understanding of the interaction effects of the two uncertainties on the long-term profit for the coordinators taking the relational or structural strategy.

Chapter 6 discusses the findings derived from analysing these data. Also, several theoretical and practical implications are proposed.

6.2 Discussion of Findings

The data for the comparison between the two types of embeddedness were gained through the experiments planned with a full factorial design. At first, the proportion of requested members and the proportion of opportunistic members were examined. Next, the cumulative number of ties and the average strength of ties were investigated. Finally, the cumulative profits for the two types of embeddedness were compared. Table 6-1 summarises the simulation results. R and S represent relational and structural embeddedness respectively. TP also indicates a test point.

Table 6-1 Conditional Superiority of Relational and Structural Embeddedness

Uncertainty		Measurement difficulty	
		High	Low
Technological unpredictability	Low	S < R at TP 1	S < R at TP 2
	High	S > R at TP 3	S > R at TP 4

The developed simulation model was verified based on the results at TP 1. When technological unpredictability was at the low level, there were existing partners who could cover technological requirements changing slowly and stably. Therefore, the coordinators taking the relational strategy did not have difficulty in finding more suitable alternatives although they maintained a small number of strong ties. Also, the strongly connected partners could be controlled with lower hidden costs at the high level of measurement difficulty. Furthermore, the proportion of opportunistic members for the relational strategy was lower than that for the structural strategy. Consequently, relational embeddedness led to better performance at this experimental point. The results at TP 1 were compared with the existing literature dealing with the advantages of relational embeddedness when it is difficult to exactly measure outcomes. Several studies on the comparison between the two types of embeddedness in other research contexts show that organisations or individuals prefer existing partners when the performance of partners or the quality of services and products is uncertain (Beckman *et al.*, 2004; DiMaggio and Louch, 1998; Podolny, 1994). Moreover, it is suggested that firms can enjoy cost-benefits from the repetition or long-term maintenance of their current outsourcing relationships at the high level of measurement difficulty because the needs for the exact outcome measurement and partner switch are reduced (Goo *et al.*, 2007; Gopal *et al.*, 2003; Kronman, 1985).

The results at TP 2 revealed that relational embeddedness made better performance as with those at TP 1. Measurement difficulty was at the low level at TP 2. Therefore, it is remarkable that the proportion of opportunistic members for the structural strategy at this test point was lower than that at TP 1. Nonetheless, the proportion for the relational strategy was somehow lower than, or similar to, that for the structural strategy. Furthermore, the coordinators taking the relational strategy could still respond to the low level of technological unpredictability with their existing partners who were coupled through strong ties.

Interestingly, structural embeddedness led to better performance at TP 3 where both uncertainties are at the high level. At this experimental point, the coordinators taking the relational strategy could not respond to the rapid and unstable change of technological requirements with only existing partners. Therefore, they found new members through competitive tenders and controlled the members' behaviour with more rigorous formal contracts. However, these formal mechanisms incurred considerable hidden costs especially at the high level of measurement difficulty. Furthermore, as the proportion of existing partners decreased and the proportion of partners selected via bidding increased, the proportion of opportunistic members became higher. In contrast, the coordinators taking the structural strategy could flexibly respond to the high level of technological unpredictability by gaining information on multiple alternative candidates through the observation of their network positions and the information transmission via third parties, and by choosing more competent partners for given technological requirements. Moreover, when it is difficult to exactly measure outcomes, the hidden costs of controlling reputational partners were smaller than those of managing partners selected via bidding.

Structural embeddedness made better performance at TP 4. The inferiority of relational embeddedness at this experimental point was derived from the fact that the coordinators taking the relational strategy were not able to react to the high level of technological unpredictability with only existing partners as shown in the test results at TP 3.

In brief, the research on relational embeddedness emphasises the advantages of trust and commitment generated by the repetition or long-term maintenance of an outsourcing relationship between specific partners as shown in the literature on ITO partnerships. The findings support this argument when measurement difficulty is at the high level and technological unpredictability is at the low level. On the other hand, the study on structural embeddedness focuses on the uses of (potential) partners' network positions and information transmitters as revealed in the literature on network-based ITO relationships. The results support this claim when technological unpredictability is at the high level regardless of the level of measurement difficulty. Especially, at the high levels of both uncertainties, structural embeddedness makes better performance than relational embeddedness.

The findings that structural embeddedness makes better performance at TP 3 and 4 need to be more specifically discussed compared with the arguments that organisations or individuals prefer existing partners who are relationally embedded when the uncertainty regarding product and service quality or partners' performance is at the high level (Beckman *et al.*, 2004; DiMaggio and Louch, 1998; Podolny, 1994).

In ITO business environments, much attention has been paid to how to successfully establish and maintain long-term cooperative outsourcing relationships such as partnerships (Kern and Willcocks, 2002; Lacity *et al.*, 2010). It has been shown that the efforts to manage outsourcing relationships through more complete formal contracts sometimes lead to unsatisfactory results (Nam *et al.*, 1996). Furthermore, formal contracts are naturally incomplete because it is almost impossible to predict and specify all of the possible contingencies in advance (Kim and Chung, 2003). Therefore, firms attempt to supplement this incompleteness with several advantages created by the repetition or long-term maintenance of outsourcing relationships with reliable partners (Banerjee and Duflo, 2000). Clients and vendors who are coupled through relationally embedded ties can flexibly respond to the high level of uncertainty (Fitzgerald and Willcocks, 1994; McFarlan and Nolan, 1995). They can resolve information asymmetry and suppress uncertainty by sharing high-quality information and tacit knowledge (Rowley *et al.*, 2000). In addition, relational embeddedness is advantageous in terms of cost-benefits. Clients consider alternative vendors for various reasons: low service or product quality, low relationship quality, contract problems, internal and external changes (Heng *et al.*, 2009). However, they should bear the considerable switching costs involved in finding and managing new vendors when they already have well-established outsourcing relationships (Gopal *et al.*, 2003). Alternatively, the behaviour of outsourcing parties connected through relationally embedded ties can be efficiently governed by trust and commitment which are manifest and developed in the process evolving through consecutive interactions between them (Kim and Chung, 2003; Poppo and Zenger, 2002).

However, a huge amount of resources should be invested in the development of relationally embedded relationships (Larson, 1992). Therefore, it is difficult to maintain a large number of strong ties. Moreover, a few strong ties may restrict access to new information and business opportunities because strongly connected outsourcing parties tend to stay within their existing relationships (Gargiulo and Benassi, 2000).

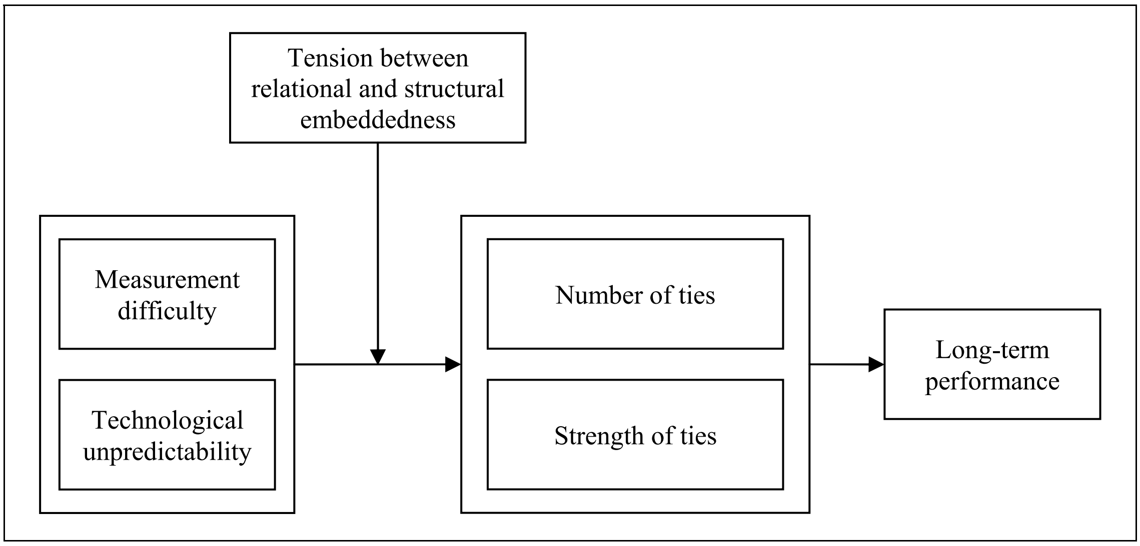
In the meantime, the selection of a competent partner is regarded as one of the most critical determinants of ITO success (Ketler and Walstrom, 1993; McFarlan and Nolan, 1995). Clients attempt to find alternatives in the case where their existing vendors cannot appropriately cover contingencies caused by the rapid and unstable change in ITO business environments (Goo *et al.*, 2007). When firms find alternative partners who are considered more suitable, they can use an ITO network which acts as a conduit of valuable information on the characteristics of multiple candidates and on the quality of their services or products (Granovetter, 1995; Podolny, 2001). Therefore, clients with a large number of weak ties can access information on diverse potential vendors and have an opportunity to compare them (Ravindran *et al.*, 2009). Also, the prominent network positions occupied by reputational vendors represent their excellent outcomes or their abilities to implement obligations (Heng *et al.*, 2009; Malik and Bouguettaya, 2009).

In addition, it is suggested that “the essence of exploitation is the refinement and extension of existing competencies, technologies, and paradigms” and “the essence of exploration is experimentation with new alternatives” (March, 1991, p.85). According to the general argument on exploration and exploitation, more resources should be invested in exploration at the high level of uncertainty (Lant *et al.*, 1992). For example, the research of Afuah (2000) implies that firms facing the rapid pace of technological change should not invest all their resources in a few existing partners who are strongly connected. Rather, they need to allocate their resources to multiple alternative relationships which could provide several options in response to the high level of technological unpredictability (Rowley *et al.*, 2000).

As a result, as shown in a body of literature concerning ITO partnerships, relational embeddedness more successfully operates at the high level of measurement difficulty. This is supported by the simulation results at TP 1. However, when existing vendors' capabilities or outsourcing parties' collaboration cannot keep up with the rapid and unstable change of technological requirements, structural embeddedness makes better performance. This is in line with the simulation results at TP 3 and 4.

Finally, this research proposes a conceptual framework including several key features which were used to compare the two types of embeddedness as shown in Figure 6-1.

Figure 6-1 Conceptual Framework of Relational and Structural Embeddedness



6.3 Theoretical Implication

The findings of this research complement and extend the existing literature in the following three research areas: IT outsourcing, network dynamics and environmental adaptation.

6.3.1 IT Outsourcing

Each ITO research stream on relational or structural embeddedness has mainly focused on its own advantages in response to uncertainty as shown in the literature on long-term cooperative outsourcing relationships or on network-based outsourcing relationships. However, the lack of comparative studies may draw the confusing conclusion that both types of embeddedness could be commonly suitable for any given uncertainty. This research provides a better understanding of which leads to better performance by examining its conditional superiority at the different levels of technological unpredictability and measurement difficulty which are regarded to be important in ITO studies.

Especially, the simulation results offer a possible theoretical answer to why an ITO partnership based on relational embeddedness sometimes fails in spite of its popularity. An ITO partnership has been prevalent in the real world and has been intensively studied in the academic area (Dibbern *et al.*, 2004; Kern and Willcocks, 2002; Lacity *et al.*, 2010). Above all, this long-term cooperative outsourcing relationship is generally perceived to be more advantageous in terms of cost-benefits because clients can reduce the considerable transaction costs involved in switching vendors and measuring performance (Goo *et al.*, 2007; Gopal *et al.*, 2003; Kronman, 1985). However, it is reported that the partnership does not always guarantee the success of ITO. Mike Lafford, the Group Vice President of Gartner Incoporate, advises that a long-term ITO contract may lead to clients' disadvantages, and the realisation of his concern is found in the example of the State of Virginia's ITO (Park, 2009). Virginia Information Technologies Agency (VITA) made a massive ITO contract with Northrop Grumman Corporation. The size and duration of this contract were approximately two billion dollars and ten years. However, the attempt to outsource the state's information systems has proven to be a failure and the Director of VITA has resigned from his position. As shown in many studies on an ITO partnership, trust and commitment were likely to be manifested and developed between the client and vendor. However, if the dynamic change of technological requirements over time was beyond the coverage of the vendor's capability or the outsourcing parties' collaboration, the client was likely to face the problem of overembeddedness and could not flexibly respond to the high level of technological unpredictability (Gargiulo and Benassi, 2000; Gulati and Westphal, 1999).

In addition, the simulation results provide a potential theoretical reply to in which condition structural embeddedness is preferred in ITO business environments. The collaborative research consortia funded by the European Union seventh framework programme perform information and communication technologies (ICT) research projects to enhance the competitiveness of European industry through the development of ICT. This programme focuses on the following research challenges, which require advanced information technologies and methods (European Commission, 2012).

Table 6-2 EU FP 7 ICT Programme

Challenge	Research Theme
Challenge 1	Pervasive and trusted network and service infrastructures
Challenge 2	Cognitive systems and robotics
Challenge 3	Alternative paths to components and systems
Challenge 4	Technologies for digital content and languages
Challenge 5	ICT for health, ageing well, inclusion and governance
Challenge 6	ICT for low carbon economy
Challenge 7	ICT for enterprise and manufacturing
Challenge 8	ICT for creativity and learning

Therefore, in accordance with previous business settings, technological requirements are likely to change rapidly and unstably, and it is probably difficult to measure outcomes. In this case, the practical survey report on how to select partners for the formation of ICT consortia shows that project managers frequently use candidates' reputations and third parties to find suitable partners who are competent as well as reliable (Drath and Wayman, 2010).

6.3.2 Network Dynamics

There has been a dramatic increase in the number of network studies which address the pattern of structuralised relationships among actors over recent decades (Brass *et al.*, 2004). A network is viewed as antecedents or consequences in various research settings. The majority of research especially at the egocentric level has investigated how an actor's network position can affect its outcomes in the perspective of antecedents. For example, a body of literature has examined the effects of network positions on a variety of important outcomes such as "power, leadership, mobility, employment, individual performance, individual creativity, entrepreneurship and team performance" (Borgatti and Foster, 2003, p.993). On the other hand, it has been examined why and how network ties are created and reinforced from the viewpoint of consequences. For instance, the strength of network ties is reinforced in the presence of the uncertainty regarding service and product quality or partners' performance since organisations or individuals tend to select their existing partners to suppress the uncertainty (DiMaggio and Louch, 1998; Kraatz, 1998; Podolny, 1994). More specifically, the research of Beckman *et al.* (2004) illustrates how firms change their network ties in accordance with the different type of uncertainty. That is, it is suggested that firms tend to reinforce and extend their network ties in response to market uncertainty and firm-specific uncertainty respectively.

In addition to the literature in the research area of network dynamics, this research improves an understanding of how the strength and structure of network ties at the egocentric level can be changed by the different levels of technological unpredictability and measurement difficulty. The simulation results in this research show that the coordinators taking the structural strategy increase the number of network ties at the high level of technological unpredictability. These heterogeneous and temporary ITO relationships allow the coordinators to flexibly respond to the rapid and unstable change of technological requirements. On the other hand, the test results in this study reveal that the coordinators taking the relational strategy consolidate their existing network ties in response to the high level of measurement difficulty. These outsourcing parties can overcome the difficulty in measuring ITO performance and enjoy advantages stemming from strong ties.

6.3.3 Environmental Adaptation

A firm's performance is affected by whether it refines and extends "existing competencies, technologies and paradigms" (i.e. exploitation) or it searches and experiments with "new alternatives" (i.e. exploration) (March, 1991, p.85). Also, exploitation and exploration compete with each other due to scarce resources and the amount of resources allocated to either of them is different in accordance with business environments (Rowley *et al.*, 2000). Therefore, a firm's strategic choice between exploitation and exploration in response to environmental changes is regarded as one of the fundamental problems for adaptive systems (Holland, 1992). Generally, it is accepted that firms should invest more resources in exploration than in exploitation in the presence of the high level of uncertainty (Lant *et al.*, 1992). However, it is shown that more investment in exploration does not always lead to better performance in uncertain business settings. For example, the research of Lee *et al.* (2003b) addresses the conditional superiority of exploitation or exploration when a new, but incompatible, technology is introduced in the market. It is suggested that exploration is more useful when an emergent technology appears before an existing technology has become too prevalent or when there are many power users. In contrast, it is proposed that exploitation is more beneficial when a new technology emerges after an old technology has been commonly adopted or when there are few power users.

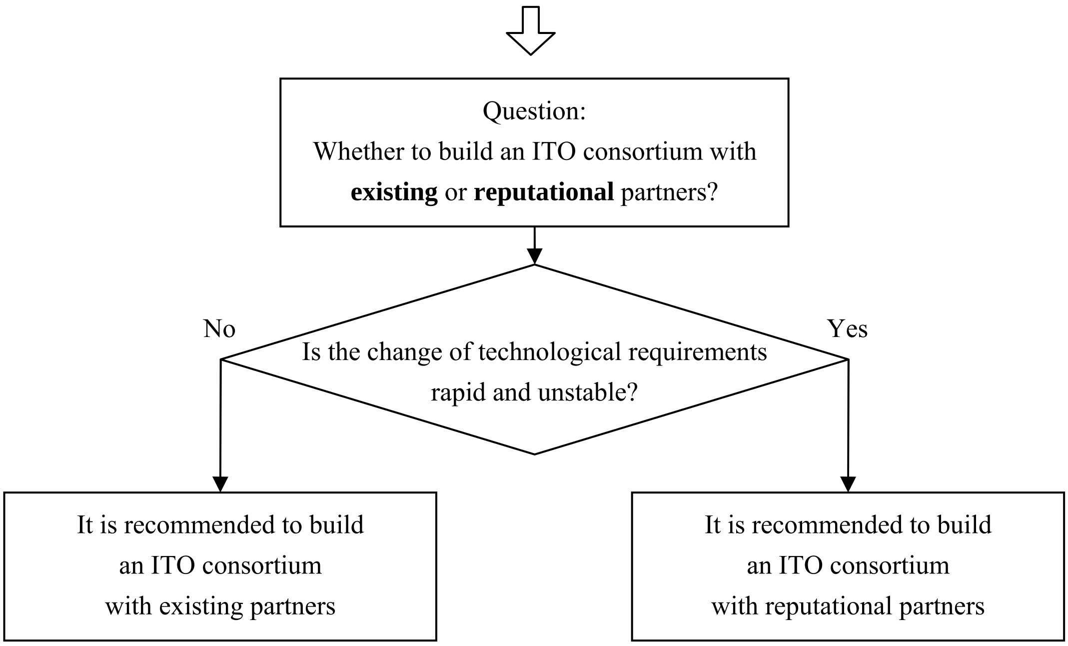
This research contributes to the research of environmental adaptation by examining the conditional superiority of each type of embeddedness according to the type and level of uncertainty. The partner selection and control strategy based on relational and structural embeddedness focus on the utilisation of present partners and the search for alternative partners respectively. Therefore, the concepts of the two strategies are in line with those of exploitation and exploration. The findings in this research suggest that the coordinators taking the relational strategy can efficiently adapt to the high level of measurement difficulty when the pace of technological change is slow and stable by exploiting existing partners. It is also proposed that the coordinators employing the structural strategy can flexibly adapt to the fast and unstable change of technological requirements by exploring multiple alternatives.

6.4 Practical Implication

In the practical perspective, the investigation on the conditional superiority of each type of embeddedness provides ITO managers with a guideline for the choice between existing partners who are strongly connected and reputational partners who occupy prominent network positions.

Figure 6-2 Guideline for Establishment of ITO Consortia

Uncertainty		Measurement difficulty	
		High	Low
Technological unpredictability	Low	S < R	S < R
	High	S > R	S > R



* S and R indicate structural and relational embeddedness respectively.

Figure 6-2 illustrates a guideline for deciding whether to establish ITO consortia with existing or reputational partners. As shown in the table summarising the simulation results, the long-term profits of coordinators are more affected by technological unpredictability than measurement difficulty in ITO business environments where the two uncertainties coexist. Therefore, coordinators should consider whether the change of technological requirements is rapid and unstable. If the answer is yes, it is recommended to build ITO consortia with reputational partners who are located in prominent network positions. Coordinators can flexibly respond to the high level of technological unpredictability with these members. However, if the reply is no, it is recommended to establish ITO consortia with existing partners who are coupled through strong ties. These members can sufficiently cover technological requirements which change slowly and stably. Furthermore, outsourcing relationships with them include trust and commitment.

6.5 Chapter Conclusion

In this chapter, the simulation results were discussed at different levels of technological unpredictability and measurement difficulty. In particular, the findings on the superiority of structural embeddedness at the high level of technological unpredictability was discussed compared with the literature which prefers existing partners in the presence of uncertainty and which favours exploration to adapt to uncertain business settings.

In addition, theoretical and managerial implications were proposed. The findings complement and extend the literature in the research area of IT outsourcing, network dynamics and environmental adaptation. Also, they provide ITO managers with a guideline for the choice between existing and reputational partners in ITO business environments where technological unpredictability and measurement difficulty exist together.

CHAPTER 7 Conclusions

7.1 Introduction

Chapter 7 describes the summary of this research. Also, the limitations and further research directions are discussed.

7.2 Research Summary

In ITO business environments, there are various forms of risks which can increase the possibility of outsourcing parties' opportunistic behaviour and threaten long-term performance. Among them, especially, the uncertainties stemming from the unpredictability of technological requirements and the difficulty in measuring outcomes have been frequently and significantly addressed (Kim and Chung, 2003; Lacity *et al.*, 2010)

Recent studies have demonstrated that relational and structural embeddedness play an important role in controlling these uncertainties in the context of ITO (Poppo and Zenger, 2002; Ravindran *et al.*, 2009). However, each research stream has mainly emphasised its own advantages as revealed in the literature regarding ITO partnerships or network-based ITO relationships. That is, the comparison between the two types of embeddedness has not been conducted in the research area of ITO. Although there are several studies which compare relational and structural embeddedness in other research contexts (Beckman *et al.*, 2004; DiMaggio and Louch, 1998; Gulati, 1995; Hansen, 1999; Kraatz, 1998; Schneider *et al.*, 1997), they do not adopt technological unpredictability and measurement difficulty imposed on ITO business environments as comparative criteria. Furthermore, these studies mainly emphasise which of the two types of embeddedness is preferred at the high level of uncertainty rather than which of them leads to better performance according to the type and level of uncertainty. There is, therefore, a paucity of literature on the conditional superiority of each type of embeddedness at the different levels of the two uncertainties in the context of ITO.

In order to fill the research gap, this research developed a simulation model which can compare the two types of embeddedness in the presence of technological unpredictability and measurement difficulty of which the levels are not uniform across a wide range of IT services. In this model, technological unpredictability is associated with the use of elaborate tender procedures and rigorous contract clauses while measurement difficulty is related to the correctness of information on (potential) partners' behavioural tendencies. In response to given outsourcing opportunities with the different levels of these two uncertainties, coordinators take the relational or structural strategy. The coordinator taking the relational strategy attempts to select an existing partner for whom it has the outsourcing history. They are coupled through a strong tie and the partner's behaviour can be managed with lower hidden costs. On the other hand, the coordinator taking the structural strategy tries to choose a reputational partner who occupies a prominent network position. The partner is likely to be more competent for a given outsourcing opportunity. However, the coordinator bears the higher hidden costs involved in controlling the partner's behaviour because they are not completely committed to each other.

A full factorial design was applied to conduct efficient and systematic simulation experiments. Technological unpredictability and measurement difficulty were used as two key factors and each of them had two levels: low and high. Simulation tests were implemented at all the possible combinations of the levels of the two uncertainties. At first, the developed simulation model was verified by examining the consistency between the existing literature addressing the advantages of relational embeddedness at the high level of measurement difficulty. Thereafter, the data for the comparison between the two types of embeddedness were gained through the experiments at the whole test points with this confirmed model.

The investigation into relational embeddedness emphasises the advantages of trust and commitment generated by the repetition or long-term maintenance of an outsourcing relationship between specific partners as shown in the literature on ITO partnerships. The results support this argument when measurement difficulty and technological unpredictability are at the high and low level respectively. On the other hand, the examination on structural embeddedness focuses on the uses of (potential) partners' network positions and information transmitters as revealed in the literature on network-based ITO relationships. The results support this claim when technological unpredictability is at the high level regardless of the level of measurement difficulty. Especially, at the high levels of both uncertainties, structural embeddedness makes better performance than relational embeddedness.

The findings of this research contribute to the existing literature in the following three research areas: IT outsourcing, network dynamics and environmental adaptation. In the practical perspective, the investigation into the conditional superiority of each type of embeddedness provides ITO managers with a guideline for the choice between existing partners who are strong connected and reputational partners who occupy prominent network positions.

7.3 Research Limitation

A simulation model is regarded as the outcome of efforts to develop or extend a theory but sometimes as a theory itself in the perspective that several theoretical notions are embodied in the model (Harrison *et al.*, 2007). Also, the findings drawn from the implementation of the model can be qualified for a well-made theory in the sense that it includes constructs derived from existing studies, theoretical logics establishing relationships among them and assumptions defining research boundary conditions (Sutton and Staw, 1995; Whetten, 1989). Furthermore, the external validity of a simulation study is guaranteed to a certain degree in the case where the related theories underlying the study are supported by a lot of empirical evidence (Davis *et al.*, 2007). Nevertheless, the results may be considered the theoretical inferences from the analysis of virtual data. Moreover, a simulation study shows its consequences only for a specific set of parameters and assumptions. Therefore, the findings in this research are not likely to be valid if the parameters are changed or the assumptions are violated.

7.4 Further Research Directions

This study needs to be empirically tested to obtain its high external validity. As discussed in Section 3.3.6 Validate Empirical Data, external validity is not likely to be an important issue in this research because the developed simulation model and the new findings are based on several well-established theories supported by a body of empirical literature. However, the model and findings may be regarded as the logical consequences drawn from the simulation tests as discussed in the previous section. Moreover, one of the significant roles of a simulation study is to provide a basis for further empirical studies (Harrison *et al.*, 2007). Therefore, the consequences in this research can be used as a foundation for the empirical examination on the conditional superiority of each type of embeddedness in the presence of uncertainty imposed on ITO business environments.

Secondly, it needs to be investigated which of the two types of embeddedness is more advantageous in the presence of both asset specificity and uncertainty in the context of ITO. This research introduced the two uncertainties for the comparison between relational and structural embeddedness. In addition to uncertainty, asset specificity has been frequently and significantly addressed in ITO studies (Dibbern *et al.*, 2004; Lacity *et al.*, 2010). Moreover, the interaction between asset specificity and uncertainty can seriously threaten the efficiency of outsourcing relationships in the context of ITO (Goo *et al.*, 2007; Poppo and Zenger, 2002). It is necessary, therefore, to compare the two types of embeddedness in a situation where asset specificity and uncertainty exist together.

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Appendix A: Notations

4.3 Vendors in ITO Network

v_{ij}	the j th vendor (for $j = 1, \cdots, n$) to provide resources for the i th type of technology (for $i = 1, \cdots, m$)
$a_{ij}(t)$	the level of coordination abilities which v_{ij} has at the period of t
s_{ij}	the strategy which which v_{ij} takes
n_r	the number of vendors taking the relational strategy
n_s	the number of vendors taking the structural strategy
$r_{ij}(t)$	the amount of resources which v_{ij} has for the i th type of technology at the period of t (for $t = 1, \cdots, T$)
b_{ij}	the behavioural tendency which v_{ij} has
n_c	the number of cooperative vendors
n_o	the number of opportunistic vendors

4.4 Two Uncertainties Imposed on ITO Business Environments

RFP(t)	the request-for-proposals published at the period of t
$pa(t)$	the level of coordination abilities required in **RFP**(t)
$pr_x(t)$	the amount of resources for the x th type of technology required in **RFP**(t)
α	the increasing rate and instability of coordination abilities and resources required in **RFP**(t)
$I(t)$	the sum of coordination abilities and resources which are actually invested by the winning ITO consortium members at the period of t
$R(t)$	the sum of coordination abilities and resources which are necessary to cover the technological requirements in **RFP**(t)
$Prop(t)$	the proportion of $I(t)$ to $R(t)$
β	the extent to which the technological requirements in **RFP**(t) can be verified

4.5 Coordinator's Decision-Making

p_1	the proportion of vendors who can be qualified to be a coordinator
$CFB_{ijx}(t)$	the call-for-proposals published by a coordinator (v_{ij}) to secure resources for the x th type of technology
$br_{ijx}(t)$	the amount of resources for the x th type of technology in $CFB_{ijx}(t)$
$p_{ij\leftrightarrow xy}(t)$	v_{ij}'s cumulative profit gained through the join in ITO consortia together with v_{xy} until the period of $t-1$
$v_{ij\leftrightarrow x,p\max}(t)$	v_{xy} with the maximum value of $p_{ij\leftrightarrow xy}(t)$
$r_{uv\leftrightarrow xy}(t)$	whether v_{uv} has the experience of participating in ITO consortia together with v_{xy} between the period of 1 to $t-1$
$c_{xy}(t)$	v_{xy}'s degree centrality at the period of t
$v_{ij\leftrightarrow x,c\max}(t)$	v_{xy} with the maximum value of $c_{xy}(t)$ among candidates who are perceived to be cooperative by v_{ij}
rc	the hidden costs of managing an existing partner who is selected by a coordinator taking the relational strategy
sc	the hidden costs of managing a reputational partner who is selected by a coordinator taking the structural strategy
$bc+cc$	the hidden costs of selecting and managing a partner who is chosen through a bid when there are no existing or reputational partners

4.6 Partner's Decision-Making

p_2	the proportion of vendors who can perform the role of a partner

4.7 Profits

$caa(t)$	the level of coordination abilities which are actually used by the winning ITO consortium coordinator (v_{ij}) at the period of t
$car(t)$	the amount of resources which are actually invested by the winning ITO consortium coordinator (v_{ij}) in the i th type of technology at the period of t
$par_x(t)$	the amount of resources which are actually invested by the winning ITO consortium partner (v_{xy}) in the x th type of technology at the period of t

4.7 Continued

$PO_u(t)$	the payoff which the market offers for the winning ITO consortium at the period of *t* when the quality of a delivered IT service is unsatisfactory
$PO_s(t)$	the payoff which the market offers for the winning ITO consortium at the period of *t* when the quality of a delivered IT service is satisfactory
r	the profit rate
$cpoa(t)$	the payoff which is allocated to the winning ITO consortium coordinator for the investment in coordination abilities at the period of *t*
$cpor(t)$	the payoff which is allocated to the winning ITO consortium coordinator for the investment in resources for the *i* th type of technology at the period of *t*
$ppor_x(t)$	the payoff which is allocated to the winning ITO consortium partner (v_{xy}) for the investment in resources for the *x* th type of technology at the period of *t*
$cpa(t)$	the profit which is gained by the winning ITO consortium coordinator for the investment in coordination abilities at the period of *t*
$cpr(t)$	the profit which is gained by the winning ITO consortium coordinator for the investment in resources for the *i* th type of technology at the period of *t*
$ppr_x(t)$	the profit which is gained the winning ITO consortium partner (v_{xy}) for the investment in resources for the *x* th type of technology at the period of *t*

4.8 Information Update and Transfer

$pb_{ab\leftrightarrow cd}(t)$	v_{cd}'s behavioural tendency perceived by v_{ab} at the period of $t-1$
pt	the probability to transfer information
$cpa_r(t)$	the profit for the winning ITO consortium coordinator taking the relational strategy for the investment in coordination abilities at the period of *t*
$cpa_s(t)$	the profit for the winning ITO consortium coordinator taking the structural strategy for the investment in coordination abilities at the period of *t*
$CPA_r(T)$	the cumulative profit for the winning ITO consortium coordinators taking the relational strategy at the period of *T*
$CPA_s(T)$	the cumulative profit for the winning ITO consortium coordinators taking the structural strategy at the period of *T*

4.8 Continued

$nt_{ij\leftrightarrow xy}(t)$	whether the tie between v_{ij} and v_{xy} is newly created at the period of t
$nt(t)$	the number of ties which are newly built by the winning ITO consortium coordinator at the period of t
$nt_r(t)$	the number of new ties which are generated by the winning ITO consortium coordinator taking the relational strategy at the period of t
$nt_s(t)$	the number of new ties which are generated by the winning ITO consortium coordinator taking the structural strategy at the period of t
$CNT_r(T)$	the cumulative number of new ties for the winning ITO consortium coordinators taking the relational strategy at the period of T
$CNT_s(T)$	the cumulative number of new ties for the winning ITO consortium coordinators taking the structural strategy at the period of T
$AST_r(T)$	the average strength of ties for the winning ITO consortium coordinators taking the relational strategy at the period of T
$AST_s(T)$	the average strength of ties for the winning ITO consortium coordinator taking the structural strategy at the period of T
$n(t)$	the number of partners in the winning ITO consortium at the period of t
$no(t)$	the number of opportunistic partners in the winning ITO consortium at the period of t
$po(t)$	the proportion of opportunistic partners in the winning ITO consortium at the period of t
$po_r(t)$	the proportion of opportunistic partners for the winning ITO consortium coordinator taking the relational strategy at the period of t
$po_s(t)$	the proportion of opportunistic partners for the winning ITO consortium coordinator taking the structural strategy at the period of t
$NW_r(T)$	the cumulative number of winning contracts for the winning ITO consortium coordinators taking the relational strategy at the period of T
$NW_s(T)$	the cumulative number for winning contracts for the winning ITO consortium coordinators taking the structural strategy at the period of T

4.8 Continued

$APO_r(T)$	the average proportion of opportunistic partners for the winning ITO consortium coordinators taking the relational strategy at the period of T
$APO_s(T)$	the average proportion of opportunistic partners for the winning ITO consortium coordinators taking the structural strategy at the period of T
$nrp(t)$	the number of requested partners in the winning ITO consortium at the period of t
$prp(t)$	the proportion of requested partners in the winning ITO consortium at the period of t
$prp_r(t)$	the proportion of requested partners for the winning ITO consortium coordinator taking the relational strategy at the period of t
$prp_s(t)$	the proportion of requested partners for the winner ITO consortium coordinator taking the structural strategy at the period of t
$APR_r(T)$	the average proportion of requested partners for the winning ITO consortium coordinators taking the relational strategy at the period of T
$APR_s(T)$	the average proportion of requested partners for the winning ITO consortium coordinators taking the structural strategy at the period of T

Appendix B: Initial Values of Parameters

$m = 5$
$n = 10$
$a_{\min}(0) = 30$, $a_{\max}(0) = 50$
$r_{\min}(0) = 30$, $r_{\max}(0) = 50$
$p_{ij\leftrightarrow xy}(0) = 0$, $r_{ij\leftrightarrow xy}(0) = 0$, $pb_{ij\leftrightarrow xy}(0) = 0$ (for all i, j, x, y)
$p_1 = 0.2$, $p_2 = 0.2$
$rc = pr_x(t) \times 0.005$, $sc = pr_x(t) \times 0.03$, $bc+cc = pr_x(t) \times 0.05$
$r = 0.1$
$pt = 0.5$

Appendix C: Source Codes

4.3 Vendors in ITO Network

```
For b = 1 To NofRT
   RT(b) = "r" & b
   INofVforRT(b) = Int((Rnd() * (MaxNofV - (MinNofV) + 1)) + (MinNofV))
Next
For b = 1 To NofRT
   NofCoopVforRT(b) = Round(INofVforRT(b) * PCandO, 0)
   NofVURelforRT(b) = Round(INofVforRT(b) * PRandS, 0)
Next
For b = 1 To NofRT
   Dim colC_1 As New Collection
      ReDim varLong(1 To INofVforRT(b), 1 To 1) As Integer
   Dim a_1 As Integer, lngRnd_1 As Integer
   Randomize
   For a_1 = 1 To INofVforRT(b)
      colC_1.Add a_1
   Next
   For a_1 = INofVforRT(b) To 1 Step -1
      lngRnd_1 = Int(a_1 * Rnd) + 1
      varLong(a_1, 1) = colC_1.Item(lngRnd_1)
      colC_1.Remove lngRnd_1
   Next
   Range(Cells(1 + TNofCoopV, 5), Cells(TNofCoopV + NofCoopVforRT(b), 5)) = varLong
   TNofCoopV = TNofCoopV + NofCoopVforRT(b)
   Dim colC_2 As New Collection
      ReDim varLong(1 To INofVforRT(b), 1 To 1) As Integer
   Dim a_2 As Integer, lngRnd_2 As Integer
   Randomize
   For a_2 = 1 To INofVforRT(b)
      colC_2.Add a_2
   Next
   For a_2 = INofVforRT(b) To 1 Step -1
      lngRnd_2 = Int(a_2 * Rnd) + 1
      varLong(a_2, 1) = colC_2.Item(lngRnd_2)
      colC_2.Remove lngRnd_2
   Next
   Range(Cells(1 + TNofVURel, 6), Cells(TNofVURel + NofVURelforRT(b), 6)) = varLong
   TNofVURel = TNofVURel + NofVURelforRT(b)
   For c = 1 To INofVforRT(b)
      IVend(b, c, 1) = "v" & b & "," & c
      IVend(b, c, 2) = Int((Rnd() * (MaxQofR - (MinQofR) + 1)) + (MinQofR))
      IVend(b, c, 4) = Int((Rnd() * (MaxLofA - (MinLofA) + 1)) + (MinLofA))
      IVend(b, c, 6) = c
   Next
Next
For b = 1 To NofRT
   For c = 1 To INofVforRT(b)
      For x = 1 + TNofCoopV To TNofCoopV + NofCoopVforRT(b)
```

```
            If IVend(b, c, 6) = Cells(x, 5) Then
                IVend(b, c, 3) = 1
            End If
        Next
    Next
    TNofCoopV = TNofCoopV + NofCoopVforRT(b)
Next
For b = 1 To NofRT
    For c = 1 To INofVforRT(b)
        If IVend(b, c, 3) = 1 Then
        Else
            IVend(b, c, 3) = -1
        End If
    Next
Next
Range(Cells(1, 5), Cells(TNofCoopV, 5)).ClearContents
For b = 1 To NofRT
    For c = 1 To INofVforRT(b)
        For x = 1 + TNofVURel To TNofVURel + NofVURelforRT(b)
            If IVend(b, c, 6) = Cells(x, 6) Then
                IVend(b, c, 5) = 1
            End If
        Next
    Next
    TNofVURel = TNofVURel + NofVURelforRT(b)
Next
For b = 1 To NofRT
    For c = 1 To INofVforRT(b)
        If IVend(b, c, 5) = 1 Then
        Else
            IVend(b, c, 5) = -1
        End If
    Next
Next
Range(Cells(1, 6), Cells(TNofVURel, 6)).ClearContents
```

4.4 Two Uncertainties Imposed on ITO Business Environments

4.4.1 Technological Unpredictability

```
For b = 1 To NofRT
    RFP(b, 1) = RT(b)
Next
For b = 1 To NofRT
    For c = 1 To NofVforRT(b)
        Sumofrij = Sumofrij + Vend(b, c, 2)
    Next
Next
MofQofRinRFP_1 = Sumofrij / TNofV
MofQofRinRFP = MofQofRinRFP_1 * Alpha
For b = 1 To NofRT
    For c = 1 To NofVforRT(b)
        SSumofrij = SSumofrij + (MofQofRinRFP_1 - Vend(b, c, 2)) ^ 2
```

```
    Next
Next
SDofQofRinRFP = Sqr(SSumofrij / (TNofV - 1)) * Alpha
For b = 1 To NofRT
    Regenerate_pri:
    RFP(b, 2) = MofQofRinRFP + SDofQofRinRFP * Abs(GaussianRandom())
    if RFP(b, 2) =< 0 Then
        GoTo Regenerate_pri
    End if
Next
For b = 1 To NofRT
    For c = 1 To NofVforRT(b)
        Sumofaij = Sumofaij + Vend(b, c, 4)
    Next
Next
MofLofAinRFP_1 = Sumofaij / TNofV
MofLofAinRFP = MofLofAinRFP_1 * Alpha
For b = 1 To NofRT
    For c = 1 To NofVforRT(b)
        SSumofaij = SSumofaij + (MofLofAinRFP_1 - Vend(b, c, 4)) ^ 2
    Next
Next
SDofLofAinRFP = Sqr(SSumofaij / (TNofV - 1)) * Alpha
Regenerate_pa:
RFP(NofRT + 1, 2) = MofLofAinRFP + SDofLofAinRFP * Abs(GaussianRandom())
if RFP(NofRT+1, 2) <= 0 Then
    GoTo Regenerate_pa
End If
```

4.4.2 Measurement Difficulty

```
AI = AI + WCoor(4)
For b = 1 To NofRT
    If RT(b) = WCoor(5) Then
        If WCoor(8) = "Yes" Then
            AI = AI + WItself_Suf(10)
        Else
            AI = AI + WItself_Ins(10)
            AI = AI + WPartner(b, 10)
        End If
    Else
        AI = AI + WPartner(b, 10)
    End If
Next
For b = 1 To NofRT + 1
    Req = Req + RFP(b, 2)
Next
PofAItoReq = AI / Req
If PofAItoReq >= Beta Then
    Quality = "Satisfactory"
Else
    Quality = "Unsatisfactory"
End If
```

4.5 Coordinator's Decision-Making

4.5.1 Whether to Become Coordinator

```
For b = 1 To NofRT
  NofVasCforRT(b) = Round(NofVforRT(b) * PforCoor, 0)
  Dim colC_3 As New Collection
    ReDim varLong(1 To NofVforRT(b), 1 To 1) As Integer
  Dim a_3 As Integer, lngRnd_3 As Integer
  Randomize
  For a_3 = 1 To NofVforRT(b)
    colC_3.Add a_3
  Next
  For a_3 = NofVforRT(b) To 1 Step -1
    lngRnd_3 = Int(a_3 * Rnd) + 1
    varLong(a_3, 1) = colC_3.Item(lngRnd_3)
    colC_3.Remove lngRnd_3
  Next
  Range(Cells(2 + TNofVasC, 5), Cells(1 + TNofVasC + NofVasCforRT(b), 5)) = varLong
  For g = TNofVasC To TNofVasC + NofVasCforRT(b)
    For c = 1 To NofVforRT(b)
      If Cells(2 + g, 5) = Vend(b, c, 6) Then
        PCoor(g + 1, 1) = RT(b)
        PCoor(g + 1, 2) = Vend(b, c, 1)
        PCoor(g + 1, 3) = Vend(b, c, 4)
        PCoor(g + 1, 4) = Vend(b, c, 5)
        PCoor(g + 1, 7) = Vend(b, c, 2)
        PCoor(g + 1, 8) = Vend(b, c, 3)
      End If
    Next
  Next
  TNofVasC = TNofVasC + NofVasCforRT(b)
Next
Range(Cells(2, 5), Cells(2 + TNofVasC, 5)).ClearContents
For g = 1 To TNofVasC
  PCoor(g, 5) = RFP(NofRT + 1, 2)
  If PCoor(g, 3) >= PCoor(g, 5) Then
    PCoor(g, 6) = "Yes"
  Else
    PCoor(g, 6) = "No"
  End If
Next
For g = 1 To TNofVasC
  If PCoor(g, 6) = "Yes" Then
    h = h + 1
    Coor(h, 1) = "C" & h
    Coor(h, 2) = PCoor(g, 2)
    Coor(h, 3) = PCoor(g, 3)
    Coor(h, 4) = PCoor(g, 4)
    Coor(h, 5) = PCoor(g, 5)
    Coor(h, 6) = PCoor(g, 1)
    Coor(h, 7) = PCoor(g, 7)
    Coor(h, 8) = PCoor(g, 8)
```

```
    End If
Next
```

4.5.2 Publication of Call-for-Bids

```
For h = 1 To NofC
    For b = 1 To NofRT
        If Coor(h, 6) = RT(b) Then
            Coor(h, 9) = RFP(b, 2)
            If Coor(h, 7) >= RFP(b, 2) Then
                Coor(h, 10) = "Yes"
                Coor(h, 10 + b) = 0
            Else
                Coor(h, 10) = "No"
                Coor(h, 10 + b) = RFP(b, 2) - Coor(h, 7)
            End If
        Else
            Coor(h, 10 + b) = RFP(b, 2)
        End If
    Next
Next
```

4.5.3 Relational vs. Structural Strategy

```
For h = 1 To NofC
    For b = 1 To NofRT
        If Coor(h, 10 + b) > 0 Then
            For e = 1 To TNofV
                If Coor(h, 2) = ColofV(e, 2) Then
                    For e_1 = 1 + TNofV_1 To TNofV_1 + NofVforRT(b)
                        If Coor(h, 2) = RowofV(2, e_1) Then
                        Else
                            If Coor(h, 4) = 1 Then
                                If Data(ColofV(e, 1), RowofV(1, e_1), 5) = 1 Then
                                    If Data(ColofV(e, 1), RowofV(1, e_1), 4) > Vmax(h, b, 1) Then
                                        Vmax(h, b, 1) = Data(ColofV(e, 1), RowofV(1, e_1), 4)
                                        Vmax(h, b, 2) = RowofV(2, e_1)
                                        Vmax(h, b, 3) = "Request"
                                        Vmax(h, b, 4) = Data(ColofV(e, 1), RowofV(1, e_1), 5)
                                        Vmax(h, b, 5) = Coor(h, 10 + b)
                                    End If
                                End If
                                If Vmax(h, b, 1) = 0 Then
                                    Vmax(h, b, 1) = 0
                                    Vmax(h, b, 2) = ""
                                    Vmax(h, b, 3) = "Notify"
                                    Vmax(h, b, 4) = 0
                                    Vmax(h, b, 5) = 0
                                End If
                            Else
                                If Data(ColofV(e, 1), RowofV(1, e_1), 5) = -1 Then
                                Else
                                    If Outdegree(e_1) > Vmax(h, b, 1) Then
```

```
                  Vmax(h, b, 1) = Outdegree(e_1)
                  Vmax(h, b, 2) = RowofV(2, e_1)
                  Vmax(h, b, 3) = "Request"
                  Vmax(h, b, 4) = Data(ColofV(e, 1), RowofV(1, e_1), 5)
                  Vmax(h, b, 5) = Coor(h, 10 + b)
                 End If
                 If Vmax(h, b, 1) = 0 Then
                  Vmax(h, b, 1) = 0
                  Vmax(h, b, 2) = ""
                  Vmax(h, b, 3) = "Notify"
                  Vmax(h, b, 4) = 0
                  Vmax(h, b, 5) = 0
                 End If
                End If
               End If
              End If
             Next
            End If
           Next
          Else
           Vmax(h, b, 1) = 0
           Vmax(h, b, 2) = ""
           Vmax(h, b, 3) = "Sufficient"
           Vmax(h, b, 4) = 0
           Vmax(h, b, 5) = 0
          End If
          TNofV_1 = TNofV_1 + NofVforRT(b)
         Next
        Next
        for h = 1 to NofC
         for b = 1 to NofRT
          for i = 1 to NofVasPforRT(b)
           If PPartner(h, b, i, 9) = "No" Then
           Else
            If PPartner(h, b, i, 9) > Bidmax(h, b, 1) Then
             Bidmax(h, b, 1) = PPartner(h, b, i, 9)
             Bidmax(h, b, 2) = PPartner(h, b, i, 1)
             Bidmax(h, b, 3) = PPartner(h, b, i, 2)
             Bidmax(h, b, 4) = PPartner(h, b, i, 3)
             Bidmax(h, b, 5) = PPartner(h, b, i, 4)
             Bidmax(h, b, 6) = PPartner(h, b, i, 5)
             Bidmax(h, b, 7) = PPartner(h, b, i, 6)
             Bidmax(h, b, 8) = PPartner(h, b, i, 7)
             Bidmax(h, b, 9) = PPartner(h, b, i, 8)
            End If
           End If
          Next
         Next
        Next
        For h = 1 To NofC
         If Coor(h, 10 + NofRT + 1) = -1 Then
         Else
          If Coor(h, 4) = 1 Then
```

```
   NofCforR = NofCforR + 1
   LofAforR = LofAforR + Coor(h, 3)
Else
   NofCforS = NofCforS + 1
   LofAforS = LofAforS + Coor(h, 3)
End If
For b = 1 To NofRT
   If Coor(h, 6) = RT(b) Then
      If Vmax(h, b, 3) = "Sufficient" Then
      Else
         If Vmax(h, b, 3) = "Accept" Then
            If Coor(h, 4) = 1 Then
               NofRPforR(h) = NofRPforR(h) + 1
               QofRPforR(h) = QofRPforR(h) + Partner(h, b, 5)
               If Partner(h, b, 6) = 1 Then
                  NofCPforR(h) = NofCPforR(h) + 1
               Else
                  NofOPforR(h) = NofOPforR(h) + 1
               End If
            Else
               NofRPforS(h) = NofRPforS(h) + 1
               QofRPforS(h) = QofRPforS(h) + Partner(h, b, 5)
               If Partner(h, b, 6) = 1 Then
                  NofCPforS(h) = NofCPforS(h) + 1
               Else
                  NofOPforS(h) = NofOPforS(h) + 1
               End If
            End If
         End If
      End If
   Else
      If Vmax(h, b, 3) = "Accept" Then
         If Coor(h, 4) = 1 Then
            NofRPforR(h) = NofRPforR(h) + 1
            QofRPforR(h) = QofRPforR(h) + Partner(h, b, 5)
            If Partner(h, b, 6) = 1 Then
               NofCPforR(h) = NofCPforR(h) + 1
            Else
               NofOPforR(h) = NofOPforR(h) + 1
            End If
         Else
            NofRPforS(h) = NofRPforS(h) + 1
            QofRPforS(h) = QofRPforS(h) + Partner(h, b, 5)
            If Partner(h, b, 6) = 1 Then
               NofCPforS(h) = NofCPforS(h) + 1
            Else
               NofOPforS(h) = NofOPforS(h) + 1
            End If
         End If
      End If
   End If
Next
If Coor(h, 10) = "Yes" Then
```

```
      If Coor(h, 4) = 1 Then
         If NofRPforR(h) = 0 Then
            PofRPforR(h) = 0
            MQofRPforR(h) = 0
            PofCPforR(h) = 0
            PofOPforR(h) = 0
         Else
            PofRPforR(h) = NofRPforR(h) / (NofRT - 1)
            MQofRPforR(h) = QofRPforR(h) / NofRPforR(h)
            PofCPforR(h) = NofCPforR(h) / NofRPforR(h)
            PofOPforR(h) = NofOPforR(h) / NofRPforR(h)
            NofCforR_1 = NofCforR_1 + 1
         End If
      Else
         If NofRPforS(h) = 0 Then
            PofRPforS(h) = 0
            MQofRPforS(h) = 0
            PofCPforS(h) = 0
            PofOPforS(h) = 0
         Else
            PofRPforS(h) = NofRPforS(h) / (NofRT - 1)
            MQofRPforS(h) = QofRPforS(h) / NofRPforS(h)
            PofCPforS(h) = NofCPforS(h) / NofRPforS(h)
            PofOPforS(h) = NofOPforS(h) / NofRPforS(h)
            NofCforS_1 = NofCforS_1 + 1
         End If
      End If
   Else
      If Coor(h, 4) = 1 Then
         If NofRPforR(h) = 0 Then
            PofRPforR(h) = 0
            MQofRPforR(h) = 0
            PofCPforR(h) = 0
            PofOPforR(h) = 0
         Else
            PofRPforR(h) = NofRPforR(h) / NofRT
            MQofRPforR(h) = QofRPforR(h) / NofRPforR(h)
            PofCPforR(h) = NofCPforR(h) / NofRPforR(h)
            PofOPforR(h) = NofOPforR(h) / NofRPforR(h)
            NofCforR_1 = NofCforR_1 + 1
         End If
      Else
         If NofRPforS(h) = 0 Then
            PofRPforS(h) = 0
            MQofRPforS(h) = 0
            PofCPforS(h) = 0
            PofOPforS(h) = 0
         Else
            PofRPforS(h) = NofRPforS(h) / NofRT
            MQofRPforS(h) = QofRPforS(h) / NofRPforS(h)
            PofCPforS(h) = NofCPforS(h) / NofRPforS(h)
            PofOPforS(h) = NofOPforS(h) / NofRPforS(h)
            NofCforS_1 = NofCforS_1 + 1
```

```
            End If
         End If
      End If
   End If
Next
For h = 1 To NofC
   If Coor(h, 10 + NofRT + 1) = -1 Then
   Else
      If Coor(h, 4) = 1 Then
         CPofRPforR = CPofRPforR + PofRPforR(h)
         CMQofRPforR = CMQofRPforR + MQofRPforR(h)
         CPofCPforR = CPofCPforR + PofCPforR(h)
         CPofOPforR = CPofOPforR + PofOPforR(h)
      Else
         CPofRPforS = CPofRPforS + PofRPforS(h)
         CMQofRPforS = CMQofRPforS + MQofRPforS(h)
         CPofCPforS = CPofCPforS + PofCPforS(h)
         CPofOPforS = CPofOPforS + PofOPforS(h)
      End If
   End If
Next
If NofCforR = 0 Then
   MLofAforR = 0
Else
   MLofAforR = LofAforR / NofCforR
End If
If NofCforR_1 = 0 Then
   MCPofRPforR = 0
   MCMQofRPforR = 0
   MCPofCPforR = 0
   MCPofOPforR = 0
Else
   MCPofRPforR = CPofRPforR / NofCforR_1
   MCMQofRPforR = CMQofRPforR / NofCforR_1
   MCPofCPforR = CPofCPforR / NofCforR_1
   MCPofOPforR = CPofOPforR / NofCforR_1
End If
If NofCforS = 0 Then
   MLofAforS = 0
Else
   MLofAforS = LofAforS / NofCforS
End If
If NofCforS_1 = 0 Then
   MCPofRPforS = 0
   MCMQofRPforS = 0
   MCPofCPforS = 0
   MCPofOPforS = 0
Else
   MCPofRPforS = CPofRPforS / NofCforS_1
   MCMQofRPforS = CMQofRPforS / NofCforS_1
   MCPofCPforS = CPofCPforS / NofCforS_1
   MCPofOPforS = CPofOPforS / NofCforS_1
End If
```

4.6 Partner's Decision-Making

```
For h = 1 To NofC
   For b = 1 To NofRT
      If Vmax(h, b, 3) = "Request" Then
         For c = 1 To NofVforRT(b)
            If Vmax(h, b, 2) = Vend(b, c, 1) Then
               If Coor(h, 4) = 1 Then
                  If Vend(b, c, 3) = 1 Then
                     If Vend(b, c, 2) >= Coor(h, 10 + b) Then
                        Vmax(h, b, 3) = "Accept"
                        Partner(h, b, 1) = RT(b)
                        Partner(h, b, 2) = Vmax(h, b, 3)
                        Partner(h, b, 3) = Vend(b, c, 1)
                        Partner(h, b, 4) = Vmax(h, b, 4)
                        Partner(h, b, 5) = Vend(b, c, 2)
                        Partner(h, b, 6) = Vend(b, c, 3)
                        Partner(h, b, 7) = Vmax(h, b, 5)
                        Partner(h, b, 8) = "Yes"
                        Partner(h, b, 9) = Partner(h, b, 5)
                     Else
                        Vmax(h, b, 1) = 0
                        Vmax(h, b, 2) = ""
                        Vmax(h, b, 3) = "Notify"
                        Vmax(h, b, 4) = 0
                        Vmax(h, b, 5) = 0
                     End If
                  Else
                     Vmax(h, b, 3) = "Accept"
                     Partner(h, b, 1) = RT(b)
                     Partner(h, b, 2) = Vmax(h, b, 3)
                     Partner(h, b, 3) = Vend(b, c, 1)
                     Partner(h, b, 4) = Vmax(h, b, 4)
                     Partner(h, b, 5) = Vend(b, c, 2)
                     Partner(h, b, 6) = Vend(b, c, 3)
                     Partner(h, b, 7) = Vmax(h, b, 5)
                     If Partner(h, b, 5) >= Partner(h, b, 7) Then
                        Partner(h, b, 8) = "Yes"
                     Else
                        Partner(h, b, 8) = "No"
                     End If
                     If Partner(h, b, 5) >= Partner(h, b, 7) Then
                        Partner(h, b, 9) = Partner(h, b, 5)
                     Else
                        Partner(h, b, 9) = Partner(h, b, 7)
                     End If
                  End If
               Else
                  If Vend(b, c, 3) = 1 Then
                     If Vend(b, c, 2) >= Coor(h, 10 + b) Then
                        Vmax(h, b, 3) = "Accept"
                        Partner(h, b, 1) = RT(b)
                        Partner(h, b, 2) = Vmax(h, b, 3)
```

```
                    Partner(h, b, 3) = Vend(b, c, 1)
                    Partner(h, b, 4) = Vmax(h, b, 4)
                    Partner(h, b, 5) = Vend(b, c, 2)
                    Partner(h, b, 6) = Vend(b, c, 3)
                    Partner(h, b, 7) = Vmax(h, b, 5)
                    Partner(h, b, 8) = "Yes"
                    Partner(h, b, 9) = Partner(h, b, 5)
                  Else
                    Vmax(h, b, 1) = 0
                    Vmax(h, b, 2) = ""
                    Vmax(h, b, 3) = "Notify"
                    Vmax(h, b, 4) = 0
                    Vmax(h, b, 5) = 0
                  End If
                Else
                  Vmax(h, b, 3) = "Accept"
                  Partner(h, b, 1) = RT(b)
                  Partner(h, b, 2) = Vmax(h, b, 3)
                  Partner(h, b, 3) = Vend(b, c, 1)
                  Partner(h, b, 4) = Vmax(h, b, 4)
                  Partner(h, b, 5) = Vend(b, c, 2)
                  Partner(h, b, 6) = Vend(b, c, 3)
                  Partner(h, b, 7) = Vmax(h, b, 5)
                  If Partner(h, b, 5) >= Partner(h, b, 7) Then
                    Partner(h, b, 8) = "Yes"
                  Else
                    Partner(h, b, 8) = "No"
                  End If
                  If Partner(h, b, 5) >= Partner(h, b, 7) Then
                    Partner(h, b, 9) = Partner(h, b, 5)
                  Else
                    Partner(h, b, 9) = Partner(h, b, 7)
                  End If
                End If
              End If
            End If
          Next
        End If
      Next
    Next
    For h = 1 To NofC
      For b = 1 To NofRT
        If Vmax(h, b, 3) = "Notify" Then
          Reselect_Vendors_as_Candidate_Partner:
          NofVasPforRT(b) = Round(NofVforRT(b) * PforPart, 0)
          Dim colC_4 As New Collection
            ReDim varLong(1 To NofVforRT(b), 1 To 1) As Integer
          Dim a_4 As Integer, lngRnd_4 As Integer
          Randomize
          For a_4 = 1 To NofVforRT(b)
            colC_4.Add a_4
          Next
          For a_4 = NofVforRT(b) To 1 Step -1
```

```
    lngRnd_4 = Int(a_4 * Rnd) + 1
    varLong(a_4, 1) = colC_4.Item(lngRnd_4)
    colC_4.Remove lngRnd_4
  Next
  Range(Cells(2 + TNofVasP + h, 5), Cells(1 + TNofVasP + NofVasPforRT(b) + h, 5)) = varLong
  For i = 1 To NofVasPforRT(b)
    For c = 1 To NofVforRT(b)
      If Cells(1 + TNofVasP + h + i, 5) = Vend(b, c, 6) Then
        PPartner(h, b, i, 3) = Vend(b, c, 1) 'vij
      End If
    Next
  Next
  For i = 1 To NofVasPforRT(b)
    If PPartner(h, b, i, 3) = Coor(h, 2) Then
      Range(Cells(1 + TNofVasP + h + 1, 5), Cells(1 + TNofVasP + h + NofVasPforRT(b),
        5)).ClearContents
      GoTo Reselect_Vendors_as_Candidate_Partner
    End If
  Next
  For i = 1 To NofVasPforRT(b)
    For c = 1 To NofVforRT(b)
      If Cells(1 + TNofVasP + h + i, 5) = Vend(b, c, 6) Then
        PPartner(h, b, i, 1) = RT(b) 'ri
        PPartner(h, b, i, 2) = Vmax(h, b, 3) 'Type
        For e = 1 To TNofV
          If Coor(h, 2) = ColofV(e, 2) Then
            Colofpbij = ColofV(e, 1)
          End If
        Next
        For e = 1 To TNofV
          If Vend(b, c, 1) = RowofV(2, e) Then
            Rowofpbij = RowofV(1, e)
          End If
        Next
        PPartner(h, b, i, 4) = Data(Colofpbij, Rowofpbij, 5)
        PPartner(h, b, i, 5) = Vend(b, c, 2)
        PPartner(h, b, i, 6) = Vend(b, c, 3)
        PPartner(h, b, i, 7) = Coor(h, 10 + b)
        If PPartner(h, b, i, 5) >= PPartner(h, b, i, 7) Then
          PPartner(h, b, i, 8) = "Yes"
        Else
          PPartner(h, b, i, 8) = "No"
        End If
        If PPartner(h, b, i, 4) = -1 Then
          PPartner(h, b, i, 10) = -1
          NofCP(h, b) = NofCP(h, b) + 0
        Else
          If PPartner(h, b, i, 6) = 1 Then
            If PPartner(h, b, i, 8) = "Yes" Then
              PPartner(h, b, i, 10) = 1
              NofCP(h, b) = NofCP(h, b) + 1
            Else
              PPartner(h, b, i, 10) = -1
```

```
                        NofCP(h, b) = NofCP(h, b) + 0
                    End If
                Else
                    PPartner(h, b, i, 10) = 1
                    NofCP(h, b) = NofCP(h, b) + 1
                End If
            End If
            If PPartner(h, b, i, 10) = 1 Then
                If PPartner(h, b, i, 6) = 1 Then
                    PPartner(h, b, i, 9) = PPartner(h, b, i, 5)
                Else
                    If PPartner(h, b, i, 5) >= PPartner(h, b, i, 7) Then
                        PPartner(h, b, i, 9) = PPartner(h, b, i, 5)
                    Else
                        PPartner(h, b, i, 9) = PPartner(h, b, i, 7)
                    End If
                End If
            Else
                PPartner(h, b, i, 9) = "No"
            End If
        End If
    Next
Next
TNofVasP = TNofVasP + NofVasPforRT(b)
End If
Next
Next
Range(Cells(2, 5), Cells(2 + TNofVasP * NofRT, 5)).ClearContents
```

4.7 Profits

4.7.1 Actual Investment

```
WCoor(10) = WCoor(4)
For b = 1 To NofRT
    If RT(b) = WCoor(5) Then
        If WCoor(8) = "Yes" Then
            WItself_Suf(10) = WCoor(7)
        Else
            WItself_Ins(10) = WCoor(6)
            If WPartner(b, 6) = 1 Then
                WPartner(b, 10) = WPartner(b, 7)
            Else
                WPartner(b, 10) = 0
            End If
        End If
    Else
        If WPartner(b, 6) = 1 Then 'Partner
            WPartner(b, 10) = WPartner(b, 7)
        Else
            WPartner(b, 10) = 0
        End If
    End If
```

```
    Next
```

4.7.2 Payoff / 4.7.3 Profit

```
    For b = 1 To NofRT
        If WCoor(5) = RT(b) Then
            If WCoor(8) = "Yes" Then
            Else
                If WPartner(b, 2) = "Notify" Then
                    NofNotify = NofNotify + 1
                Else
                    If WCoor(3) = 1 Then
                        NofRPart = NofRPart + 1
                    Else
                        NofSPart = NofSPart + 1
                    End If
                End If
            End If
        Else
            If WPartner(b, 2) = "Notify" Then
                NofNotify = NofNotify + 1
            Else
                If WCoor(3) = 1 Then
                    NofRPart = NofRPart + 1
                Else
                    NofSPart = NofSPart + 1
                End If
            End If
        End If
    Next
    WCoor(11) = WCoor(4) * (1 + PRate)
    If Quality = "Sastisfactory" Then
        If WCoor(3) = 1 Then
            WCoor(12) = WCoor(11) - WCoor(10) - NofNotify * (((WCoor(11) - WCoor(10)) / NofRT) *
CPforBidding) - NofRPart * (((WCoor(11) - WCoor(10)) / NofRT) * CPforRPartner)
            WCoor(15) = NofNotify * (((WCoor(11) - WCoor(10)) / NofRT) * CPforBidding) + NofRPart *
(((WCoor(11) - WCoor(10)) / NofRT) * CPforRPartner)
        Else
            WCoor(12) = WCoor(11) - WCoor(10) - NofNotify * (((WCoor(11) - WCoor(10)) / NofRT) *
CPforBidding) - NofSPart * (((WCoor(11) - WCoor(10)) / NofRT) * CPforSPartner)
            WCoor(15) = NofNotify * (((WCoor(11) - WCoor(10)) / NofRT) * CPforBidding) + NofSPart *
(((WCoor(11) - WCoor(10)) / NofRT) * CPforSPartner)
        End If
    Else
        If WCoor(3) = 1 Then
            WCoor(12) = -1 * NofNotify * (((WCoor(11) - WCoor(10)) / NofRT) * CPforBidding) - 1 * NofRPart *
(((WCoor(11) - WCoor(10)) / NofRT) * CPforRPartner)
            WCoor(15) = NofNotify * (((WCoor(11) - WCoor(10)) / NofRT) * CPforBidding) + NofRPart *
(((WCoor(11) - WCoor(10)) / NofRT) * CPforRPartner)
        Else
            WCoor(12) = -1 * NofNotify * (((WCoor(11) - WCoor(10)) / NofRT) * CPforBidding) - 1 * NofSPart *
(((WCoor(11) - WCoor(10)) / NofRT) * CPforSPartner)
```

```
        WCoor(15) = NofNotify * (((WCoor(11) - WCoor(10)) / NofRT) * CPforBidding) + NofSPart *
(((WCoor(11) - WCoor(10)) / NofRT) * CPforSPartner)
      End If
   End If
   For b = 1 To NofRT
      If RT(b) = WCoor(5) Then
         If WCoor(8) = "Yes" Then
            If Quality = "Pass" Then
               WItself_Suf(11) = WCoor(7) * (1 + PRate)
               WItself_Suf(12) = WCoor(7) * PRate
            Else
               WItself_Suf(11) = WCoor(7) 'Payoff
               WItself_Suf(12) = 0 'Profit
            End If
            WItself_Suf(13) = WCoor(13)
         Else
            If Quality = "Satisfactory" Then
               WItself_Ins(11) = WCoor(6) * (1 + PRate)
               WItself_Ins(12) = WCoor(6) * PRate
               WPartner(b, 11) = WPartner(b, 7) * (1 + PRate)
               WPartner(b, 12) = WPartner(b, 11) - WPartner(b, 10)
            Else
               WItself_Ins(11) = WCoor(6) 'Payoff
               WItself_Ins(12) = 0 'Profit
               If WPartner(b, 6) = 1 Then 'Payoff
                  WPartner(b, 11) = WPartner(b, 7)
               Else
                  WPartner(b, 11) = 0
               End If
               WPartner(b, 12) = WPartner(b, 11) - WPartner(b, 10) 'Profit
            End If
         End If
      Else
         If Quality = "Satisfactory" Then
            WPartner(b, 11) = WPartner(b, 7) * (1 + PRate)
            WPartner(b, 12) = WPartner(b, 11) - WPartner(b, 10)
         Else
            If WPartner(b, 6) = 1 Then 'Payoff
               WPartner(b, 11) = WPartner(b, 7)
            Else
               WPartner(b, 11) = 0
            End If
            WPartner(b, 12) = WPartner(b, 11) - WPartner(b, 10)
         End If
      End If
   Next
```

4.7 Information Update and Transfer

```
   For b = 1 To NofRT
      If WCoor(8) = "Yes" Then
         If WCoor(5) = RT(b) Then
         Else
```

```
            If Quality = "Satisfactory" Then
               Data(WCoor(13), WPartner(b, 13), 1) = Data(WCoor(13), WPartner(b, 13), 1) + 1
               Data(WCoor(13), WPartner(b, 13), 2) = Data(WCoor(13), WPartner(b, 13), 2) + (WCoor(12) +
WItself_Suf(12)) / (NofRT - 1)
               Data(WCoor(13), WPartner(b, 13), 3) = 1
               Data(WCoor(13), WPartner(b, 13), 4) = Data(WCoor(13), WPartner(b, 13), 4) + (WCoor(11) +
WItself_Suf(11)) / (NofRT - 1)
               Data(WCoor(13), WPartner(b, 13), 5) = 1
            Else
               Data(WCoor(13), WPartner(b, 13), 1) = Data(WCoor(13), WPartner(b, 13), 1) + 1
               Data(WCoor(13), WPartner(b, 13), 2) = Data(WCoor(13), WPartner(b, 13), 2) + (WCoor(12) +
WItself_Suf(12)) / (NofRT - 1)
               Data(WCoor(13), WPartner(b, 13), 3) = 1
               Data(WCoor(13), WPartner(b, 13), 4) = Data(WCoor(13), WPartner(b, 13), 4) + (WCoor(11) +
WItself_Suf(11)) / (NofRT - 1)
               If WPartner(b, 6) = -1 Then
                  Data(WCoor(13), WPartner(b, 13), 5) = -1
               Else
                  Data(WCoor(13), WPartner(b, 13), 5) = 1
               End If
            End If
         End If
      Else
         If Quality = "Satisfactory" Then
            Data(WCoor(13), WPartner(b, 13), 1) = Data(WCoor(13), WPartner(b, 13), 1) + 1
            Data(WCoor(13), WPartner(b, 13), 2) = Data(WCoor(13), WPartner(b, 13), 2) + (WCoor(12) +
WItself_Ins(12)) / NofRT
            Data(WCoor(13), WPartner(b, 13), 3) = 1
            Data(WCoor(13), WPartner(b, 13), 4) = Data(WCoor(13), WPartner(b, 13), 4) + (WCoor(11) +
WItself_Ins(11)) / NofRT
            Data(WCoor(13), WPartner(b, 13), 5) = 1
         Else
            Data(WCoor(13), WPartner(b, 13), 1) = Data(WCoor(13), WPartner(b, 13), 1) + 1
            Data(WCoor(13), WPartner(b, 13), 2) = Data(WCoor(13), WPartner(b, 13), 2) + (WCoor(12) +
WItself_Ins(12)) / NofRT
            Data(WCoor(13), WPartner(b, 13), 3) = 1
            Data(WCoor(13), WPartner(b, 13), 4) = Data(WCoor(13), WPartner(b, 13), 4) + (WCoor(11) +
WItself_Ins(11)) / NofRT
            If WPartner(b, 6) = -1 Then
               Data(WCoor(13), WPartner(b, 13), 5) = -1
            Else
               Data(WCoor(13), WPartner(b, 13), 5) = 1
            End If
         End If
      End If
   Next
   For b = 1 To NofRT
      If WCoor(8) = "Yes" Then
         If RT(b) = WCoor(5) Then
         Else
            For b_1 = 1 To NofRT
               If RT(b_1) = WCoor(5) Then
                  Data(WPartner(b, 13), WCoor(13), 1) = Data(WPartner(b, 13), WCoor(13), 1) + 1
```

```
                    Data(WPartner(b, 13), WCoor(13), 2) = Data(WPartner(b, 13), WCoor(13), 2) + WPartner(b,
12) / (NofRT - 1)
                    Data(WPartner(b, 13), WCoor(13), 3) = 1
                    Data(WPartner(b, 13), WCoor(13), 4) = Data(WPartner(b, 13), WCoor(13), 4) + WPartner(b,
11) / (NofRT - 1)
                Else
                    If WPartner(b, 1) = WPartner(b_1, 1) Then
                    Else
                        If Quality = "Satisfactory" Then
                            Data(WPartner(b, 13), WPartner(b_1, 13), 1) = Data(WPartner(b, 13), WPartner(b_1,
13), 1) + 1
                            Data(WPartner(b, 13), WPartner(b_1, 13), 2) = Data(WPartner(b, 13), WPartner(b_1,
13), 2) + WPartner(b, 12) / (NofRT - 1)
                            Data(WPartner(b, 13), WPartner(b_1, 13), 3) = 1
                            Data(WPartner(b, 13), WPartner(b_1, 13), 4) = Data(WPartner(b, 13), WPartner(b_1,
13), 4) + WPartner(b, 11) / (NofRT - 1)
                            If Data(WPartner(b, 13), WPartner(b_1, 13), 5) = -1 Then
                            Else
                                Data(WPartner(b, 13), WPartner(b_1, 13), 5) = 1
                            End If
                        Else
                            Data(WPartner(b, 13), WPartner(b_1, 13), 1) = Data(WPartner(b, 13), WPartner(b_1,
13), 1) + 1
                            Data(WPartner(b, 13), WPartner(b_1, 13), 2) = Data(WPartner(b, 13), WPartner(b_1,
13), 2) + WPartner(b, 12) / (NofRT - 1)
                            Data(WPartner(b, 13), WPartner(b_1, 13), 3) = 1
                            Data(WPartner(b, 13), WPartner(b_1, 13), 4) = Data(WPartner(b, 13), WPartner(b_1,
13), 4) + WPartner(b, 11) / (NofRT - 1)
                            If Data(WPartner(b, 13), WPartner(b_1, 13), 5) = -1 Then
                            Else
                                If WPartner(b_1, 6) = -1 Then
                                    Data(WPartner(b, 13), WPartner(b_1, 13), 5) = -1
                                Else
                                    Data(WPartner(b, 13), WPartner(b_1, 13), 5) = 1
                                End If
                            End If
                        End If
                    End If
                End If
            Next
        End If
    Else
        Data(WPartner(b, 13), WCoor(13), 1) = Data(WPartner(b, 13), WCoor(13), 1) + 1
        Data(WPartner(b, 13), WCoor(13), 2) = Data(WPartner(b, 13), WCoor(13), 2) + WPartner(b, 12) /
NofRT
        Data(WPartner(b, 13), WCoor(13), 3) = 1
        Data(WPartner(b, 13), WCoor(13), 4) = Data(WPartner(b, 13), WCoor(13), 4) + WPartner(b, 11) /
NofRT
        For b_1 = 1 To NofRT
            If WPartner(b, 1) = WPartner(b_1, 1) Then
            Else
                If Quality = "Satisfactory" Then
```

```
                  Data(WPartner(b, 13), WPartner(b_1, 13), 1) = Data(WPartner(b, 13), WPartner(b_1, 13), 1)
+ 1
                  Data(WPartner(b, 13), WPartner(b_1, 13), 2) = Data(WPartner(b, 13), WPartner(b_1, 13), 2)
+ WPartner(b, 12) / NofRT
                  Data(WPartner(b, 13), WPartner(b_1, 13), 3) = 1
                  Data(WPartner(b, 13), WPartner(b_1, 13), 4) = Data(WPartner(b, 13), WPartner(b_1, 13), 4)
+ WPartner(b, 11) / NofRT
                  If Data(WPartner(b, 13), WPartner(b_1, 13), 5) = -1 Then
                  Else
                     Data(WPartner(b, 13), WPartner(b_1, 13), 5) = 1
                  End If
               Else
                  Data(WPartner(b, 13), WPartner(b_1, 13), 1) = Data(WPartner(b, 13), WPartner(b_1, 13), 1)
+ 1
                  Data(WPartner(b, 13), WPartner(b_1, 13), 2) = Data(WPartner(b, 13), WPartner(b_1, 13), 2)
+ WPartner(b, 12) / NofRT
                  Data(WPartner(b, 13), WPartner(b_1, 13), 3) = 1
                  Data(WPartner(b, 13), WPartner(b_1, 13), 4) = Data(WPartner(b, 13), WPartner(b_1, 13), 4)
+ WPartner(b, 11) / NofRT
                  If Data(WPartner(b, 13), WPartner(b_1, 13), 5) = -1 Then
                  Else
                     If WPartner(b_1, 6) = -1 Then
                        Data(WPartner(b, 13), WPartner(b_1, 13), 5) = -1
                     Else
                        Data(WPartner(b, 13), WPartner(b_1, 13), 5) = 1
                     End If
                  End If
               End If
            End If
         Next
      End If
   Next
   For b = 1 To NofRT
      If WCoor(8) = "Yes" Then
         If WCoor(5) = RT(b) Then 'Partner = Coordinator
         Else
            For e = 1 To TNofV
               If RowofV(2, e) = WCoor(1) Then
               Else
                  If RowofV(2, e) = WPartner(b, 3) Then
                  Else
                     If Data(WCoor(13), RowofV(1, e), 3) = 1 Then
                        If Data(WCoor(13), RowofV(1, e), 5) = 1 Then
                           Data(RowofV(1, e), WPartner(b, 13), 5) = Data(WCoor(13), WPartner(b, 13), 5)
                        End If
                     End If
                  End If
               End If
            Next
         End If
      Else
         For e = 1 To TNofV
            If RowofV(2, e) = WCoor(1) Then
```

```
                Else
                    If RowofV(2, e) = WPartner(b, 3) Then
                    Else
                        If Data(WCoor(13), RowofV(1, e), 3) = 1 Then
                            If Data(WCoor(13), RowofV(1, e), 5) = 1 Then
                                Data(RowofV(1, e), WPartner(b, 13), 5) = Data(WCoor(13), WPartner(b, 13), 5)
                            End If
                        End If
                    End If
                End If
            Next
        End If
    Next
    For b = 1 To NofRT
        If WCoor(8) = "Yes" Then
            If RT(b) = WCoor(5) Then
            Else
                For b_1 = 1 To NofRT
                    If RT(b_1) = WCoor(5) Then
                    Else
                        If WPartner(b_1, 1) = WPartner(b, 1) Then
                        Else
                            For e = 1 To TNofV
                                If RowofV(2, e) = WCoor(1) Then
                                Else
                                    If RowofV(2, e) = WPartner(b, 3) Then
                                    Else
                                        If RowofV(2, e) = WPartner(b_1, 3) Then
                                        Else
                                            If Data(WPartner(b, 13), RowofV(1, e), 3) = 1 Then
                                                If Data(WPartner(b, 13), RowofV(1, e), 5) = 1 Then
                                                    Data(RowofV(1, e), WPartner(b_1, 13), 5) = Data(WPartner(b, 13),
WPartner(b_1, 13), 5)
                                                End If
                                            End If
                                        End If
                                    End If
                                End If
                            Next
                        End If
                    End If
                Next
            End If
        Else
            For b_1 = 1 To NofRT
                If WPartner(b_1, 1) = WPartner(b, 1) Then
                Else
                    For e = 1 To NofRT
                        If RowofV(2, e) = WCoor(1) Then
                        Else
                            If RowofV(2, e) = WPartner(b, 3) Then
                            Else
                                If RowofV(2, e) = WPartner(b_1, 3) Then
```

```
                            If Data(WPartner(b, 13), RowofV(1, e), 3) = 1 Then
                                If Data(WPartner(b, 13), RowofV(1, e), 5) = 1 Then
                                    Data(RowofV(1, e), WPartner(b_1, 13), 5) = Data(WPartner(b, 13),
WPartner(b_1, 13), 5)
                                End If
                            End If
                        End If
                    End If
                End If
            Next
        End If
    Next
  End If
Next
```