RECONCEPTUALISATION OF INFORMATION TECHNOLOGY FLEXIBILITY FOR SUPPLY CHAIN MANAGEMENT: A MULTIDIMENSIONAL APPROACH

By

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ABSTRACT

Information technology (IT) flexibility is an important aspect of today's dynamic business environment. However, earlier research on this topic has not included the following: 1) a multidimensional structure that corresponds to diverse activities for supply chain management (SCM), 2) an informative explanation of how and by what means IT flexibility affects firm performance and 3) guidance to prioritise the flexibility dimensions to gain a competitive advantage. To fill these gaps, this study identified three dimensions of IT flexibility, namely transactional, operational and strategic flexibility, taking a systematic approach. Moreover, by combining dynamic capability (DC) and relational view (RV) theory, this study theorised a research model that links IT flexibility and firm performance. Process integration capability (PIC) was incorporated into the model as a mediator to provide a SCM research context.

From the results of a partial least squares structured equation modelling (PLS SEM) analysis of 128 questionnaires from supply chain practitioners, this study validated the three IT flexibility dimensions and their hierarchical relationship. Moreover, it identified that transactional and operational flexibilities affect firm performance indirectly via PIC, while strategic flexibility directly affects firm performance. The model's PLS SEM result was extended to an importance - performance analysis (IPA) matrix. By taking the importance and performance of each flexibility dimension as generic measurement criteria, this study prioritised the IT flexibility dimensions. Moreover, applying the same research model and methods to a specific focal firm offered a strategic way to allocate firm resources to the three IT flexibility dimensions.

The theoretical contributions of this study are as follows: 1) the attainment of a multidimensional structure of IT flexibility, 2) identification of IT flexibility's influencing mechanism on firm performance, 3) composition of DC and RV to provide a perspective on the explicit roles of IT flexibility and 4) a clear structure of the IT flexibility analysis framework within a context of SCM. Its practical contribution is the prioritisation IT flexibility dimensions, which will support firms in achieving the full potential of IT flexibility for SCM.

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ABBREVIATIONS

AHP: Analytical Hierarchy Process

ANP: Analytic Network Process

APS: Advanced Planning Systems

B2B: Business to Business

CB SEM: Covariance-based Structural Equation Modelling

CRM: Customer Relationship Management

DSS: Decision Support System

EDI: Electronic Data Exchange

EDI/EDIFACT: Electronic Data Interchange for Administration, Commerce and Transport

ELM: Electronic Logistics Market

ERP: Enterprise Resource Planning

FP: Firm Performance

GPS: Global Positioning System

HTML: Hypertext Markup Language

ICT: Information and Communication Technology

IOS: Interorganisational Systems

IS: Information Systems

IPA: Importance - Performance Analysis

KPIs: Key Performance Indicators

LAN: Local Area Network

MAUT: Multi-attribute Utility Theory

MCDA: Multiple Criteria Decision Analysis

MRP: Manufacturing Resource Planning

MLE: Maximum Likelihood Estimation

MMS: Multimedia Message Service

OLS: Ordinary Least Squares

OM: Operations Management

OP flexibility: Operational flexibility

PIC: Process Integration Capability

PLS SEM: Partial Least Squares Structural Equation Modelling

POS: Point of Sales

RBV: Resource-based View

RFID: Radio Frequency Identification

ROI: Return On Investment

SaaS: Software as a Service

SAP: Systems, Applications, and Products in Data Processing

SCM: Supply Chain Management

SRM: Supplier Relationship Management

STR flexibility: Strategic flexibility

TMS: Transportation Management System

TR flexibility: Transactional Flexibility

WMS: Warehouse Management System

VIF: Variance Inflation Factor

VMI: Vendor-managed Inventory

XML: Extensive Markup Language

3PL: Third Party Logistics

CHAPTER 1. INTRODUCTION

1.1 OVERVIEW

This chapter introduces the research objectives and provides contextual information about this study. It begins by outlining the research background and motivation in section 1.2 to highlight the importance of this study's objectives. In section 1.3, research questions are presented, followed by an outline of the research structure in section 1.4 and the contributions of the study in section 1.5.

1.2 RESEARCH BACKGROUND

With the intensified competitions in business practice brought about by globalisation and rapid changes in market preferences, organisations need to rely more on information technology (IT) to cope with growing changes in the market and business relationships. There is a body of literature arguing that IT needs to be flexible to effectively manage these changes; that is, IT should support firms' ability to cope with a certain amount of variation generated in business processes (Duncan 1995; Byrd and Turner 2000; Gebauer and Schober 2006; Bush 2010; Liu et al 2013; Kumar and Stylianou 2014).

In fact, IT flexibility is thought to be a critical capability of a firm in managing its supply chain, which is affected by environmental dynamics and complexity. IT flexibility enables firms to support the evolving requirements of business processes and to share intra/interfirm information with flexible business processes and inter-relational coupling (Duncan 1995; Duclos et al. 2003; Lummus et al. 2005; Saraf et al. 2007; Stevenson and Spring 2007; Bush et al. 2010; Kumar and Stylianou 2014; Tiwari et al. 2015). However, despite the growing recognition of the importance of IT flexibility, an understanding of the concept of IT flexibility – particularly for supply chain management (SCM) – remains incomplete, as it has only been partially examined in previous research.

On the one hand, the IT infrastructure–focussed view, one of two partial examinations, emphasises the supporting role of IT infrastructure in aiding IT network arrangement and interfirm connectivity. Despite the importance of IT infrastructure as a foundation for conducting interfirm business, however, the current physical IT–focussed approach does not capture the evolving role of IT to support a wide range of value creation activities and strategies in modern SCM. On the other hand, there is another stream that highlights the role of IT for value creation to actively react to the changes. Its focus on potential/strategic value gains emphasises the role of IT flexibility in the context of strategic supply chain configuration with organizations' trade partners. However, in this emerging stream, the importance of IT infrastructure has been overlooked because such strategic value creation flexibility inevitably requires an advanced IT infrastructure.

Any partial, unidimensional approach to IT flexibility will be ineffective when it comes to satisfying the divergent requirements of SCM. IT is not only a physical element aiming to generate the intra-/internode connectivity or network, but it is also a capability, control process and strategy that aims to acquire and create information to support the development of new processes and implement supply chain strategies (Shi and Daniels 2003; Sanders 2007; Adamides et al. 2008; Kohli and Grover 2008; Pereira 2009). Therefore, an integrative structure for IT flexibility that covers IT infrastructural support and facilitates divergent, supply chain–wide value creation activities is required. This has given rise to the concept of IT flexibility in its multiple dimensions.

The multidimensional approach is based on the existing flexibility literature. To adapt to changes, a consensus in the operations management (OM) and SCM literature has developed regarding the necessity for multiple dimensions of flexibility. The basic idea is that the availability of different change options is primarily required to the concept of flexibility to cope with diverse types of environmental changes. (e.g. Gerwin 1987; Sethi and Sethi 1990; Upton 1994; Koste and Malhotra 1999; Vickery et al. 1999; Duclos et al. 2003; Lummus et al. 2005; Sánchez and Pérez 2005; Stevenson and Spring 2007; Bernardes and Hanna 2009; Tiwari et al. 2015). However, with the current single dimensions, existing IT flexibility cannot achieve such a multidimensional flexibility structure to truly realise its potential usefulness in SCM.

Given the above considerations, in this study, IT flexibility is regarded as a wider concept, emphasising not only the technical capability of creating, transmitting and interpreting information between organisations but also a capability to manage organisational, relational value creation activities with supply chain partners. Based on this idea, the concept of IT flexibility is reconceptualised through a broader perspective by identifying diverse supply chain processes and strategies.

This study uses the term *IT flexibility* rather than similar terms, such as *IT infrastructure flexibility* or *information exchange flexibility*, because such terms frequently focus on information sharing–related hardware or physical information-transmission devices. In this study, IT is used in the broader meaning of the term to include IT capabilities, IT processing and strategies. In contrast, the concept of *IT infrastructure* is too rigid to explore and synthesise the nature of intra-/interorganisational relationships where various types of issues emerge. By developing the concept of IT flexibility rather than IT infrastructure flexibility, one can crystallise the concept of IT flexibility for SCM in a comprehensive sense that is applicable to various levels of intra-/interfirm value creation activities.

1.3 RESEARCH QUESTIONS

Given the discussion in section 1.2, the overarching objective of the current study is to take the first step towards the development of a multidimensional IT flexibility framework for SCM. Taking the previous partial examinations as a starting point, this study addresses the problem of simplification of the current IT flexibility concept and provides directions to develop it; it also validates the IT flexibility concept though empirical analysis. The study proposes that a comprehensive decomposition of IT flexibility into multiple dimensions, subdimensions and attributes is required to accommodate the diverse requirements of different types of supply chain value creation activities. This argument leads to the develop of research question 1, as follows:

Research question 1: What are the key dimensions of IT flexibility for SCM?

In the partial and inconsistent approaches to IT flexibility, ambiguous explanations of the impact of IT flexibility on firm performance (FP) in SCM have been provided. Moreover, the newly captured IT flexibility dimensions in this study may take different roles and responsibilities when it comes to FP. To identify the mechanisms by which multiple IT flexibilities improve FP in the SCM context, this study conceptualises a research model that links IT flexibility and FP. In particular, this study theorises that IT flexibility enhances FP because it increases a firm's process integration capability (PIC), the mediating concept in this research. PIC is incorporated to provide a SCM context to the research model, as process integration is regarded as a normative way of executing supply chain operations. Based on the IT flexibility structure, the present study empirically tests a structural model representing the impact of IT flexibility on FP via PIC. This argument leads to the development of research question 2, as follows:

Research question 2: How do IT flexibility dimensions affect FP in the context of the supply chain execution?

Although the prioritisation of different flexibility dimensions is important to achieve firm competitiveness (Sethi and Sethi 1990; Upton 1994; Upton 1995; Kumar and Stylianou 2014), the comparison of different flexibility dimensions is hard to achieve due to the lack of adequate flexibility measurements (Stevenson and Spring 2007). By considering the importance and performance of flexibility as general measurement criteria (Upton 1995), this study attempts to prioritise the different flexibility types. Moreover, in accordance with this prioritisation, the study suggests a strategic way to (re)allocate firm resources to multiple IT flexibility dimensions to support firms in concentrating on the appropriate dimensions to gain a competitive advantage. This argument leads to the development of research question 3, as follows:

Research question 3: How should firms prioritise different dimensions of IT flexibility and allocate resources to them in a strategic manner?

By answering these questions, this study will provide a comprehensive construct of IT flexibility that covers the heterogeneous use of IT embedded in diverse types of supply chain activities. Moreover, it will identify how IT flexibility dimensions enhance FP in the SCM context. Finally, prioritisation initiatives to manage different IT flexibility dimensions to gain a competitive advantage are suggested.

1.4 STRUCTURE OF THE THESIS

To achieve the research objectives discussed above, this study is organised as follows. Chapter 2 begins with an overview of the established literature on flexibility to provide an overall picture of the flexibility concept. With well-established manufacturing flexibility literature and its application to supply chain flexibility, this chapter demonstrates that a multidimensional structure is an important characteristic of the flexibility concept. Following this, a review on the existing IT flexibility literature is provided; and the review identified that none of the research streams in disparate approaches corresponds to the use of IT for supply chain–wide value creation activities. Based on the findings from the literature review, this chapter concludes that a multidimensional structure of IT flexibility for SCM is required. This finding developed to research questions 1, 2 and 3.

Chapter 3 identifies the IT flexibility dimensions for SCM. With the given requirements of the multidimensional IT flexibility concept, this chapter conducts a systematic review to identify the dimensions of IT flexibility. The systematic review approach has been employed because it provides an exhaustive, integrative review result; it is also useful for classifying the dimensions with evidence-based identification from empirical studies. By examining IT and IT capabilities that enable a certain level of change, adjustment or development of supply chain–wide activities, this chapter identifies three dimensions of IT flexibility and redefines IT flexibility for SCM. This chapter addresses research question 1 by identifying the different dimensions of IT flexibility for SCM. The multiple dimensions are further validated by hypothesis testing in Chapter 6.

In Chapter 4, due to the absence of an appropriate theoretical lens for newly conceptualised IT flexibility, this research combines dynamic capability (DC) theory and relational view (RV) theory to develop a research framework with a proper theoretical foundation. The research framework links IT flexibility dimensions to FP. Moreover, PIC is incorporated into the research framework to provide the context for SCM. With theoretical and practical justifications of the relationships between the types of IT flexibility and their impact on PIC and FP, this chapter develops a research model that links the three IT flexibility dimensions, PIC and FP with hypotheses.

Chapter 5 discusses methodological justifications by addressing the research design, including the research philosophy, approach, strategy and methodological choices. In addition, the methods of empirical analysis and data collection are described. This study uses two empirical analysis methods, namely partial least squares structural equation modelling (PLS SEM) and the importance–performance analysis (IPA) matrix. Based on the research objectives, justifications for the two empirical research methods are also discussed in this chapter.

Chapter 6 consists of three main parts. These comprise the following topics: 1) descriptive statistics on the collected data, 2) IT flexibility research model validation with hypothesis testing and alternative model testing and 3) extension of the research model test results to the IPA matrix. Descriptive statistics of the data are presented to provide an overview of the respondents participating in the current study and an analysis on the key constructs of the IT flexibility research model. Research model validation is carried out through hypothesis testing with PLS SEM. The measurement model is assessed to ensure that it meets four types of validity assessment criteria, followed by structural model assessment with the explained variance (R^2), the standardised path coefficient and the t values produced with the level of significance using the bootstrapping technique. By developing the IT flexibility constructs and the relationships between the flexibility dimensions, it validates the multidimensional structure of IT flexibility for SCM, so the answer provided in Chapter 3 to research question 1 is confirmed. Moreover, by identifying how the three IT flexibility dimensions affect FP, this chapter answers research question 2. In addition, by testing alternative models and comparing the alternative model test results to the IT flexibility research model, this chapter confirms that the proposed model is the most appropriate for describing the characteristics of IT flexibility in the SCM context. Finally, the model test result is extended to prioritise the multiple IT flexibility dimensions. This shows that the prioritisation among flexibility can be determined using the two general measurements, that is, importance and performance. To suggest a strategic way to allocate resources in accordance with the prioritisation, a client firm's data are used for the IT flexibility research model, and the test results are extended to the IPA matrix. This also shows that strategic resource allocation throughout the dimensions can be determined using importance and performance measurements. This finding addresses research question 3.

Chapter 7 closes this study by providing discussions concerning the answers to the research questions. It also covers the implications and limitations of the current research and provides some recommendations for further research. Figure 1.1 summarises the structure of this thesis.

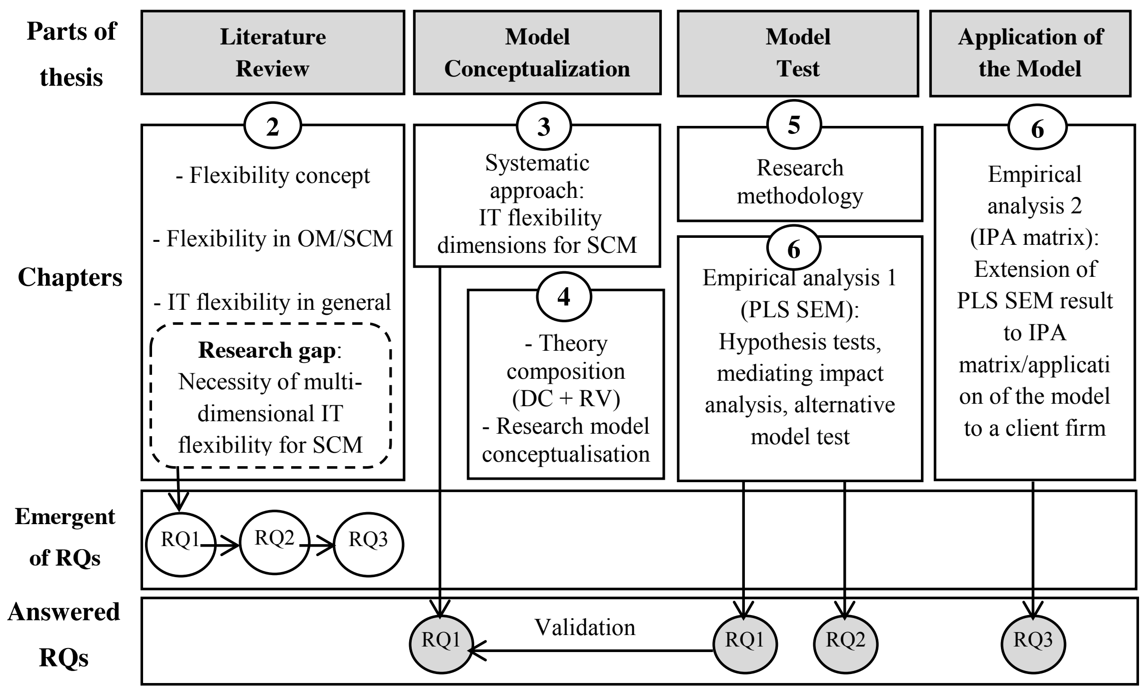


Figure 1.1 Structure of this study with research questions.
Note: OM - operations management, SCM - supply chain management, DC - dynamic capability theory, RV - relational view theory, IPA - importance-performance analysis,, PLS SEM - partial least squares structural equation modeling, RQ - research question
Source: Author.

1.5 CONTRIBUTION OF THE THESIS

The major contribution of this study lies in the reconceptualisation of IT flexibility for SCM into a multidimensional concept. The present study accomplishes this via the development of a model through a comprehensive literature review. The IT flexibility structure is further validated by hypothesis testing. The influential mechanism of IT flexibility on FP is also identified, and the model test result is extended to the IPA matrix to prioritise multiple IT flexibility dimensions. By applying the model to a specific firm and extending the results to the IPA matrix, a strategic approach to allocating firm resources to different IT flexibility dimensions is suggested.

To the best of the author's knowledge, no relevant research has considered multiple dimensions of IT flexibility in their complementary relationships in a way that covers the end-to-end supply chain activities. The proposed IT flexibility model provides a comprehensive approach to IT that shares the allied considerations from technology to intra-/interorganisational issues in SCM. The identification of influential mechanism of IT flexibility for FP also extends the existing knowledge regarding the positive effect of IT flexibility on FP.

While the traditional resource-based view (RBV) explains the infrastructure-based approach to IT flexibility well, this research contributes to existing literature by conjoining DC theory and RV theory. DC theory supports the diverse dimensions of IT flexibility while taking into account the changing business environment. RV theory supports the complementary use of IT resources and their supporting role for interfirm process integration. The composition of theories for IT flexibility validated in this study indicates IT flexibility is a supporter and enabler of divergent interfirm operations and relational strategies in a dynamic business environment and challenges the assertion of the RBV that internal firm resources confine firm boundaries.

Suggestions made concerning the strategy to allocate given resources to multiple flexibility types based on the prioritisation of flexibility dimensions should be highlighted as a key practical contribution of the study. By extending the PLS SEM results to the IPA matrix, this study identifies that the prioritisation can be developed using the two objective measurements, namely importance and performance. Moreover, resource allocation for the most important construct exhibiting low performance is suggested. By applying this process to a specific client firm's data, the study visualises how this firm should allocate resources in accordance with the prioritisation of multiple dimensions of IT flexibility.

The effort to develop and validate the integrative IT flexibility model contributes to the flexibility literature by providing clearer elements in the flexibility analysis framework (Upton 1994; Koste and Malhotra 1999), namely heterogeneity of range (difference between the flexibility dimensions), uniformity (similarity of flexibility dimensions regarding their performance outcomes) and mobility (switching from one dimensions to another). First, the three types of IT flexibility covering supply chain–wide activities in different levels are consistent with the heterogeneity of flexibility dimensions. Second, the positive impact of the three dimensions on FP also indicates that the IT flexibility dimensions have uniformity. Finally, the resource reallocation strategy that was developed by via the IPA matrix indicates that firms can switch their focus from one option to other option, so this research clarifies the concept of mobility with empirical analysis. Figure 1.2 illustrates how this study identified the above three elements from the IT flexibility for the SCM model.

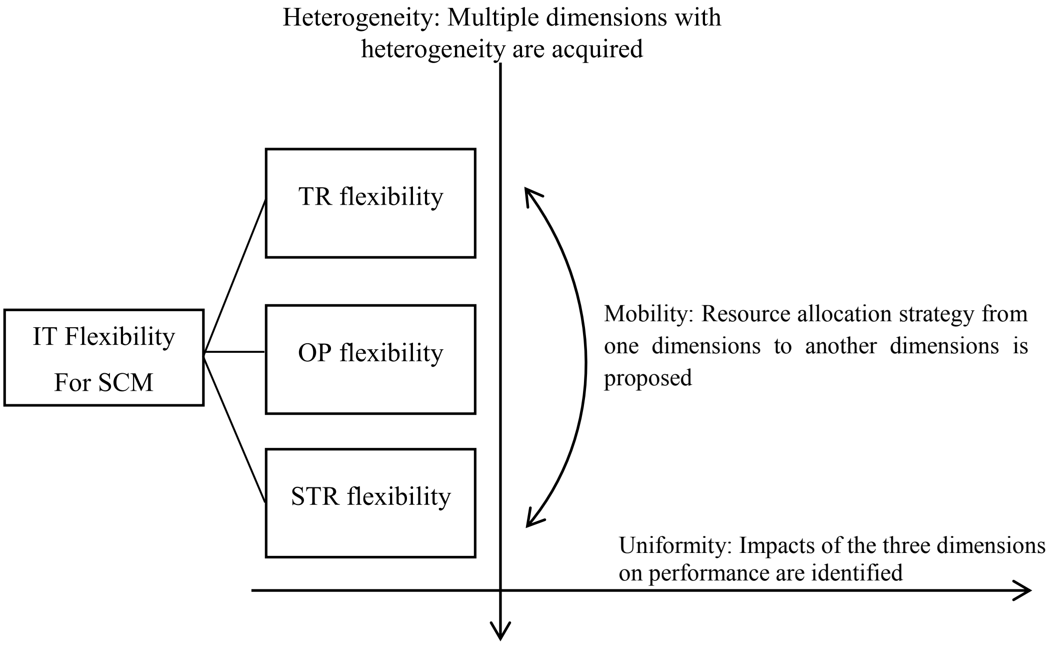


Figure 1.2 IT flexibility for SCM in the flexibility analysis framework.
Note: TR flexibility - Transactional flexibility, OP – Operational flexibility, STR flexibility - Strategic flexibility
Source: Adapted from Upton (1994) and Koste and Malhotra (1999).

CHAPTER 2. GENERIC CONCEPT OF IT FLEXIBILITY

2.1 INTRODUCTION

In this chapter, a literature review is conducted to present the motivation for this study by exploring the current IT flexibility concept and determining the necessity for a multidimensional IT flexibility concept for SCM. A literature review is 'a process to develop the current stratus of knowledge on the research objective' (Thomas 2004, p. 73). By reviewing what is already known about the topic, such as ideas, concepts, controversies and theories, a literature review can helps to generate and refine research ideas (Bryman 2012). Moreover, by critically assessing the existing literature, one can identify the significant results of the existing research (e.g. its limitations and how one's research may fit into the research area), thereby allowing a clear research argument to be constructed (Saunders et al. 2012).

This chapter reviews the three following themes: 1) the characteristics of the flexibility concept, 2) the existing IT flexibility concept and 3) characteristics of IT flexibility required for SCM. In section 2.2, the study clarifies the concept of flexibility in a multidimensional structure by reviewing flexibility studies in OM and SCM literature. In section 2.3, based on the flexibility concept identified, this study reviews the current IT flexibility literature and shows that the current IT flexibility concepts are not suitable for SCM research due to their partial and unidimensional examinations of the roles of IT flexibility. In addition, in section 2.4, by exploring IT use for SCM, this study shows that a multidimensional structure of IT flexibility is required in SCM. Section 2.5 states the findings from the literature review, and section 2.6 develops the three research questions of this study based on the findings. Finally, section 2.7 synthesises the findings in the form of research gaps.

2.2 FLEXIBILITY IN THE LITERATURE

2.2.1 Flexibility in the Literature: Manufacturing Flexibility

1) The concept of flexibility

Flexibility is one of the most extensively used concepts for describing a firm's capability to react to a wide range of possible changes in the business environment (Sethi and Sethi 1990; Upton 1994; Koste and Malhotra 1999; Fredericks 2005; Stevenson and Spring 2007; Bernardes and Hanna 2009; Jain et al. 2013; Mendes and Machado 2015). It is known that much of the literature related to flexibility originated from OM literature (Shi and Daniels 2003; Sánchez and Pérez 2005), including the early notable studies, such as those of Gerwin (1987), Slack (1987), Sethi and Sethi (1990), Upton (1995) and Koste and Malhotra (1999), that dealt with uncertainties in a changing market.

The term 'flexibility' is derived from the Latin word, *flectere,* which means 'to bend' (de Haan et al. 2011). The original meaning has a number of implications when it comes to understanding its evolving meaning in the literature. First, the meaning 'to bend' indicates that flexibility is a firm's capability to change or adjust its status. Second, it implies that there are external forces requiring firms to do this (Beach and Muhlemann 2000; de Haan et al. 2011). Third, the meaning 'to change or adjust' contrasts with the meaning 'to break'; thus, flexibility represents the extent to which a firm is capable of changing or adjusting its status (de Haan et al. 2011).

Numerous articles have defined flexibility in the OM literature, and there has been a consistent focus on the capability of adapting to changes, as discussed above. One of the most widely used definitions was provided by Gerwin (1987), who described the flexibility concept as "the ability to respond effectively to changing circumstances. " (p. 1172). Sethi and Sethi (1990) also defined the flexibility of a system as "its adaptability to a wide range of possible environments that it may encounter." (p. 295). According to Upton (1995), defined that "Flexibility is about increasing range, increasing mobility, or achieving uniform performance across a specified range" (p. 76). Key flexibility definitions widely used in the literature are listed in Table 2.1.

Reference	Definitions
Bernardes and Hanna (2009)	Ability of a system to change status with extendable change options.
Yi et al. (2011)	"Flexibility represents the capability of a firm to respond to unanticipated environmental changes in its production process and in the marketplace" (p. 272).
Gerwin (1987)	"[F]lexibility is the ability to respond effectively to changing circumstances" (p. 1172).
Golden and Powel (2000)	The capacity to adapt with the multi-dimensional elements of a firm
Groote (1994)	Capability to yield the best desirable/possible performance in the face of environmental variability than other capability under the same condition.
Kickert (1985)	"It is a form of meta-control aimed at increasing control capacity by means of an increase in variety, speed, and amount of responses as a reaction to uncertain future environmental development" (p. 24).
Leeuw and Volberda (1996)	"In terms of management and organization, flexibility is a function of the control capability of the management and the changeability of the organization" (p.130).
Mendes & Machado (2015)	"[T]he capability or ability to make adjustments needed to adapt or react to environmental uncertainties and changes, paying special attention to critical factors like time, performance or cost, among others"(p. 4088).
Sanchez (1995)	"[F]irm abilities to respond to various demands from dynamic competitive environments" (p.138).
Sawhney (2006)	"[T]he ability to react or transform with minimum penalties in time, cost and performance" (p. 476)
Sethi and Sethi (1990)	"Flexibility of a system is its adaptability to a wide range of possible environments that it may encounter" (p. 295).
Slack (1987)	"Flexibility means being able to change the operation in some way. This may mean changing what the operation does, how it is doing it or when it is doing it" (p. 39).
Slack et al. (2013)	"Flexibility means being able to change the operation in some way. This may mean changing what the operation does, how it is doing it, or when it is doing it" (p. 52).
Saghiri and Barnes (2016)	"[T]he ability to respond effectively to changing circumstances, or meeting changes demanded by the customer or business environment" (p. 172).
Upton (1995)	"Flexibility is about increasing range, increasing mobility, or achieving uniform performance across a specified range" (p. 76).
Zhang et al. (2003)	The organisation's ability to meet an increasing variety of customer expectations without excessive cost, time, organizational disruptions, or performance losses.

Table 2.1 Key Definitions of Flexibility
Source: Compiled by author.

2) Characteristics of flexibility

The characteristics of flexibility can be clarified by comparing the idea of flexibility to other similar ideas. The concept of flexibility is often used interchangeably with agility or responsiveness because these are all responsiveness constructs related to adapting to changes (Bernardes and Hanna 2009). Specifically, OM literature – particularly manufacturing literature – has demonstrated that flexibility highlights the importance of available change options as a major element of the flexibility concept compared to agility or responsiveness (Bernardes and Hanna 2009).

According to Bernardes and Hanna's (2009) review, flexibility is a capability 'to change' status; thus, it has scopes, which refer to the number of options that can be achieved by investing time/cost. With explanations of the achievability of changes, the change options can be extended to a large group of entities. In contrast, the concept of agility highlights competitiveness through being able to adapt in a changing and unpredictable business environment in a rapid and smooth manner. Agility refers to the ability to reconfigure available options to accommodate environmental uncertainties, so the concept of agility is dedicated to rapid reorganisation of the firm's status. Meanwhile, responsiveness is interpreted not as an available option but rather as an outcome. Associated with the idea of external impact and awareness of the impact of the firm, responsiveness is defined as the timely and commensurate reactions of a system supported by flexibility and agility (Bernardes and Hanna 2009). Table 2.2 summarises the differences between these synonyms.

Organisational perspective	Flexibility	Agility	Responsiveness
Definition	Ability of a system to change status with extendable change options	Ability of the system to rapidly reconfigure with a new parameter set	Propensity for purposeful and timely behaviour change in the presence of modulating stimuli

Table 2.2 Conceptualisation of Flexibility, Agility and Responsiveness
Source: Adapted from Bernardes and Hanna (2009).

The available change options for flexibility have been highlighted in the OM literature, and there is a general consensus among researchers that the flexibility idea is a multidimensional concept (Gerwin 1987; Upton 1994; Koste and Malhotra 1999; Beach and Muhlemann 2000; Golden and Powell 2000; Bernardes and Hanna 2009; Rogers et al. 2011; Jain et al. 2013; Mendes and Machado 2015; Saghiri and Barnes 2016). Early researchers argue that, to construct a flexibility concept, the identification of multiple change options is the first step and the operationalisation of the options should follow. Such multiple change options are described as the *dimensions of change*, which refers to the situation for which flexibility is required due to the variety of changes firms are required to adapt to changes (Upton 1994; Koste and Malhotra 1999; Beach and Muhlemann 2000; Golden and Powel 2000; Rogers et al. 2011).

Beach and Muhlemann (2000) ascertained that these dimensions are required to adapt to the uncertainties and variables in the business environment. Specifically, they argued that there are stimuli, originating internally and externally that are “the cause of the requirements for flexibility” (Beach and Muhlemann 2000, p. 43); thus, firms require managerial actions that deal with the stimuli through operational changes. Such changes require managerial actions that are categorised into size, novelty, frequency, creation and rate, generating the dimensions of flexibility (Figure 2.1); these can then be extended and developed into manufacturing flexibility dimensions (Beach and Muhlemann 2000).

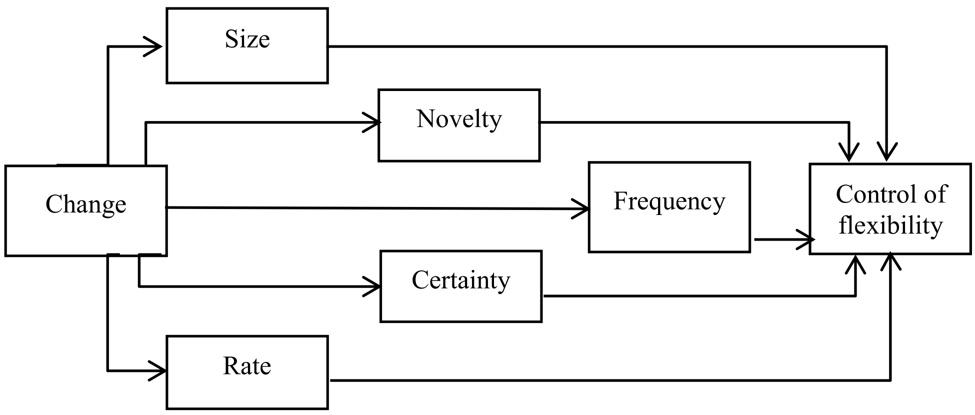


Figure 2.1 Linkages from operational change dimensions and flexibility.
Source: Adapted from Beach and Muhlemann (2000).

The approach to flexibility through identifying the change options indicates that flexibility is not just about to change a specific status or a capability to adapt to a certain change. To be flexible, a firm needs to operate a range of options. According to Slack (1987), such an approach is called the identification process of range and response flexibility. *Range flexibility* signifies the range of status the system can achieve; *response flexibility* refers to the ease with which changes can be made (in terms of cost or time). Therefore, to be flexible, determining the dimensions of flexibility that are to be changed or adapted is the first step; following this, firms need to elastically switch their focus from one specific dimension to another according to the requirements of external changes.

Based on this multidimensional structure of flexibility, Upton (1994) provided a flexibility analysis framework with three elements of flexibility to describe how firms should utilise such multiple dimensions (Figure 2.2). These elements were range, uniformity and mobility. *Range* refers to the dimensions of change with a variety of options in terms of size, volumes and product. *Uniformity* is used when a system shows similar performance measures with the ranges. *Mobility* refers to the ability to move from one dimension to another with low cost penalties. Upton (1994) argued that multiple flexibility dimensions need to be operated elastically, so that it is possible to move from one to another; at the same time, it is necessary to incur lower costs in terms of transition penalties and similarity of outcomes.

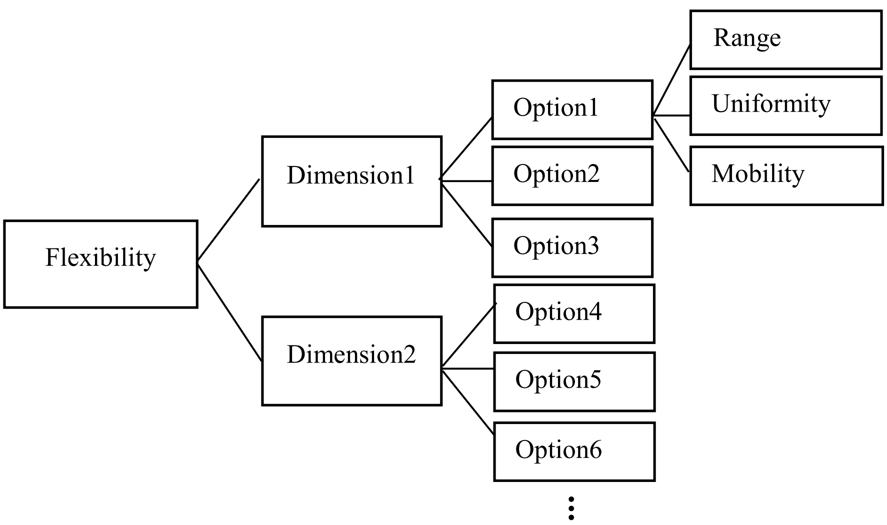


Figure 2.2 A framework for analysing flexibility.
Source: Adapted from Upton (1994).

Koste and Malhotra (1999) further developed the three elements of flexibility by investigating the characteristics required for each element. One notable difference in Koste and Malhotra's (1999) work is that they argued that the ranges (a series of dimensions of change, such as operations, processes and products) need to be *heterogeneous* to increase the size options or alternatives in a changing business environment. *Mobility* refers to movement within the range of options; here, transition penalties are created so that mobility can be measured by the time or cost of change. *Uniformity* is a certain type of performance measurement within the range, and this should be indifferent within a system. Koste and Malhotra (1999) reported that the quality of service, cost and time required to generate a product are examples of performance outcomes. This multidimensional framework structure has been applied widely to manufacturing and supply chain flexibility. Table 2.3 summarises the elements of flexibility and their indicators.

Elements	Indicators
Range – number (with number of options)	Number of options (operations, tasks, products, etc.)
Range – heterogeneity (with heterogeneity of options)	Differences between options (operations, tasks, products, etc.)
Mobility	Transition penalties – time, cost, effort of transition
Uniformity	Similarity of performance outcomes – quality, cost, time, etc.

Table 2.3 Dimensions of Flexibility and Potential Indicators
Source: Adapted from Koste and Malhotra (1999).

3) Dimensions of manufacturing flexibility

In line with the concept of flexibility as a capability to adapt to changes with multiple change options, manufacturing flexibility was explored to represent the capability to cope with uncertainties, particularly those faced by manufacturing systems (Gerwin 1987; Sethi and Sethi 1990; Upton 1994).

Gerwin (1987) identified several domains of uncertainty in manufacturing systems and linked different flexibility dimensions according to the nature of each type of uncertainty. Gerwin (1987) argued that by identifying dynamic uncertainties and developing flexibility dimensions to adapt to those uncertainties, a firm can create a significant competitive advantage. For example, *mix flexibility* is an ability to provide several different products at the same time. *Changeover flexibility* denotes an ability to manage additions to the mix over time. Furthermore, *modification flexibility* is an ability to build functional changes, while *rerouting flexibility* is the degree to which the operating flow can be changed. *Volume flexibility* refers to the ease of the changes in the aggregate amount of production of a manufacturing process. *Material flexibility* is the ability to handle variations in the composition of the parts being processed, finally, *sequencing flexibility* denotes the arrangement of the order in which different kinds of parts are provided to the manufacturing process (Gerwin 1987). Table 2.4 summarises the environmental changes and associated flexibility types.

Flexibility dimension	**Uncertainty type**
Mix	Demand for the kinds of products offered
Changeover	Length of products' lifecycles
Modification	Appropriate product characteristics
Rerouting	Machine downtime
Volume	Amount of aggregate product demand
Material	Meeting raw material standards
Sequencing	Timing of arrival of inputs

Table 2.4 Types of Environmental Changes and Associated Flexibility Types
Source: Gerwin (1987).

This clarification of manufacturing flexibility according to different dimensions was also supported by Slack (1987). By observing the flexibility in resource and systems level from perspectives of managers, Slack (1987) found machine (labour) flexibility at the resource level and product, mix, volume and delivery flexibility at the systems level. Slack (1987) thus considered more tangible elements than Gerwin (1987), who focussed on the order fulfilment process. According to Slack (1987), *machine flexibility* refers to the ability to modify or reschedule production of given parts. *Product flexibility* denotes the ability to introduce new products or modify existing ones, while *mix flexibility* describes the ability to change the range of products made in a given period. *Volume* *flexibility* refers to the ability to change the level of aggregated output, and *delivery flexibility* denotes the ability to change planned or assumed delivery dates.

Koste and Malhotra (1999) also identified a range of manufacturing flexibility elements in a systematic review which became major dimensions of manufacturing flexibility (Jain et al. 2013; Saghiri and Barnes 2016). Apart from the flexibility types discussed above, they identified expansion, operation and material handling flexibility. *Expansion flexibility* refers to the number of change options that can be accommodated with heterogeneity. *Operation flexibility* describes the development of multiple processing plans available for multiple products. *Material handling* denotes the number of existing paths between processing centres and the variety of material that needs to be transported along the path. Moreover, they divided *product flexibility* into a *new product flexibility* category for the introduction of new product and modification flexibility for product modification.

One of the notable contributions of Koste and Malhotra (1999) is a flexibility hierarchy that identifies the relationships between the flexibility dimensions. For instance, machine flexibility and material handling flexibility are necessary building blocks for other dimensions, so they are listed at the bottom of the hierarchy in Tier 1: Individual Resources. New product flexibility (the number and heterogeneity of new products introduced into the production) and modification flexibility (the number and variety of product modifications) are supported by machine flexibility, so they are found in Tier 3: Plant Level, as presented in Table 2.5.

Tier	Flexibility dimensions
Tier 4: Functional	Organisational, manufacturing flexibility
Tier 3: Plant	Mix, expansion, new product, modification, volume flexibility
Tier 2: Shop floor	Operation and routing flexibility
Tier 1: Individual resource	Machine, labour, material handling flexibility

Table 2.5 Flexibility Dimension Hierarchy

Source: Adapted from Koste and Malhotra (1999).

This flexibility hierarchy was elaborated on further by Stevenson and Spring (2007) to highlight the multidimensional structure of flexibility ranging from operational flexibilities on the shop floor to strategic flexibility at the firm level (Table 2.6). In their conception, together with the above dimensions in the hierarchy, the capability to adapt to market requirements was highlighted with the concept of market flexibility at the strategic flexibility level, as shown in Table 2.6.

Hierarchical level	Flexibility dimensions	Description
Strategic flexibilities (firm level)	New design	Speed (and cost effectiveness) at which the firm can design and introduce new products into the system
	Expansion	Ease with which the firm can add long-term capacity to the system
	Market	In-house ability to adapt to changes in the market environment
Tactical flexibilities (plant level)	Product/ modification	Ability to add or substitute new parts into the system
	Volume	Range of output levels at which the system can cost effectively produce products
	Delivery	Ability of the system to respond to changes in delivery requests
	Production	Range of products the system can produce without adding new equipment
Operational flexibilities (resource and shop floor level)	Machine	Range of operations that a piece of equipment can perform without resulting in a major setup
	Material handling	Capability of a process to move different parts throughout the shop
	Operations	Range of alternative processes or ways in which a part can be produced within the shop
	Automation	Extent to which flexibility relies upon automated manufacturing technologies
	Labour	Number of tasks that an operator can perform on the shop floor
	Process	Range of parts that can be produced without resulting in a major setup
	Routing	Number of alternative paths that a part can take through the shop to be completed
	Program	Length of time the shop can operate unattended

Table 2.6 Hierarchy of Flexibility

Source: Adapted from Stevenson and Spring (2007).

In a similar vein, by incorporating customer requirements into the flexibility idea, Zhang et al. (2003) argued that task-sequencing flexibilities focussing on internal competency creation may not enhance market satisfaction. To understand manufacturing flexibility, the concept of external capabilities was highlighted as representing new types of manufacturing flexibilities, namely volume and mix flexibility. In Zhang et al.'s (2003) work, machine, labour, material handling and routing flexibility were viewed as flexible manufacturing competences that support the flexible manufacturing capability. Flexible manufacturing capability is consisted with volume and mix flexibility. *Volume flexibility* refers to the organisation's ability to operate at various batch sizes or at different production output levels. *Mix flexibility* refers to the ability to produce different combination of products with a given capacity. Volume flexibility's focus is its economical approach to the production output according to the demand scale, whereas mix flexibility considers the customer requirements as a change to be managed.

The internal and external elements of flexibility were further distinguished by Naim et al. (2006), who found that *internal flexibility*, which refers to system behaviour, determines the actual performance of a firm, such as machine and routing flexibility. *External flexibility* is capability seen by customers, such as in the cases of mix, volume and delivery flexibilities. Table 2.7 presents the categorisation of manufacturing flexibility.

Internal flexibility	Definition	External flexibility	Definition
Machine	Ability to easily modify production of given parts	(New) product	The range and ability to accommodate the production of new products
Process	Ability to produce the same parts in different ways	Mix	The range of and ability to change the products currently being produced
Operation	Ability to sequence production in certain ways	Volume	The range of and ability to accommodate change in production output
Capacity	Ability to easily add to production capacity	Delivery	The range of and ability to change delivery dates
Routing	Ability to carry on production despite internal uncertainties		

Table 2.7 Types of Manufacturing Flexibility
Source: Naim et al. (2006).

This external capability–focussed flexibility frequently overlaps with product flexibility in the supply chain flexibility literature, as the manufacturing system is often viewed as a part of the supply chain. While manufacturing systems involve internal product–related manufacturing systems (Gerwin 1987; Sethi and Sethi 1990; Upton 1994), supply chain flexibility takes a broader perspective, considering the relationships with other trade partners. For example, product flexibility generally indicates two types flexibilities, namely product flexibility and new product flexibility. The former refers to the capability to customise products to meet specific customer requirements, while the latter describes the capability to introduce new or revised products to cope with decreasing product lifecycles and increasing demand for many new products on the market (Slack 1987; Koste and Malhotra 1999; Stevenson and Spring 2002).

By composing and extending these two capabilities, launch flexibility is introduced in the supply chain context to emphasise the importance of integration of divergent value activities across the supply chain (Vickery et al. 1999). In fact, the rich body of manufacturing flexibility literature – which provides insights into the characteristics of flexibility, such as the context-based approach on uncertainty (Shi and Daniels 2003), and multiple dimensions of flexibility, such as basic flexibility, system flexibility and aggregate flexibility (Tiwari et al. 2015) – provides a sound foundation from which to build supply chain flexibility.

One of the recent studies that has broadened the scope of manufacturing flexibility to supply chain management flexibility is Rogers et al. (2011). Through an extensive literature review they suggested a holistic view of manufacturing flexibility with six dimensions. One of the notable differentiations made by Rogers et al. is the inclusion of supply management into the concept of manufacturing flexibility. Supply management was considered as a part of the external environment in which firms can extend their control as firms are able to reduce some uncertainties through supplier reconfiguration. Therefore, supply flexibility is included to support the idea that buyer–supplier relationship management affects manufacturing flexibility. In the same context, Aissa Fantazy et al. (2009) and Yi et al. (2011) stated that, with the demands for interfirm cooperation with trade partners and jointly produced profits, the concept of manufacturing flexibility now needs to be extended to the supply chain to cover interfirm business scenarios. The necessity of such extension was further discussed by Mendes and Machado (2015), who argued that manufacturing flexibility is a multidimensional concept and thus different dimensions frequently intertwined in different functional areas and extended to different areas such as the supply chain. Table 2.8 summarises the six dimensions of manufacturing flexibility, and shows that supply chain flexibility is included to extend the scope of manufacturing flexibility.

Flexibility dimension	Definition
Product mix flexibility	The ability to offer a broad product line through the ability to change the product.
Routing flexibility	The ability to move parts, tooling and materials along multiple routes in the facility.
Equipment flexibility	The ability of machines to perform multiple operations for different products.
Volume flexibility	The ability of the systems to increase or decrease volume while remaining profitable.
Labour flexibility	The ability of workers to perform more than one task within a system.
Supply management flexibility	The ability of suppliers to respond to changes requested by the customers.

Table 2.8. Manufacturing Flexibility from a Comprehensive View.
Source: Rogers et al. (2011)

2.2.2 Supply Chain Flexibility

The changes in the current business environment, which involve intensified competition, rapid technological changes, shortened product lifecycles and mass customisation, require supply chains to be more responsive to those changes with their extended dependencies (Bernardes and Hanna 2009; Bhatt et al. 2010; Duclos et al. 2003). Along with the development of IT and the expanded market, the idea of SCM has developed into a strategic concept related to firm competitive advantage; it has accomplished this by integrating diverse functional areas, such as material production, procurement, transportation, warehousing and distribution (Lancioni et al. 2000; Zeng and Pathak 2003). Thus, the goal of SCM is to streamline all activities and strategies involved in the supply chain to increase efficiency with the aim of meeting the market requirements while generating benefits for participating firms. In this context, SCM is defined as the management of an extended enterprise as a network of processes, relationships and technologies creating interdependence and shared destiny to create a competitive advantage (Power 2005)[1].

As collaboration with supply chain partners has received greater emphasis, SCM researchers have linked manufacturing flexibility elements to external supply chain practices by extending the scope of change options to interorganisational dimensions of SCM. According to Stevenson and Spring (2007), the focus of flexibility has now been extended from the focal firm's view to the supply chain, so that in the hierarchy of flexibility (e.g. Tables 2.5 and 2.6), supply chain flexibility is located at the top of the hierarchy (i.e. above strategic flexibility) making the manufacturing/operational flexibility a fundamental element of supply chain flexibility (Merschmann and Thonemann 2011).

1) Dimensions of supply chain flexibility

Vickery et al. (1999) defined five supply chain flexibilities based on previous manufacturing flexibility. The five dimensions of flexibility types include the following: 1) *product flexibility* to customise product in features, options, sizes or colours to meet specific customer demand; 2) *volume flexibility* to adjust (accelerate or deaccelerate) production capacity to meet changes in customer quantities; 3) *new product flexibility* to launch a large number of new or revised products; 4) *distribution flexibility* to provide widespread, intensive distribution coverage; and 5) responsiveness flexibility to respond to target market requirements. .

While the above dimensions of flexibility focus on the internal or functional area of a firm, especially in manufacturing and distribution to the market, a body of literature has attempted to capture the various types of supply chain flexibility dimensions by

[1] The characteristics of supply chain management are discussed further in section 2.4.1 in terms of the requirements of IT flexibility for supply chain management.

considering cross-functional (intrafirm) and cross-business (interfirm) characteristics of SCM. According to Lummus et al. (2005) and Merschmann and Thonemann (2011), supply chain flexibility needs to consider the inter-organisational activities and the customer's ultimate satisfaction from the perspective of the entire value chain. Therefore, supply chain flexibility should be understood at the network level of analysis, such as analysis of lead/cycle time to customers, customer delivery times, visibility in customer demand and so on. Table 2.9 represents these characteristics of supply chain flexibility.

Supply chain flexibility characteristics
Ability to synchronise to customer delivery dates and times
Ability to shorten cycle times
Visibility of customer demand
Efficient information flow throughout the supply chain network
Ability to shorten lead times
Accurate and timely data
Clear company strategy
Inventory visibility
Internal communications
Supplier collaboration to improve delivery and quality

Table 2.9 Supply Chain Flexibility Characteristics from the Network Perspective

Source: Adapted from Lummus et al. (2005).

Duclos et al. (2003), Lummus et al. 2005, Sánchez and Pérez (2005), Stevenson and Spring (2007) and Tiwari et al. (2015) have adopted the ideas of manufacturing flexibility, but they also considered the firm boundary–spanning operations of SCM. The focus of these studies has been to extend the concept of flexibility from manufacturing systems to interfirm operations to demonstrate a supply chain's ability to satisfy the market requirements.

Although the titles of flexibility are sometimes slightly different from each other, such an approach incorporates supply chain–wide issues, such as product and service offering, material distribution, supply chain structure, collaboration and information systems. Table 2.10 summarises the supply chain flexibility dimensions covering supply chain–wide issues, including the flexibility interfirm operations.

Supply chain flexibility dimension	Description	Reference
Launch/product mix flexibility	Ability to rapidly introduce a diverse range of products and services.	Sánchez and Pérez (2005), Sawhney (2006), Aissa Fantazy et al. (2009), Rogers et al. (2011), Mendes and Machado (2015), Saghiri and Barnes (2016).
Operations (systems) flexibility/ reconfiguration flexibility	Ability to (re)configure/reinvent assets and operations to react to market change at each node of the supply chain.	Duclos et al. (2003), Lummus et al. (2005), Sánchez and Pérez (2005), Sawhney (2006), Stevenson and Spring (2007), Yi et al. (2011), Mendes and Machado (2015), Tiwari et al. (2015).
Adaptation/modification/expansion flexibility	Ability of the firm to quickly adapt and adjust to internal and external variances.	Sawhney (2006), Tiwari et al. (2015), Saghiri and Barnes 2016
Logistics/ delivery flexibility	Ability to cost effectively and rapidly receive and deliver products as customers and sources of supply change, e.g. adjusting the physical distribution process or warehouse capacity and career arrangement according to changes in customer requirements.	Duclos et al. (2003), Lummus et al. (2005), Sánchez and Pérez (2005), Sawhney (2006), Stevenson and Spring (2007), Aissa Fantazy et al. (2009), Yi et al. (2011).
Supply/network/relationship/ partnering flexibility	Ability to build or reconfigure supply chain collaboration relationships such as adding or selecting suppliers and altering the supply of products or new product development in line with customer demand.	Duclos et al. (2003), Lummus et al. (2005), Sánchez and Pérez (2005), Stevenson and Spring (2007), Rogers et al. (2011), Tiwari et al. (2015).
Offering flexibility	Ability of supply chain linkages to incorporate modification and changes in products or services.	Gosain et al. (2004), Tiwari et al. (2015).
Backward and forward/full integration/ access flexibility	Ability of supply chain to extend its participations backward and forward.	Sánchez and Pérez (2005), Tiwari et al. (2015).
Organisational/ design flexibility/routing flexibility	Ability to align or redistribute labour force skills to meet the current needs of the whole supply chain / to meet customer service/demand	Duclos et al. (2003), Lummus et al. (2005), Sawhney (2006), Stevenson and Spring (2007), Yi et al. (2011),

	requirements, e.g. a change in organisational structure, human resource processes, workforce capabilities, link between workforce and the nodes.	Rogers et al. (2011).
Information systems/ interorganisational information systems flexibility	Ability to align information (systems) to the supply chain process for existing supply chain entities to meet changing customer demand.	Duclos et al. (2003), Lummus et al. (2005), Stevenson and Spring (2007), Aissa Fantazy et al. (2009), Tiwari et al. (2015).
Robustness/input- quality flexibility	Range of market change/requirements with which the current supply chain configuration is able to cope.	Sawhney (2006), Stevenson and Spring (2007).
Postponement flexibility	Ability to keep products in their generic form.	Sánchez and Pérez (2005).
Market flexibility	Ability to mass customise and build close relationships with customers, e.g. customising of procurement and services to changes in the market environment.	Duclos et al. (2003), Stevenson and Spring (2007).
Volume flexibility	Ability to effectively increase or decrease production in response to customer demand.	Sánchez and Pérez (2005), Sawhney (2006), Rogers et al. (2011), Mendes and Machado 2015, Saghiri and Barnes 2016.

Table 2.10 Supply Chain Flexibility Dimensions

Source: Compiled by author

As supply flexibility and partnering flexibility (Duclos et al. 2003; Lummus et al. 2005; Sánchez and Pérez 2005; Stevenson and Spring 2007; Rogers et al. 2011; Tiwari et al. 2015), in Table 2.10 indicate supply chain flexibility studies have argued that the collaboration to meet the market requirements is one of the key aspects of supply chain flexibility. Researchers have ascertained that elasticity in the alteration of supply chain relationships will support rapid changes in the supply chain structure so that more flexible products in its new or modified features will be available. Information system flexibility (Duclos et al. 2003; Lummus et al. 2005; Stevenson and Spring 2007; Tiwari et al. 2015) is another example. Although the constructs or dimensions are not specified and its role is described as an IT infrastructure supporting a higher-level organisational capability, recognition that information systems interlink supply chain processes and participating firms strongly highlights the importance of collaboration between supply chain–participating firms.

To incorporate a more strategic view on product handling, the concept of market flexibility was introduced by Duclos et al. (2003) and Stevenson and Spring (2010). Market flexibility is based on the importance of the capability to mass customise and build close relationships with customers regarding the design and modifications of existing and new products; however, it also considers the rapid changes in customer requirements. What makes market flexibility different from product flexibility is that it includes the capability of product postponements (Sánchez and Pérez 2005). The delay of product differentiation to the last possible stages enables supply chain managers to manage the volatile demand patterns of customers by reacting to the order patterns in an expedited manner; for example, this may be done though packaging in distribution centres rather than the factory (Anderson et al. 1997; Sánchez and Pérez 2005; Saghiri & Barnes (2016). This is relevant to the customer-focussed approach to supply chain flexibility. Specifically, the flexibility via customisation has been discussed as one of the major issues related to achieve flexibility, as supply chain flexibility is often understood as the result of supply chain activities geared towards providing customised services to meet diverse customer requirements (Anderson et al. 1997; Hausman 2004; Tallon and Pinsonneault 2011; Lee 2012).

This market condition–based view emphasises the optimisation of core service activities in the chain to maximise the speed of response to the changes in customer requirements. For example, to increase the responsiveness of a supply chain to customer demand, Prater et al. (2001) argued that the inbound logistics and manufacturing process can exhibit complementary relationships; if one of these operations shows shortcomings, the other can compensate for the slow operation, so that the overall process is flexible. In Sanchez's (1995) model, the necessity of three types of flexibility is emphasized. *Access flexibility* is defined as the ability to provide wide, intensive distribution coverage that can be enhanced by the close coordination of internal or external activities of the firm that are downstream in the chain . *Delivery flexibility* is the capability to control the lead times to the customers, such as just in time with the right quantity, place and time. *Tranship* *flexibility* refers to the ability to tranship stocks at a particular supply chain stage with given physical distances.

In line with the interrelated business relationships in SCM, Gosling et al. (2010) outlined the supply chain flexibility framework. Their framework is based on the idea that the external flexibility of a supply system is determined by two internal supply chain flexibilities; thus, existing flexibility types are categorised into internal supply chain flexibility and external flexibility. Internal flexibility consists of *vendor flexibility*, which refers to the capability of individual vendors to support manufacturing warehousing and transport, and *sourcing flexibility*, which represents the ability to reconfigure a supply chain network through the selection of vendors. The external flexibility consists of *new products* (to accommodate the new production), *mix* (to change products), *volume* (to accommodate changes in production output), *delivery* (to change delivery date) and *access* (to provide extensive geographical coverage) *flexibility*. Figure 2.3 depicts such relationships between internal supply chain flexibility and external flexibility.

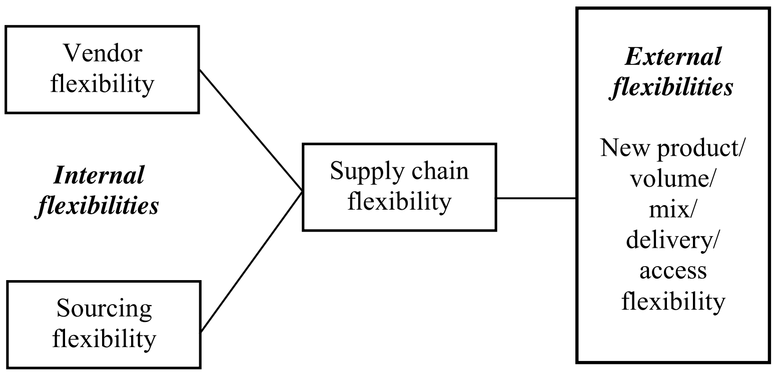


Figure 2.3 The supply chain flexibility framework.
Source: Gosling et al. (2010).

Overall, although it has been recognised that the dimensions are hard to capture due to the complexity of the supply chain structure (Stevenson and Spring 2007), supply chain flexibility is identified in a comprehensive manner in the existing literature in terms of divergent dimensions of flexibility. Thus, a range of dimensions and their indicators are actively discussed with their importance related to adapting to the changes.

2.3 IT FLEXIBILITY

Whereas manufacturing and supply chain flexibility focus on the firm's activities to adapt to changes in manufacturing systems and the interfirm business environment, the focus of IT flexibility has been on supporting such manufacturing and supply chain activities with IT. After an extensive investigation of the existing IT flexibility concept, it can be recognised that the concept of IT flexibility has not been as well established as that of manufacturing or supply chain flexibility, although IT flexibility need to be a multidimensional concept depending on the divergent supporting and enabling roles with which IT flexibility needs to cope (Kumar and Stylinanou 2014). The investigation on the IT flexibility concept conducted in this section aims to generate insights into how the current literature characterises IT flexibility. In particular, the focus of the review comprises the operationalisation of IT flexibility dimensions to review the dimensions developed by the current IT flexibility studies.

2.3.1 IT Flexibility: An Overview

Table 2.11 presents key representative definitions of IT flexibility identified from IT/information systems (IS) literature that provide an explicit explanation of IT-related flexibility and exhibit the development in understanding the meaning and scope of the IT flexibility concept[2]. Definitions of IT flexibility from the OM/SCM area have been established in papers that normally treat IT flexibility as one of the supporters of a higher-level organisational capability without much attention devoted to their constructs (IS/inter-organisational IS flexibility in Table 2.10). However, definitions developed from the IT/IS usually locate IT flexibility idea more as a core element of their discussions. There is a strong consensus that IT needs to be flexible to support firms to accommodate variances from external uncertainties through developing, adjusting or integrating the functionalities of IT. From the definitions, it is confirmed that IT flexibility is also a capability for adapting to changes, as they also emphasise the capability to accommodate

[2] The articles cited in Tables 2.11 and 2.12 were selected through searches on several databases using keywords (e.g. IT flexibility, IS flexibility, IT infrastructure flexibility, etc.) and citation review of the selected articles. In Table 2.12, to use reliable works with a balance of evidence, only empirical research that tested the effect of IT flexibility on other types of organisational competitiveness considered (Tranfield et al. 2003; Bryman 2012; Saunders et al. 2012). This approach is discussed further in section 3.2.1.

changes in business environment. For example, its adaptability to new/different environment/scalability (Tallon and Pinsonneault 2011), variety of support (Byrd and Turner 2000), support to alter business strategies (Armstrong and Sambamurthy 1999), accommodate variations (Gebauer and Schober 2006), handle multiple applications (Bhatt et al. 2010), and change communication linkages (Bush et al. 2010) are highlighted in the definition as the primary features of IT flexibility. It should be noted that the current IT flexibility concept is strongly affected by Duncan (1995). All the articles cite Duncan (1995) or Byrd and Turner (2000), and Byrd and Turner's (2000) IT flexibility is based on Duncan's three IT flexibility components. This strong impact is discussed in the next section.

IT-related flexibility	Definition	Reference
IT infrastructure flexibility	IT infrastructure flexibility is characterised by using the constructs of connectivity, compatibility, and modularity.	Duncan (1995)
IT infrastructure flexibility	"IT infrastructure sophistication refers to the extent to which a firm has diffused key information technologies into its base foundation for supporting business applications. A sophisticated infrastructure provides the flexibility to alter business strategies in response to competitiveness" (p.309).	Armstrong and Sambamurthy (1999)
IT infrastructure flexibility	"[T]he ability to easily and readily diffuse or support a wide variety of hardware, software, communication technologies, data, core applications, skills and competencies, commitments and values within the technical physical base and the human component of the existing IT infrastructure" (p. 172).	Byrd and Turner (2000)
IT infrastructure flexibility	"A flexible IT infrastructure facilitates rapid development and implementation of IT applications that enhance customer service process performance by enabling the organization to respond swiftly to take advantage of emerging opportunities or to neutralize competitive threats" (p. 631).	Ray et al. (2005)
IS flexibility	"[A] flexible information system must be able to accommodate a certain amount of variation regarding the requirements of the supported business process." (p 123). It incorporates both flexibility-to-use and flexibility-to-change (conceptually related to infrastructure).	Gebauer and Schober (2006)
IT infrastructure flexibility	"ITI-enabled flexibility is defined here as the ability of ITI to adapt to new, different, or changing business requirements." (p. 91).	Fink and Neumann (2009)
IT infrastructure flexibility	IT infrastructure flexibility includes connectivity, compatibility, modularity and IT personnel competency.	Zhang et al. (2009)

IT infrastructure flexibility	"IT infrastructure flexibility depends on the degree to which the IT infrastructure is scalable, compatible, modular, and can handle multiple business applications." (p. 342).	Bhatt et al. (2010)
IT infrastructure flexibility	"[W]e define IT infrastructure flexibility as the extent to which the focal firm can readily change the IT-based communication linkages across the supply chain, switch firms participating in a supply chain, redesign supply chain processes, and change the scale of the supply chain's operations upward or downward." (p.245).	Bush et al. (2010)
Strategic IT flexibility	"Strategic IT flexibility is the organizational capability that facilitates the adaptation of the information systems to environmental changes by integrating new IT components into the existing information technology infrastructure or by changing the configuration of the existing information systems." (p.241).	Tian et al. (2010)
IT flexibility	"IT flexibility is defined as the ability of IT infrastructure to adapt to both incremental and revolutionary change in the business or business process with minimal penalty to current time, effort, cost, or performance." (p. 237).	Ngai et al. (2011)
IT infrastructure flexibility	"IT infrastructure flexibility encompassing hardware, software, and networks could have a positive moderating effect on the link between alignment and agility. Two specific properties of a flexible IT infrastructure- scalability and adaptability" (p.470).	Tallon and Pinsonneault (2011)
IT infrastructure flexibility	"Flexible IT infrastructure refers to a firm's ability to establish a complete set of technological resources, which provides the foundation for the development of IT applications. In particular, IT infrastructure includes the computing platform, communication networks, critical shared data, and core data processing applications"' (p. 1455).	Liu et al. (2013)
IT infrastructure flexibility	"Information technology infrastructure flexibility is defined as the set of resources for science and technology enterprises to provide rapid development and into the future application of information technology." (p. 175).	Cheng et al. (2014)

Table 2.11 Key Definitions of IT Flexibility

Note: ITI - IT infrastructure
Source: Compiled by author.

2.3.2 IT Flexibility Dimensions

1) A major stream: The impact of Duncan's (1995) infrastructure-focussed view

IT flexibility has been mainly conceptualised within the context of technical/physical elements (the infrastructure-focussed view in Table 2.12). Specifically, its existing definitions and operationalisation is largely based on connectivity, modularity and compatibility, as proposed by Duncan (1995). Duncan's IT flexibility idea was created by combining the concepts of IT and flexibility in the strategic management literature, that is Chatterjee and Wernerfelt (1991). Based on Chatterjee and Wernerfelt (1991), Duncan argued that IT resources can be used more than once, creating multiple options to diversify firm activities and making a firm flexible (Chatterjee and Wernerfelt 1991). Such an approach to IT highlights that IT can serve more than one purpose; thus, in accordance with the idea of many SCM studies, it supports divergent processes and strategies (e.g. Henderson and Venkatraman 1999; Chandra and Kumar 2001; Hong 2002; Shi and Daniels 2003; Vickery 2003). However, in Duncan's (1995) work, the roles of IT were confined to the IT network arrangement enabled by technological infrastructure.

With IT's characteristic as a physical resource, shareability (reach/range) and reusability were proposed as critical sources of IT flexibility for firm competitiveness. Duncan (1995) explained that *reach* describes the connectivity of IT platforms or the number and variety of internal and external platforms to which a firm can connect. Furthermore, *range* refers to the capacity to share different types of information. *Reusability* represents the effective long-term use of IT with standardised and reusable implementations (Duncan 1995). Three elements are interpreted as the key constructs of IT flexibility, as follows:

① Platform connectivity to attach any technological components to other components according to the organisational environment;

② Network compatibility to share various types of information across other technical components; and

③ Application modularity to add and modify any technical components with low cost and penalties.

Connectivity, compatibility and modularity have been the backbone of IT flexibility literature, leading to the claim that IT flexibility is a prerequisite for firms' competitive advantage. Indeed, these three technical elements make up the foundation of IT flexibility on which most business activities depend. Owing to their capability for seamless, cheap, automated operation in the global market, the technical IT components are increasingly vital for information and knowledge sharing throughout the organisations (Byrd and Turner 2000). The following studies have been identified as examples of IT flexibility using the three elements in the dominant infrastructure-focussed view.

Byrd and Turner (2000) conceptualised IT flexibility by incorporating the three elements proposed by Duncan (1995) and supplementing the construct with data transparency. By combining connectivity and compatibility into the category of integration and combining compatibility and data transparency in the concept of modularity, they argued that integrated and modularised information systems have the potential to contribute to organisational flexibility and ultimately to the firm's competitive advantage.

In Liu et al.'s (2013) research, the concept of flexible IT was also structured using Duncan's (1995) three constructs. Specifically, the researchers argued that compatible IT is an enabler of increasing knowledge richness (various formats of information). Modularity contributes to meeting the requirements generated when information exchange occurs with low technical constraints.

Tallon and Pinsonneault (2011) defined IT flexibility as the adaptability and scalability of IT elements, with an emphasis on physical infrastructure. In their work, hardware compatibility was interpreted as adaptability representing interoperable devices. Modularity was regarded as software scalability in which the software functions were modified. Connectivity translated to network connectivity in the sense that IT applications are seamlessly connected to the network. Similar to Ngai et al.'s (2011) conceptualisation, Tallon and Pinsonneault (2011) argued that IT flexibility in technical elements will enhance the firm's agility in internetworked business environments.

Ngai et al. (2011) considered that IT flexibility with three IT elements is required to prepare for coping with unexpected market changes without cost or time penalties. Specifically, they determined that the ease of integration of new and different IT applications through connectivity, compatibility and modularity will equip firms with advanced interfirm operations. Therefore, they argued that the three technical elements contribute to supply chain agility.

In a similar vein, Zhang et al. (2009) argued that connectivity, compatibility and modularity enhance a firm's process improvement and service changes in meeting customer requirements. By placing compatibility and connectivity in a resource category and allocating modularity to a firm-specific–capability category, they attempted to explain how different IT flexibility dimensions play different roles. However, their dimensions were also based on Duncan (1995), and the differentiation focussed on categorising the currently identified dimensions into two areas, namely resources and firm-specific capabilities.

Some research has developed new constructs of IT flexibility to mirror the development of IT for more flexible information sharing while incorporating the infrastructure-focussed view described above. For example, Ravichandran and Lertwongsatien (2005) considered data and core application sophistication as different dimensions of IT flexibility beyond Duncan's (1995) three elements. Based on the idea that reusable data and applications will also reduce the need for new integration with the legacy system, data core application sophistication was defined as the data shareability and reusability in core business activities.

Based on platform compatibility and network connectivity, data standardisation/shareability was also incorporated into the IT flexibility concept by Ray et al. (2005). In their work, flexible IT was viewed as an independent capability that enhances the customer service performance. Although the impact of IT flexibility on FP was not significant, they argued that that IT flexibility is a firm-wide capability that may affect other business processes and not only the FP.

Armstrong and Sambamurthy (1999) also proposed that data shareability needs to be incorporated into the concept of IT flexibility. In their work, which was based on Duncan's (1995) technological view, a sophisticated IT infrastructure (data imaging technology, electronic data interchange [EDI], object-oriented database) is expected to provide flexibility to alter business strategies in response to competitive pressure, thereby supporting firms to achieve IT assimilation.

Bhatt et al. (2010) contended that IT flexibility should be understood according to the degree to which the IT infrastructure is scalable, compatible and modulable, as well as the level of multiple application management. In their work, IT flexibility was regarded as a critical resource to support market-oriented capabilities, such as information generation and dissemination, allowing the firm to meet changing market requirements.

Tafti et al. (2013) incorporated cross-functional transparency with an open information standard and modularity of the IT architecture. In their work, interfunctional transparency was interpreted as digital reach, which represents the capability to widely deploy the IT architecture across different functions to enable a strategic alliance with trade partners.

Overall, in highlighting the three IT elements as the foundations of IT flexibility, the current IT-flexibility literature demonstrates that, IT flexibility's primary goal is to support firms with flexible networks and network arrangements. With the support of IT flexibility focussing on wider connectivity and rich compatibility, different business processes are supported and firm competitive advantages are improved. There are additional attributes emphasising information sharing–related flexibility. They address the fact that flexible information sharing supports a firm's ability to respond to the changes in the market requirements (e.g. Ray et al. 2005; Bhatt et al. 2010) or compete with rivals through enhanced performance (e.g. Armstrong and Sambamurthy 1999; Tafti et al. 2013). However, these researchers' approach is not significantly differentiated from the dominant one, as their ideas still rest on the importance of technological advancements, focussing on IT infrastructure as a main component of IT flexibility.

2) An emerging stream: The value creation–focussed view

Together with a strong tendency to continue a primary focus on connectivity, compatibility and modularity by way of an infrastructure focussed-view, there is another stream of research centring on value creation. Although notably fewer articles have been published on this topic, this research stream investigates the supporting role of IT flexibility to enable firms to develop new strategies for adapting to environmental changes. This stream pays attention to radical and strategic gains, with direct attention to emerging technologies and new processes. The former stream, in which most of the constructs are directly derived from Duncan (1995)'s flexibility constructs, focusses on technological IT infrastructure to connect to trade partners. Thus, the ways in which these constructs are employed to respond to market changes are related to adjusting and leveraging IT infrastructure resources within the existing configuration. In contrast, the latter stream includes constructs that measure the extent to which IT resources can be are reconfigurable (Grewal and Tansuhaj 2001; Fredericks 2005) and partnerships are renewable through IT alignment (Malhotra et al. 2005; Rai and Tang 2010) to proactively respond to the market requirement by seeking potential value.

In the second stream, IT flexibility constructs were derived to stress the importance of IT's new opportunity-seeking capabilities. Bush et al. (2010) argued that the main responsibility of IT flexibility is to redesign the supply chain process. Specifically, they considered IT flexibility as a firm capability that allows a firm to add or remove new suppliers and business partners or to reconfigure existing partners according to the market requirements. They argued that, firms' ability to capture new opportunities in the market is supported by IT flexibility, the ease of reconfiguration of partners and ability to combine resources and capabilities from new or existing supply chain partners.

In a similar vein, Saraf et al. (2007) viewed the role of IT flexibility as enabling the optimal configuration of partnerships to cope with fluctuations in customer demand. In particular, they claimed that IT flexibility is a dimension of organisational flexibility in terms of changing supply chain partners elastically and a capability to accommodate a large volume and variety of information in interfirm business; this enhances the value-creation activities derived from the interorganisational collaboration. Moreover, these researchers argued that IT flexibility needs to support incremental or revolutionary changes of business processes in SCM, thereby enabling firms to handle new business requirements. One of Saraf et al.'s (2007) notable contributions is that they argued that IT flexibility is an ability embedded in the business process, so the value of IT flexibility depends on the business requirements at different organisational levels, such as the tactical, operational or strategic level. In their work, the focus was on value creation at the strategic level, as they highlight IT's ability to adapt to incremental/evolutional changes by providing customised IT solutions for specific partners, thereby supporting new business processes and accommodating new changes in interfirm business.

Tian et al.'s (2010) perspective on IT flexibility was that it is a strategic concept involving ease and speed of performing IT-related activities to adapt to changes in the business and market environment. Specifically, they argued that integration of new IT components into existing ones will develop new IT capabilities to adapt to a dynamic, competitive environment. They identified cutting-edge IT that enable customisation, reaction to competitors' new IT capabilities, market expansion and partnership configuration are examples of IT flexibility components.

Cheng et al. (2014) argued that IT flexibility can support firms to have innovative applications, that is, IT can be employed to meet market changes and customer needs in interorganisational relationships. Specifically, they found that IT flexibility facilitates the communication structure between trade partners, which serves to develop new business process and firms' dynamic capability to respond to market turmoil and customer requirements.

The value creation focussed perspective considers firms' activities when it comes to utilising IT resources to meet the new requirements of the market through resource and partnership configuration. Therefore, this approach focusses on the enabling role of IT flexibility Table 2.12 presents the two research streams of IT flexibility research with the IT flexibility components each stream operationalises.

Research streams	Reference	Information technology (IT) flexibility components	Empirical approach	Major arguments and findings
IT infrastructure focussed view	Armstrong and Sambamurthy (1999)	Client/server computing, local area network (LAN), imaging technology, computer - aided software, database management system, electronic data interchange (EDI), graphical user interface	Primary	IT flexibility directly affects IT assimilation for firm strategies and value-chain activities
	Bhatt et al. (2010)	Scalability, compatibility, sharing, modularity, capability to handle multiple applications	Primary	IT flexibility is positively linked to a firm's competitive advantage. It is mediated by market orientation capabilities (information generation and dissemination).
	Byrd and Turner (2000)	IT connectivity, applications' functionality, IT compatibility, data transparency, technology management, business knowledge, management knowledge	Primary	Integrated and modularised information systems have the potential to contribute to organisational flexibility and firm competitive advantages
	Byrd and Turner (2001)	Data transparency, compatibility, application functionality, connectivity, technical skills, boundary skills, functional skills, technology management	Primary	IT flexibility is positively related to competitive advantages in innovation, customisation and market position.
	Duncan (1995)	Platform compatibility, network connectivity, data modularity	Primary	An organisation with a high level of connectivity, compatibility and modularity will have high IT infrastructure flexibility.
	Fink and Neumann (2009)	Modularity, compatibility, connectivity, technical knowledge, behavioural knowledge, business knowledge	Primary	Among Duncan's (1995) elements, connectivity is positively associated with physical flexibility (range of information sharing–related service diversification).
	Kim et al. (2011)	Connectivity, compatibility, modularity	Primary	The impact of IT flexibility on firm performance is mediated by firm level, process-oriented capability.
	Liu et al (2013)	Connectivity, compatibility, modularity	Primary	IT flexibility indirectly affects firm performance. It is mediated by IT assimilation and firm absorptive capacity.
	Nelson and Ghods (1998)	Modularity, change acceptance, consistency, rate of response, coordination of action	Primary	IT flexibility is positively associated with firm structural flexibility and process flexibility.
	Ngai et al. (2010)	Connectivity, compatibility, modularity	Primary	IT flexibility is a component of IT competence that directly affects supply chain agility.

	Ravichandran (2005)	Network, platform, data and core applications	Primary	IT flexibility positively affects firm operational performance. It is also mediated by information systems (IS) capabilities and IT supports for core competencies.
	Ray et al. (2005)*	Hardware compatibility, data identification, accessibility, standardised data, data shareability	Primary	IT flexibility directly affects customer satisfaction–related process performance.
	Tallon and Pinsonneault (2011)	Hardware compatibility, software modularity, network connectivity	Primary	IT flexibility facilitates the level of firm agility.
	Tafti et al. (2013)	Open communication of standards, cross-functional transparency, modularity	Primary	IT flexibility affects the formation of interfirm collaborative alliances.
	Zhang et al. (2009)	Compatibility, connectivity, modularity, IT personnel competency	Primary	As resources, compatibility and connectivity affect firm performance indirectly; however, as a capability, modularity affects IT responsiveness directly.
Value creation–focussed view	Bush et al. (2010)	Changing communication and reporting linkages, scaling transaction processing up and down, changing partners, redesigning supply chain processes	Primary	IT flexibility moderates the link between product-design modularity and supply-chain responsiveness. It also positively affects supply-chain responsiveness.
	Cheng et al. (2014)	Interoperable network, external integration for rapid change, support new business, design for quick response to changes	Primary	IT flexibility is positively associated with innovative performance. It is mediated by dynamic capabilities.
	Saraf et al. (2007)	Scalability, IT integration for rapid changes, supporting new business, accommodation of new changes	Primary	IT flexibility affects business performance. It is mediated by integration with customer and channel partners.
	Tian et al. (2010)	Responsiveness to changes, customisation, reaction to competitors, new application launching, expand to new market, change of application, new technology adaption, switch to new suppliers	Primary	(Strategic) IT flexibility is positively associated with firm competitive advantage.

Table 2.12 Empirical Research on IT Flexibility

Note: * The test was to identify the moderating role of IT flexibility in the link between strategic IT alignment and firm agility. The moderating effects are not significant, but the effect of IT alignment on firm agility is large (Ray et al. 2005).

Source: Compiled by the author.

3) Current IT flexibility dimensions: The disparate and unidimensional approach

Overall, there are two research streams related to the current IT flexibility dimensions. First, the dominant research stream views Duncan (1995)'s three IT elements as the main constructs of IT flexibility, and they providing infrastructure to maintain firm competitiveness. Second, the emerging research stream views IT flexibility as comprising IT capability to enable new business and processes, meaning that it is required to adapt to changes. Although these two streams have emerged in the same context of IT flexibility research, they indicate disparate (unidimensional) approaches were made towards IT flexibility. The next section discusses why such disparate/unidimensional approaches are not appropriate for IT for SCM.

2.4 THE NECESSITY OF MULTIDIMENSIONAL IT FLEXIBILITY FOR SUPPLY CHAIN MANAGEMENT

2.4.1 Suitability of the Dominant IT Infrastructure–focussed View

Infrastructure-focussed IT flexibility stresses the importance of IT network arrangement–related issues in the supply chain. In fact, the role of IT infrastructure is crucial for supply chains, as the chain may not operate well without flexibility in linking the trade partners via information linkages, as discussed in section 2.3.2. However, in focussing on the connectivity and network arrangement, the current IT flexibility constructs do not mirror the evolved role of IT, which enables a wide range of redesigned business processes and strategies in modern SCM. The following paragraphs review how supply chains cope with changes with newly designed processes and strategies with the support of IT.

According to many researchers, a supply chain is a set of multiple organisations involved in the upstream and downstream flow of products, information and services, producing value for the end customer (La Londe and Masters 1994; Mentzer et al. 2011; Stadtler 2005). Through the collaborative and interdependent efforts of participating firms, they maintain business processes in the shape of a chain to fulfil customer requirements by addressing their diverse, changing needs (Chandra and Kumar 2001). Such interdependency stresses that all of the activities involved in a supply chain should be built according to the interactions of participating firms, which have common problems to solve (Cooper and Ellram 1993; Lambert et al. 1998; Ho et al. 2002).

Gerwin (1987) and Davis (1993) demonstrated that uncertainties propagate in networks of partner firms because emergent situations in the daily processes, such as order cancellations, can affects partner firms' longer term issues, such as inventory levels. Based on this idea, Davis (1993) proposed three types of uncertainty, as follows: 1) supplier uncertainty, which is related to delivery on time/lateness; 2) manufacturer uncertainty related to the production process; and 3) demand uncertainty, which is associated with irregular purchases or orders. The key idea of this categorisation is that the control of uncertainty should be based on the understanding of the relative impact of different sources of uncertainty, since demand, manufacture and supply are correlated with each other in a chain.

To manage the interrelated effects of uncertainty on supply chains, firms requires a flexible IT that allows them to incorporate complementary capabilities of partner firms and not just the technological elements interconnecting trade firms (Bush et al. 2010; Camisón and López 2010; Liu et al. 2013; Jin et al. 2014). This is because IT needs to support and enable supply chain wide activities which are created and managed by the collaborations of firms

Point of sale (POS) provides a practical example of IT use to deal with the market changes in a collaborative manner. POS information is acquired from a retailer; aggregate demand forecasts are available and the supplier can gain a strategic idea of sales patterns to make segment-specific forecasts (Seidmann and Sundararajan 1998) or identify patterns in complementary products (Subramani 2004). Therefore, this is not a simple information exchange; rather, it provides strategic capability of a firm to provide new services and strategic benefits to other organisations (Seidmann and Sundararajan 1998).

Zara's (a well known Spanish clothing retailer) supply chain employs strategic IT systems to make new products available to stores worldwide in 15 days (Qrunfleh and Tarafdar 2014). This is possible with the deployment of IT, such as customized handheld devices, for real-time monitoring of customer demand; IT applications to interpret the hard data (e.g., order and sales data) to soft data (e.g., customer reactions); decision-making systems to determine order quantities; and inter-operable communication process between its stores and production/design facilities which enable strategic information sharing. It facilitates quick responses to market changes and allows firms to take more strategic actions with reengineered business process (Ferdows et al. 2004; Wong and Cheng 2011; Qrunfleh and Tarafdar 2014).

To cope with changes from the market side, firms use IT to enable customisation and to enhance responsiveness. Customisation has relatively direct requirements for supply chains compared to other changes, as it is primarily applied to products and services that the customers directly experience (Bask 2001; Naim et al. 2006). Therefore, IT supports for customisation have involved the following: 1) identification of customer requirements and 2) support in providing customised products and service. To provide customised services, IT needs to employ a close interface that creates value (and not just connectivity) to the market and customers by allowing the firm to track and understand customer requirements and mirror such requirements in the services and products (Sanders and Premus 2002; Devaraj et al. 2007; Qrunfleh and Tarafdar 2014).

Dell (an American computer technology company) allows its customers to assemble personal computers virtually to their own specifications by providing modular choices via a Web-based interface. Moreover, this company has linked the online order capturing application with its in-house enterprise resource planning (ERP) system. This strategy has enhanced the flexibility of Dell's offering flexibility in terms of variety and meeting the preferences of multiple customers without significant penalties related to increasing costs. This mass-customised service would not be feasible without an IT enabling strategic value creation in service and product offering activities (Sahin and Robinson 2002; Ravichandran and Lertwongsatien 2005; Wang and Wei 2007; Wang et al. 2013).

To manage the changes emerging on the trade partner side, firms also require the support of IT. IT has developed over the last five decades, enabling closer collaboration between trade partners and creating value focussed networks. In this regard, IT needs to support supply chain partnering activities, particularly new suppliers' integration into the existing network (Duclos et al. 2003; Swafford et al. 2008). This is important for industries in which product/service lifespans are relatively short and the business environment is changes rapidly, for example, the fashion industry or electronic sector. Hence, when the necessity for changes in supply chain partnerships is identified, firms will require flexibility to (re)configure information linkages with their new (potential) or existing business partners (Wang et al. 2013).

To offer this configuration capability, the IT capability has developed. For example, Gosain et al. (2004) identified that a standardised interface, interoperable interfirm processes and quality of information sharing are required to search and identify a new partner quickly in a low-cost manner. In the same context, Wang and Wei (2007) argued that flexible supply chain reconfiguration is enabled by interorganisational systems (IOS), Internet applications and information visibility.

Web-based IT applications enable flexible business-to-business (B2B) integration by matching separate systems that are geographically or organisationally dispersed. Specifically, Web-based systems are designed to allow supply chain participants to share a single system. Recently, the rapid development of Internet technologies has also led to the creation of the relatively new concept of 'cloud computing' (Hayes 2008; Oliveira et al. 2014; Battleson et al. 2015). Unlike traditional technologies that require an up-front license fee and implementation on a company's own facilities, cloud-computing applications are hosted by the service provider and are normally paid on a subscription basis. By providing a higher level of flexibility for interfirm collaboration, such applications allow large and small- to medium-sized firms to work together (Wang et al. 2013).

One of the good examples of a Web-based shared system is the electronic logistics marketplace (ELM), which includes the Directory of Freight Forwarding Services (http://www.forwarders.com), Gt Nexus (http://www.gtnexus.com) and FREIGHTQUOTE (http://www.freightquote.com). The ELM links shippers, carriers and customers for the purpose of information sharing and long-term collaborative activities; as a result, supply chain partnerships can be configured with the optimal approach to shipping. The ELM identifies synergies within product flows and the capacity of carriers involved in the market. Moreover, it helps shippers to gain better visibility with tracking and tracing functions, thereby supporting the optimisation of interfirm operations (Wang et al. 2011).

The virtual facilitation of partnerships has also been described by Gunasekaran and Ngai (2004). Specifically, these authors demonstrated that virtual logistics involves the information aspects of logistics operations that are managed independently by partner firms. In such operations, the control of resources and the ownership of materials are determined by IT shared among key trade partners. By using IT for virtual partnerships, firms in different geographical areas experience enhanced external business communications and strategic decision-making processes. In association with the emergence of Internet and advances in IT capabilities, IT has dramatically changed the way in which interfirm processes are newly structured and managed (Lancioni et al. 2000; Pereira 2009; Ranganathan et al. 2011). For example, IT produces the electronic integration effect, which means that trade partners can extend their capabilities to use other partners' information databases to create value for customers.

A vendor-managed inventory (VMI) is a practical example of this. Using this system, if the inventory falls below a certain level due to unexpected demand from the customers, the system can execute orders or transmit alerts as programmed (Holweg et al. 2005; Samaddar et al. 2006). With a given/calculated reorder point, some applications, such as warehouse management systems (WMS), automatically issue purchase orders as programmed when the inventory level of a raw material reaches the reorder point (Lancioni et al. 2000); through direct real-time inventory management in the warehouse activities, order flow automation is available (Malone et al. 1987; Humphreys et al. 2001; Turban and Volonino 2010; Wiengarten et al. 2013) . WMS can be integrated with transport management systems (TMS) via ERP to reduce costs and lead times. In such a system, customer orders are transferred from the ERP to the order management system, and then the order passes to the WMS to carry out planning for the packing process in the warehouse. Simultaneously, the TMS computes the best way to ship the materials according to the order (Mason et al. 2003).

In focussing on the physical IT connectivity, current IT flexibility constructs do not take into account the evolved role of IT, which enables a wide range of designed business processes and strategies in modern SCM. In other words, the connectivity and network arrangement–focussed view is not sufficient to cover the redesigned value-creation activities in the supply chains. In fact, Duncan (1995) described one critical characteristic of IT flexibility as anticipating the support of technical IT components for evolved business processes in the future according to the changes in business practices or strategies. Duncan (1995) stated that "the ideally flexible infrastructure would be on that was designed to evolve, itself, with emerging technologies and [that] would support the continuous redesign of business and related IS processes." (p. 44). Therefore, a true idea of IT flexibility as a change-oriented capability to enable value-creation activities with the developed business processes and strategies has not been properly articulated in the dominant literature in the field.

2.4.2 Suitability of the Emerging Value Creation-focussed View

With regard to the emerging stream of value creation, the approach to strategic relationship configuration and offerings for partner firms addresses the role of IT flexibility in the context of potential/strategic value gains. However, it also lacks a comprehensive approach to IT flexibility. First, it mainly focusses on intangible attributes for value creation. Such a unidimensional approach overlooks the importance of IT flexibility in connectivity because the strategic value-creation-related flexibility should be supplemented by the advanced IT infrastructure, such as through compatibility and connectivity, as stressed in the infrastructure focused view. In other words, having effective interorganisational interconnectivity supports firms to arrange smooth information flow to direct the material flows and enables continuous process coordination (Simatupang and Sridharan, 2005). Focal firms with high level of information sharing capability should then be allowed to change or modify their interfirm operations according to the changing customer or market requirements (i.e. value-seeking activities). In doing so, firms can develop long-term planning and promote approaches to create new/potential value (Stank et al. 1999; Stank et al. 2001; Gosain et al. 2004; Rai & Tang 2010; Wang et al. 2011).

POS generates and spreads inventory position information easily so that the information can be shared throughout the supply chain network. However, the inventory information can be used at a much higher level of detail to enable segment-specific demand forecasting when the information is provided “by offering access to information” (Seidmann and Sundararajan 1998, p. 116). In other words, it would not be possible to enable the buyer and supplier to generate advanced forecasts without the network and access (Seidmann and Sundararajan 1998).

Williams et al. (2013) argued that supply chains can be responsive through advanced access to trade partners. Specifically, it is necessary to access partner-level information acquired from the supply chain partners and market-level information on aggregated demand from the marketplace to efficiently respond to the dynamic market requirements (Table 2.13).

	Partner-level information		**Market-level information**
Types of information	Downstream or demand-related information	Upstream or supply-related information	Information in aggregate demand and supply marketplaces from internal/external sources of the supply chain
Examples	Point of sale (POS)/ demand forecasts, customer inventory levels	Supplier inventory, supplier delivery dates, advanced shipment notices, network inventory levels	Overall requirements and availabilities of product at given prices

Table 2.13 Types of Information Required for Supply Chain Responsiveness
Source: Williams et al. (2013).

This is consistent with the argument of Duclos et al. (2003), who argued that to be flexible, supply chains require supply chain partners, including suppliers, carriers and third-party service providers, to gather information regarding the market demand and to exchange information between organisations. IOS represent an example of IT in basic use to link firms together in the supply chain. Information is internally generated and sent, received and transformed via the system; thus, shared throughout the firms participating in the supply chain in widely dispersed areas (Zhang et al. 2011). With IOS permitting information access to other organisations, the organisational boundary is redefined and extended to the extent that a firm's value chain needs to be redesigned (Hong 2002).

According to Narasimhan and Kim (2002), the role of IT can be categorised in three ways. In their argument, IT not only improves the physical activities in supply chains but also creates and optimises their structural operations. Specifically, these authors highlighted IT utilisation for logistical and value-creation activities as higher levels of IT support for firms in supply chains. Moreover, IT for infrastructural support was conceptualised as a foundation for such higher level IT supports. In a similar vein, Muckstadt et al. (2001) found that building tight interfirm networks is a precondition for adapting to uncertainty, and this will support strategic interfirm processes and decision making.

To summarise, despite the role of IT flexibility in supporting value-creation activities in the changing business environment, the emerging stream of research has overlooked the importance of IT infrastructure with technological attributes. In this stream, although many researchers have cited Duncan (1995), the fundamental role of IT infrastructure for such critical value-creation activities is not clearly addressed.

2.5 FINDINGS FROM THE LITERATURE REVIEW

The literature review on the flexibility concept in OM and SCM indicates that being flexible primarily means having a range of options available when changes occur (Slack 1987; Upton 1994; Sanchez 1995; Koste and Malhotra 1999; Stevenson and Spring 2007; Bernades and Hanna 2009; Rogers et al 2011; Jain et al 2013; Mendes and machado 2015). By maintaining a range of different change options, firms can cope with the variations derived from the changing market environments. Such findings indicate that to construct the appropriate flexibility structure, a proper set of flexibility dimensions is required, and these have been identified in the OM and SCM literature. However, the concept of IT flexibility is still unidimensional due to current disparate approaches to the concept of flexibility. Such approaches do not correspond to the requirements of supply chain–wide activities. The literature review on IT flexibility indicates that by simply relying on the attributes proposed by Duncan (1995), many of the contributions of IT flexibility to supply chain value-creation activities are not considered in the dominant stream of research. Moreover, in the emerging stream, due to its focus on IT use for potential value creation, the role of IT infrastructure as a foundation for supply chain value creation is not treated as a critical element.

This study ascertained that the inability to realise the true value of IT flexibility in SCM is due in part to a lack of understanding of the different roles of IT, that is, IT as infrastructure that provides physical network for interfirm operations (e.g. Duncan 1995) and a capability to develop interfirm operations and strategies (e.g. Sanders 2007; Pereira 2009; Bush et al. 2010). A single feasible dimension of IT, such as connectivity, will not be effective in satisfying the divergent requirements of supply chain process and strategies (Henderson and Venkatraman 1999; Chandra and Kumar 2001), since IT can be used to support and enable any aspects of business resources, control procedures or the overall strategy (Shi and Daniels 2003).

Based on the considerations described above, two findings regarding the characteristics of the IT flexibility concept for SCM emerge. First, an integrative structure of IT flexibility is required that covers IT infrastructural support and divergent enabling roles for supply chain value-creation activities. Thus, the requirements for IT flexibility lay in several different areas and take on different forms throughout the various levels of the supply chain processes and strategies. Therefore, to structure a concept of IT flexibility mirroring the true value of flexibility, the multiple dimensions need to be discussed (Kumar and Stylianou 2014). Second, with the fundamental role of IT infrastructure, there may be an opportunity to build the dimensions of flexibility in a hierarchical manner, as illustrated in the OM/SCM flexibility literature. By extending the change options for flexibility from a fundamental functionality (e.g. machine flexibility) to other variables required at a higher organisational level (e.g. market flexibility), manufacturing and supply chain flexibility have developed according to multiple dimensions with a hierarchy of flexibility types. If IT flexibility in the physical infrastructure is the building block of other value-creation activities in the supply chain, several dimensions supported by IT infrastructure can be constructed in a hierarchy.

Some studies, such as those of Bush et al. (2010) and Cheng et al. (2014), have begun to recognise that IT flexibility should be regarded as a comprehensive set of organisational capabilities, including technical components and value-creation capabilities to adapt to environmental changes. However, in both of these studies, IT flexibility was categorised as a single construct without definite conceptual boundaries between technological elements and supply chain value-creation capabilities, so the complementary support of infrastructure-related IT flexibility to other dimensions was not clearly discussed. Moreover, their IT flexibility attributes are not truly comprehensive with their focuses on supply chain responsiveness (Bush et al. 2010) and technology innovation performance (Cheng et al. 2014).

The most integrative research model so far is that conceptualised by Kumar and Stylianou (2013)[3] on Information Systems flexibility. The proposed Information Systems flexibility model layouts the necessity of effective IS flexibility management, from understanding the research context and perceiving why flexibility is required to which dimensions need to be flexible, providing a framework for the synergy analysis in the trade-off among different flexibilities. One of the notable elements of this study is that it distinguished nine dimensions of IS flexibility (volume, operating, input/output, integration, development, new technology deployment, financial, sourcing and staffing), each of which was explicitly definition. However, it is not clear if their focus on IT flexibility is at the organisational or supply chain–network level. Moreover, the supporting role of infrastructure-related flexibility for other flexibility dimensions has not been discussed, and no empirical tests have been conducted with this model.

2.6 RESEARCH QUESTION DEVELOPMENT

Based on the requirements of the multidimensional IT flexibility concept for SCM, the research questions for this study are developed below.

[3] Kumar and Stylianou (2013) did not provide an overarching definition of IT flexibility and did not test the model's validity. Therefore, their publication is not included in Table 2.12.

2.6.1 Research Question 1: Dimensions of IT Flexibility

To capture the true value of IT flexibility for SCM, there should be an effort to identify the dimensions of IT flexibility derived from multiple types of supply chain processes and strategies rather than a focus on specific aspects of IT flexibility. In other words, the dimensions of supply chain business activities that require flexible support need to be comprehensively identified.

There may also be a particular opportunity to supplement the supply chain value-creation-related dimensions with a physical element–focussed infrastructure approach because there could be room to incorporate the supporting role of IT infrastructure–related flexibility for supply chain–wide value creation activities with a given dominant IT infrastructure–focussed IT flexibility concept. In terms of manufacturing and supply chain flexibility, an investigation was carried out to identify the relationships between the flexibility dimensions in the hierarchical structure (Tables 2.5 and 2.6); however, as discussed in section 2.5, there has been little effort made to identify the relationships among the various flexibility types in the IT flexibility literature. If there are multiple types of IT flexibility identified, this effort to identify the relationships between different IT flexibility dimensions will be another important characteristic of multidimensional IT flexibility for SCM.

The additional dimension should be supported by theoretical justification to meet the requirements of supply chain processes and strategies to contribute to the SCM philosophy and practices. Thus, a new IT flexibility concept that comprehensively covers supply chain–wide business activities with a wider range of services will be developed. Moreover, heterogeneity – which refers to a variety of changes option – can be demonstrated in IT-relevant SCM literature (Upton 1994; Koste & Malhotra 1999; Jain et al. 2013; Fayezi et al. 2015) (Table 2.14 summarises the direction of building multidimensional IT flexibility for SCM.

Reconceptualisation of IT flexibility	
As is	**To be**
Unidimensional structure	Multidimensional structure
Disparate dimensions	Complementary role of information technology (IT) infrastructure to other dimensions
Technological-/physical elements–based construct	Technical and supply chain–wide value-creation activity enabling construct

Table 2.14 Direction of IT Flexibility Reconceptualisation
Source. Author.

This argument led to the development of research question 1, as follows:

Research question 1) What are the key dimensions of IT flexibility for SCM?

2.6.2 Research Question 2: The influential mechanism of IT flexibility

As the current IT flexibility literature was mainly discussed within the context of IT infrastructure, the effects of the emerging IT flexibility dimension (i.e. value creation flexibility) that are associated with the IT infrastructure focused view are not considered in the current literature. In other words, the influential mechanism in the case of multiple dimensions incorporating the two streams of IT flexibility has not yet been considered. Moreover, the current literature has provided conflicting evidences on the impact of IT flexibility for firm competitiveness. For example, some literature identified the indirect impact of IT flexibility for firm performance. Fink and Neumann (2009) conceptualised IT flexibility as affecting the organisation's performance via the physical and managerial capabilities of a firm. In a similar vein, Bhatt et al. (2010) identified that IT flexibility which is based on Duncan's three constructs affects a firm's competitive advantage via information generation/dissemination and also organisational responsiveness. Ngai et al. (2011) demonstrated that IT flexibility affects a firm's performance through supply chain agility. Saraf et al. (2007) argued that IT flexibility affects business performance via the integration of information systems with customers and channel partners. Ravichandran and Lertwongsatien (2005) considered that IT flexibility affects firm performance via Information systems (IS) capability. Liu et al. (2013) argued that IT flexibility affects firms' performance via firm absorptive capacity, which is an ability to acquire and assimilate the value of external knowledge.

In contrast, some literature argued that IT flexibility affects firm competitiveness directly. For instance, Armstrong and Sambamurthy (1999) identified that IT infrastructure flexibility affects firm competitiveness in a direct manner in the IT assimilation process. Byrd and Turner (2001) identified IT flexibility as being directly associated to firm competitiveness, particularly for innovativeness, mass customisation and market position. Ray et al. (2005) argued that IT infrastructure flexibility directly affects a firm's process performance in customer service. Tian et al (2010) identified strategic IT flexibility for new markets and customer requirement changes as being directly associated with a firm's competitive advantage in product differentiation and customer satisfaction.

Therefore, the influential mechanism that determines how the multiple dimensions of IT flexibility affects firm competitiveness should be clarified in the SCM context to expand the current knowledge on IT flexibility. Especially, this study focuses on the role of different IT flexibility dimensions in execution of supply chain process integration—a gap overlooked by the extant literature. Current research models do not articulate how IT flexibility enhances FP through process integration, which is regarded as an essential way to implement supply chain operations (Frohlich and Westbrook 2001; Zailani and Rajagopal 2005; Flynn et al. 2010; Teller et al. 2012). For example, some studies demonstrate that IT flexibility is one of the preconditions for a higher level of firm capability (Ravichandran and Lertwongsatien 2005; Ngai et al. 2011; Jin et al. 2014) while others argue that IT flexibility acts as a moderator for an organisational capability that affects firm performance (Bush et al. 2010). Therefore, they provide limited insights regarding how IT flexibility affects firm performance within the context of supply chain execution.

This investigation of the impact of IT flexibility dimensions on FP is also required to clarify the concept of uniformity, which is highlighted as an element of the flexibility concept (Upton 1994; Koste and Malhotra 1999). If the IT flexibility dimensions and their attributes are developed to show similarity in their performance outcomes, uniformity—in the form of direct and indirect effects on FP in a SCM context—will be identified. This idea underpins research question 2.

Research question 2) How do IT flexibility dimensions affect firm performance in the context of the supply chain execution?

2.6.3 Research Question 3: Prioritisation of flexibilities and resource allocation

Previous researchers have recognised the necessity for optimal levels of different flexibility types where priorities are assigned to flexibility dimensions; this is because strategic priorities often determine the level of a firm's business position compared to competitors (Sethi and Sethi 1990; Upton 1994; Upton 1995; Kumar and Stylianou 2014). However, the comparison of different types of flexibility is a difficult task due to the lack of adequate flexibility measurement (Stevenson & Spring 2007; He et al. 2012; Jain et al. 2013). Specifically, different flexibility types require different measurements because a measure suitable for s specific type of flexibility may not be representative when it is applied to another type of flexibility (Gerwin 1987; Sethi and Sethi 1990; Upton 1994). Moreover, a specific dimension is regarded as a more important aspect when a certain environmental requirement is identified (Stevenson and Spring 2007). For example, a large range of service availability and quick changeover capabilities both represent flexibility. However, when the market requires a higher level of service variety at a certain time, flexibility in a large range of services will have higher value (Upton 1995).

To prioritise flexibility dimensions, this study adopts the idea of "general features" proposed by Upton (1994, p. 76). Upton (1994; 1995) argued that there should be an effort to identify the general and comprehensive features of flexibility that should be measured to improve overall flexibility. This implies that an operational/practical level of measurement that works for a specific type of flexibility is not applicable to measure other flexibility types; thus, comprehensive and objective criteria that are aligned to different flexibilities but also contribute to the overall system are required (Upton 1995; Stevenson and Spring 2007). Koste and Malhotra (1999) described such criteria as an objective measurement with numerical counts.

To identify general/objective features, this study adopts the concept of the importance and performance of a flexibility type following the IPA matrix (Martilla & James 1977; Slack 1994; Tontini & Silveira 2007; Pezeshki et al. 2009; Hair et al. 2013); it attempts to prioritise the flexibility dimensions by quantifying the importance and performance of each flexibility. Moreover, in accordance with the level of importance and performance, it suggests a way to allocate firm resources to gain a competitive advantage. Resource reallocation means switching the input of resources, such as financial or managerial activities, from one dimension to another (Pezeshki et al. 2009; Hair et al. 2013). By reallocating resources, supply chain practitioners can review their IT flexibility and rearrange their resource concentration to the right dimension, thereby improving their level of IT flexibility and gaining competitive advantages.

The approach used here is related to the idea of mobility, which represents the capability of moving from one dimension to another to cope with changes without incurring high costs (Upton 1994; Koste and Malhotra 1999). If a resource allocation strategy can be suggested in this study, then the research can demonstrate how firms need to operate their multiple dimensions of IT flexibility with mobility to adapt to the changes with the available resources. This idea is used to formulate research question 3 below.

> **Research Question 3) How should firms prioritise different dimensions of IT flexibility and allocate resources to them in a strategic manner?**

2.7 IDENTIFIED RESEARCH GAPS

Table 2.15 represents the research gap identified from the literature review in this section. It summarises the requirements for multiple dimensions covering physical IT elements and IT capabilities for supply chain value-creation activities. No research has validated multiple dimensions of IT flexibility while taking into account the complementary role of physical IT infrastructure for the other dimensions. The adoption of the RBV in most current IT flexibility research also supports the current approaches to IT infrastructure. Previous researchers adopted the RBV because they conceptualised IT flexibility with its construct of physical IT elements as a competitiveness resource for firms to adapt to the changing business environment. This is consistent with the argument in the RBV that firms possess unique valuable resources that enable them to achieve a competitive advantage and longer-term performance (Wernerfelt 1984; Barney, 1991, Teece et al 1997 Lavie 2006). Moreover, the influencing mechanism of IT flexibility on FP is ambiguous, as no consensus has emerged on the role of IT flexibility for FP. Finally, there is no relevant research that has prioritised IT flexibility dimensions.

Reference	Conceptualisation		IT flexibility dimensions			Influential mechanism			Prioritisation of dimensions	Foundation theory
	Physical, connectivity-specific IT infrastructure	Value creation–focussed capability	Uni-dimensional	Multi-dimensional	Complementary relationships	Direct	Indirect	Moderator		
Armstrong and Sambamurthy (1999)	X		X			X				RBV
Bhatt et al. (2010)	X		X				X			RBV
Bush et al. (2010)		X	X					X		MST
Byrd and Turner (2000)	X		X							Implicit but similar to RBV
Byrd and Turner (2001)	X		X			X				Implicit but similar to RBV
Cheng et al. (2014)		X	X			X	X			DC
Duncan (1995)	X		X							RBV
Fink and Neumann (2009)*	X			X	X		X			DC
Kim et al. (2011)	X		X				X			DC
Liu et al (2013)	X		X				X			Implicit but similar to RBV
Nelson and Ghods (1998)	X									RBV
Ngai et al. (2010)	X		X				X			RBV
Ray et al. (2005)	X		X			X				RBV
Ravichandran (2005)	X		X				X			RBV
Saraf et al. (2007)	X	X	X				X			RBV

Tafti et al. (2013)	X		X			X				Implicit but similar to RV
Tallon and Pinsonneault (2011)	X		X					X		RBV
Tian et al (2010)		X	X			X				MST
Zhang et al. (2009)*	X			X	X		X			RBV

Table 2.15 Research Gap Identification: Summary of the Literature Review on Current IT Flexibility Literature

Source: Author

Note: IT - information technology, DC - dynamic capability theory, RBV - resource-based view, RV - relational view theory, MST - modular systems theory.

* In these articles, IT technological elements derived from Duncan (1995) are treated as multiple dimensions, but the value-creation view is not incorporated.

2.8 SUMMARY

This chapter gave an overview of several theoretical contexts that have contributed to the conceptualisation of the IT flexibility model. A review of the current IT flexibility dimensions was presented; this clarified that the current IT flexibility conceptualisation and operationalisation are not sufficient to cover the diverse uses of IT for supply chain value-creation activities. A lack of understanding of the different roles of IT, that is, IT as infrastructure and as a capability to develop interfirm strategies is identified as the primary reason of the current lack of understanding of IT flexibility. Because technical element–based dimensions do not cover the role of IT enabling redesigned supply chain–wide value-creation activities. Moreover, value creation–focussed flexibility cannot be achieved without IT infrastructure. Consequently, neither of the research streams corresponds to supply chain–wide value creation activities. Thus, the notion of a multidimensional IT flexibility concept that integrates divergent types of support and enablement of IT for SCM activities was identified as a research gap to be filled. There may also be a particular opportunity to identify the relationships between the flexibility dimensions in the hierarchical structure with a supporting role of IT infrastructure–related flexibility for supply chain–wide value creation flexibilities.

Based on the research gap, three research questions were developed for this study. Research question 1 (RQ 1) seeks to identify the structure of IT flexibility in integrative and multidimensional concept. Research question 2 (RQ 2) considers the influential mechanism of IT flexibility on FP. Finally, research question 3 (RQ 3) aims to prioritise the IT flexibility dimensions and strategic resource allocation to multiple IT flexibility dimensions. Chapter 3 reconceptualises the structure of IT flexibility for SCM using a systematic approach.

CHAPTER 3. IT FLEXIBILITY FOR SUPPLY CHAIN MANAGEMENT

3.1 INTRODUCTION

IT flexibility in SCM should be a multidimensional concept, as discussed in Chapter 2. To identify the dimensions of IT flexibility in the SCM context, this chapter conducts a systematic review and provides three dimensions of IT flexibility for SCM. By doing so, it establishes building blocks for the research model of IT flexibility for SCM.

This chapter is structured as follows: In section 3.2, the justification for using a systematic approach is provided. Section 3.3 identifies the flexibility dimensions in existing SCM literature through a systematic review. Based on the dimensions of IT flexibility identified in section 3.3, the definition of IT flexibility for SCM is provided in section 3.4.

3.2 IDENTIFICATION OF IT FLEXIBILITY DIMENSIONS: A SYSTEMATIC APPROACH – ADDRESSING RESEARCH QUESTION 1

To outline the structure of IT flexibility that generates the true value for SCM, IT flexibility should be conceptualised through consideration of its multiple dimensions supporting different supply chain activities and processes rather than partial approaches with sectional IT flexibility attributes. Thus, an exhaustive and systematic examination (from end to end) of IT support is needed to outline the dimensions. With the need for a comprehensive search on the supply chain activities relying on support from IT, the current research aims to conduct a systematic literature review.

3.2.1 Systematic Review

A systematic review is "a replicable, scientific and transparent process . . . that aims to minimise bias through exhaustive literature searches of published and unpublished studies and by providing an audit trail of the reviewer's decisions, procedures and conclusions." (Tranfield et al. 2003, p. 209). This method has been chosen to identify the IT flexibility dimensions for the reasons outlined below.

First, it provides an exhaustive, integrative review result by adopting explicit procedures from which biases less likely to emerge. Therefore, a systematic review is useful when exploring the literature with biases; such an approach is helpful when a comprehensive search on a specific topic is required (Tranfield et al. 2003; Bryman 2012). Owing to the skewed research streams with partial attributes of the current IT flexibility, there is a strong need to review the role of IT to support supply chain–wide activities (without any missing aspects). This approach is well supported by existing studies on manufacturing and supply chain flexibility in which end to end dimensions of flexibility have been introduced to cover the different roles of different flexibilities (e.g. Gerwin 1987; Upton 1994; Koste and Malhotra 1999; Duclos et al. 2003; Stevenson and Spring 2007).

Second, evidence-based identification and classification of dimensions can be used in systematic reviews. The systematic review approach can be used to explore the literature, particularly, in fields that aim to elucidate particular interventions that have specific benefits, such as cause-and-effect analysis (Tranfield et al. 2003; Saunders et al. 2012). By adopting empirical research that validates the impact of IT on supply chain activities requiring flexibility, the systematic review will summarise reliable work with a balance of evidence (Bryman 2012).

Third, the method is useful when it comes to classifying dimensions. After selecting a reliable body of literature with inclusion and exclusion protocols, such as keywords or combinations of keywords (Tranfield et al. 2003; Kembro et al. 2014; Kembro and Näslund 2014), a systematic review analyses and synthesises the relevant research by breaking down each study into its constituent parts (Bryman 2012). This enables a conceptual discussion of the research problems (Tranfield et al. 2003). This procedure of classifying the research contents will be useful for characterising the dimensions of IT flexibility. Based on the identified literature on the role of IT for supply chain activities, classification of this role according to the business requirements will be a good solution when it comes to identifying the dimensions.

3.2.2 Identification Process for IT Flexibility Dimensions

1) Scope of analysis: Preparation of keywords

IT is an extensively applied concept in SCM and covers a wide range of information-related technologies, applications and capabilities. To capture IT-related themes, specific keywords were deployed in line with the recommendations provided by Tranfield et al. (2003), as described below.

IT-relevant articles were selected by searching for 'information' OR 'IT' OR 'ICT' OR 'e-'.[4] In order to narrow down the research scope to the supply chain management context, only articles containing 'logistic*', 'supply chain*', 'demand chain*' and 'value chain*' were captured. The set of business environments in which the technologies operate should be included when analysing flexibility (Groote 1994). In the same context, the reason for narrowing down the context to the interfirm supply chain environment was to focus on the interfirm network characteristics of the supply chain. Moreover, it was expected that the required role of IT in supply chain activities could materialise in various forms, such as improved organisational capability, which also affects firms' performance. Therefore, articles including the terms 'impact*', 'affect*', 'improv*' or 'increas*' were captured.

It should be noted that the purpose of this review was to identify the dimensions of processes in current supply chain practices that have not been considered in the current IT flexibility literature. Therefore, this research did not use the term 'flexibility' as a keyword; rather, it focussed on unknown dimensions. This also generates some advantages for developing the IT flexibility concept in SCM as the IT flexibility concept tends to be treated implicitly in the literature due to its characteristic of potential capability that does not have to be demonstrated (Upton 1994; Stevenson and Spring 2007). For instance, it is useful to capture some studies that treat IT flexibility as one of the prerequisites to enable/support other organisational capabilities such as organisational agility (Overby et al. 2006; Chakravarty et al. 2013), improvisational ability (Pavlou and

[4] IT is for information technology, ICT is for information and communication technology and e- is for electronic.

Sawy 2010) and information management capability (Mithas et al. 2011; Youn et al. 2014). However, the restriction on the term 'flexibility' also excluded a considerable amount literature from the OM/SCM field that did elaborate the enabling role of IT/IS in firm or supply chain performance, but did not primarily consider IT flexibility.

Instead of excluding the term 'flexibility', this study identifies the IT flexibility dimensions throughout the review. Upton (1994) recommended identifying the dimensions of change as the first step in characterising the concept of flexibility. The dimension refers to the situation for which flexibility is required (Upton 1994; Beach and Muhlemann 2000). Upton (1994) argued that by asking "what exactly is it that flexibility is required over—what needs to be changed or be adapted to?" (Upton 1994, p.77), the dimension of flexibility can be identified. To identify the dimensions, this study examined IT and IT capabilities that enable a certain level of change, adjustment or development in supply chain-wide activities. The approach was based on the characteristics of IT flexibility identified in sections 2.2 and 2.3, where IT flexibility was identified as a capability to adapt to changes by changing/adjusting/developing a given status (Gerwin 1987; Sethi and Sethi 1990; Duncan 1995; Koste and Malhotra 1999; Bernardes and Hanna 2009).

2) Literature selection process 1: Pilot search

It should be noted that if this study considered the fact that a certain database may not subscribe to every academic journal and employed several databases for the journal search, the number of articles discussing the impact of IT related capabilities for firm competitiveness in an SCM context to be explored could have increased exponentially (e.g. Burgess et al. 2006). For this reason, this study used the pilot systematic literature review to estimate the breadth of the literature review search space (Brereton et al. (2007). ABI/INFORM GLOBAL database was employed because it returned the largest number of search results when compared to other data bases such as, EBSCO, Emerald Library and ScienceDirect. The combination of keywords provided above generated 613 search results from the ABI/INFORM GLOBAL database. By investigating the abstract and full text of each article, the review narrowed down the number of articles to 200.

Moreover, content screening was administered as described below to capture those articles indicating the flexibility dimensions. First, as flexibility is embedded in IT and IT use, articles that clearly specified which aspects of IT they were discussing—such as IT or IT capability—in a clear statement of the aims of their research were selected (Bryman 2012). Second, for the identification of the supply chain activities or processes supported by IT, articles clearly addressing the purposes of IT use and the areas supported by IT were selected (Bryman 2012). Finally, only empirically tested research was selected to draw on validated support for IT, as flexibility should be assessed against the performance criteria for evaluation in different business environments (Groote 1994; Upton 1994). In all, 14 articles from 8 academic journals were identified as fully satisfying the three aforementioned criteria.

3) Literature selection process 2: Final structured review

The pilot search indicated that the focus on peer-reviewed journals satisfied the screening criteria, providing appropriate literature for the specific topic, namely IT in logistics and supply chains. As the pilot search employed one specific database, there might be possible peer reviewed journals that address the research topic that the ABI/INFORM GLOBAL database does not capture. Therefore, to stand on a more exhaustive and integrative review result (Tranfield et al. 2003; Bryman 2012), this research further extended the search to 15 academic journals that are identified as the most significant in IT, logistics, supply chain management and performance by Zhang et al. (2011). In the second phase of the review, this research captured more articles from the supplementary journals by using the same key words and screening process that the pilot search used. In doing so, different databases (EBSCO, Emerald Library and ScienceDirect) that subscribes to each supplementary journal are employed then the required articles captured. This second phase search identified 9 articles from 5 academic journals. The combination of the two phases of the search yielded 23 articles from 13 academic journals (Table 3.1).

Overall, the review process is in line with the recommendations provided by Tranfield et al. (2003), Burgess et al. (2006) and Bryman (2012). First, a comprehensive body of literature is gained by systematically exploring a wide range of articles with its combination of keywords. Second, an explicit process of review is demonstrated for its replication with the use of inclusion and exclusion content screening criteria. Third, the credibility of the literature search is also ensured by selecting only peer reviewed articles. Finally, summarized evidence of the impact of IT flexibility on firm competitiveness is identified with empirically tested research models. The 23 articles are analysed to capture the dimensions of IT flexibility in the following section.

Journals identified from the pilot review	**Number of articles identified**
Decision Sciences	1
Information Systems Research	1
International Journal of Logistics Management	1
International Journal of Operations & Production Management	2
International Journal of Physical Distribution & Logistics Management	3
Journal of Supply Chain Management	3
Journal of the Academy of Marketing Science	1
Supply Chain Management: An International Journal	2
	14 articles from 8 academic journals
Additional journals explored from the supplementary search	**Number of articles identified**
Information and Management	0
International Journal of Production Economics	4
International Journal of Production Research	1
Journal of Business Logistics	0
Journal of Management Information Systems	2
Journal of Supply Chain Management	1
MIS Quarterly	1
Production and Operations Management	0
	9 articles from 5 academic journals

Table 3.1 Final List of Selected Academic Journals

Source: Author.

3.3 DIMENSIONS OF IT FLEXIBILITY—Response to Research Question 1

Throughout the systematic review of the articles, which captured the IT supports to enable a certain level of change, adjustment or development in supply chain operations, this study broke down the IT supports according to their underlying emphases. It distinguished three dimensions of support and enablement to make firms adapt to changes. These are summarised as follows:

1. *Dimension 1* describes the capability to extend connectivity and develop advanced networks to enable flexible supply chain activities. For this dimension, IT should be flexible in terms of the reach and range of the network and the interoperable interface arrangement. This dimension is labelled *transactional flexibility*.

2. *Dimension 2* describes the capability to coordinate and adjust supply chain operations with external partners to achieve greater control over process execution and make operational efficiency gains. To accomplish this, IT needs to be flexible in terms of interfirm operational process coordination and information sharing capability. This dimension is labelled *operational flexibility*.

3. *Dimension 3* describes the value of IT in enabling a firm to discover new methods of value creation through the resource of partnership configuration and to explore emerging IT portfolios and practices bringing innovative products and services to meet the changes. For this dimension, IT should be flexible to enable supply chain (re)configuration and to offer new service or product development, thereby allowing the firm to discover novel ways of creating value. This dimension is labelled *strategic flexibility*.

The following sections provide the articles that demonstrated three different dimensions. There is a considerable body of literature that highlights the importance of networking and connectivity with a firm's supply chain partners for competitive advantages. Section

3.3.1 introduces such articles that represent the idea of *transactional flexibility* (dimension1). The second and the third dimension are differentiated by the purpose of IT use for SCM as follows. Section 3.3.2 provides articles demonstrating the idea of o*perational flexibility* (dimension 2)— that firms should exploit IT capabilities to support continuous improvement of existing process and information sharing. Articles representing the idea of *strategic flexibility (*dimension 3) are discussed in section 3.3.3. They suggest that firms need to have the capability to explore their IT proficiency to create new business opportunities and new solutions to the changes in interfirm networks. It should be noted that transactional flexibility goes beyond the concept of infrastructure by developing a capability to utilise interconnectivity for exploitative (operational flexibility) and explorative (strategic flexibility) purposes. Therefore, this pivotal role differentiates transactional flexibility from the other two flexibility dimensions.[5]

3.3.1 Transactional Flexibility

The transactional flexibility dimension mirrors the infrastructure-focussed view of IT flexibility which is discussed in section 2.3.2. It primarily represents the idea that IT flexibility for elastic networking and rich connectivity with partner firms is critical for establishing a competitive advantage (e.g. Duncan 1995; Byrd and Turner 2000; Zhang and Dhaliwal 2009).

Bayraktar et al. (2009) emphasised the role of IT by developing the notion of IS practice. IS practice consists of three elements, namely IS facilitators, enterprise-wide IS and IS integrators. The first two are connectivity-related infrastructure such as EDI, radio frequency identification (RFID), ERP and bar codes. In Bayraktar et al.'s (2009) work, these elements were found to be positively associated with and to affect operational performance, covering production lead time, forecasting, operational efficiency and inventory level. As they conceptualised the capability for interfirm IT connectivity, their article falls to the categories of dimension 1.

[5] The pivotal role of transactional flexibility is discussed further in section 4.3.1.

According to Bharadwaj (2007), the dynamic changes in business needs require IT to support business goals. This author viewed integrated IT capability as a support in linking internal and external processes. One of the critical elements of integrated IT capability was the reach in access to data in different interfirm functional areas in supply chains.

Closs and Savitskie (2003) focussed on extended information sharing capabilities across the supply chain, particularly to respond to customer expectations. They argued that successful SCM largely depends on the identification of changing customer needs. In their work, logistics IT integration plays a critical role for customer integration by providing supply chain-wide interfaces. IT integration in logistics was conceptualised with wide/direct access to trade partners, so Closs and Savitskie's (2003) work falls into the category of dimension 1.

Devaraj et al. (2007) argued that e-business capabilities enhance information integration in the production process, so value is added to the supply chain process. Specifically, an e-business capability was defined as "the ability of a firm to use Internet Technologies to share information process transactions, coordinate activities and facilitate collaboration with supplier and customers" (p. 120). The IT capability concept suggests that supply chain activities require IT. In Devaraj et al.'s (2007) work, e-business capability consists of three subdimensions and two dimensions fall into the category of dimension 1. First, IT for customers refers to the extended access and interoperable interface for configuration and customisation. Second, IT for suppliers involves extended access to online partners.

Fawcett et al. (2011) conceptualised IT management skills as a dynamic capability to manage the rapidly changing environment. Specifically, the role of supply chain connectivity, which is defined as a capability to use IT to collect, analyse and disseminate information, was emphasised for value-added supply chain activities. Supply chain connectivity was structured with the following elements: 1) system satisfaction for interfirm information connectivity; 2) intra-/interfirm application integration; and 3) wide system linkages with supplier and customers. Therefore, this perspective emphasises the role of IT in network connectivity and linkages and falls into the category of dimension 1.

Kim et al. (2006) emphasised that the role of applied technological innovation is critical to enable closer activity integration and close channel partnerships. Specifically, applied technologies—which are defined as the extent to which a firm adopts or uses the most advanced communication technology for SCM, e.g. advanced/state-of-the-art IT for interfirm connectivity—were identified as a precondition of market performance. Therefore, in their work, the role of advanced IT for rich connectivity (dimension 1) is highlighted.

Klein and Rai (2009) argued that information sharing has different purposes, and IT should thus support information sharing according to the operational requirements. For example, if the interfirm partnership moves beyond transactional information exchange, participating firms share strategic information. In their study, Klein and Rai (2009) contended that, rather than generic applications, customised EDI connectivity, B2B and ERP interfaces with trade partners are required to improve relationship-specific performance. Thus, their work identified the importance of the connectivity and network related infrastructure, i.e. customised EDI connectivity, B2B and ERP interfaces (dimension 1).

Prajogo and Olhager (2012) conceptualised IT support as consisting of two categories: 1) IT for interconnection and 2) IT for information sharing. In the context of interconnection, they argued that e-linkages and interconnection are precedents for logistics integration. Specifically, IT was conceptualised as a crucial supporter of logistics integration by providing information linkages, such as B2B communication, Web, Internet and Ethernet. Therefore, it falls into the category of dimension 1.

By categorising IT capabilities into two types, namely internal and external supply chain information systems capabilities, Savitskie (2007) found that intra- and interfirm process coordination supported by extended connectivity is crucial for FP improvement. They stated that external connectivity (with customer access and direct/extended information linkages) plays a key role regardless of environmental differences, i.e. operations in the international market. Therefore, they captured dimension 1.

Wong et al. (2011) described information integration as an enabler of improved business performance. One of the critical elements of information integration is information sharing infrastructure such as electronic linkages, a data warehouse and scalability of infrastructure. These researchers showed that information integration with such connectivity focused capabilities facilitate interfirm transactions and communications Therefore, Wong et al. (2011) emphasised how the role of IT involved wide electronic connectivity for intra-/interfirm transactions (dimension 1).

Zhou et al. (2014) demonstrated that information quality plays a critical role for FP when it is well aligned with effective supply chain practices. In their work, information quality consisted of information systems capability and information sharing excellence. The information systems capability was conceptualised as supply chain-wide internal and external connectivity and information accessibility in a timely manner. Since these researchers emphasised the role of IT for supply chain connectivity, dimension 1 is identified.

3.3.2 Operational Flexibility

The systematic review indicated that the second IT flexibility dimension can be used to describe the capability for support information sharing and process improvement; this is called operational flexibility. In this section, the articles demonstrating the idea that a firm needs to efficiently exploit its existing IT competency for interfirm information sharing and process improvement are discussed. Compared to other flexibility dimensions, the idea of operational flexibility thus focuses on efficiency gains in interfirm relationships as captured from following articles.

In Closs and Savitskie's (2003) work, logistics IT integration—which covers quality information sharing (e.g., accurate, timely and formatted information), effective sharing of information and real-time data/information exchange—is identified as playing a critical role in customer integration. They argued that successful SCM depends largely on the identification of changing needs through customer integration. Thus, their work falls into the category of dimension 2.

In Klein and Rai's (2009) work, which conceptualised information sharing for different purposes, they reported that strategic information sharing is another key factor in improving supply chain relationships. Strategic information flow covers information sharing related to inventory information, production schedules and customer demand patterns that are supported by IT customisation. Thus, they highlighted the role of IT for information sharing and flows between trade partners (dimension 2).

Olorunniwo and Li (2010) reported that aspects of information sharing quality, such as accuracy, scale and functional data exchange positively affect logistics performance. They emphasised that the role played by information sharing in collaborative activities in logistics—such as inventory management, sales data identification and on time delivery through product tracking—plays a critical role for logistics performance. Therefore, dimension 2 is captured.

In Prajogo and Olhager's (2012) conceptualisation of IT support, information sharing is also highlighted. They argued that the quality of information sharing in the supply chain process was the key aspect of logistics integration. Within this context, they demonstrated that using POS history supports suppliers in managing inventory from a longer-term perspective, thereby improving the service level and efficiency. Moreover, sharing the real-time inventory position with trade partners also supports suppliers in optimising their service levels with replenishment and delivery scheduling. Therefore dimension 2 for information sharing and process improvement is identified.

Savitskie's (2007) concept of IT capabilities, in which internal and external supply chain information systems capabilities are discussed, highlighted the role of interfirm process coordination supported by quality information sharing (with standardised, internet-enabled and customised information). Savitskie (2007) identified that such quality information sharing positively related to a firm's operations in the international market.

Therefore, Savitskie (2007) captured dimension 2, which is in charge of interfirm information sharing.

Wiengarten et al. (2010) pointed out the importance of information quality for FP. In their work, information quality was conceptualised according to relevance, value added, optimisation, timeliness and completeness. The researchers treated information quality as a part of collaborative supply chain practice, which was associated with information sharing practice. Information practice represents the level of information exchange with key suppliers. Therefore, dimension 2 was identified in Wiengarten et al.'s (2010) work.

Wong et al. (2011) also discussed the role of quality information sharing in terms of accuracy and timeliness. Quality information sharing is regarded as an element of information integration, which enables business performance improvement. They argued that supply chain performance is also improved when complex issues related to products are considered as environmental factors. Therefore, the importance of the capability to provide quality information sharing in changing business environment, which requires an efficient IT role, was highlighted (dimension 2).

In Zhou et al.'s (2014) work, information quality is viewed as a critical enabler of FP. Information sharing excellence is conceptualised according to the accuracy, frequency, relevance and availability of information for formulating information quality. Therefore, these researchers highlighted the role of IT in the effectiveness of information sharing (dimension 2).

IT for enhanced information visibility was emphasised by Wang and Wei (2007). They identified that IT completeness—which includes the reliability and timeliness of functional information (in various nodes in the supply chain such as manufacturing, supplying, planning, etc.)— plays a critical role in a firm's competitiveness. Therefore, in Wang and Wei's (2007) study, the role of IT was observed in information sharing (dimension 2).

Together with information sharing and information sharing quality, process improvement has also been identified as an important area requiring IT flexibility to deal with the variations in the process.

Bharadwaj's (2007) work identified integrated IT capability as supportive of linking interfirm process enablement, thereby enabling supply chain wide interfunctional/interfirm process coordination. IT capability was thus characterised as facilitating interfirm process improvement with customers and suppliers in different functional areas such as delivery and inventory; thus, dimension 2 is identified.

Gosain (2004) argued that standardisation of the processes, modular interconnected processes and the quality/breadth of information sharing are necessary characteristics of IT. Especially, these are required for addressing changes 1) in the offer of services/products; and 2) in partnering flexibility that require altering linkages to different supply chain players. Thus, in their work, dimension 2 is also identified.

Jayaram and Vickery (2000) explored the role of IT for process improvement. Here, IT was conceptualised as a key process-improvement tool in time performance, particularly in terms of eliminating delays in material handling, information exchange and delivery. Moreover, standardisation of information sharing supported by IT was the most influential enabler of process improvement as simplifying the process helps firms to identify sources of delay, unnecessary steps and opportunities for parallelism. Thus, dimension 2 was captured in their work.

Kim et al. (2006) also highlighted the critical role in market performance played by information exchange and interfirm coordination through conceptualising them as channel capability. They defined information exchange as the sharing of information and knowledge with channel partners to meet the customers in efficient and effective way. They argue that to ensure the quality of information exchange, timeliness, accuracy, adequacy and completeness and credibility in information sharing are required. Interfirm coordination was defined as those activities between channel partners that consider the customer's needs in their interfirm process. Therefore, they captured the role of IT in information sharing and interfirm process improvement (dimension 2).

In Lai et al.'s (2008) article, they argued that interfirm information sharing is critical because logistics are shifting to high-value-added services where IT has a great effect when it comes to fostering firm capability in supply chain networks. To identify the role of IT in SCM, these researchers conceptualised two constructs, namely IT orientation and IT capability. To achieve IT capability for competitive advantage, they argued that IT orientation (the philosophy of leveraging IT for competitiveness) needs to be ensured. This indicates that the role of IT for SCM is as critical as in other management philosophies, such as customer or value orientation; this implies that there should be a large effort to increase IT value in the supply chain process. They identified that a technological orientation improves IT capability. IT capability was characterised through online transactions with customers, tracking and tracing of products, reliable information sharing and real-time information sharing with trade partners. Therefore, Lai et al. (2008) emphasised the role of IT in interfirm process improvement and information sharing (dimension 2).

The idea of process improvement supported by IT flexibility has also been conceptualised from the view point of lean operation by Qrunfleh and Tarafdar (2014). Qrunfleh and Tarafdar (2014) demonstrated that IT used for efficiency moderates the effect of a lean supply chain strategy on supply chain performance. IT for efficiency was characterised through inventory management, material management, production control and supply coordination. Therefore, Qrunfleh and Tarafdar (2014) validated the role of IT for process improvement and coordination (dimension 2).

Sanders (2005) identified that IT alignment—in operation process improvement and information sharing such as order tracking, invoicing, billing and inventory management—enables buyer–supplier integration thereby increasing firm performance. Therefore, dimension 2 is identified.

In a similar vein, Vanpoucke et al. (2009) classified three types of information flow strategies according to the level of information sharing and information quality. In their classification, different levels of coordination, information participation and constructive conflict resolution techniques in the supply chain process were identified from the different levels of information flow strategies. Therefore, this research captured the role of IT for process coordination and improvement (dimension 2).

Vickery et al. (2010) showed that firm agility is affected by IT. Their arguments were based on the notion that IT facilitates the coordination and integration of a variety of boundaries in an extended enterprise thereby increasing firm performance with the support of organisational initiatives from suppliers and within a firm. Thus, their work is categorised into dimension 2.

Wiengarten et al. (2013) argued that IT for interfirm information sharing and process coordination has a critical role in interfirm collaboration. They defined e-business applications as IT that the focal organisation has implemented to support interaction (sharing of data and information), coordination (tracking and tracing orders and process monitoring) and integration (an automated and seamless process) of the business process. In their work, e-business applications highlight the role of IT for interfirm process improvement (dimension 2).

3.3.3 Strategic Flexibility

This represents the value creation focussed research stream in section 2.3.2. Strategic flexibility allows a firm to configure new or reconfigure existing interorganisational relationships to offer innovative products and services. In the systematic review, some articles addressed that firms need to utilise IT for potential value gains and to provide new products and services to deal with dynamic market changes. Therefore, the characteristic of strategic flexibility is differentiated from others as it emphasises explorative IT use for supply chain management, as the following articles argue.

One of the critical elements of the concept of IS practice proposed by Bayraktar et al. (2009) is IS integrators; this refers to IT applications for strategic partnering such as customer relationship management (CRM), supplier relationship management (SRM) and advanced planning systems (APS). With the support of IT, the researchers argued that SCM practices with IS integration (strategic collaboration with reconfiguration of partnerships, strategic supplier selection and elastic procurement) affect operational performance. Thus, they captured the role of dimension 3.

In Devaraj et al.'s (2007) conceptualisation of IT capability, one of the three elements of IT capability was IT for collaboration, which provides strategic channel relationships to trade partners. It is identified that IT capability enables strategic partnering regarding future demand forecast and planning. These researchers emphasised the role played by IT in the configuration of firms' supply chain partnering for new business opportunities. Therefore, they captured dimension 3.

Fawcett et al. (2011) identified that strategic collaboration between firms—such as joint objective achievement, joint performance monitoring and sharing value-added resources with supply chain members—are enabled by IT. Therefore, Fawcett et al. (2011) emphasise the importance of IT for strategic partnering, which also falls into the category of dimension 3.

In Gosain et al.'s (2004) work, the role of IT was focused on two types of flexibility—offering and partnering flexibility. This supports changes in offering services and products and changes in partnership reconfiguration. Along with the basement role of IT for rich connectivity and information sharing, the role of IT for partnering and offering configuration for extra value creation (dimension 3) is also highlighted.

Kim et al. (2006) demonstrated that the use of IT facilitates a firm's partnership responsiveness. The responsiveness of a partnership was defined as the extent to which a firm with the channel partners accommodate environmental changes. They conceptualised the responsiveness of a partnership as a capability to cope with changing customers' needs, competitors strategies, and a capability to develop new products with support from the strategic partnership. Therefore, their work falls into the category of dimension 3.

Olorunniwo and Li (2010) identify that IT for information sharing enables supply chain collaboration. The collaboration includes longer term strategic attributes such as joint planning and forecasting of demand, cost sharing, risk and reward sharing, jointly established performance measures and strategic alliances with trust. Therefore, their work is categorised as dimension 3.

Other than IT for efficiency and geared towards the lean strategy, as mentioned in terms of dimension 2, Qrunfleh and Tarafdar (2014) also reported that IT for flexibility moderates the impact of an agile supply chain strategy and supply chain performance. While the lean strategy focusses on the elimination of waste and non-value-added activities, the IT strategy for flexibility centres on a firm's agility to track and understand customer requirements by interfacing closely with the market. Thus, firms aiming to produce in any volume (not just the optimal capacity utilisation volume) and deliver simultaneously to a wide variety of markets benefit from IT for flexibility, and such firms are able to provide customised products with short lead times. Zara's supply chain is an example of a notable effect of IT for flexibility. Zara introduced IT applications for real-time monitoring of customer requirements in its stores, thereby enabling rapid and new product production (dimension 3).

Sanders (2005) also demonstrated that the use of IT for process improvement (IT alignment between buyer and sellers) affects the level of strategic collaboration. She defined strategic collaboration as collaborative planning, new product/opportunity creation and joint team development with buyers. Therefore, in her work dimension 3 is identified.

Tan et al.'s (2010) approach to IT focussed on supply chain configuration. In their view, the EDI capability in supplier management affects the relationship alignment with suppliers. They conceptualised EDI for supplier management with reference to performance evaluation, supplier selection and customer service improvement capabilities.

They found that collaborating with suppliers through IT enables partnership configuration according to the culture, relationship expectations and strategic needs. Therefore, IT for strategic partnering and reconfiguration is identified (dimension 3).

Vickery et al. (2010) identified supply chain IT as enabling firm agility in activities related to the introduction of new products, manufacturing, delivery and response to customers with support from organisational initiatives. Thus, their work is categorised as dimension 3.

Wang and Wei (2007) identified the role of IT completeness in partnering flexibility in interfirm relationships. Here, partnering flexibility (the ease of changing supply chain partners according to the strategic decisions made in the changing environment) was enabled by integrating value-adding activities through IT because information precedes the movement of tangible resources thereby enhancing strategic process adjustment. Therefore, the role of IT in supply chain partnership reconfiguration is categorised as dimension 3.

Wiengarten et al. (2013) identified that previous research had ignored the value creation process in e-business applications. They reported that the implementation of e-business applications enhances buyer–seller strategic collaboration, covering new production development or changes, entering new markets or acquiring new customer demand forecasts from suppliers. Thus, their work is categorised into dimension 3. Table 3.2 summarises the studies identified from the systematic review and the dimensions into which each study is categorised.

Reference	**Considered environmental conditions in supply chain management (SCM)**	**Dimensions**		
		Transactional dimension	**Operational dimension**	**Strategic dimension**
Bayraktar et al. (2009)	Global competition/large number of customers	X		X
Bharadwaj et al. (2007)	Need for interfirm/functional coordination between manufacturing and supply chain processes	X	X	
Closs and Savitskie (2003)	Changing customer requirements	X	X	
Devaraj et al. (2007)	Supplier and customer integration for production planning	X		X
Fawcett et al. (2011)	Resource heterogeneity in the networked environment	X		X
Gosain et al. (2004)	Increasing business dynamics, customer needs and disruptive information technology (IT) changes		X	X
Jayaram and Vickery (2000)	Interorganisational process integration for value creation		X	
Kim et al. (2006)	Resource heterogeneity/interfirm integration for firm performance	X	X	X
Klein and Rai (2009)	Supply chain relationship transition from transaction to collaboration	X	X	
Lai et al. (2008)	Change of customer needs and market requirements		X	
Olorunniwo and Li (2010)	Need for interorganisational collaboration for logistics performance		X	X
Prajogo and Olhager (2012)	Time and spatial distance between supply chain partners	X	X	
Qrunfleh and Tarafdar (2014)	Transaction cost/changing customer requirements/market environment		X	X
Sanders (2005)	Power structure in buyer and supplier relationships in the supply chain		X	X
Savitskie (2007)	International operations in SCM	X	X	
Tan et al. (2010)	Dependence relationships in the supply chain power structure			X

Vanpoucke et al. (2009)	Strategic alliance between trade partners		X	
Vickery et al. (2010)	Need for interorganisational process integration for firm performance		X	X
Wang and Wei (2007)	Uncertainty in dyadic relationships and changing environments		X	X
Wiengarten et al. (2010)	Changing customer needs		X	
Wiengarten et al. (2013)	Complexity of collaboration in buyer and seller relationships		X	X
Wong et al. (2011)	Uncertainty in the business environment	X	X	
Zhou et al. (2014)	Need for diverse supply chain strategies	X	X	

Table 3.2 Summary of Systematic Review: IT-supported/enabled Dimensions in Supply Chain Activities

Source: Author.

3.4 FINDINGS FROM THE SYSTEMATIC APPROACH – ADDRESSING RESEARCH QUESTION 1

By taking a systematic approach to the IT flexibility concept, the multidimensional structure of IT flexibility for SCM was identified. The dimensions are transactional, operational and strategic flexibility, which are summarised as follows:[6]

1) Transactional flexibility: A capability for extended networks and interoperable interface arrangement–focussed infrastructure;

2) Operational flexibility: A capability for interfirm process coordination/ improvement based on information sharing; and

3) Strategic flexibility: A capability for partnering configuration and innovative service/product offering based on the new and/or potential value creation.

These three categories construct the multiple dimensions of IT flexibility. This study labels the first category *transactional flexibility* because it focusses on the extended network and interface arrangement to be prepared for lower level business transactions. The second category is *operational flexibility* due to its focus on process and information quality at the operational level of processes. Following the same logic, the third category is called *strategic flexibility*, as it focusses on strategic value creation through the partnering configuration and new product and service development. The identification of multiple types of IT flexibility addresses RQ 1: What are the key dimensions of IT flexibility for SCM?

Based on the multidimensional flexibility concept, this study suggests that to achieve the true value of flexibility, firms need to be able to utilise the three types of IT flexibility simultaneously. In other words, IT flexibility for SCM denotes the extent to which firms

[6] The definition and characteristics of each type of flexibility is discussed further in section 4.3.

elastically handle their IT for supply chain–wide activities with the three dimensions. Elastic handling means that firms should be able to switch from a specific IT use to other types according to the requirements related to the business variables. Based on this notion, the present study redefines IT flexibility for SCM as a capability to operate diverse IT support/enablement dimensions for supply chain–wide activities elastically to react to variations derived from different levels/types of business processes in supply chains.

It should be noted that this is a partial answer to the RQ 1, as it does not identify the relationships between the flexibility dimensions. Hypotheses on these relationships are developed in Chapter 4 and tested in Chapter 6.

3.5 SUMMARY

Due to the requirements of an integrative/multidimensional format of IT flexibility for SCM, this chapter identified the three dimensions of IT flexibility by conducting a systematic review. The identified IT flexibility dimensions were transactional flexibility, operational flexibility and strategic flexibility. By delineating these dimensions, a multidimensional concept of IT flexibility covering supply chain–wide activities was developed. Based on these dimensions, the definition of IT flexibility for SCM was provided. This identification of IT flexibility partially addressed RQ 1. In Chapter 4, the relationships between the IT flexibility dimensions are discussed in relation to the IT flexibility research model development process.

CHAPTER 4. RESEARCH MODEL CONCEPTUALISATION

4.1 INTRODUCTION

Chapter 2 reviewed the existing IT flexibility concept and characteristics of IT flexibility for SCM. In Chapter 3, through a systematic review, the structure of IT flexibility – which consisted of transactional, operational and strategic dimensions – was outlined. Based on these dimensions, in this chapter, an IT flexibility research model is developed along with hypotheses to determine the route of causality of IT flexibility for FP.

The present chapter is structured as follows. In section 4.2, the current dominant RBV-based approach to IT flexibility is discussed in terms of its limitations when applied to IT flexibility for SCM. Moreover, based on the composition of DC theory and RV theory, this study justifies the link between IT flexibility and FP in the supply chain context. Before moving to hypothesis development, in section 4.3, the definitions of IT flexibility dimensions, the mediating concept of PIC and the target construct of FP are provided. In section, 4.4 hypotheses are presented with the IT flexibility research model. In section 4.5, the measures to be used for later survey analysis are presented.

4.2 THE THEORETICAL PERSPECTIVE ON IT FLEXIBILITY FOR SUPPLY CHAIN MANAGEMENT

4.2.1 Requirements of Theory Composition and Matching

1) Limitations of the Resource-based View (RBV)

As shown in Table 2.15, the RBV is the dominant theory in the literature. It has advantages when it comes to explaining IT as an internal capability for competitiveness; however, as described below, it also has limitations in explaining the role of IT flexibility in SCM.

The basic assumption of the RBV concerning the organisational phenomenon is that all business participants (e.g. customers, suppliers and intermediaries) are competitiveness seekers (Lavie, 2006). According to the RBV, firms possess unique resources that enable them to achieve a competitive advantage and better long-term performance. The resources are defined as a set of valuable assets and useful capabilities controlled by firms to achieve competitive advantage; the firms need these resources to protect against imitation and transfer from competitors (Wade and Hulland 2004).

The RBV considers business decision making to be determined by the rational decision makers of organisations based on reasonable analysis of industrial and organisational factors. Therefore, when a firm develops its capability with its resources, it is in the position to leverage organisational relationships and internal capabilities to react to the business environment (Holweg and Pil 2008). This indicates that the internal factors have been arranged prior to involvement in supply chains (Tan and Cross 2012), and the interorganisational relationships are generated within the process of achieving a competitive advantage (Yao et al. 2009). In this context, IT is regarded as a coherent infrastructure for relationship-formation processes (Yao et al. 2009), an asset for sustained competitive advantage (Hong et al. 2010) or a type of resource for higher order organisational capabilities in supply chains (Wu et al. 2006).

One of the main reasons to deploy the RBV in SCM research is that it is easily applicable to the capability implications of firms pursuing competitiveness (Hsu et al. 2008).Especially, by conceptualising firms as optimal solution seekers, the RBV justifies firms' participation in interfirm networks and provides a rational argument for the role of IT as an internal resource that enhances organisational capability. As shown in Table 2.15, the RBV is dominantly used to explain the infrastructure-based approach of IT flexibility.

The main criticism of the RBV relates to its position that the resources for competitive advantage need to be confined by the firm's boundaries pertaining to internal resources (Wade and Hulland 2004; Lavie 2006; Kraaijenbrink et al. 2010); thus, it overlooks the characteristics of the interdependent environment in which the firms share resource and make investments together (Dyer 1996; Dyer and Singh 1998; Devaraj et al. 2007; Liu et al. 2013). As a result, it does not fully justify the joint benefits generated by widely shared IT in supply chains. A second criticism is that RBV's path dependent logic of utilising *existing* firms resource to acquire competitive advantage is not applicable in high velocity markets. Because a volatile market would require firms to develop *new* resource configurations and to make movement into new competitive positions with a path breaking changes (Eisenhardt and Martin 2000). In sum, RBV is not fully applicable for the IT flexibility idea in the SCM context as its internal/existing resource based arguments and its relative paucity of attention for the interdependent business environment.

2) Requirements of theory composition

Theory is important for research for the following reasons: 1) it produces an analysis framework for the research aims, 2) it guides an efficient method for the application of the research to the field and 3) it provides clear explanations for the practical world. A good theory needs to provide a precise structure for areas in which different opinions coexist (Wacker 1998). To identify appropriate theories for such support of IT flexibility other than the RBV, an effort to match new theories or extend existing theories to the role of IT flexibility for SCM is required (Dubois and Gadde 2002). This is particularly necessary in the present study because its aim is to understand the research objective by interpreting and reconceptualising a research concept in a new framework (Dubois and Gadde 2002; Spens and Kovács 2006).

According to a recent literature review by Kembro et al. (2014) regarding theoretical perspectives on supply chain information sharing, "most, if not all, empirical papers coverage into the conclusion that one size does not fit all" (p.618). This suggests that IT use decisions are contingent on the supply chain context. Therefore, decisions about resource and relational configurations with supply chain partners should be based on the context in which a focal company operates (Wong et al. 2011; Kim et al. 2014). As this research is interested in exploring the impact path way of IT flexibility to FP, its research focus is on how focal firms' flexible deployment of IT resources and relational configurations in a changing environment could lead to improvements in FP. Moreover, motivated by the importance of multidimensional IT flexibility in interfirm relationships in the changing business environment, this study draws upon DC and RV by synthesising the logic of each perspective. Given the limitations of the RBV, social science researchers have added relational extensions (Lavie 2006; Jin et al. 2014) and dynamic extensions (Teece et al. 1997; Teece 2007; Fawcett et al. 2011) of the RBV to improve its applicability in an interorganisational business setting. The next section provides justifications for the conjoining of RV and DC for the concept of IT flexibility in SCM.

4.2.2 Theoretical Framework: Dynamic Capability Theory and Relational View Theory

1) Dynamic capability: Managing the changing business environment

DC is widely used to explain the variance of organisational capability (Liu et al. 2013). This theory's key premise is that the DC is a change-oriented source of competitiveness allowing firms to reconfigure their resources to meet dynamic demand from the changing business environment (Teece et al. 1997; Eisenhardt and Martin 2000; Fink and Newman 2009). Specifically, DC emphasises two types of capabilities, namely exploitation capability and exploration capability (March 1991; O'Reilly and Tushman 2008). Exploitation is about efficiency, increasing productivity and control within the refinement of existing knowledge and technology in benefit producing. In contrast, exploration involves the search for new knowledge, innovation and embracing variation to capture new opportunities with the reconfiguration of organisational assets for unknown demand. Exploration capability relates to longer term success via the recombination of organisational assets and structures to adapt to the changing environment with the alignment of operational capability (March 1991; Benner and Tushman 2002; Greve 2007; O'Reilly and Tushman 2008).

Subramani (2004) further developed these capabilities for IT use by introducing the exploitative and explorative use of IT based on the idea of appropriation. Subramani's (2004) idea was that appropriation, which refers to the patterns of IT use, can lead to diverse outcomes to adapt to changes. The exploitive use of IT refers to the execution of structured tasks with the support of IT in interorganisational processes within the current supply chain structure. According to Subramani (2004), a structured task signifies the processes associated with the interfirm business process that generate definable benefits; these include process efficiency and consistency. The explorative use of IT represents the achievement of unstructured tasks to create new capabilities to provide new solutions to the changes. Unstructured tasks represent non-routine, newly emerging issues to be resolved by new IT skills with new solutions with trade partners (Subramani 2004). With its characteristics of new technology and resource use, IT sometimes enables radical and revolutionary changes (Lee 2012). Table 4.1 summarises the two types of IT use.

	Information technology (IT) use for exploitation	**IT use for exploration**
Definitions	Execution of structured interfirm processes	Execution of unstructured interfirm processes
Goals	Improving, applying and incrementally refining firm capabilities	Creating new capabilities, devising novel solutions to current problems
Outcomes	Clearly definable benefits (e.g. cost reduction, process consistency, process efficiency)	'Soft' benefits that are difficult to evaluate in advance (e.g. shared understanding, a clearer picture of cause-effect relationships, a greater understanding of the operating environment).

Table 4.1 IT Use for Exploitation and Exploration
Source: Subramani (2004).

These different types of IT capability are in line with the idea of IT flexibility in this study. Multidimensional IT flexibility indicates that IT flexibility is acquired not only from the exploitive perspective of IT, which emphasises improving interfirm processes and process efficiency (i.e. operational flexibility; Subramani 2004), but also the explorative view, which comprises the new configuration of services, products and supply chain structure for new opportunities (i.e. strategic flexibility; Subramani 2004).

Moreover, the concept of being pivotal – that is, carrying out exploitative and explorative processes together (O'Reilly and Tushman 2008) – can be interpreted to the role of transactional flexibility focussing on IT infrastructure in SCM[7]. Therefore, DC is suitable for explaining the role of IT flexibility in its multidimensional capability by suggesting that the ways in which firms deploy IT resources to cope with the changing market environment varies in terms of the emphasis on market volatility (Eisenhardt and Martin 2000; Teece 2007; Jin et al. 2014).

2) The relational view: Managing interfirm relationships

From the perspective of the RV, critical resources are embedded in complementary interfirm relationships (Dyer and Singh 1998); thus, the focus of RV theory is networked relationships and capabilities in the partnership (Chen and Paulraj 2004; Straub et al. 2004). According to this theory, firms complement their internal resources or capabilities with partner firms' capabilities to acquire desired outcomes that cannot be achieved by acting alone. The collaborative outcome is described as the relational rent, which refers to a supernormal profit that is jointly generated by alliance partners (Dyer and Singh 1998).

The necessity of interdependence encourages firms to exchange and share information with trade partners (with more solid relationships) to create relational value (Dyer 1996; Dyer and Singh 1998). In this theory, one of the effective ways to achieve such capabilities is to build tight relationships with trade partners who possess the resources or capabilities that the focal firm does not have (Prajogo and Olhager 2012).

This study takes the view that IT flexibilities are embedded in the interfirm network interface, which is the RV's fundamental condition to describe firm boundary–spanning resources for joint profit. Therefore, it is argued that the role of IT flexibility should be extended as the source of joint value creation in interorganisational relationships; in

[7] Such characteristics of transactional flexibility are discussed further section 4.3.1.

contrast, it should not be seen as an internal resource to be confined within a firm boundaries by extending the arguments of RBV.

The RV addresses four sources of value creation, as follows: 1) interfirm relationship–specific investment, 2) complementary resources/capabilities, 3) interfirm knowledge-sharing routines and 4) effective governance. The first two sources are IT-intensive variables related to interfirm business processes (Klein and Rai 2009; Rai et al. 2012); thus, they justify the role of IT flexibility in supply chain. Meanwhile, the last two sources focus on incentives and enforcement to oversee the network partnerships embedded in the supply chain structure. IT flexibility as a relationship specific complementary capability (as the first two types of resources) can be explained as follows. First, IT flexibility requires investment to arrange and maintain the interfirm relationship because IT value is increasingly being created by multiple stakeholders and not single firms to generate value from collaborative relationships in supply chains (Kohli and Grover 2008; Klein and Rai 2009; Rai et al. 2012). Second, IT flexibility for interfirm business processes can be complementary; that is to say, "doing more of one thing increases the returns to do doing more of another" (Milgrom and Roberts 1995, p. 181). Thus, the value of an organisational resource can increase in interorganisational relationships. In other words, IT is also a resource that can be used to complement partner firms' value when it is employed for boundary-spanning collaborations in supply chain processes (Bharadwaj 2007).

The composition of RV and DC characterises IT flexibility for SCM. First, IT flexibility consists of multiple types of capabilities that allow firms to cope with environmental changes by operating them according to the changes. Second, at the same time, IT flexibility enables firms to manage interfirm relationships to create joint value. This composition of DV and RV indicates that to develop IT flexibility for SCM, transactional flexibility (i.e. infrastructure focused flexibility) plays a pivotal role in supporting the other two dimensions. This is consistent with many studies in the literature that employ the RBV as a supporting theory, which have found that the flexibility of IT infrastructure can be considered as a rare, valuable and inimitable strategic resource. However, developing flexibility at the infrastructure level is not sufficient to manage the operations in a dynamic business environment. For example, a firm may employ cloud computing–based IT infrastructure for a quick and wide (and therefore flexible_ information network, but if the infrastructure does not support flexible interfirm information sharing and process coordination (operational flexibility), quick and elastic partnership (re)arrangement and customised/innovative product/service offering (strategic flexibility) at the network level, then IT flexibility is still confined within a focal firm's boundary and will not contribute to SCM with enhanced performance. Therefore, IT flexibility for SCM should be regarded as a dynamic capability that rests on relational processes in interfirm relationships. Figure 4.1 depicts the composition of DC and RV for IT flexibility.

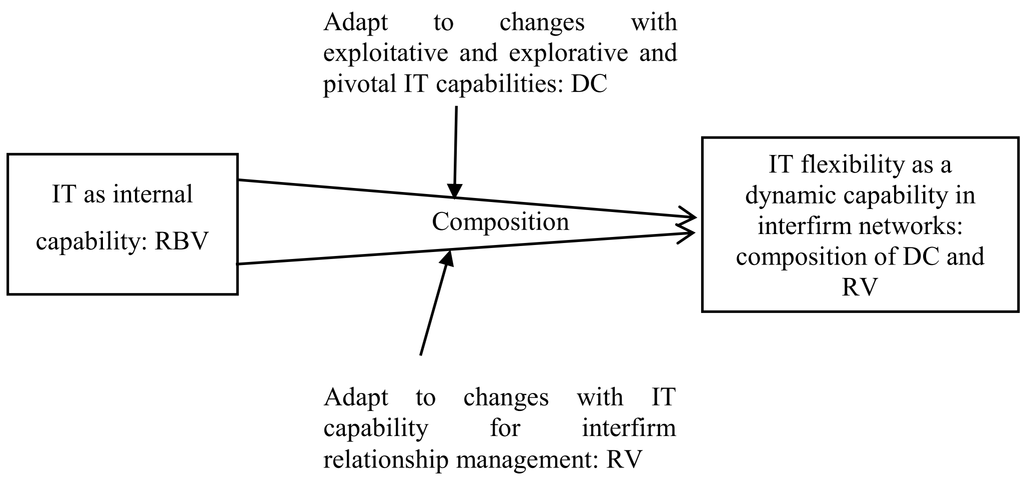


Figure 4.1 Composition of dynamic capability (DC) theory and relational view (RV) theory for IT flexibility in SCM.
Source: Author.

3) Theoretical framework of IT flexibility for SCM

To test the role of IT flexibility for SCM, the research model must include the SCM context. To do so, this study theorises that the roles of IT flexibility in a supply chain are linked to intra- and interorganisational process integration. PIC refers to the magnitude of intra- and interorganisational process integration measured from the perspective of a focal firm[8].

Owing to the SCM requirements to coordinate the material flows within and between firms, a common finding in the IT literature is that business processes mediate the IT business value for organisational performance (Melville et al. 2004; Gattiker and Goodhue 2005). This is because IT interacts with intermediate business practices, such as logistics, distribution and customer services, which underpin value-creation tasks in a networked business environment (Melville et al. 2004). In this context, considering the importance of process integration, this study takes the view that benefits from the supply chain network are produced when the integration of business processes within the firm (among departments) and with external firms, such as suppliers, distributers and customers, are ensured. Thus, by incorporating PIC, which measures the level of supply chain execution, this research seeks to investigate, first, if the multiple dimensions of IT flexibilities are well engaged in the supply chain interface, and second, whether this approach will justify the characteristics of IT flexibility developed for SCM by testing its role against the basic requirements of the SCM context. Many studies have been published on supply chain integration, and most of these have taken a process view; that is, they have described SCM as a series of connected input–process–output chains of activities (Gunasekaran and Ngai 2004; Power 2005; Droge et al. 2012; Schoenherr and Swink 2012; Maiga et al. 2015; Rahimi et al. 2016; Titah et al. 2016). The necessity of taking a process view for execution is also recognised by scholars in the IT/IS field (Rai et al. 2006, Kamal and Irani 2014).

The associated role of IT flexibility with PIC has not been investigated explicitly in existing IT-flexibility research, although there have been some generic studies investigating the mediated relationship between information communication technology (ICT) and supply chain performance (see Zhang et al. 2011). For instance, through a

[8] The concept of PIC is clarified in more detail in section 4.3.2.

survey conducted in the automotive sector, Vickery et al. (2003) found that integrative IT affects both internal process integration, by increasing the flow of relevant information among process participants, and external integration with suppliers and customers, by forging closer supplier and customer relationships. Based on a survey of 127 companies in China, Peng et al. (2016) empirically confirmed that a firm's capability to manage both internal and external business processes fully mediates the impact of IT on FP.

The incorporation of PIC within the framework of DC and RV is supported by the empirical studies that view PIC as a relational competency and a dynamic capability required to mediate firms to achieve relational rent in supply chain relationships. According to Jin et al. (2014), the impact of IT-enabled information capability on competitive advantage is associated with the flexible execution of production, logistics and supply. This extended role of IT for supply chain processes is made available by extending the use of IT to IT exploitation in different ways, such as the integration of IT applications and reconfiguration of IT networks from the viewpoint of DC. Moreover, by extending the role of IT to interfirm relationship–specific capabilities, such as using open-standard EDI, Jin et al. (2014) explained that IT facilitates interfirm information sharing from the perspective of RV. Kim et al. (2011) also found that IT enables process-oriented dynamic capabilities, such as better communication and information sharing with supply chain partners or sharing detailed information in a business process from the view of DC. In a similar vein, Paulraj et al. (2014) showed that IT is a relational competency leading to increased behavioural transparency and reduced information asymmetry, which is associated with interfirm information sharing and affects supply chain performance from the perspective of RV. Furthermore, Rai et al. (2012) argued that IT can be an interfirm relationship–specific capability that facilitates business communications in the logistics industry from the stance of RV.

If the effects of the three IT-flexibility dimensions are mediated by PIC, this will mean that the dimensions represent the dynamic capability of firms to manage the changing business environment; they will also represent a relationship-specific capability that facilitates the execution of interfirm supply chain operations. Following this rationale, this study presents the IT flexibility conceptual framework depicted in Figure 4.2.

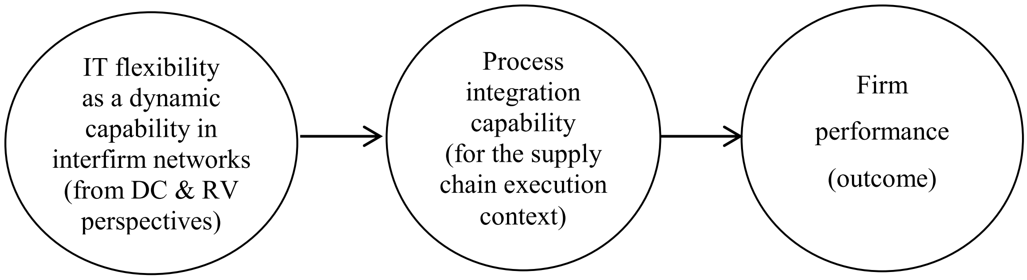


Figure 4.2 Theoretical framework of IT flexibility for SCM.
Source: Adapted from Rai et al. (2006)

4.3 DEFINITION OF KEY CONSTRUCTS

4.3.1 IT Flexibility: Transactional Flexibility, Operational Flexibility, Strategic Flexibility

1) Transactional flexibility

Transactional flexibility (TR flexibility hereafter) highlights the importance of IT infrastructure as TR flexibility leverages the advancement of IT infrastructure and interfirm connectivity to adapt to changes in business requirements driven by market conditions and firm strategy. For example, when a focal firm's Web EDI, which enables wider geographical connectivity with diverse IT platforms from trade partners, is used to link to divergent interoperable interfirm systems with their trade partners, such as in ERP, then the focal firm's EDI can behave flexibly according to the numbers of trade partners that the firm can access and the number of compatible platform types. Moreover, the modularity of IT systems would enable quick and timely reconfiguration of information linkages, especially when a new operating entity is formed from a new partnership (Mithas et al. 2011). Modularity and open transaction standards also reduce the switch and/or exit cost when partnerships are ceased to exist (Tafti et al. 2013). This study suggests that organisations' decisions regarding how firms make investment and utilise their IT infrastructure significantly affect their productivity, as TR flexibility is an important mean to produce elastic intra-/interorganisational process integration and effective SCM (Henderson and Venkatraman 1997; Paulraj et al. 2008; Mithas et al. 2011).

The importance of TR flexibility in SCM was well demonstrated by Collins et al. (2010) using the example of a trading company; Li & Fung. This firm serves retailers with clothing and other commodity produced in Asia, Africa and America; the researchers described it as follows: 'Each order requires orchestration of a variety of services, from design and sourcing through production, logistics, quality management, finance and billing, all within a customised worldwide workflow that may exist only for the duration of that specific order' (Collins et al. 2010, pp. 436–437). This indicates that a firm's ability to serve customers relies heavily on its capability to elastically integrate its IT infrastructure beyond organisational boundaries to support interfirm business processes. As given above, this study defines *TR flexibility* as a firm's capability to configure and reconfigure its network with its trading partners to address the rapidly changing environment.

✓ ***The pivotal role of Transactional flexibility for operational and Strategic flexibility***

TR flexibility has a pivotal characteristic in supporting the other two flexibilities; this is based on the notion that IT can serve more than one purpose in interorganisational business networks (Hong 2002; Vickery et al. 2003). IT infrastructure for supply chains, such as interoperable networks with higher levels of accessibility for multiple trade partners, can be considered either to support process improvement in streamlining delivery schedule or underpinning value creation with strategic partnering. Thus, it is flexible in the sense that TR flexibility can be configured to serve one or many purposes. Therefore, TR flexibility is posited as a building block with dual purposes, where it has both a facilitative role for quality information sharing and process improvement in operational flexibility and an enabling role for strategic flexibility in the effort to launch competitive business actions. This is in line with the concept of ambidexterity, where exploitation and exploration are carried out together for 'asset orchestration', and this is critical for sustaining competitiveness (O'Reilly and Tushman 2008; Lee et al. 2015). DC requires the senior management team to balance two completely different organisational capabilities – exploitation and exploration, making it an objective that is hard to achieve (March 1991; Gupta et al. 2006; Greve 2007). Thus, asset orchestration is viewed as a kind of strategic fit that is not a source of competitiveness but rather an intangible decision-making mechanism or competency (March 1991) of a senior management team to meet the requirements of the changing business environment (O'Reilly and Tushman 2008).

In a similar vein, this study conceptualises the role of TR flexibility as a capability that enables firms to enhance the two other types of IT flexibility simultaneously with the support of tangible and physical IT attributes. This study argues that the simultaneous support from TR flexibility for the other two types of flexibility is available because IT for interfirm relationships could support the current supply chain strategy initiatives or facilitate the development of new supply chain strategy (Henderson and Venkatraman 1999; Chandra and Grabis 2016). Thus, in this context, TR flexibility is not a competency for resource allocation decision making; rather, it is a technical capability that facilitates the other two types of IT flexibility.

2) Operational flexibility

OP flexibility (OP flexibility hereafter) is defined as a firm capability to use IT for efficient and quality information sharing to improve shared process handling in the network. This is based on the idea that an important factor for attaining this capability is not a specific set of technological IT elements but rather the organisational capabilities to exploit IT attributes to gain advantages in information sharing and process improvement (Jayaram and Vickery 2000; Prajogo and Olhager 2012; Wiengarten et al. 2013). According to Henderson and Venkatraman (1999), "no single IT application – however sophisticated and state of the art it may be – could deliver a sustained competitive advantage. Rather, advantage is obtained through the capability of an organisation to exploit I/T functionality on a continuous basis' (p. 473).

OP flexibility focuses on the capacity for process optimisation and cooperation through interorganisational information sharing between partner firms. With the support of OP flexibility, firm IT resources can be allocated for process improvement, especially in regards to coordinating interfirm business processes, such as ordering, inventory, transport and distribution arrangement (Helo and Szekely 2005; Turban and Volonino, 2010). Improved process coordination contributes to cost savings and reduced customer lead times; it may also enable firms to achieve better alignment of interfirm decision making processes, cultivating overall performance improvement of the whole chain (Chandra and Kumar 2001; Vickery et al. 2010). Corresponding to DC theory, the purpose of OP flexibility is defined as exploitation; that is, a firm's elastic employment of existing IT resources will enable continuous interfirm process improvement and greater control over process execution in the chain (Subramani 2004; Lee et al. 2015). Hence, OP flexibility serves firms as a catalyst to support a current interorganisational relationship portfolio with improved efficiency (March 1991; Subramani 2004; Im and Rai 2013).

3) Strategic IT flexibility

Strategic flexibility (STR flexibility hereafter) refers to a firm's capability to proactively utilise its own and its supply chain partners' IT proficiency to capture innovative and new business capabilities under uncertainty and market shifts.

Supply chains involve not only physical networking but also interfirm cooperation activities, such as sharing business goals and utilising joint polices. Strategies maintained by decision-supported systems contribute to the implementation and control of tactical and strategic operations (Chandra and Kumar 2001). Firms pursue higher order goals, such as understanding new market dynamics and discovering new partnering arrangements to provide greater customer value (Eisenhardt and Schoonhoven 1996). This affects FP in terms of revenue growth by enabling flexible partnering (the capability to establish and change linkages with different supply chains partners) and flexible offerings (the capability of interfirm alliances to support changes in product/service offerings for new value creation; Gosain et al. 2004; Rai and Tang 2010; Wiengarten et al.

2013; Qrunfleh and Tarafdar 2014). Therefore, STR flexibility emphasises the ease of building and altering relational linkages with new or existing trading partners to support new market acquisition or product and service innovation; thus, it can be regarded as a explorative capability that focuses on the achievement of new resource use and new capabilities to provide innovative solutions to the changes (Subramani 2004; Lee et al. 2015).

Partnering represents the ability to build and alter linkages with different supply chains (Gosain et al. 2004). Sambamurthy et al. (2003) argued that partnering is a kind of dynamic capability that can be used to leverage the resources and competencies of trade partners in supply chains in the exploration and exploitation of innovation opportunities. In these endeavours, IT should support interfirm collaboration via collaborative portals and platforms or supply chain–related IT applications. Offering refers to interfirm relationships' ability to back changes in product/service offerings for value creation (Gosain et al. 2004; Wiengarten et al. 2013; Qrunfleh and Tarafdar 2014). These two aspects - partnering and offering - enable firms to reconfigure their supply chain structures to handle changing market environments and achieve potential value. STR flexibility offer a measure of a firm's managerial skills in that it includes strategic partnering, which reveals how firms reconfigure their relational linkages and offering, as well as how firms innovate with their IT to bring new products and services to the market. Wang et al. (2011) demonstrated how three international manufacturers sought collaborative opportunities by developing an innovative consortium in the form of electronic logistics marketplace and jointly arranged their transport provision and execution. Here, STR flexibility was viewed as an aid to pursue novel ways of creating value and adopting new solutions, thereby promoting "exploration" and "learning" related to supply chain activities (March 1991; Subramani 2004).

Table 4.2 summarises the classification of the identified IT flexibility dimensions and their characteristics. The role of TR flexibility to support other two types is described as a pivotal role; thus, it is located between the OP and STR flexibilities.

Type	Purpose of information technology (IT) use	Focus	Flexibility characteristics
OP flexibility	Exploitation	Process	Capability for - Information sharing - Process automation and synchronisation - Process coordination and streamlining
TR flexibility	Pivotal role	Network	Capability to use - A wide range of IT infrastructure - A high level of IT connections and access - High interoperability
STR flexibility	Exploration	Value, market and customer	Capability to - Respond to the business environment - Configure according to changing customer needs - Support changes in products or services - Develop new business models

Table 4.2 Characteristics of the IT Flexibility Dimensions

Source: Author.

4.3.2 Process Integration Capability

PIC was conceptualised in the research model to test whether the three dimensions of IT flexibility are well engaged with the supply chain execution requirements; in extant literature on SCM, it has been shown that supply chain process integration is one of the basic requirements of supply chain execution as clarified in the discussion about the characteristics of SCM in sections 2.2.2 and 2.4.1. Moreover, studies investigating the impact of process integration on supply chain execution support such a position of PIC. For example, Frohlich and Westbrook (2001) investigated the strategic importance of integrating operations between suppliers and customers in supply chains with data 322 manufacturing companies. They identified five different strategies (described as the 'arc of integration') in the sample by direction (upwards/downwards) and degree of integration activity, as follows: inward facing, periphery facing, supplier facing, customer facing and outward facing. The study showed that firms with wider supply chain process integration with their chain partners exhibit the highest level of performance improvement compare to organisations showing a narrow scope of integration with customers and suppliers.

Zailani and Rajagopal (2005) also identified the positive relationships from process integration to performance. By investigating the integration strategies in US and East Asian firms, they identified that when the interdependencies among different parts of supply chain are well recognised and properly aligned, supply chain integration (via internal/external information sharing) is positively associated with operational performance even in a large global group of companies.

Flynn et al. (2010) explored supply chain integration, defined as the degree to which a firm strategically collaborates with trade partners in three dimensions rather than a conventional single construct. The three dimensions they employed were the customer, supplier and internal integration, which were considered from the perspective of contingency and configuration. They found that supply chain integration is positively associated with both operational performance and FP. In particular, internal and customer integration were the most influential dimensions related to performance.

According to Davenport (1993), a business process is "the specific ordering of work activities across time and space, with a beginning, an end, and clearly identified inputs and outputs." (p. 5). Based on this definition, the term *process* in this study refers to the process involved in supply chain–related business activities covering sourcing, such as procurement and supply of materials; transport for material distribution and delivering; and finally service processes, representing the activities to meet the requirements of customers.

Supply chain process integration can be achieved intra/interfirm process integration to respond to changing needs (Chandra and Kumar 2001). External linkages need to be treated/absorbed intra-organisationally and finally tuned for external collaboration closeness; this contributes to creating value for the final customers (Morash and Clinton 1998). In other words, internal integration in the SCM context should represent the degree to which a focal firm structures its internal activities into synchronised and collaborative processes for the purpose of fulfilling customer requirements (Flynn et al. 2010). These processes requires organisations to have the capability to integrate SCM within the focal firms' internal boundaries (Teller et al. 2012). The extended linkages from the trade partners facilitate internal operations by enabling close coordination in intra-organisational operations (Barratt and Barratt 2011). This indicates that the various internal functions within a firm are also a part of the supply chain (Sanders 2007). This claim was supported by the findings of Stank et al. (2001), who demonstrated the positive interrelationships between integration and external integration in seeking firm competitiveness in a networked business environment.

To incorporate these supply chain processes into the scope of internal and external PIC, this study defines PIC as "a firm's internal and external integration of business processes with suppliers and customers in order to create value and to improve the total performance of the chain" (Teller et al., 2012 p. 714).

4.3.3 Firm Performance

The idea of FP was adopted from Mentzer and Konrad (1991). They defined FP as an assessment of both effectiveness (the extent to which goals are achieved) and efficiency (the measure of how well the resources are utilised) in accomplishing a given task. The concept of FP that this research adopted can be addressed with its construct.

Selecting the appropriate performance measurement is not an easy task because there is inherent complexity in measuring flexibility (Flynn et al. 2010). For example, financial measurement considering the shareholders' profit motive (e.g. Vickery et al. 2003) and the incorporation of nonfinancial operational performance considering the interdependency of supply chain members (e.g. Lai et al. 2002) often make the measurement difficult (Flynn et al 2010). Researchers frequently utilise both financial and nonfinancial approaches simultaneously (e.g. Hudson et al. 2001; Narasimhan and Kim 2002). However, according to Bayraktar et al. (2009), it has been argued that obtaining quantitative measures is a challenge for researchers. Moreover, Chakravarthy

(1986) pointed out that quantitative measures, such as financial account–based performance measurements, may be criticised for the following reasons: 1) issues in accounting manipulation, 2) underestimation of firm assets, 3) distortions owing to depreciation policies, 4) different methods of consolidating accounts, 5) differences caused by lack of standardisation and 6) measurement of past records of a firm. She argued that measurements capturing potential improvement may be more meaningful.

There is a strong tendency to adopt a subjective approach based on qualitative/opinion-related attributes for performance measurement in the SCM area (Bayraktar et al. 2009; Kembro et al. 2014). The justification for this approach was discussed by Lai et at. (2002), who argued that the traditional financial performance measures, such as profitability, are less relevant to firms in supply chains. This is because such measures tend to focus on individuals rather than supply chain–wide areas for performance improvement. By taking a systematic approach covering inputs, outputs, member firm and performance assessment on a supply chain–wide basis, they argued that service effectiveness and efficiency for supply chain members should be considered as the dimensions of the performance.

This performance measurement at the network level can be identified in several supply chain studies that investigated the positive impact of IT on FP. Such research occasionally considered performance as the result of interfirm collaborative operations; thus, financial benefits was not a major issue, but interfirm operational efficiency or customer satisfaction was emphasised. For example, Sanders (2007) conceptualised organisational performance with improvement in product quality and delivery speed by taking organisational collaboration as the foundation of SCM. Ranganathan et al. (2011) measured performance by emphasising that integration with suppliers will enhance FP. They used improvement in customer service, inventory control, relationships with suppliers, reduced cycle time and operational cost. In a similar vein, Prajogo and Olhager (2012) stressed that the integration of material and information throughout the chain will improve FP. To support this argument, delivery speed, volume capacity, product variety and production costs were used to measure operational performance. Devaraj et al. (2007)

found that production information should be integrated to share accurate production-related information with channel partners. They measured performance with returns and defects of products, delivery speed and reliability, inventory turns, flexibility and production cost.

In sum, in the supply chain context, performance measurement needs to incorporate supply chain–wide effectiveness and efficiency enhanced by interfirm business coordination and integration. Therefore, considering the research context (supply chain–wide interfirm IT use for FP) and unit of analysis of this study (respondents' perceptions of the impact of IT use for interorganisational business process), this study also mainly uses nonfinancial-based FP measurement. The measurement items are discussed in section 4.5.5.

4.4 STRUCTURING THE IT FLEXIBILITY RESEARCH MODEL: HYPOTHESIS DEVELOPMENT

4.4.1 Relationships between IT Flexibility Dimensions (H1a, H1b and H1c)

It should be noted that a firm's strategy for IT flexibility can be developed in a top-down manner. A firm's strategy will define the characteristics of interfirm relationships with its multiple trade partners and what interfirm-specific IT investment need to be made for customers. This will then determine, at the operational level, how multi-functional IT capabilities need to facilitate interfirm process to meet the partnership requirements and customer requirements. Operational-level requirements will then guide the implementation of IT infrastructure and arrangement of network connectivity required at the transactional level.

However, once the strategy is established its implementation normally follows the reverse order taking a bottom-up approach to translate strategy into action. This approach can be found in the supply chain literature—for example, Muckstadt et al. (2001), Kim and Narasimhan (2002), Stadtler (2005), Klein and Rai (2009), Nan (2011) and Reaidy et al. (2015)—which argues that an interconnected network enables self-organised interfirm process execution, where satisfactory performance in a dynamic business environment is materialised. With the given research objective of examining how different IT flexibility dimensions execute supply chain process integration and improve firm performance, this research takes a bottom-up approach rather than top-down approach. The application of the IT flexibility idea through a bottom-up approach can be elaborated as follows.

To execute intra/interfirm process integration with IT flexibility and materialise its impact in the form of a firm's performance, one should build fundamental IT infrastructure with connectivity, and then proceed to provide operational level process improvement. This is because, without appropriate network connectivity at a transactional level, it is hardly possible to achieve the desired supply chain visibility for the execution of supply chain order capturing and fulfilment processes between organisations at an operational level. Both transactional IT flexibility and operational IT flexibility will then allow firms to achieve strategic IT flexibility that enables flexible partnering and product/service offering. This is because such value creation activities require transactional and operational IT flexibility to integrate more resources and coordinate interfirm process with the support of interfirm connectivity. This is in line with the guideline, proposed by Muckstadt et al. (2001), for supply chain systems to execute a collaborative SCM. They argued that firms should take a bottom-up approach that involves 1) intra-/interfirm information infrastructure that supports 2) a tightly coupled interfirm process to leverage the capabilities of partners and 3) the achievement of strategic supply chain objectives and plans. This is due to the uncertainties of, for example, demand fluctuation, which require operational-level treatment enabled by IT—such as the rapid adjustment of firm capacity on a daily basis—which cannot be executed by strategic-level decisions that deal with aggregate demand over a long period. Such a bottom-up approach, from the role of IT to the operational-level processes resulting in strategic achievement, has also been discussed in the literature below with detailed explanations of their relationships.

1) The impact of transactional flexibility on operational flexibility

The positive effect of TR flexibility to OP flexibility has been described in the literature of electronically enabled interfirm business processes where interdependent IT systems are interacting to support the interfirm business process (Shi and Daniels 2003). In this context, firms use IT infrastructure for interfirm business activity facilitation (Hong 2002). Byrd et al. (2008) found that an advanced IT infrastructure provides a foundation for logistics IS in which accurate, timely and complete information sharing is required to increase firm information-sharing capability and enhance the level of interfirm process handling. In a similar context, Jayaram and Vickery (2000) reported that the IT infrastructure interacts with supply chain process improvement tools, such as concurrent engineering IT use for overlapping business processes, standardised process tools and value analysis tools. It was ascertained that IT for interorganisational relationships is a precursor for supply chain information alignment through quality interfirm communication and compatible information sharing (Tan et al. 2010); thus, IT advancement and compatibility for interorganisational business processes mirrors the degree of IT diffusion of the supply chain process (Wu et al., 2006). This suggests that TR flexibility is positively associated with OP flexibility.

2) The impact of transactional flexibility on strategic flexibility

The positive impact of TR flexibility on STR flexibility can be identified in the literature, which has shown that TR flexibility supports firms to develop new strategy initiatives in dealing with partners and customer requirements. For instance, physical IT infrastructures, such as IT applications and virtual platforms, support firms' IT use for market-related competence, such as in providing quick and responsive service for customers; determining whether the current services met a specific group's requirements; and determining customer requirements regarding preference, process and quantity (Ravichandran and Lertwongsatien 2005). Moreover, it has been identified that interoperable IT is positively associated with the use of IT in leveraging firms' potential business strategies in dealing with customers and partners, such as in supplier selection, e-procurements and demand management (Ranganathan et al. 2011). Finally, the use of compatible IS (Tan et al. 2010) to share customers' and trade partners' strategic needs to meet the market demand can be also categorised under the impact of TR flexibility on

STR flexibility. For example, a focal firm in a supply chain can rapidly scale its IT infrastructure up or down in accordance with rising or falling market demand using cloud computing. Cloud computing concepts, such as 'infrastructure as a service' or 'software as a service' (SaaS) offer desired flexibility for firms without incurring high implementation costs (West et al. 2015).

3) The impact of operational flexibility on strategic flexibility

This study proposes that the OP flexibility supports STR flexibility because firms that successfully share information through interorganisational systems should have the ability to alter or modify their operations for customer and market requirements. High levels of information sharing and process coordination enable supply chain–participating firms to analyse the requirements of new or existing trade partners (Hong 2002). Zhang and Dhaliwal (2009) argued that divergent supply chain process management by IT leads to technology diffusion in collaborations with trade partners. Interfirm process efficiency encourages firms to share and synchronise information with partner firms and customers (Zelbst et al. 2010). Qrunfleh and Tarafdar (2014) found that IT for process handling can support supply chain agility because agile supply chains require IT that can be quickly and easily reconfigured in response to changing market demand.

The logic supporting the effects of TR and OP flexibility on STR flexibility is that the strategic use of IT requires a balance between TR and OP flexibility. For example, to carry out supply chain reconfiguration for strategic needs, IT should be able to support firms by allowing them to build and alter the information linkages with new or existing trade partners. Then, the STR flexibility focussing on that reconfiguration capability could suffice, as the firm now has the capability to link and communicate with trade partners. This is consistent to the role of constant IT support for supply chain–wide activities discussed in section 2.4. In accordance with the extant literature, this study expects that transactional, OP and STR flexibilities are interrelated, as indicated in the following hypotheses:

H1a. Transactional flexibility positively affects operational flexibility.

H1b. Transactional flexibility positively affects strategic flexibility.

H1c. Operational flexibility positively affects strategic flexibility.

In the light of the above discussion, hypotheses H1a, H1b and H1c can be linked as illustrated in Figure 4.3.

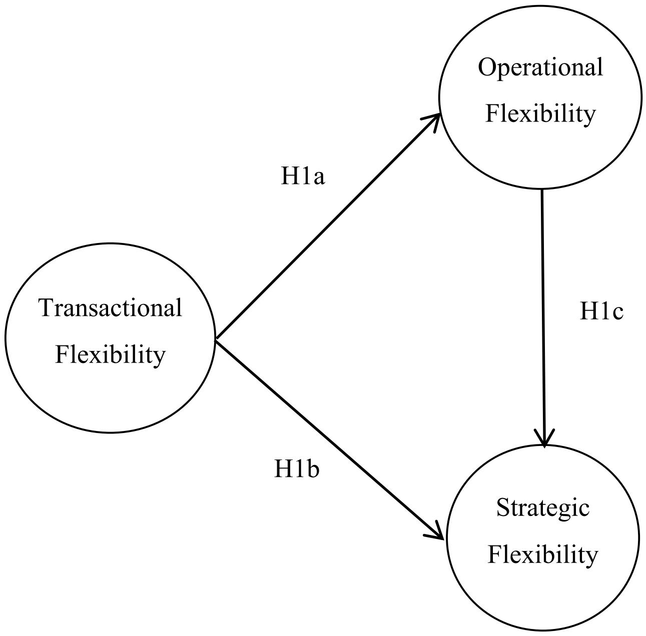


Figure 4.3 Relationships between IT Flexibility dimensions (H1a, H1b, and H1c)
Source: Author.

4.4.2 The Impact of IT Flexibility on Process Integration Capabilities (H2a, H2b and H2c)

As previously discussed, this study proposes that the three types of IT flexibility are mediated by internal and external process integration. At the supply chain level, achieving internal process integration is the primary objective of overall supply chain process integration (Lambert et al. 2005; Narayanan et al. 2011). IT for *internal* process integration is responsible for facilitating cross-functional (intrafirm) information sharing and process coordination (Schoenherr and Swink 2012; Williams et al. 2013). A common IT solution in this functionality is the adoption of ERP. An ERP system enhances a firm's capacity to integrate its intrafirm business processes (such as manufacturing, logistics, marketing and finance) in a seamless process to respond quickly and efficiently to the requirements of customers and suppliers (Su and Yang 2010).

The influence of IT flexibility on intrafirm process integration can be outlined from the literature. First, the positive effect of TR flexibility on internal PIC was examined by the study of Zhang and Dhaliwal (2009), which ascertained that IT deployment for interfirm operations enhance internal supply chain operations by stimulating intra-organisational IT use. Vickery et al. (2003) ascertained that the use of integrative IT affects the integration in cross-functional departments. Moreover, Kim et al. (2011) demonstrated that physical IT infrastructure has a direct influence on internal process–oriented dynamic capability, enhancing a firm's ability to innovate its business process on a continuous basis than its competitors. This capability enhances the firm's ability to adapt resiliently to changes in business environment and leads to sustainable competitive advantages.

The positive impact of OP flexibility on internal PIC can be identified from Sanders' (2007) research. Sanders (2007) found that the use of Web-based IT in interorganisational processes positively affects intra-organisational database integration, thereby improving organisational performance. OP flexibility affects internal PIC through processes streamlined across interfirm functions. For instance, Leonardi et al. (2013) demonstrated that implementation of enterprise social media enables quick, efficient intra-organisational information sharing; thus, it enhances interdepartmental collaboration and firm productivity. In a similar vein, Qrunfleh and Tarafdar (2014) argued that IS use for efficiency improves internal operational integration through day-to-day coordination occurring internally across the firm's departments and externally with trade partners.

STR flexibility emphasises the capability to enable flexible interorganisational configurations with supply chain–participating firms, as well as new product and service offerings. The engagement with interfirm collaboration for such configuration and offering results in higher pressure on firms to ensure internal integration (Droge et al. 2004). For instance, Subramani (2004) identified that IT use for strategic gains (explorative use) between supply chain partners enhances a focal firm's capability to integrate internal processes of production and material handling processes. Along similar lines, information sharing about market-side demand information and manufacturer-side production-related information between supply chain partners enables the supplier to forecast specific demand patterns, thereby allowing suppliers to align their production schedule with actual demand from the market (Seidmann and Sundararajan 1998; Barratt and Barratt 2011).

In terms of the roles of IT as a supporter and enabler of *external* process integration, there seems to be a consensus in the existing literature (Zhang et al. 2016). For example, concerning TR flexibility's influence, Prajogo and Olhager (2012) reported that physical information-sharing networks, such as electronic networks and interfirm logistics systems, have a positive effect on process integration with trade partners. Moreover, Mithas et al. (2011) argued that physical IT infrastructure is the foundation for building interfirm process management capability. Rai et al. (2006) also contended that data consistency and IT interconnection between supply chain applications determines the level PIC of a focal firm. The PIC was conceptualised with supply chain–wide operations covering shipment, inventory, distribution and production-related activities. Liu et al. (2013) demonstrated that flexible IT infrastructure enables seamless information flow throughout the supply chain, thereby facilitating timely decision making and leading to enhanced interfirm process coordination.

In terms of OP flexibility's effect on PIC, the advantages achieved via IT capability or services for process improvement should be highlighted. For example, Saeed et al. (2011) argued that IT application for process optimisation and integration positively affects process integration with trade partners in supply chains. Moreover, Wiengarten et al. (2013) argued that IT application for seamless data flow of the focal organisation facilitates buyer and supplier collaboration. Such collaboration was conceptualised in relation to information sharing and joint business processing.

STR flexibility has also been identified as having a positive impact on PIC. For instance, Devaraj et al. (2007) observed the positive influence of the strategic use of IT on supplier selection and customer participation from the viewpoint of supplier and customer integration. Saraf et al. (2007) also found that IT integration with supply chain partners positively affects interfirm process integration and knowledge sharing. Moreover, Rai and Tang (2010) argued that IT configuration to enable external resource management enhances competitive process capabilities.

Based on the above studies, the following hypotheses are proposed:

H2a: Transactional flexibility positively affects process integration capability.
H2b: Operational flexibility positively affects process integration capability.
H2c: Strategic flexibility positively affects process integration capability.

In the light of the above discussion, hypotheses H2a, H2b and H2c can be linked as illustrated in Figure 4.4.

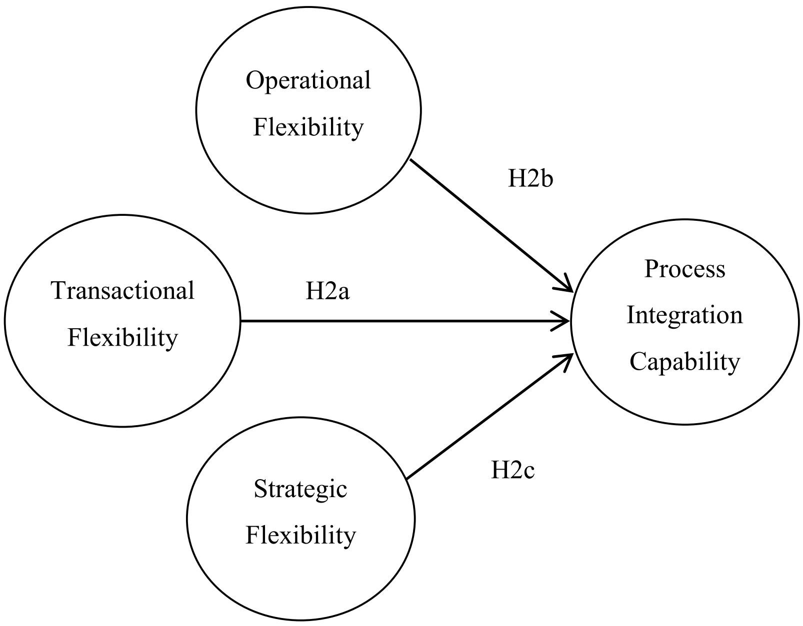


Figure 4.4 The Impact of IT Flexibility on Process Integration Capabilities (H2a, H2b and H2c)
Source: Author.

4.4.3 The Impact of IT Flexibility on Firm Performance (H3a, H3b and H3c)

Regarding the positive influence of TR flexibility on FP, both Ray et al. (2005) and Bhatt et al. (2010) ascertained that IT infrastructure and physical system-level resources positively affect customer satisfaction–related aspects of performance, including speed, accuracy and identification of service. Fink and Neumann (2009) also observed that IT physical infrastructure is positively associated with the cost efficiency of focal firms in supply chains. Moreover, Jayaram and Vickery (2000) identified the positive relationships between physical IT infrastructure and supply chain time performance. Sanders and Premus (2002) clarified that IT applications, such as ERP, real-time access to POS and access to inventory information, positively affect operational performance elements, such as cost, cycle time and quality. Finally, Vickery et al. (2010) showed that integrated infrastructure supports speed and quality performance.

In terms of the positive effect of OP flexibility on FP, Zhang et al. (2009) found that the quality of information sharing affects cost performance. Moreover, Wiengarten et al. (2013) argued that shared process coordination and interaction enabled by IT have a positive impact on cost- and quality-related performance. Bharadwaj (2007) identified that that the IS capability for data and process integration positively affects cost performance. STR flexibility's effect on FP has also been considered in the literature. Cheng et al. (2014) reported that IT capability designed for a quick and innovative response to market changes can enhance the quality and speed of service for customers. Klein and Rai (2009) contended that a strategic collaboration enabled by IT affects partner-specific performance elements, such as cost, value and quality. Furthermore, Tan et al. (2010) concluded that supplier-management IT capability affects FP in the forms of cost, level of quality and service provided for customers. Based on this, the present research offers the following hypotheses:

H3a: Transactional flexibility positively affects firm performance.

H3b: Operational flexibility positively affects firm performance.

H3c: Strategic flexibility positively affects firm performance.

In the light of the above discussion, hypotheses H3a, H3b and H3c can be linked as illustrated in Figure 4.5.

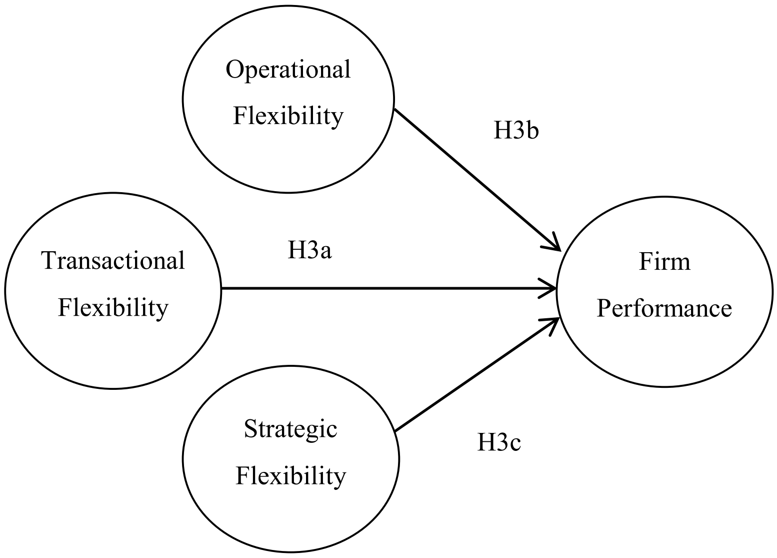


Figure 4.5 The Impact of IT Flexibility on Firm Performance (H3a, H3b and H3c)
Source: Author.

4.4.4 The Impact of Process Integration Capabilities on Firm Performance (H4)

Internal and external business process integration is a key element in improving FP (Huo 2012; Tafti et al. 2013). In this context, the present study argues that a firm's ability to integrate processes, which is enhanced by IT flexibility, will positively affect FP, as discussed in the literature. Overall, it has been argued that improved coordination can contributes to cost savings and reduced lead times and better alignment of complementary decision-making processes in the chain, resulting in the overall performance improvement of participating firms and the whole chain (Chandra and Kumar 2001). According to Vickery et al. (2003), supplier partnering and close customer relationships affect performance outcomes. In addition, Rai et al. (2006) found that process integration covering internal and external processes with supply chain partners is positively associated with FP. Hafeez et al. (2010) demonstrated that interfirm integration is also positively associated with FP in firms in terms of financial value and efficiency. To examine this impact of the three different IT flexibility dimensions of FP via PIC, this study proposes the following hypothesis:

H4: Process integration capability positively affects firm performance.

In light of the above discussion, hypotheses H4 can be illustrated as shown in Figure 4.6.

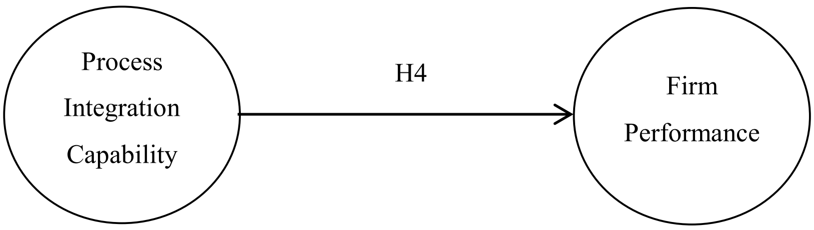


Figure 4.6 The Impact of Process Integration Capabilities on Firm Performance (H4)
Source: Author.

Based on the previous considerations, this study proposes the framework for our research model in Figure 4.7. The research model indicates that the key dimensions of IT flexibility affect each other and influence PIC and FP. Furthermore, this model tests whether IT flexibility affects FP indirectly via effect analysis of the mediating role of PIC. In the hierarchical order of IT flexibility dimensions, TR flexibility influence OP flexibility and STR flexibility. OP flexibility also affects STR flexibility. This study models IT flexibility as a driver of PIC rather than abstract of PIC so it does not consider PIC as a second-order construct of IT flexibility; as a result, it is able to highlight IT flexibility dimensions' hierarchical relationships as one of the distinct characteristics of IT flexibility.

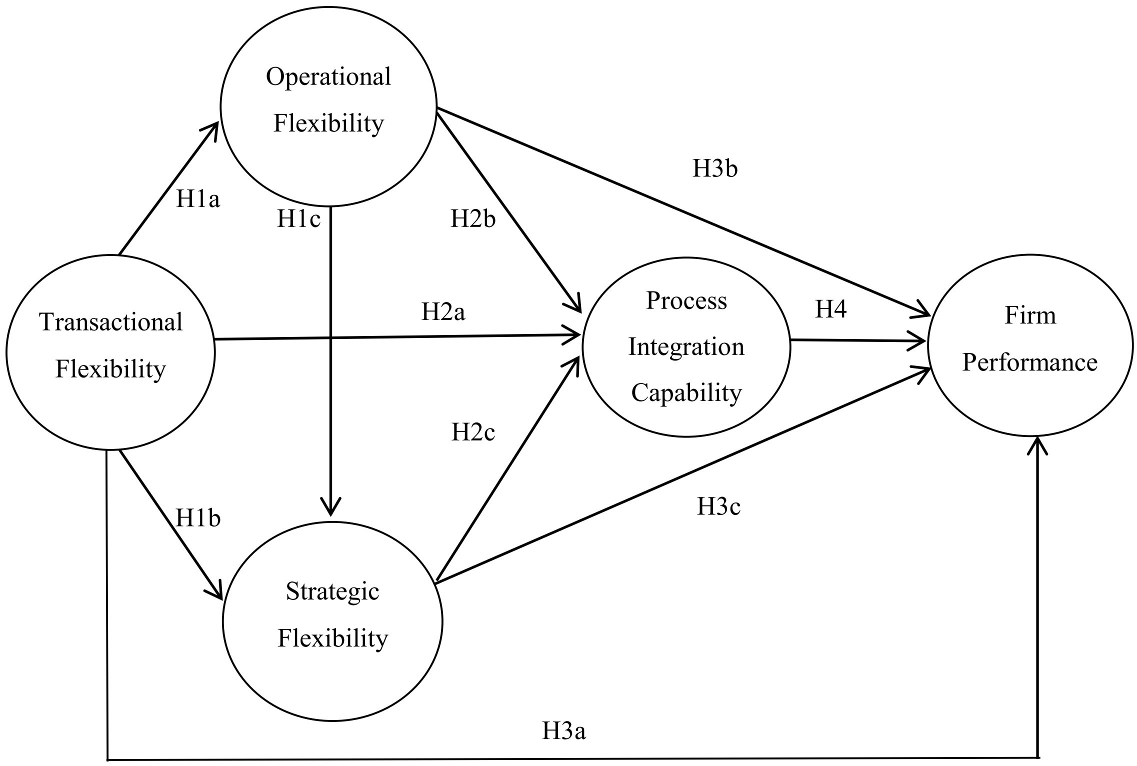


Figure 4.7 A conceptual model of IT flexibility and the associated hypotheses.

Source: Author.

4.5 MEASUREMENT CONSTRUCT INDICATORS

IT flexibility dimensions are constructed with subordinate IT attributes (indicators) that support and enable supply chain activities. The attributes are also derived by taking into account the different responsibilities of the different flexibility dimensions.

4.5.1 Transactional Flexibility Indicators

This dimension focusses on the physical IT network arrangement with IT infrastructure and connectivity as discussed in section 3.3.1, TR flexibility was measured using two subdimensions, namely the levels of IT infrastructure and interfirm connectivity. IT infrastructure is a composition of hardware, software and networks (Lai et al. 2007; Turban and Volonino 2010); thus, this subdimension was measured according to the following indicators: 1) advancement of *hardware*, which enables information flow and facilitates decisions; 2) advancement of *software*, which involves advancement of IT applications or operating systems (Kim 2006; Lai et al. 2007; Turban and Volonino 2010; Tallon and Pinsonneault 2011); and 3) advancement of *networks*, which allows the hardware to enable information flow and facilitate decisions (Vickery et al. 2010; Tallon and Pinsonneault 2011).

EDI is an example of such hardware used for supply chain operations. This refers to interorganisational or computer-to-computer transmission of business process–related information in a standardised and machine-processable format without rekeying. With the development of the Internet, Internet EDI offers the synchronisation of information to business transactions (Rebecca 2000), so this has been a key enabler of efficient SCM because it allows processing and transmission of a large amount of data in complex interfirm channels (Pramatari 2007). Software enables data entry, information mapping and reporting for the users by giving instructions to hardware (Turban and Volonino 2010). Networks interconnect platforms or computers via information-sharing devices and applications to circulate and transmit information among trade partners (Rainer et al. 2015).

As mentioned above, the second subdimension under the dimension of TR flexibility is connectivity. Connectivity represents IT infrastructure's ability to reach, analyse and disseminate information to other trade partners and capacity to allow a certain amount of data variation (Closs and Savitskie 2003; Fawcett et al. 2011).

To describe this network access–focussed subdimension, connectivity was measured through access, linkages and interoperability. *Access* represents the capability of IT systems to legitimately access information resources (Bharadwaj 2007). It is required to connect to customers and suppliers to identify business requirements and collaborate with supply chain partners (Devaraj et al. 2007). *Linkages* refer to the level of reach (i.e. e-connection with a wide audience in different locations) and range (i.e. sharing information across a variety of IT platforms and services; Duncan 1995; Byrd and Turner 2001). Finally, *interoperability* refers to the ability of IT systems to enable firms to work together through mutually agreed-upon technical and operational standards (Mouzakitis et al. 2009). Linkages are often examined in conjunction with interoperability because interoperability is an elemental precondition for coherent information linkages across firm boundaries. In this study, interoperability is considered in terms of the enabling of information circulation in a standardised network connection and information formant (Mouzakitis et al. 2009. In a similar vein, Gosain et al. (2004) mentioned that process standardisation in interfirm networks can be defined as a consensus on "the syntax, semantics, and pragmatic aspects of documents that are to be exchanged for the specific process being coordinated. The lack of standardisation means that exchanges are idiosyncratic to each relationship" (p. 14). From Electronic Data Interchange for Administration, Commerce and Transport (EDI/EDIFACT) in the 1960s to the Internet/Extensive Markup Language (XML) in the 1990s and the Web services and service-oriented architecture in recent years, the information exchange format has evolved over time for smart communication to interlink firm activities (Doukidis and Pramatari 2007; Schubert and Legner 2011). In particular, XML and Web-enabled services should be emphasised, as they provide easily extendable and flexible technologies that support communications across heterogeneous platforms and applications throughout the network (Power 2005, Zhu et al. 2006). Table 4.3 presents the indicators of TR flexibility.

Sub-dimensions	Indicators	Definition	Reference
Transactional (TR) information technology (IT) flexibility			
IT Infrastructure	Hardware	Advancement of hardware that enables information flow and facilitates decisions	Kim (2006), Lai et al. (2007), Turban and Volonino (2010)
	Software	Advancement of software and IT applications that permit the hardware to enable information flow and facilitate decisions	Kim (2006), Lai et al. (2007), Turban and Volonino (2010), Tallon and Pinsonneault (2011)

	Networks	Advancement of network enablement that allows hardware to enable information flow and facilitate decisions	Ray et al. (2005), Lai et al. (2007), Vickery et al. (2010), Turban and Volonino (2010), Tallon and Pinsonneault (2011)
Connectivity	Access	IT systems' ability to legitimately access information resources	Bharadwaj (2007), Devaraj et al. (2007)
	Linkages	Level of reach (i.e. e-connection with a wide audience) and range (i.e. sharing information across a variety of IT platforms)	Duncan (1995), Byrd and Turner (2001)
	Inter-operability	The ability of IT systems to enable firms to work together through mutually agreed-upon technical and operational standards	Gosain et al. (2004), Mouzakitis et al. (2009)

Table 4.3 Transactional Flexibility Indicators
Source: Author.

4.5.2 Operational Flexibility Indicators

As discussed in section 3.3.2, OP flexibility focusses on the capacity to coordinate and adjust supply chain operations with information sharing. Therefore, it is consistent with two subdimensions, which are the level of information sharing and process improvement.

Without a proper level of information sharing, the supply chain could not survive because the flow of information across the supply chain is as critical as the flow of goods or services in the chain. Information flow that eliminates mismatches of information among supply chain participating firms can produce "one version of the truth" (Turban and Volonino 2010 p. 569)"; this enables order fulfilment by matching actual demand and supply. In practice, mismatches between the demand and supply grow along with the incorporation of intermediaries in the chain, but information sharing reduces such mismatches via visible, accurate and timely information sharing (Turban and Volonino 2010).

To measure the level of information sharing, this study adopts quality, visibility and speed as its indicators. To ensure a high level of information sharing, the information should be accurate, timely and completed in a useful format; thus, complete, appropriate information should be delivered in a rapid manner (Williams et al. 2013). *Quality of* information sharing refers to the timeliness and accuracy of information (Wong et al. 2011; Wiengarten et al. 2013). *Visibility* of shared business processes refers to the level of knowledge about where materials and parts are located at any given time (Wang and Wei 2007; Turban and Volonino 2010). *Speed* refers to the capability to complete transactions and information exchange in a rapid manner (Zhou et al. 2014).

SCM covers the interfirm activities required to control the movement of products and information. Thus, the improvement of interfirm process handling is one of the primary concerns of SCM (Turban and Volonino 2010). For the level of process handling, two indicators were used. First, *process streamlining* was employed; this refers to the integration and automation of business processes for better monitoring and control (Duclos et al. 2003; Wiengarten et al., 2013). Second, *process optimisation* – which means the role of business intelligence for process coordination and dynamic rerouting of processes (Qrunfleh and Tarafdar, 2014) – was employed. Most IT tools are designed and developed for process improvement, particularly in terms of streamlining business processes, such as order management, inventory management, transport and distribution (Ray et al. 2005; Turban and Volonino 2010; Ngai et al. 2011) and process optimisation (Qrunfleh and Tarafdar 2014). In the supply chain field, process improvement through IT mainly involves the computerised automation and integration of business processes in supply chain activities (Duclos et al. 2003). Table 4.4 presents the indicators of OP flexibility.

Sub-dimensions	Indicators	Definition	Reference
Operational (OP) information technology (IT) flexibility			
Inform-ation sharing	Quality	Timeliness and accuracy of information	Wong et al. (2011), Wiengarten et al. (2013)

	Visibility	The level of knowledge about where materials and parts are located at any given time	Wang and Wei (2007), Turban and Volonino (2010)
	Speed	How quickly transactions are conducted and information is exchanged	Zhou et al. (2014)
Process improvement	Streamlining	The level of automation and integration of business processes for better monitoring and control	Duclos et al. (2003), Ray et al. (2005), Turban and Volonino (2010), Ngai et al. (2011), Wiengarten et al. (2013)
	Optimisation	Business intelligence, what-if, dynamic rerouting	Duclos et al. (2003), Qrunfleh and Tarafdar (2014)

Table 4.4 Operational Flexibility Indicators
Source: Author.

4.5.3 Strategic Flexibility Indicators

As discussed in section 3.3.3, STR flexibility can be divided into two dimensions, namely are partnering and offering capability. Many organisations utilise IT for strategic benefits, potential supply chain gains and value seeking. *Partnering* refers to the ability to build and alter linkages to partner with different supply chain players in response to changes in the business environment. This mainly occurs due to changes in the cost of procuring materials and other technological or operational requirements in distribution activities (Gosain et al. 2004; Wang and Wei 2007; Chandra and Grabis 2016) or alterations in contracts due to changes in revenue/cost/technology/resource sharing between business partners. This allows companies to configure and reconfigure their supply chain structures to be responsive to customers' changing needs and increasing uncertainties (Tafti et al. 2013a). Partnering ability was measured with the ability to build information linkages with existing external partners and the ability to build and alter information linkages with new external firms (Gosain et al. 2005; Tan et al. 2010; Chandra and Grabis 2016). The concept of *offering* in this study is adapted from Armstrong and Sambamurthy

(1999), Gosain et al. (2004) and Wiengarten et al. (2013). It refers to the ability of interorganisational linkages to support changes in product or service offerings to customers. The limited lifecycle of products and the variability in customer demands are driving forces for the attribute of flexibility. Offering was measured according to the ability of interfirm linkages to support new product/service offerings to customers in the changing business environment owing to new functional requirements with customer needs, performance standards and service criteria (Gosain et al. 2004; Wiengarten et al. 2013; Chandra and Grabis 2016). Table 4.5 presents the indicators of STR flexibility.

Sub-dimensions	Indicators	Definition	Reference
Strategic (STR) information technology (IT) flexibility			
Partnering 1	Partnering 1	The ability of interorganisational systems to build and alter linkages to existing partner with different supply chain players	Gosain et al. (2004), Tan et al. (2010), Chandra and Grabis (2016)
	Partnering 2	The ability of interorganisational systems to build and alter linkages to new partner with different supply chain players	Gosain et al. (2004), Wang and Wei (2007), Chandra and Grabis (2016)
Offering	Offering	The ability of interorganisational linkages to support changes in product or service offerings to customers	Armstrong and Sambamurthy (1999), Gosain et al. (2004), Wiengarten et al. (2013)

Table 4.5 Strategic Flexibility Indicators
Source: Author.

4.5.4 Process Integration Capability Indicators

PIC is incorporated to the model to measure the levels of internal, external and customer integration that provides the context of supply chain execution as discussed in sections 4.3.2 and 4.4.2. PIC was measured with the ability to integrate sourcing, transport and service processes internally (Cooper et al. 1997; Wamba and Chatfield 2010); the ability to integrate sourcing, transport and service processes with external firms (Lambert et al. 1998, Wiengarten et al. 2013); and the ability to integrate processes with customers

(Frohlich and Westbrook 2001). This study retained the construct of supply chain execution from Teller et al. (2012) for PIC to ensure the content validity of indicators. Table 4.6 presents the indicators of PIC.

Indicators	Definition	Reference
Process integration capability (PIC)		
PIC 1	Capability to integrate sourcing, transport, service processes and other areas internally	Cooper et al. (1997), Wamba and Chatfield (2010)
PIC 2	Capability to integrate sourcing, transport, service processes and other areas with suppliers	Lambert et al. (1998), Wiengarten et al. (2013)
PIC 3	Capability to integrate sourcing, transport, service process and other areas with customers	Frohlich and Westbrook (2001)

Table 4.6 Process Integration Capability Indicators
Source: Author.

4.5.5 Firm Performance Indicators

Performance measurement is defined as the process of quantification whereby various aspects of a firm process or overall operations are measured and assessed against performance objectives (Slack et al. 2007). According to the research question posed in this study and discussions regarding the performance measurement in the supply chain context (section 4.3.3.), the focus of performance measurement is extended to the network level efficiency and effectiveness. Such extension covers two dimensions: 1) performance improvement in supply chain operations and 2) customer (market) satisfaction. So, each dimension of performance needs to capture many influences affecting performance improvement in the supply chain operations and the market satisfaction.

To draw a picture of these two dimensions, aggregated performance measures with greater relevance to those dimensions are selected (Zhang et al. 2011; Slack et al. 2013). For the measurement of performance improvement in supply chain operations, this study adopts cost, speed and value creation.

Cost indicates that doing supply chain operation transactions cheaply—i.e. to produce goods and services at a low cost—so enables firms to have a return (Sanders 2007; Devaraj et al. 2007; Slack et al. 2013; Wiengarten et al. 2013). This is closely related to the productivity of a firm's operations that can be interpreted through the ratio of what is produced by an operation to what is required to produce it (Slack et al. 2013).

Speed represents the elaspsed time required by supply chain operations to deliver products or services (Devaraj et al. 2007; Prajogo and Olhager 2012; Slack et al. 2013). The speedy adaptation to change of interfirm operations is greatly supported by decision making and information sharing supported by IT attributes (Slack et al. 2013).

Value creation indicates the value adding activities acquired in supply chain operations through efficiency. With a given process to be completed and the limited capacity of a firm, the efficiency is dependent on the technology and the method used to complete the task by eliminating some steps, such as movements, delays and inspections, thereby improving firm performance (Wang et al. 2007; Wang et al. 2008; Slack et al. 2013; Wiengarten et al. 2013).

In terms of market satisfaction, this study adopts two measures: the quality of the product (services) and service level provided for customers.

Quality refers doing things right, measuring the conformity between an operation and the customers' expectations by asking "is the product or service as it is supposed to be?" (Slack et al. 2013, P.46). As it assesses customers' perceptions of the consumed products or services, it is closely related to the likelihood that the customer will return the product or be dissatisfied with the service (Slack et al. 2013). Based on this idea, the quality of products/services can be interpreted through defects per unit and levels of customer complaints (Devaraj et al. 2007; Ranganathan et al. 2011; Sanders (2007); Wiengarten et al. 2013).

Service level is also in line with customer satisfaction, but focuses on the improvement of services and the creation new services provided for customers (Agarwal and Selen 2009).

It covers aspects like increased level of service customisation or new offerings (Gosain 2004; Wang and Wei 2007; Agarwal and Selen 2009), short order lead time and reduced customer query time (Devaraj et al. 2007; Sanders, 2007; Pragojo and Olgar 2012).

It should be noted that the indicators discussed above are interrelated due to their internal effects. For example, quality does not only represent external customer satisfaction, but is also important in satisfying the internal members as fewer mistakes in each process means less time and cost are required to correct the mistakes (Slack et al. 2007; Slack et al. 2013). Thus, quality is interrelated to the speed and cost of supply chain operations while contributing to the overall FP. In the same context, speed reduces the operational cost as speedy interfirm operations reduces the inventory cost; value adding activities in supply chain operations and may also reduce their cost with improved economic efficiency (Slack et al. 2007; Slack et al. 2013). This is consistent with the characteristic of FP as a reflective variable[9]. A reflective variable measures the same aspects of the construct (FP in this case) to reflect the characteristics of the variable (Petter et al. 2007; Hair et al. 2013). Therefore, the indicators are interrelated to represent their common theme (Gefen et al. 2000; Petter et al. 2007; Coltman et al. 2008; Hair et al. 2013). Table 4.7 summarises the indicators of FP.

Indicators	Definition	Reference
Firm performance		
Cost	Transaction costs for supply chain operations.	Sanders (2007), Devaraj et al. (2007), Slack et al. (2013), Wiengarten et al. (2013).
Speed (SPD_P)	The elapsed time of supply chain operations required to deliver products or services.	Devaraj et al. (2007), Prajogo and Olhager (2012), Slack et al. (2013).
Value creation	The value adding activities acquired in supply chain operations through efficiency.	Wang et al. (2007), Wang et al. (2008), Slack et al. (2013), Wiengarten et al. (2013).

[9] The concept of reflective variable will be discussed in section 5.4.3

Quality (QUL_P)	Consistent conformance of service or product to customers' expectations.	Devaraj et al. (2007), Sanders (2007), Ranganathan et al. (2011), Slack et al. 2013, Wiengarten et al. (2013).
Service level (SVC)	The improvement of services and the creation new services	Gosain (2004), Devaraj et al. (2007), Sanders (2007), Wang and Wei (2007), Agarwal and Selen (2009), Pragojo and Olgar (2012).

Table 4.7 Firm Performance Indicators.
Source: Author.

4.6 SUMMARY

Due to the lack of proper theoretical support for the RBV in the present context, this study sought to combine the DC and RV to justify the multiple dimensions of IT flexibility and their role in the interorganisational business environment. Such extension signifies that IT flexibility is a fundamental capability that enables divergent interfirm operations in the dynamic business environment.

The dimensions of IT flexibility were incorporated into a three-layer hierarchical model that defines inherent flexibility capabilities with TR flexibility, OP flexibility and STR flexibility. By centring the TR flexibility, the proposed research model illustrates that the use of IT leads to firms' ability to conduct businesses at the operational and strategic level rather than simply assuming that the use of IT enhances FP. Moreover, the model clarifies that the IT flexibility dimensions affect the PIC and FP to identify the intervening mechanism of IT flexibility for FP. To illustrate these potential relationships, 10 hypotheses were formulated based on the literature covering the role of IT for SCM, process integration and FP. Finally, measurement indicators for each construct were presented by taking account of the different characteristics of IT flexibility dimensions and their roles in adapting to changes. The next chapter presents the research methodology used to validate the structure of IT flexibility, identify the influential mechanism of IT flexibility on FP and prioritise different IT flexibility dimensions.

CHAPTER 5. RESEARCH METHODOLOGY

5.1 INTRODUCTION

The preceding chapters have focussed on identifying the research gap and research framework. Before reporting on the data collection and data analysis using the research framework, this chapter presents the research design and methodology adopted in this study; thus, the chapter links the preceding chapters on the conceptual framework and the following chapter on the empirical analysis.

According to Saunders et al. (2012), the term *research methodology* refers to the theory of how a research study should be undertaken. Based on Saunders et al.'s (2012) research process, which depicts critical issues related to the research methodology from the perspectives of the research philosophy, approach, methodological choice, strategy and data collection technique, three main themes are addressed in this chapter. The first theme is the research design related to the research philosophy, approach, strategy and methodological choice presented in section 5.2. The second theme encompasses the data analysis methods for testing the hypotheses discussed in section 5.3. These are PLS SEM and the IPA matrix discussed in section 5.4 and 5.5. The final theme is the data collection method presented in section 5.6.

5.2 RESEARCH DESIGN

A research design refers to the overall plan of the research process relating to the conceptual research problem and empirical research (Ghauri and Grønhaug 2002); thus, it aims to address the research questions with clear objectives, methods of analysis and research constraints (Saunders et al. 2012). In this section, this research plan is presented by discussing the research philosophy, strategy, approach and methodological choices.

5.2.1 Research Philosophy

Two major approaches to representing a research philosophy are ontology and epistemology (Saunders et al. 2012). Ontology asks how the research recognises the research object's being (existence), which can be therefore known. In contrast, epistemology concerns the researcher's view on what constitute the knowledge about the research object in a field of study (Bryman 2012; Saunders et al. 2012). Epistemology is often interpreted as the branch of philosophy that asks questions like 'How can we know anything about the research object with certainty?' or 'How is knowledge of the research object to be distinguished from belief or opinion?' (Thomas 2004).

1) Ontological background

From this study's perspective, the business environment in SCM is continuously changing due to the changing business requirements from the market and the reaction of complex interorganisational relationships of supply chain stakeholders to those changes. From this viewpoint, interfirm relationships are coordinated to adapt to changes in the form of networks; thus, supply chains are evolving organic systems based on shared control and trust rather than merely a connected physical network like a machine network (Johannessen and Solem 2002). This conceptualisation is presented in Table 5.1.

	Machine	**Process**	**Sociotechnical**	**Network**
Management principle	Total control	Delegated control	Partly delegated control	Shared control and trust
Value creation principle	Coordinated production	Coordinated supply and delivery	Coordinated production and human responsibility	Coordinated collaboration, supply and delivery
Information principle	Control of information	Sharing of information	Partly shared Information	Sharing of information
Change principle	Stability	Adaptation and stability	Adjustment and stability	Adaptability and stability

Table 5.1 Action Principles and Supply Chain Organisational Ideologies

Source: Adapted from Johannessen and Solem (2002).

Based on this view, this study recognises that the role of IT flexibility is not a fixed resource or an infrastructure to connect IT platforms. Rather, it represents a capability to cope with changes via process improvement and new strategies at the network level.

Oral (2009) identified the ontological areas via multiple levels in the supply chain, namely the firm, the business environment and the society levels (Table 5.2). Considering that the role of IT flexibility should be recognised at the network level and through multiple IT flexibility dimensions while taking account the interfirm processes and strategies, the ontological position of IT flexibility falls into the Level 1, the business environment perspective, where the collaboration between supply chain partners is emphasised.

Level	Title	Main research area
0	Firm perspective	Cost, profit, productivity, supply chain performance
1	Business environment perspective	Collaboration (between SCM members for competitiveness)
2	Society perspective	Collaboration (includes public sector) Needs of the societies in connection with SCM

Table 5.2 The Ontological Levels of the Author's Research Scope
Source: Adapted from Oral (2009).

2) Epistemological background

Healy and Perry (2000) and Guba and Lincoln (2005) synthesised the existing socioscientific paradigms into four categories, which are positivism, critical theory, constructivism and realism. Their synthesis also includes three elements, which are ontology, epistemology and methodology, as shown in Table 5.3.

Element	Paradigms			
	Positivism	**Critical theory**	**Constructivism**	**Realism**
Ontology	Reality is real and apprehensible	'Virtual' reality shaped by social, economic, ethnic, political, cultural and gender values crystallised over time	Multiple local and specific constructed realities	Reality is real but only imperfectly and probabilistically apprehensible
Epistemology	Objectivist: findings true	Objectivist: value-mediated findings	Subjectivist: created findings	Modified objectivist: findings probably true
Methodologies	Experimental/ surveys: verification of hypothesis, quantitative methods	Dialogic/dialectical: researcher is a transformative intellectual who changes the social world within which participants live	Hermeneutical/ dialectical: researcher is a passionate participant within the world being investigated	Case studies/convergent interviewing: interpretation of research issues using qualitative and some quantitative methods, such as SEM

Table 5.3 Categories of Philosophical Paradigms and Their Elements
Source: Adapted from Healy and Perry (2000).

According to Mentzer and Kahn (1995) and Näslund (2002), most supply chain research paradigms fall under positivism, which seeks objective reality with measurements based on a natural science approach and the idea of 'quasi-experimentation' (Näslund 2002; May 2011). The key idea of positivism is that the social world exists externally, so the properties of reality need to be measured using objective methods (Easterby-Smith et al. 2012). Thus, positivism assumes that knowledge can be obtained through observations, which are expressed by natural descriptions based on the application of the scientific method to identify relations between variables (Thomas 2004). In other words, the collected data and data analysis are value free, so the data do not change as they are being observed (Healy and Perry 2000).

According to Guba and Lincoln (2005), the positivistic research method involves quantitative hypothetical–deductive experiments/manipulation. Bryman and Bell's (2012) principles of positivism in Table 5.4 summarise its implications for research methodologies.

Principles of positivism
1) Principle of phenomenalism: Only phenomena that can be confirmed by the senses can genuinely be warranted as knowledge.
2) Principle of deductivism: The purpose of theory is to generate hypotheses that can be tested and that will thereby allow explanations of laws to be assessed.
3) Principle of inductivism: Knowledge is arrived at through the gathering of facts, which provide the basis for laws.
4) Objective: Science must be conducted in a way that is value free.

Table 5.4 Principles of Positivism

Source: Adapted from Bryman and Bell (2012).

These principles indicate that if a study adopts the positivistic approach, then the research will take the philosophical position of natural science; thus, the researcher prefers working on collecting observable/objective data and searching for law-like generalisation through verification of causal relationships (Saunders et al. 2012).

SCM is a practice- and solution-based sector under the influence of physical science with nonliving and tangible objectives (Aastrup and Halldórsson 2008). Even the concept of a supply chain is expanding its research scope to organisational theories involving systematic thinking with cross-disciplinary approaches (Näslund 2002; Aastrup and Halldórsson 2008). Here, the key research objectives are still physical dimensions, so the dominant research paradigm is positivism (Mentzer and Kahn 1995; Näslund 2002; Craighead et al. 2007). This is partly due to the deterministic and mechanical view of the supply chain, which perceives cause-and-effect interrelations as self-evident scientific issues upholding the image of an assembly line (Aastrup and Halldórsson 2008).

The present study aims to determine the right structure of IT flexibility and the influence of IT flexibility on FP. Its goal is to do so by providing a conceptual model that explores how IT flexibility improves FP in the SCM context.

In this study, IT flexibility is measured according to the types of IT and IT use at different levels of interfirm business practice, that is, the transactional, operational and strategic levels. IT and the use of IT are physical and tangible attributes that are objectively observed and described. Moreover, in the research design of this study, the researcher observes events (improved PIC and FP) and identifies their cause (business activities enabled by IT flexibility) by assessing the relationship between the variables using the quantitative method, which views the relationships as the reality in experimental setting. Considering the research theme (IT flexibility) and research framework established to conduct the cause-and-effect analysis (the effects of IT flexibility dimensions on FP), this research's underlying philosophy is positivism.

It should be noted that this research could be also regarded as taking a realist perspective in terms of the research background, that is, the supply chain environment. Like positivism, realism is based on objective and observable phenomena; the phenomena are credible from a scientific perspective (Thomas 2004). However, the realist perspective is differ from positivistic perspective because the realist perspective considers that the phenomena is not perfect to measure (Guba and Lincoln 2005; Saunders et al. 2012) because there is a reality outside world that is independent of our knowledge (Healy and Perry 2000; Holden and O'Toole 2004; Guba and Lincoln 2005). Realism argues that what we experience is sensation, the image mirroring a part of the social world; therefore, our knowledge should be based on the understanding of social conditions and the structure generating social events (Saunders et al. 2012). In other words, "the participants perceptions are being studied because they provide a window onto the reality beyond those perceptions" (Healy and Perry 2000, p. 120).

The realist perspective supports the idea of IT flexibility for SCM. This study recognises that the role of IT flexibility is an observable and sensible event (in the nature of scientific practice – a positivistic view); however, the shape of IT flexibility can also be characterised and its roles activated by certain requirements from the supply chain network that evolve over time (a reality outside – a realist view). Therefore, this study takes the view that IT flexibility for SCM can be structured and presented by viewing the supply chain environment as a perceived reality determining the shape of IT flexibility from a realist perspective and by measuring IT flexibility with an experimental quantitative setting from the positivistic perspective.

5.2.2 Research Approach

1) Deductive, inductive and abductive approaches

This section examines the decisions made to select a proper research approach considering the relationships between the theory and empirical research (Bryman 2012). There are three types of main research approaches, as follows: deduction, induction and abduction (Saunders et al. 2012).

Deduction is the dominant research approach in natural science involving theory testing (Bryman and Bell 2012). This approach is adopted to explain causal relationships between concepts, and therefore it allows prediction of relationships. To test the hypotheses and to enable the data to be measured and generalised, the collection of a large amount of quantitative data is normally carried out using a highly structured methodology to facilitate replication (Saunders et al. 2012). The deductive approach is based on established theories, and it explores whether the theory applies to a specific phenomenon (Bryman 2012). Therefore, it is often referred to as a theory-testing approach; philosophically, this is highly related to positivism and the most influential approach in supply chain research (Spens and Kovács 2006)

The *inductive* approach is used to make sense of data, which are mainly collected in a qualitative manner, such as by considering specific cases or a collection of observations (Spens and Kovács 2006). This is done through an analysis to formulate a theory that is often interpreted as a conceptual framework (Saunders et al. 2012). Thus, it does not require a general frame or literature; instead, empirical observations are the starting point for developing theories (Spens and Kovács 2006). The inductive approach particularly concerns a context in which a social phenomenon is occurring; thus, researchers normally work with small sample of qualitative data to establish different, newly created views on the phenomenon of interest (Saunders et al. 2012).

Finally, *abduction* begins with the observation of surprising (Ketokivi and Mantere 2010; Saunders et al. 2012) or new facts in real life (Bryman 2012). Considering the surprising or new fact as a conclusion, a set of premises are developed to explain the conclusion. If the premises nearly support the conclusion then the conclusion is believed to be true (Niiniluoto 1999; Ketokivi and Mantere 2010; Saunders et al. 2012) and is a testable conclusion (Saunders et al. 2012). From the perspective of generalisability, deduction moves from theory to data, induction moves from data to theory, but abduction moves back and forth in an interplay between the specific and the general (Suddaby 2006). Thus, in an abductive approach, a researcher collects primary data to explore phenomenon and to develop new theories (Saunders et al. 2012). Subsequently, the theory (the testable conclusion) is investigated through additional data collection for generalisation rather than application (Spens and Kovács 2006; Saunders et al. 2012).

Figure 5.1 illustrates the characteristics of the different research approaches and how the research process relates to each one. For example, deductive research is based on prior theoretical knowledge, establishing a research/theoretical framework, suggesting/testing an hypotheses and extending it to application to create new knowledge. Meanwhile, abduction begins with real-life observations from which the researcher attempts to understand a new phenomenon with theories, making interactions between the data and theory. To test the theory, hypotheses are suggested and tested, and a further test is conducted to generalise.

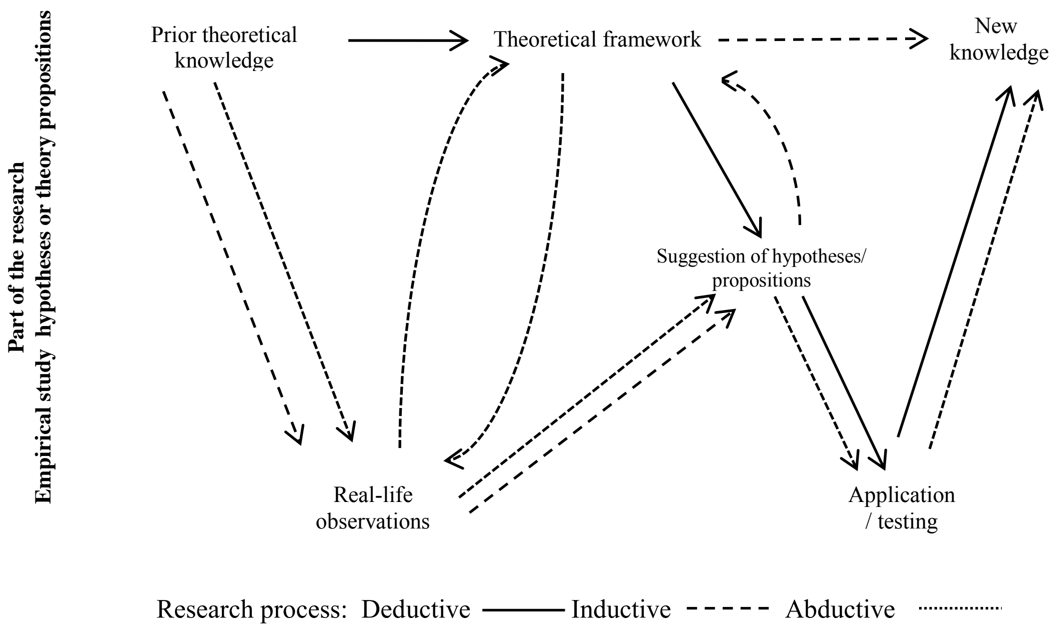


Figure 5.1 The three different research approaches.
Source: Adapted form Spens and Kovács (2006).

2) Deductive approach to the IT flexibility research process

The present study's research approach is a deductive approach. First, variables such as TR, OP and STR flexibility are developed from a close examination of the prior literature. Second, by reviewing relevant prior studies in IT use for SCM, this research sets up a theoretical framework by deducing hypotheses that will be tested with empirical data for generalisation. Therefore, it is inferred that a deductive logical process, which moves from theory to data (Saunders et al. 2012), is the main approach in this study. Third, this study also investigates the causal relationships between IT flexibility and FP by testing the hypotheses with PLS SEM. One of characteristics of a deductive approach is that quantitative data is analysed with a scientific and structured methodology (PLS SEM in this study) that can be replicated (Saunders et al. 2012). This deductive quantitative approach is in line with the dominant use of deductive positivism in supply chain management. With a strong emphasis on using the survey method to investigate the cause and effect relations between interrelated activities in supply chains, deductive approach is a dominant method to explore important scientific issue in supply chains ((Spens and Kovács 2006; Aastrup and Halldórsson 2008). Finally, a specific firm's data is applied to the model to develop industrial guidelines. This is another characteristic of deductive approach—to create new knowledge through the application of a research model. The deductive approach of this study is illustrated in Figure 5.2. A more detailed explanation of each process is provided in section 5.2.4 with the research strategy.

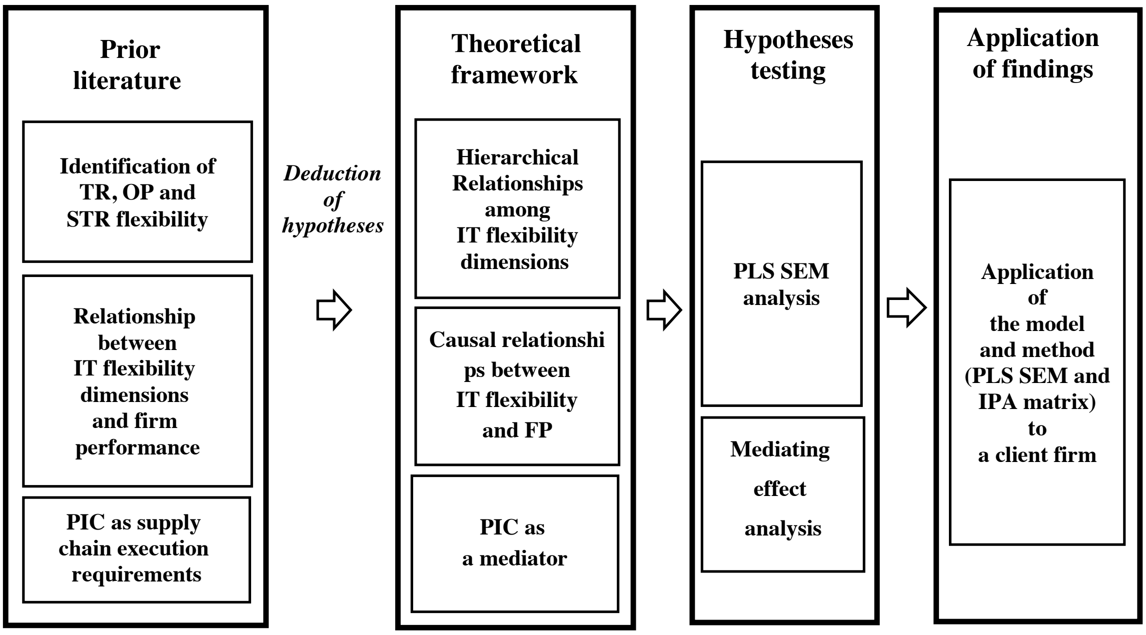


Figure 5.2 Research approach of this study.

Note: TR: transactional; OP: operational; STR: strategic; IT: information technology; PIC: process integration capability, PLS SEM: partial least squares structural equation modelling, IPA: importance–performance analysis.
Source: Author.

5.2.3 Choice of Methodology: A Quantitative Research Design

Decisions on quantitative versus qualitative research designs are important when it comes to guiding the data collection and analysis method (Saunders et al. 2012). The characteristics of a quantitative approach can be clarified by comparing it the qualitative approach.

Qualitative research refers to a research activity that attempts to make sense of the object or deliver the research objective's meanings using an interpretive and naturalistic approach to the world (Guba and Lincoln 2005). It seeks answers by questioning how social experience is created and emphasising interpretation, a rational approach, a subjective 'insider view' and the explorative process for social science analysis (Guba and Lincoln 2005). In contrast, quantitative research concentrates on testing, verification, facts about social events and an objective 'outsider view' in its research process (Ghauri and Grønhaug 2002). Hence, in the qualitative research approach, the meaning is imposed on specific measurements by interpretation (Ragin 2008), whereas quantitative methods emphasise the measurement of causal relationships between variables (Guba and Lincoln 2005).

Different characteristics can also be identified when researchers use the same method with different approaches. For example, when they conduct interviews, quantitative studies use fixed-choice questions to large samples. In contrast, qualitative studies use 'open-ended' questions and small samples (Silverman 2006), thereby allowing more flexibility and possibilities in the responses. To support each approach's different process, different types of data analysis can be also deployed (Saunders et al. 2012). In quantitative research, the data need to be quantified by transforming them in a numerical, straightforward way. Hence, this approach can be used to analyse the relationships among variables; thus, it is helpful for investigating the relationships between variables with a statistical method in an experimental design (Bryman and Bell 2003; Saunders et al. 2012). In contrast, qualitative data analysis requires interpretation of data through categorisation, conceptualisation (Bryman and Bell 2003); thus, such an approach focuses on participants' subjective perceptions (Saunders et al. 2012). Table 5.5 summarises the characteristics of quantitative and qualitative data.

Quantitative data	Qualitative data
Based on meanings derived from numbers	Based on meanings expressed though words
Collection results in numerical and standardised data	Collection results in nonstandardised data requiring classification into categories
Analysis conducted through the use of diagrams and statistics	Analysis conducted through the use of conceptualisation

Table 5.5 Distinctions Between Quantitative and Qualitative Data
Source: Saunders et al. (2012).

Quantitative research design is mainly associated with positivism and realism, as well as with a highly structured data collection method (Figure 5.3). Using the objective, observable data collection of positivism and the hypothesis testing process of critical realism via questionnaires, this study adopts a quantitative research design. One of the main research objectives is to identify the influential mechanism of IT flexibility in FP. In particular, by measuring respondents' perceptions of the use IT for interfirm business activities in numerical ways, it quantifies the data to be used for hypothesis testing. Therefore, a quantitative research design is used, and a statistical data analysis method is adopted as the research approach.

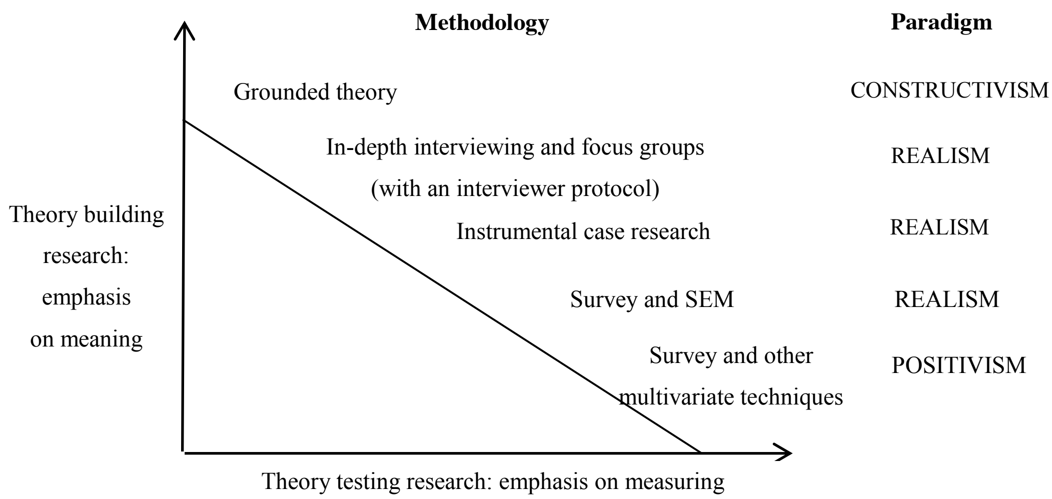


Figure 5.3 A representative range of methodologies and their related paradigms.
Source: Healy and Perry (2000).

5.2.4 Research Strategy

A research strategy represents an action plan concerning how a study will address the given research question. It is a methodological link between the research philosophy, research method and the approach to data collection and analysis (Saunders et al. 2012).

As previously discussed, the objectives of this research are as follows: 1) to conceptualise an IT flexibility research model; 2) to investigate how IT flexibility affects FP in the supply chain execution process; and 3) to prioritise IT flexibility dimensions with an application of the model. To pursue these research objectives, the research strategy of this study is built on three research phases, namely research model conceptualisation, theory validation and theory application.

1) Research model conceptualisation: Systematic review and theory composition

In this phase, with the given research gap—the lack of understanding of multidimensional IT flexibility for SCM—the plan for IT flexibility conceptualisation is executed via a systematic review.

A systematic review is selected because its review protocols and criteria for inclusion and exclusion, as recommended by Tranfield et al. (2003), are considered to capture a supply chain-wide range of IT flexibility attributes from the existing IT and supply chain literature. Based on the review result, which may cultivate a series of attributes of IT flexibility, the current study's approach is to identify a specific flexibility structure by classifying the identified attributes according to the purpose of IT use in supply chain processes. To incorporate an interorganisational relationship paradigm into the IT flexibility idea, a specific review protocol has been created, as explained in section 3.2.2.

With the given IT flexibility dimensions, this study determined the organisational theories that would be useful and how the theory aspects and assumptions would explain the key characteristics of IT flexibility dimensions. DC and RV were adopted to explain the nature of IT flexibility because DC is applicable to different IT flexibility dimensions supporting organisations in a changing environment and RV captures the nature of IT flexibility embedded in interfirm relationship-specific business processes.

Based on the systematic review results complemented by the theory compositions from DC and RV theory, this study conceptualised a research model that links IT flexibility dimensions to FP. PIC was incorporated into the model to provide the research context of SCM. In this framework, it was conceptualised that TR flexibility supports OP flexibility and STR flexibility, thereby exhibiting a pivotal role. Moreover, OP flexibility affects STR flexibility. The three IT flexibility dimensions also affect PIC and FP. Such relationships were hypothesised with further discussions identified from the existing literature.

2) Theory validation: Hypothesis and alternative model testing

Hypothesis testing was conducted with the following two objectives: 1) To identify the relationships between the IT flexibility dimensions and 2) To identify the influential mechanism of IT flexibility dimensions on FP. The relationship identification is part of the answer to RQ 1. Although the systematic review identified the three dimensions of IT flexibility for SCM, the relationships between the dimensions were not clearly validated. By testing hypotheses, this research identifies the relationships between the dimensions. Moreover, this study conducts mediating effect analysis to identify the influential mechanism of IT flexibility on FP. By comparing the model test result without the mediator (i.e. PIC) and the results with the mediator, this study identifies the direct and indirect effects of each flexibility dimension on FP. Finally, to confirm that the proposed research model appropriately mirrors the relationships, this study includes an alternative model test.

3) Theory application: IPA matrix

With three types of IT flexibility, this study tries to provide a way to prioritise the IT flexibility dimensions and suggest a way to allocate firm resources to the different types of IT flexibility in a strategic manner. The allocation will be available when the importance of IT flexibility in each dimension is measured and compared against the importance of the other dimensions to identify which dimensions need priority management attention or investment for improvement. To accomplish this prioritisation, first, the results of PLS SEM are extended to the IPA matrix. The most important dimension of IT flexibility, which should show the highest performance, is identified. Second, the response data, which was collected from a specific firm (using the same questionnaire), was applied to the same research model and tested using the PLS SEM technique. Finally, the results are extended to IPA. By doing this, the study considers whether the firm's IT flexibility dimensions show a proper level of performance in accordance with their importance. Detailed explanations regarding this PLS SEM and IPA matrix research method are provided in chapter 6. The strategies are summarised in Table 5.6.

Research phase	Research model conceptualisation	Theory validation	Theory application
Research focus	- Identification of IT flexibility dimensions and their characteristics. - Theorisation of relationships among IT flexibility, process integration capability and firm performance.	- Analysis of the relationships between the IT flexibility dimensions. -Analysis of the direct/indirect impact of IT flexibility dimensions on firm performance.	Application of the research model/ flexibility prioritisation strategy development.
Research strategy	- Systematic review. - Theory composition.	Hypothesis testing with PLS SEM/ mediating impact analysis/ alternative model test.	- Model application to a client firm. - Extension of PLS SEM results to the importance–performance analysis matrix.

Table 5.6 Research Strategy Used for Each Research Phase.

Source: Author.

5.3 SELECTION OF THE RESEARCH METHOD

5.3.1 Multiple Criteria Decision Analysis and Structural Equation Modelling

In terms of empirical analysis, the research strategy also considers the choice of research method from a pool of research methods. According to Healy and Perry (2000) and Saunders et al. (2012) – with this study's positivistic and quantitative approach – instruments like surveys or other multivariate methods are required. In terms of the research objective, the relationships between constructs and the prioritisation among the IT flexibility constructs need to be available with the support of the research method. Moreover, with regard to the unit of analysis, as IT flexibility is an organisational capability that is expressed in opinions, specific methods that can translate multiple intangible objects into a numerical scale need to be employed.

There are several alternative quantitative survey based methods that could be used to assist this study. Considering multiple dimensions of IT flexibility and their relationships with other constructs and the necessity to prioritise the multiple dimensions, the analytical hierarchy process (AHP), the analytic network process (ANP) and multi-attribute utility theory (MAUT) from the multiple criteria decision analysis (MCDA) literature, as well as PLS SEM and covariance-based SEM (CB SEM) from the multivariable analysis techniques, are considered as candidate methods for this study.

MCDA is used to aggregate the opinion or preferences of a community into collective preferences by using a survey technique. It is especially useful when there is conflict in the criteria or the decision making is unsatisfactory. By using survey analysis, a multicriterion approach contributes to delimiting a broad range of viewpoint, constructing an original meaning of the evaluations (Figueira et al. 2005). MAUT can be conducted to measure and compare the values of specific attributes in a pool. This is done by employing the following series of steps: 1) identifying objectives and functions, 2) identifying stakeholders, 3) identifying attributes and constructing value trees, 4) assessing the relative importance of weights, 5) ascertaining attribute scales, 6) aggregating weights and utilities and 7) performing sensitivity analysis (Edwards 1977; Lagoudis et al. 2006) This is done using directly evaluated preferences of the decision makers with general aggregation (Montis and Toro 2004).

Many of the benefits of MAUT are also applicable to AHP (Davies 2001). AHP uses a multilevel hierarchical structure of objective criteria and subcriteria to determine the best alternative or the relative importance of all alternatives under consideration (Triantaphyllou and Mann 1995). To assess the priorities among the criteria, this approach uses pairwise comparison to quantify the linguistic choices selected by the decision maker (Agarwal et al. 2014). By aggregating the relative weights of decision elements, it arrives at a set of ratings for the alternatives. Figure 5.4 depicts the structure of AHP.

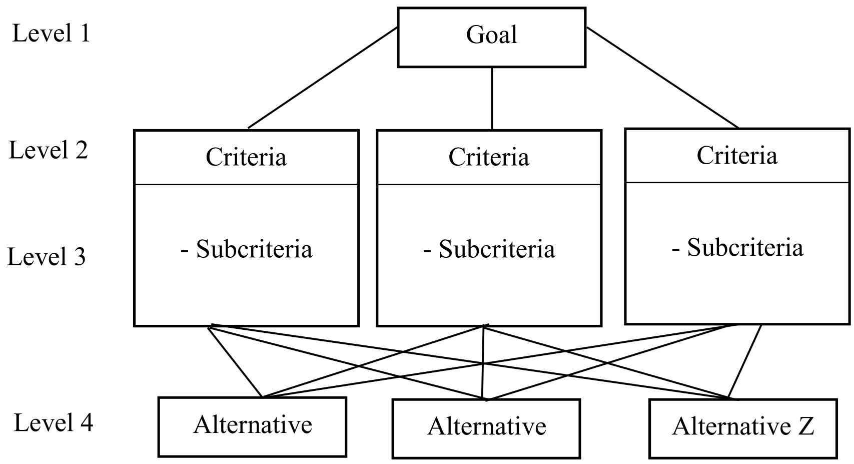


Figure 5.4 The structure of AHP.
Source: Agarwal et al. (2014).

Another example of MCDA is ANP, which is a generalisation of AHP. Here, priorities are established in the same way as in AHP, but the basic structures are composed of networks to include interaction and dependence between alternatives. Therefore, ANP allows interdependencies among decision attributes to be captured and a more systematic analysis to be carried out as a two-way arrow between different levels of attributes represents this interdependency (Figueira et al. 2005; Agarwal et al. 2006; Tseng et al. 2009). The relative importance of the influence on a given element is determined by using pairwise comparison, as in AHP. However, ANP must evaluate interdependencies within levels and clusters. Therefore, it allows the research model to have a more complex and dynamic structure influenced by external forces (Meade and Sarkis 1998). However, MCDA's primary focus is on classification of importance among multiple attributes, that is, comparative judgment and the synthesis of prioritisation (Sha and Che 2005). MCDA research mainly involves support for decision-making processes among multiple alternatives rather than relationship identification among multiple constructs covering a mediator and target construct. Table 5.7 highlights the primary focus of using MCDA. Studies in SCM literature use MCDA when their search objective focusses on the decision-making process.

Reference	Purpose of research	Applied MCDA
Agarwal and Shankar (2003)	To provide a framework for the selection of alternatives in e-enabled supply chains	ANP
Gaudenzi and Borghesi (2006)	To create a prioritisation among supply chain objectives	AHP
Lagoudis et al. (2006)	To identify the different contribution of different value-adding attributes in the marine transport industry	MAUT
Meade and Sarkis (1998)	To provide an assessment tool for supply chain strategy choices	ANP
Sha and Che (2006)	To identify the preferences of the suppliers and the customers at different levels in the supply chain network.	MAUT and AHP
Sharma and Bhagwat (2007)	To prioritise and choose the most critical SCM evaluation processes	AHP
Tseng et al. (2009)	To provide a framework to assist in the selection of appropriate suppliers in SCM strategies	ANP

Table 5.7 Examples of Using MCDA in SCM Research.
Source: Compiled by Author.

An SEM-based approach has advantages in analysing multiple and interrelated dependence relationships (Chin 1998; Gefen et al. 2000) by performing the following: 1) modelling relationships among multiple latent variables, 2) using unobservable latent variables and 3) statistically testing a priori theoretical and measurement assumptions against empirical data Therefore, SEM is able to present and test a complicated construct relationships which can be expressed with (non) hierarchical or (non) recursive structural model simultaneously (Gefen et al. 2000, Hair et al. 2010).

SEM is consisted of measurement model and structural model. The measurement model specifies how the observed variables (indicators) measure their expected latent variables (unobservable construct). This means that measurement on latent variables are possible indirectly by linking a latent variable to more than one observed variables (Byrne 2009). A structural model specifies the assumed causal relationships among such latent variables so it is called a path model (Hair et al. 2010; Hair et al. 2013). Independent variables (i.e., exogenous latent variables) cause fluctuations in the value of other latent variables whereas dependent variables (i.e., endogenous latent variables) are affected by other variables (Byrne 2001; Hair et al. 2013). By using such advantages to identify specific relationships between constructs, the researcher can develop hypotheses regarding the impact of one latent variable on another latent variable in modelling of causal directions. Moreover, the research can characterize the manner by which a particular latent variable directly or indirectly causes changes in the value of a certain other latent variables (Byrne 2001). A simple construct of the SEM model structure is provided in Figure 5.5.

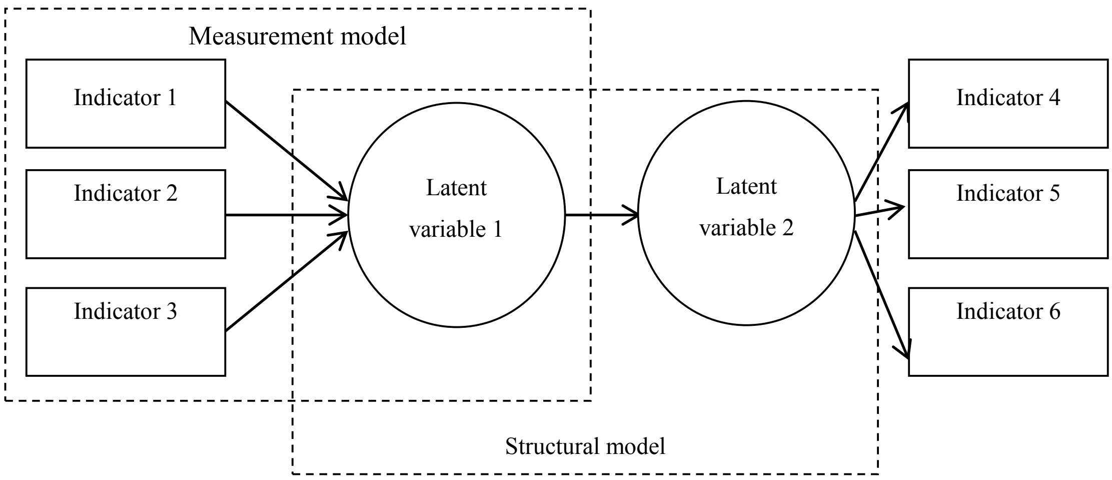


Figure 5.5 SEM structure.

Source: Adapted from Byrne (2009) and Hair et al. (2013).

5.3.2 Justification of Structural Equation Modelling

Overall, MCDA can be used to this study to conceptualise the three different IT dimensions in the framework of alternatives. Moreover, its usefulness to aggregate the opinion or the preferences can be used to prioritise multiple IT flexibility dimensions. However, its critical weakness is that the relationship analysis between variables including the PIC which might affect FP in direct/indirect manner is not allowed. On the other hand, SEM has advantages to identify the relationships between multiple constructs of the research model. Moreover, it allows one to analyse the mediating effect of PIC on FP but has limitation in prioritizing multiple constructs.

Considering that the structure of the IT flexibility research model, a research method that has primary interested in the identification of the relationships between variables along with mediating effect analysis seems to be appropriate for this study. From this perspective, the SEM approach is adopted for this study and the MCDA-based approach is excluded for the following reasons.

First, SEM has its primary focus on relationship identification (Bryne 2009; Hair et al. 2010). This is suitable to identify the relationship between IT flexibility dimensions and their impact to FP. Second, the use of latent variable and the measurement indicators allows one to examine the validity of each IT flexibility dimension and its constructs (Bryne 2009; Hair et al. 2013). Third, one of the strong advantages using SEM is the analysis of the mediating effect of PIC which identifies the direct and indirect impact of IT flexibility on FP (Hair et al. 2010; Hair et al. 2013). Finally, the advantage of MCDA to prioritise multiple constructs can be also acquired in PLS SEM by supplementing PLS SEM with IPA matrix. This can be done by extracting latent variable scores which judge the relative importance of constructs in the structural model with the deployment of IPA matrix (Hair et al. 2013)[10]. In sum, there are several advantages and disadvantages using MCDA and SEM for this research. Considering the characteristics of IT flexibility

[10] The application of IPA matrix by using PLS SEM will be further discussed in section 5.5.

dimensions, the research model structure and the overall research objective, SEM is identified as a most suitable method among the alternatives. A summary of the justification for using SEM is provided in Table 5.8.

It should be noted that one of the reasons MCDA is considered is its usefulness to prioritise the multiple constructs. However, this research complements the use of PLS SEM regarding this issue with the IPA matrix. By extending the PLS SEM results to the IPA matrix, it is possible to prioritise the dimensions. The application of the IPA matrix using SEM is further discussed in section 5.5.

There are two main approaches using the principle of SEM. These are PLS SEM and CB SEM. Both methods allow one to examine multiple relationships of the measurement scale of observed indicators, so they answer a set of related research questions in a systematic and comprehensive way (Gefen et al. 2000). However, by adopting PLS SEM over CB SEM, this study's empirical test satisfies the requirements arising from the relationships between IT flexibility dimensions and the prioritisation of the IT attributes, as presented in Table 5.8. The rationale for employing PLS SEM rather than CB SEM is discussed further in the following section.

Criteria		MCDA		SEM	
		MAUT/AHP	ANP	CB SEM	PLS SEM
Quantification of respondents' perception		Available	Available	Available	Available
Suitability to IT flexibility dimensions	Presentation of multiple dimensions	Available (multiple dimensions)	Available (multiple dimensions)	Available (multiple latent variables)	Available (multiple latent variables)
	Relationship identification between dimensions	Not available	Partially available (interdependency between alternatives but not mediator)	Available (latent variables with interrelationships)	Available (latent variables with hierarchical relationships)
Suitability to respond to research purposes/research questions	Purpose of research model measurement	Decision-making support (comparison of alternatives)	Decision-making support (comparison of alternatives)	Measurement of overall fit of the model/impact path identification between variables	Prediction of relationship between variables/impact path identification between variables
	Identification of influential mechanism	Not available	Not available	Available (mediating effect analysis)	Available (mediating effect analysis)
	Availability of resource allocation decision making	Available (Prioritisation of construct by comparison)	Available (prioritisation of construct by comparison)	Not available	Available (extension of PLS SEM results to IPA matrix)
	Theory development/building	Available	Available	Not preferred	Available

Table 5.8 Suitability: MCDA Versus SEM

Source: Author.

5.4 EMPIRICAL ANALYSIS METHOD 1: PARTIAL LEAST SQUARES STRUCTURAL EQUATION MODELLING (PLS SEM)

PLS SEM and CB SEM differ in their approach to estimation problems (Reinartz et al. 2009). CB SEM is the dominant approach in the literature. However, in recent years, a growing body of research applying the PLS SEM method has been found in OM/SCM research (Peng and Lai 2012) and IT management (Ringle et al. 2012). The criteria for selecting an appropriate SEM type between the two and the justification for choosing PLS SEM are discussed in this section.

5.4.1 Justification for Using Partial Least Squares Structural Equation Modelling

1) Suitability for exploratory research

The decision on which method to adopt depends on whether to SEM is used for theory testing or for relationship prediction between variables (Anderson and Gerbing 1988). One of the main reasons for choosing PLS SEM over CB SEM is that it is more suitable for exploratory analysis as opposed to confirmatory analysis (Anderson and Gerbing 1988; Gefen et al. 2000; Henseler et al. 2009; Reinartz et al. 2009; Peng and Lai 2012; Hair et al. 2013). According to Hair (2009), exploratory analysis defines possible relationships in the most general form and uses the multivariate technique to identify relationships. Hence, one does not confirm any relationships prior to the analysis; instead, one defines the nature of the relationships in exploratory research.

In detail, the PLS SEM design is used to explain the significance of the relationships with the resulting R^2 (explained variance) by adopting ordinary least squares (OLS) for estimation. OLS formulates a linear regression function that minimises the error between the line and the variables by observing every variance in the population. Hence, it tries to present a high R^2 and significant *t*-values while rejecting the null hypothesis of no effect

(Gefen et al. 2000) with the aim of predicting or identifying relationships between the latent variables in the model (Reinartz et al. 2009). Therefore, it is more suitable for the early stage of theory building to predict relationships between variables (Gefen et al. 2000; Reinartz et al. 2009; Peng and Lai 2012).

CB SEM is a parameter-oriented approach used to confirm that the complete set of paths in the model is plausible with the goodness of fit test (Gefen et al. 2000). Parameters in this study refer to "a characteristic of an entire population, such as the mean" (Brace et al. 2012, p. 420). In other words, CB SEM estimates the complete research model and generates fit statistics to identify how well the observed data explain the given research model (Fornell and Bookstein 1982; Anderson and Gerbing 1988; Henseler et al. 2009; Peng and Lai 2012; Hair et al. 2013). Therefore, it requires sound theory to specify relationships in the research model and other aspects of model estimation (Hair 2009), and it mainly supports a confirmatory approach (Gefen et al. 2000; Reinartz et al. 2009), which aims to confirm a prespecified relationship. Theory is needed. In sum, PLS SEM has advantages when a research model predicts values in other parts of the model, while CB SEM has advantages when estimating the complete model and generating fit statistics that represent how well the data fit the theoretical model (Peng and Lai 2012).

With its prediction and theory-building/exploratory approach, PLS SEM is adopted in this study. First, the primary goal of this research is to assess the extent to which one part of the research model (IT flexibility) predicts values in other part of the model (PIC and FP), where the measurement models are reconceptualised so that the structural path is newly created to develop a theory. These characteristics of exploratory research in the present study were also discussed in section 5.2.2.

2) Suitability of the sample size

Sample size is an important issue in hypothesis analysis because it should be large enough to ensure the statistical power of the data analysis. The '10 times' rule (10 times the most complex relationships in the model) is frequently used to estimate the minimum sample size requirement in PLS SEM; in contrast, CB SEM requires a minimum sample size of 200 (Reinartz et al. 2009). Thus, a relatively smaller sample size (< 200) can be sufficient to acquire an acceptable level of statistical power in PLS SEM; as Reinartz et al. (2009) stated, "PLS is the preferable approach when researchers focus on prediction and theory development, our simulations show that PLS requires only about half as many observations to reach a given level of statistical power as does ML-based CBSEM" (p. 334).

The differences in required sample size between the two methods emerge from the different estimation processes each method employs. As mentioned above, PLS SEM uses OLS; it does not require any assumptions regarding the indicator distribution, so it is less affected by the sample size and deviations from multivariate normal distribution In contrast, CB SEM uses maximum likelihood estimation (MLE). MLE estimation leads to parameter estimates that maximise the likelihood of the observed data (Chin 1998; Gefen et al. 2011). It requires normally distributed and interval-scaled variables, and therefore it requires a relatively large sample size (Gefen et al. 2000; Reinartz et al. 2009; Peng and Lai 2012).

The necessary sample size of the this study was determined by multiple aspects considered in PLS SEM, such as the number of structural paths indicating the target construct, the significance level and R^2 (Hair et al. 2013). The sample size required for this study is 27–111, considering that an error rate of 10% is expected from hypothesis testing with an exploratory approach (Hair et al. 2013), and it should have four paths indicating the target construct, namely FP (Table 5.9, values in bold). The prepared (completed questionnaire) sample size of 128 of this study meets the requirements of PLS SEM Therefore, PLS SEM is considered as a suitable method for this study in terms of sample size.

Maximum number of arrows pointing at construct	Significance level											
	1%				5%				10%			
	Minimum R^2				Minimum R^2				Minimum R^2			
	0.1	**0.25**	**0.05**	**0.75**	**0.1**	**0.25**	**0.05**	**0.75**	**0.1**	**0.25**	**0.05**	**0.75**
2	158	75	47	38	110	52	33	26	88	41	26	21
3	176	84	53	42	124	59	38	30	100	48	30	25
4	191	91	58	46	137	65	42	33	**111**	**53**	**34**	**27**
5	205	98	62	50	147	70	45	36	120	58	37	30
6	217	103	66	53	157	75	48	39	128	62	40	32
7	228	109	69	56	166	80	51	41	136	66	42	35
8	238	114	73	59	174	84	54	44	143	69	45	37
9	247	119	76	62	181	88	57	46	150	73	47	39
10	256	123	79	64	489	91	59	48	156	76	49	41

Table 5.9 Sample Size Recommendation in PLS SEM
Source: Hair et al. (2013).

3) Availability of the IPA matrix

One of the key characteristics of PLS SEM is the extraction of latent variable scores that can be used to judge the relative importance of constructs in the structural model via the IPA matrix (Hair et al. 2013). In contrast, CB SEM does not support the use of the IPA matrix. One of the research objectives of this research is to prioritise the dimensions of IT flexibility (RQ 3). Due to the requirements in the prioritisation of IT flexibility dimensions which can be achieved by using the IPA matrix in the composition of PLS SEM, the adoption of PLS SEM rather than CB SEM is appropriate for this study.

4) Summary of the justification for using PLS SEM

It is sometimes difficult to distinguish exploratory and confirmatory research, so the two types of methods of PLS SEM and CB SEM can be used in complementary relationships (Anderson and Gerbing 1988). However, each approach has strengths that make it more appropriate for the primary goal of each type of research. For predictive-oriented exploratory research with a relatively small sample size, PLS SEM is more suitable than CB SEM. Gefen et al. (2011) summarised this view as follows: "'In a nutshell, PLS shines forth in exploratory research and shares the modest distributional and sample size requirements of OLS linear regression"' (p. 5). The availability of the IPA matrix is another unique advantage of using PLS SEM compared to CB SEM. Table 5.10 compares the methodological characteristics of the two methods.

Criterion	PLS SEM	CB SEM
Objective of analysis	Reject path-specific null hypothesis	Show that the null hypothesis of the entire model is plausible
Objective of variance analysis	Variance explanation for predictive applications and theory building	Overall model fit to see how good the model really is
Theory base	No need for sound theory base	Requires sound theory as it is confirmatory approach
Analysis of all impact paths	Supported	Supported
Formative observed variables	Supported	Not supported
Reflective observed variables	Supported	Not supported
Analysis of individual causation paths and item-loading path	Supported	Supported
Examination of interaction effect with numerous variable levels	Supported	Problematic
Analysis of statistical power	Supported	Not supported
Assumed distribution	Does not require distributional assumptions	Normal distribution of observed indicators when using maximum likelihood
Required sample size	Low (min. 30)	High (min. 200)
Support for IPA matrix	Yes	No

Table 5.10 Methodological Characteristics of PLS and CB SEM

Note: PLS SEM - partial least squares structural equation modelling, CB SEM - covariance based structural equation modelling

Source: Adapted from Gefen et al. (2000); Reinartz et al. (2009).

5.4.2 The Partial Least Squares Structural Equation Modelling Analysis Procedure

1) Overview

As mentioned above, PLS SEM does not assume that the collected data are not normally distributed, so parametric significance tests are not applied to test the coefficients, loadings and path coefficient. Instead, this approach uses nonparametric evaluation criteria based on a technique called bootstrapping (Efron and Tibshirani 1993; Hair et al. 2013). In this process, a large number of subsamples are selected from the original data with replacement; that is, a sample is drawn at each time of observation and returned to the population and another sample is drawn (5000 samples are recommended). If the recommended bootstrapping samples are used, 5000 PLS path models are estimated. The estimates of the coefficient create a bootstrap distribution, which is an approximation of the sampling distribution that can be used to determine the standard error and the standard deviation of the estimated coefficient (Hair et al. 2013). Therefore, compared to CB SEM, PLS SEM does not provide a goodness of fit criterion for the model. Instead, to assess the partial model structure, a systematic application of a two-stage, PLS SEM–specific assessment procedure is required. The stages are as follows: 1) assessment of the measurement model by examining its reliability and validity and 2) structural model assessment, which examines the variance explanation of the endogenous construct and predictive relevance (Chin 1998; Henseler 2009; Hair et al. 2011; Hair et al. 2012; Hair et al. 2013).

2) Measurement model assessment: Reliability and validity

The level of reliability and validity of measurement construct are crucial elements of PLS SEM, particularly for reflective measurement models (Hair et al. 2013). Reliability refers to whether the employed data collection and analysis technique will produce consistent findings when they are repeated (Saunders et al. 2012). Validity refers to whether the approach in fact measures the intended phenomenon (Sarstedt and Mooi 2011), and it is therefore related to the integrity of the conclusions produced from a piece of research (Bryman and Bell 2012). The difference between reliability and validity can be explained by comparing them as shown in Figure 5.6. The black circles represent measurements and the star refers to the average value of the circles. In the upper left box, the measures are reliable but not valid. The lower left box represents the scenario in which the measure is neither reliable nor valid. In the upper right box, all of the circles cover the centre of the target, implying that the measurement is both reliable and valid (Sarstedt and Mooi 2011). To assess the reliability and validity of measurement models, four types of tests are required, namely internal consistency reliability, convergent validity, indicator reliability and discriminant validity. These tests are explained below based on previous research (Chin 1998; Hair et al. 2011; Peng and Lai 2012; Hair et al. 2012; Hair et al. 2013).

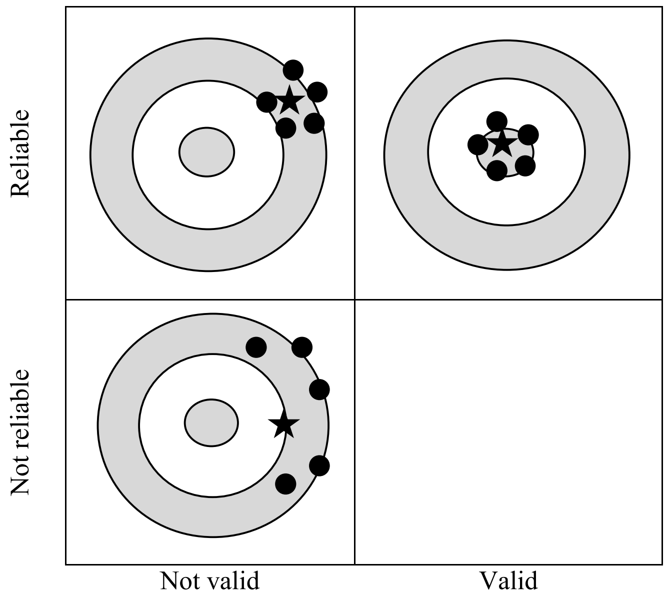


Figure 5.6 Concept of reliability and validity.
Source: Sarstedt and Mooi (2011).

✓ ***Internal consistency reliability***

The conventional criterion for internal consistency is Cronbach's alpha, which provides an estimate of reliability based on the intercorrelations of the observed indicator variables.

However, due to the limitations of Cronbach's alpha, which are sensitivity to the number of indicators and a tendency to underestimate internal consistency reliability, PLS SEM also uses composite reliability. This takes into account the different outer loadings of the individual variables. Cronbach's alpha and composite reliability vary between 0 and 1, with higher values indicating higher levels of reliability. Values of 0.60 and 0.70 are acceptable in exploratory research, while in more advanced stages of research, values between 0.70 and 0.90 can be regarded as satisfactory (Hair et al. 2011; Hair et al. 2013).

✓ ***Convergent validity***

Convergent validity refers to the extent to which a measure correlates positively with alternative measures of the same construct. In a reflective model[11], indicators are treated as different approaches that measure the same construct sharing a high proportion of variance. To establish convergent validity, researchers consider the outer loadings of the indicators, as well as the average variance extracted (AVE).

AVE is a common measure to establish convergent validity at the construct level. An AVE value of 0.50 or higher indicates that, on average, the construct explains more than half of the variance of its indicators. Conversely, an AVE of less than 0.50 represents that, on average, more error remains in the items than the variance explained by the measurement construct (Chin 1998; Hair et al. 2011; Peng and Lai 2012; Hair et al. 2012; Hair et al. 2013).

✓ ***Indicator reliability***

For indicator reliability, higher outer loadings of a construct denote that the associated indicators share a common theme, which is conceptualised by the construct. A common rule of thumb is that the outer loadings should be 0.708 or higher. The rationale behind this rule is that the square of a standardised indicator's outer loading (communality)

[11] Types of latent variables, such as the reflective and formative types, are explained in section 5.4.3.

represents how much of the variation in an item is explained by the constructs. A latent variable should explain at least 50% of an indicator's variance. To accomplish this, an indicator's outer loading needs to be above 0.708 (0.708^2 is 50; Hair et al. 2013).

✓ ***Discriminant validity***

Discriminant validity represents the extent to which a construct is truly distinct from other constructs by empirical standards; thus, it implies that a measurement model is unique and captures a phenomenon not captured by other constructs in the model. A method for assessing discriminant validity is the investigation of the cross-loadings of the indicators. In particular, an indicator's outer lading on the associated measurement model should be greater than all of its loadings on other constructs (the cross-loadings). Moreover, the Fornell–Larcker criterion is a second, conservative method of examining discriminant validity. It investigates the square root of each construct's AVE with the latent variable correlations with the threshold that the square root of the AVE should be greater than its highest correlation with any other construct (or the AVE should exceed the squared correlation with other constructs). The underlying logic here is that a construct shares more variance with associated indicators than with other constructs (Chin 1998; Hair et al. 2011; Peng and Lai 2012; Hair et al. 2012; Hair et al. 2013). .

3) Structural model assessment

Instead of applying measures of goodness of fit, as done in CB SEM, PLS SEM assesses the structural model in terms of predictive capabilities related to how well it predicts the endogenous constructs. The key parameters for assessing the structural model are as follows: 1) collinearity, 2) the significance and relevance of the model and 3) predictive relevance with R^2 (Hair et al. 2013).

✓ ***Collinearity assessment***

One needs to apply the same measures, that is, tolerance and variance inflation factor (VIF). In doing so, one needs to examine each set of predictor constructs separately for each subpart of the structural model. A tolerance level below 0.20 (VIF above 5.00) in the predictor constructs is indicative of collinearity. If collinearity is indicated, one should consider eliminating constructs, merging predictors into a single construct or creating higher order constructs to treat it (Hair et al 2012; Hair et al. 2013).

✓ ***Structural model path coefficient***

The structural model relationships, that is, the path coefficients, represent the hypothesised relationships among constructs. These have standardised values between +1 and –1. Estimated path coefficients close to +1 represent strong positive relationships and statistical significance. The significance depends on the standard error obtained by means of bootstrapping, which computes the empirical *t*-value. When the empirical *t*-value is larger than the critical value, it can be concluded that the coefficient is significant at a certain error probability (i.e. significance level). Commonly used critical values for two-tailed tests are 1.65 (significance level of 10%), 1.96 (significance level of 5%) and 2.57 (significance level of 1%).

When a study is exploratory in nature, researchers assume a significance level of 10% (Hair et al. 2013). For example, a path model has a value of 0.25 if the bootstrapping routine delivers the empirical *t*-value of 2.119. This value is higher than the theoretical *t*-value of 1.96 for a 5% of probability of error. As a result, one can conclude that the relationship is significant at a level of 5% (Chin 1998; Hair et al. 2011; Hair et al. 2013). After examining the significance of relationships, it is important to assess the relevance of significant relationships. This is the critical part and closely related to the direct and indirect effects for analysing mediating effects.

✓ ***Coefficient of determination (R^2 value)***

R^2 is the most commonly used measure to evaluate a structural model. It measures the model's predictive accuracy and the squared correlation between specific endogenous actual predictive values. It also represents the amount of variance in the endogenous constructs explained by all of the exogenous constructs linked to them. It is difficult to provide rules of thumb for R^2. A rough characterisation is that 0.75 is substantial, 0.5 is moderate and 0.25 is weak (Hair et al. 2011; Hair et al. 2013). Table 5.11 summarises the rules of thumb in PLS SEM tests.

Model	Rules of thumb
Reflective measurement models	• Internal consistency reliability: Composite reliability should be higher than 0.70 (in exploratory research, 0.60 to 0.70 is considered acceptable). • Indicator reliability: Indicator loadings should be higher than 0.70. • Convergent validity: The average variance extracted should be higher than 0.50. • Discriminant validity: The AVE of each latent construct should be higher than the construct's highest squared correlation with any other latent construct (Fornell–Larcker criterion).
Structural model	• R^2 values of 0.75, 0.50 or 0.25 for endogenous latent variables in the structural model can be described as substantial, moderate or weak, respectively. • Bootstrapping is used to assess the path coefficients' significance. The minimum number of bootstrap samples is 5000, and the number of cases should be equal to the number of observations in the original sample. • Critical *t*-values for a two-tailed test are 1.65 (significance level = 10%), 1.96 (significance level = 5%) and 2.58 (significance level = 1%).

Table 5.11 Summary of Rules of Thumb in Model Evaluation
Source: Adapted from Hair et al. (2011); Hair et al. (2013).

To be able to evaluate the conclusions drawn from data, it is necessary to report the appropriate statistics. Table 5.12 provides a checklist of the statistics to be reported for the PLS SEM method. This checklist was used to assess the appropriateness of the whole data analysis process in the present study.

Position	Required statistics
In the text	1) Standard reporting of expectations and hypotheses 2) Why the researchers chose PLS 3) If items are deleted to improve model fit, this must be reported 4) Software used 5) Latent variable type used
In appendix or table	1) Scales with their means, standard deviations and correlation among each pair of scales 2) Indicator reliability, internal consistency reliability, convergent validity, discriminant validity 3) R^2, and square root of the AVE 4) List of items in each scale with their wordings and loadings 5) Significant of path coefficients 6) Total effects 7) Mediator analysis
Recommended but optional	1) Common method bias analysis 2) Nonresponse bias analysis based on Armstrong and Overton (1977) 3) Second-order constructs, where applicable 4) Multicollinearity issues 5) Missing values

Table 5.12 Checklist of Issues to be Reported in Studies Employing PLS SEM

Source: Adapted from Gefen et al. (2011), Ringle et al. (2012), Hair et al. (2013).

5.4.3 Issues Concerning the Use of Partial Least Squares Structural Equation Modelling

1) Mediating effect analysis

This research theorises that IT flexibility improves the FP because it also increases PIC, the mediator variable of the model. Mediation is a causal model that specifies the process of 'why' and 'how' a causal relationship occurs. In contrast, the moderation effect is a causal model that specifies 'when' and 'for whom' an independent variable model strongly causes a dependent variable (Baron and Kenny 1986; Wu and Zumbo 2008). The concept of the mediation effect is compared to moderating effect to emphasise its characteristics in Figure 5.7.

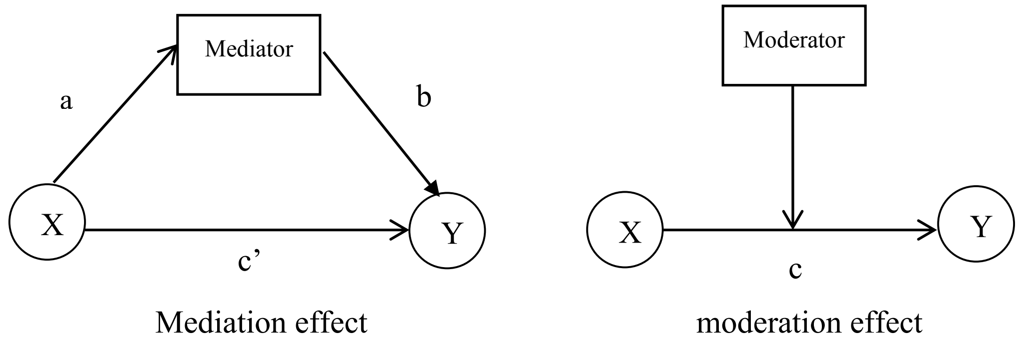


Figure 5.7 Mediation and moderation effect.
Source: Wu and Zumbo (2008).

In a mediation model, the independent variable is presumed to cause the mediator and the mediator also causes the dependent variable (Wu and Zumbo 2008). To test the mediating role, the following conditions need to be considered (Baron and Kenny 1986; Iacobucci et al. 2007; Preacher and Hayes 2008):

① The independent variable must affect the dependent variable (X - Y);

② The independent variable must affect the mediator (X - Mediator);

③ The effect of the independent variable on the dependent variable must diminish after controlling for the effects of the mediator;

④ If all conditions are satisfied, and the influence of the independent variable is reduced to no significance, this effect is referred to as a full or complete mediating effect; and

⑤ If all conditions are satisfied, but the influence of the independent variable remains significant, it is referred to as a partial mediating effect.

The mediating effect is widely used in OM/SCM literature, especially for investigating the relationships between organisational factors and performance-related variables using

SEM, as presented in Table 5.13. As mediating impact analysis is deployed to identify the influence of the independent construct on the dependent construct with a mediator, this research also adopts such analysis due to the theorisation of PIC as a mediator to the research model. It should be noted that bootstrapping is also used to determine the mediating effect of PIC. This is recommended by Preacher and Hayes (2008) and Sattler et al. (2010).

Antecedents	Mediators	Outcome	Purpose of investigation	Reference
Communication/ operational performance measures	Socialisation Mechanism	Business performance	To examine the role of the mediator in interfirm relationships	Cousins et al. (2008)
Manufacturing flexibility	Product, process & organisational innovation	Firm performance	Relationship finding between manufacturing flexibility and performance	Camisón and López (2010)
Product modularity	Supplier/design/ manufacturing integration	Competitive performance	Relationship finding and mechanism identification	Jacobs et al. (2007)
Internal assimilation External diffusion	IT-enabled operations improvement	IT-enabled strategic performance	Relationship identification on the influence of operational value	Zhang and Dhaliwal (2009)
Synergy, IT investment, knowledge capital, governance	Web-enabled SCM	Performance impact	Knowledge expansion on Web enabled SCM	Ranganathan et al. (2011)
EDI in supplier management	Information alignment/ relational alignment	Firm performance	To reveal the value of information/relational alignment	Tan et al. (2010)

Table 5.13 Example Research Using Mediating Effects in SCM Studies
Source: Compiled by author.

2) Selection of the latent model type

To ensure the validity of the conceptual model, the nature of the latent construct needs to be considered (Petter et al. 2007). There are two types of measurement models in PLS SEM – reflective and formative latent models. The type of model relates to the directions of the causality between the measurement indicators and latent construct (Coltman et al.

2008). According to Petter et al. (2007), each reflective construct should be unidimensional, as the items measure the same aspect of the unobservable construct. Thus, the observed variables reflecting the characteristics of latent variable are affected by latent variables (Petter et al. 2007). The formative construct tends to have multidimensional constructs that are structured with more than one dimension to represent the overall latent construct. Formative observed variables are considered to cause the latent construct and represent different dimensions of this construct (Gefen et al. 2000; Petter et al. 2007). Figure 5.8 and Table 5.14 present the differences between reflective and formative latent variables.

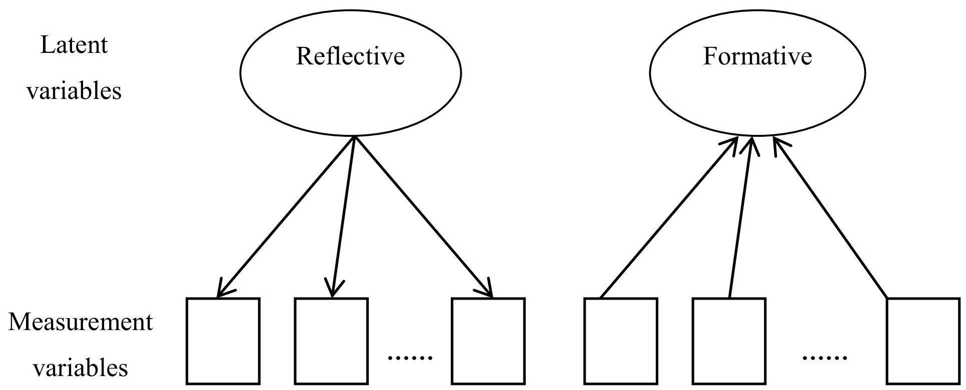


Figure 5.8 Formative and reflective constructs.
Source: Adapted from Peng and Lai (2012).

Determinants	Reflective	Formative
Definition	A construct observes measures affected by latent variables	A construct consisting of indicators determines latent variables
Direction of causality	From constructs to measures	From measures to construct
Construct pattern	Unidimensional	Multidimensional
Correlation among items	-Correlated with internal consistency - Items share common themes	-Measures should not be correlated - Items do not share common themes

Table 5.14 Reflective Versus Formative Constructs
Source: Adapted from Gefen et al. (2000), Petter et al. (2007), Coltman et al. (2008).

A common reflective construct covers measurements of attitude or personality on certain issues (Coltman et al. 2008). One good example in IT-relevant literature is perceived ease of use (Davis et al. 1989). This is defined as "the degree to which the prospective user expects the target system to be free of effort" (Davis et al. 1989, p. 985). This is measured by four indicators, exemplified in the following:

- 'Learning to operate WriteOne[12] would be easy for me (easy to learn)';
- 'I would find it easy to get WriteOne to do what I want it to do (fitness for use)';
- 'It would be easy for me to become skilful at using WriteOne (easy to become skilful)'; and
- 'I would find WriteOne easy to use (easy to use)' (Davis et al. 1989).

In Figure 5.9, all of the arrows indicate measures and share the common themes as reflective latent variables.

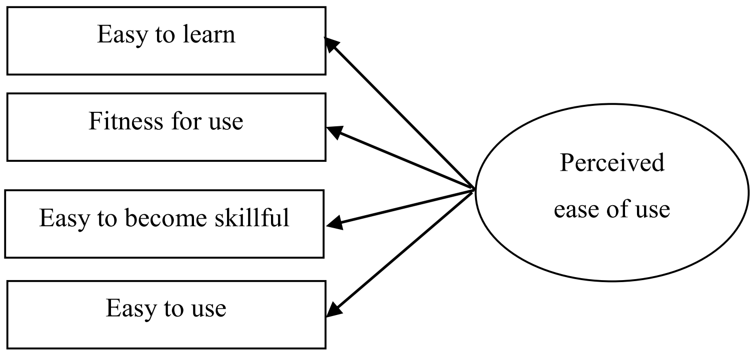


Figure 5.9 Example of a reflective measurement model.
Source: Davis et al. (1989).

This approach to the latent variable is similar to the conceptualisation of IT flexibility, which measures respondents' perceptions concerning the impact of IT use for

[12] WriteOne is the name of a software program.

interorganisational business processes. This study conceptualises the IT flexibility dimensions and proposes measurements based on respondents' perceptions of the impact of IT use for interorganisational business processes. Thus, each IT flexibility dimension is classified according to the use of IT for specific purposes. Moreover, the measures are prepared to represent a specific observable characteristic of each dimensions. Therefore, each dimension's attributes share common themes. Accordingly, each construct represents a particular classification theme for a specific IT flexibility dimension, where the items are collected within a pool of similar correlated IT capabilities for interfirm operations. In sum, each variable is designed to be a reflective measurement model considering their characteristics and role in the research model.

5.5 EMPIRICAL ANALYSIS METHOD 2: THE IMPORTANCE–PERFORMANCE ANALYSIS MATRIX (IPA MATRIX)

5.5.1 The Importance and Performance Analysis Matrix: An Overview

An IPA matrix is another data analysis method adopted for extra empirical study to guide to answer to RQ 3 (How should firms prioritise different dimensions of IT flexibility and allocate resources to them in a strategic manner?). Developed by Martilla and James (1977) to measure customer satisfaction, IPA is a useful technique to rank competitive factors by considering the gap between performance and importance; this enables firms to determine improvement priorities among the competitiveness factors (Slack 1994). The traditional IPA matrix is based on two primary assumptions, as follows: 1) performance and importance are independent of each other and 2) there is a symmetrical relationship between the performance of the measurement model and the improvement of the target construct – if the performance of a measurement model increases, the target construct will also improve (Pezeshki et al. 2009). By indexing the performance level on the Y axis and importance level on the X axis using a numerical scale, as shown in Figure 5.10, the distribution of the combination of importance and performance level in the four quadrants can be presented in a form of a table.

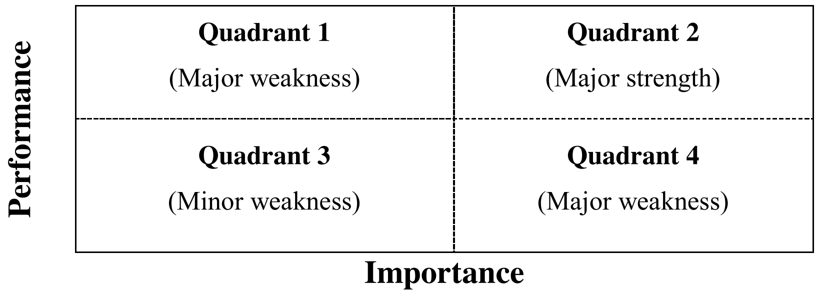


Figure 5.10 The importance–performance grid with attribute ratings.
Source: Tontini and Silveira (2007).

According to the level of performance of an attribute showing a certain level of importance, the IPA matrix can explain the position of a specific attributes in terms of resource allocation as described below.

Quadrant 2 contains high importance and high performance indicators, which specify the competitive advantage of an organisation. In quadrant 4, the attributes have high importance and low performance, implying that these attributes should receive immediate attention. Quadrant 3 contains low-importance, low-performance indicators; therefore, no additional effort is required in this area, but the same or higher performance levels should be maintained to sustain the firm’s competitive advantage. Finally, quadrant 1 specifies high-performance, low-importance attributes, indicating that the company has invested too many resources into this area, and it would be better to relocate them (Tontini and Silveira 2007).

5.5.2 Extension of Partial Least Squares Structural Equation Modelling to the Importance–Performance Analysis Matrix

1) Measuring the importance and performance of a construct

The extension of results to IPA is available for PLS SEM but not CB SEM approaches (Sattler et al. 2010), as the IPA method relies on one of the key characteristics of PLS

SEM, that is, the extraction of latent variable scores (Hair et al. 2013). By utilising this characteristic, the extension of PLS SEM result to the IPA matrix is conducted through the steps described below.

First, it is necessary to identify the target construct, because the total effects and the performance values need to be generated for the target constructs within the cause-and-effect relationships. Importance on the X axis follows the estimation of the direct, indirect and total relationships of latent variables, which is computed from the inner and outer coefficient from 0 to 1.0. The performance is rescaled to 0 to 100 on the Y axis based on the average values of the latent variable scores. Second, the scores for importance and performance of each construct or indicator are combined in a plot after the bootstrapping technique assesses the statistical significance of the indicators' importance on the target constructs (Rigdon and Ringle 2011; Berghman et al. 2013; Hair et al. 2013). This study used the SmartPLS 3.0 software for this analysis.

When the research model has a mediator or multiple endogenous constructs, the effects of the exogenous constructs can be dispersed to several latent variables, including the mediator; alternatively, the mediator may absorb the cause-and-effect relationships to some extent (Hair et al. 2013). However, in this study, FP was selected as a single target construct, as specified in the research model. Moreover, all dimensions of IT flexibility were treated as predecessors; thus, they were all expected to affect FP. Thus, in this step, the importance and performance level of each construct for FP is identifiable. For example, if one generates an example construct of a research model, as shown in Figure 5.11, the information for each construct represents the performance of each measurement model on a scale from 0 to 100. In contrast, the standardised path coefficients, which are shown beside the arrows, represent the level of relationships between the measurement models (Rigdon and Ringle 2011; Berghman et al. 2013; Hair et al. 2013).

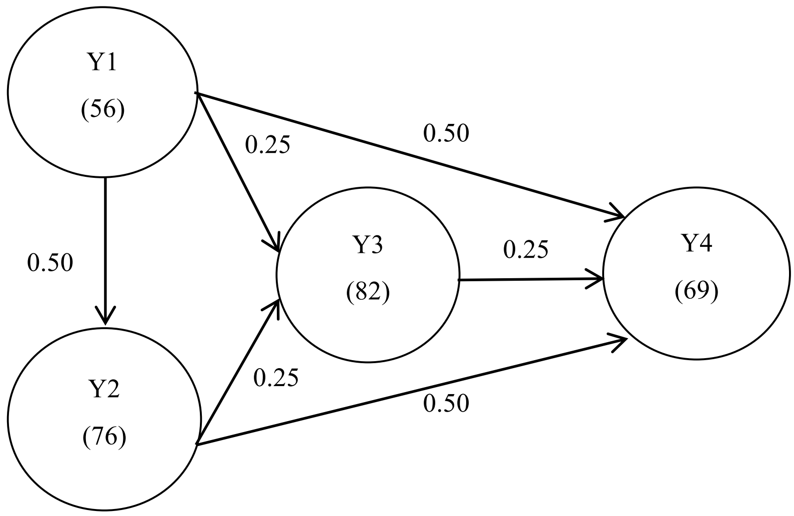


Figure 5.11 PLS SEM example.
Source: Hair et al. (2013).

The total effect of a specific measurement model is the sum of the direct effect and indirect effect of the measurement model for the target construct. In this case, the calculation of the total effect of Y1 on Y4 can be illustrated as follows: The direct effect of Y1 to Y4 (0.50) + indirect effect of Y1 to Y4 (0.34) where (Y1–Y2–Y4:0.5*0.5) + (Y1–Y2–Y3–Y4: 0.5*0.25*0.25) + (Y1–Y3–Y4:0.25*0.25) = 0.84. Y1 shows a performance value of 56. Following this logic, the performance and importance can be computed as shown in Table 5.15.

Latent variables	**Direct effect on target construct**	**Indirect effect on target construct**	**Importance (total effects on Y4)**	**Performance (latent variable score)**
Y1	0.50	0.34	0.84	56
Y2	0.50	0.06	0.56	76
Y3	0.25	0.00	0.25	82

Table 5.15 Importance and Performance Table
Source: Adapted from Hair et al. (2013).

In this table, the importance of Y1 is the highest, but the performance shows the lowest value among the three constructs. Therefore, it is identified that Y1 is the most relevant construct for managerial treatment, as shown in Figure 5.12.

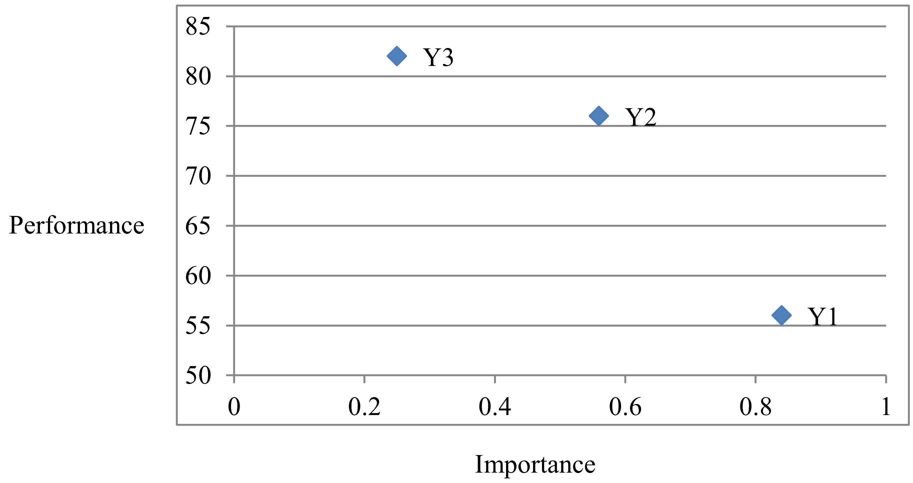


Figure 5.12 Example of an importance and performance matrix.
Source: Adapted from Hair et al. (2013).

2) Prioritisation and resource allocation

In the IPA matrix, the performance score indicates potential improvement. The lower the performance score, the more scope for improvement there is (Rigdon and Ringle 2011; Berghman et al. 2013; Hair et al. 2013). If the investment costs for the improvement initiatives, such as technological or financial investments, are disregarded, the results of the analysis can be interpreted as described below.

In Figure 5.12, the indicator in the right part of the plot – Y1 – represents high importance in the target constructs; it is an important candidate for additional investments to ensure that the current level of performance is maintained or improved. The indicator positioned on the relative left side – Y3 – has lower importance on the target construct than the other items. The level of Y3's performance needs to be decreased in the matrix because it shows too-high performance considering its low importance. Thus, Y1 with high importance and lower performance should be treated preferentially with additional efforts or investments for performance improvement in the target construct (i.e. Y1 → Y1*). Moreover, investment in indicator Y3, with its low importance but higher performance, should be downsized (i.e. Y3 → Y3*). Thus, firms are motivated to review their existing investments according to the priorities identified from the analysis, as depicted in Figure 5.13. This process is applied to the empirical research in section 6.4.

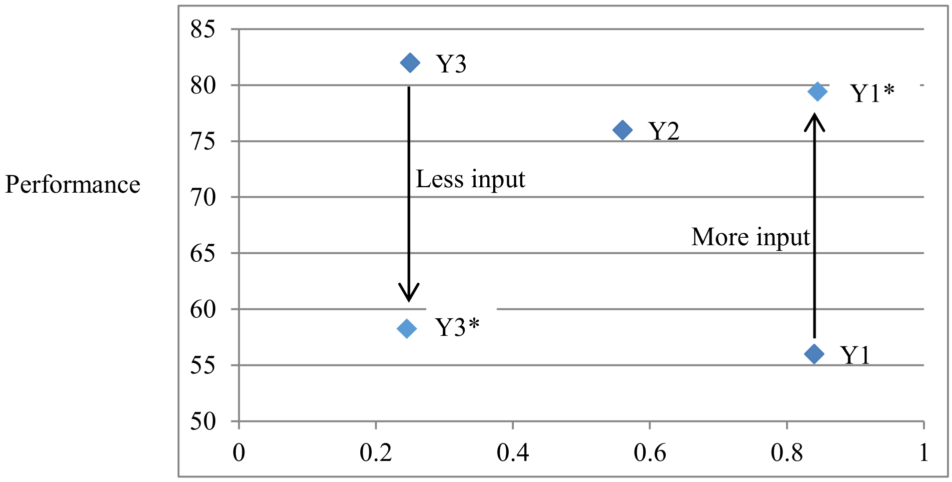


Figure 5.13 Resource reallocation plan.
Source: Author.

If a model has several constructs that consist of several indicators, the IPA matrix can be used at two levels, namely the construct level and indicator level. At the construct level, the importance and performance of each construct can be shown in a plot with each construct's aggregated value of importance and performance (Figure 5.13). At this level of analysis, the relative importance and performance of each construct can be measured. One can observe which construct has the most importance in the model and identify whether the level of performance of this construct is appropriate; ideally, the most important construct is expected to show the highest performance score. At the indicator level, every (measurement) indicators in the model can be shown in a single plot, so comparisons between each indicator's importance and performance can be carried out.

5.6 THE DATA COLLECTION METHOD

5.6.1 Characteristics of Required Data

For this study, the data for hypothesis testing needs to be collected from respondents who use IT for interorganisational business activities. To elaborate, the questionnaire in this study needs to investigate respondents' perceptions of the following: 1) dynamic IT supports for interfirm relationships at different levels, i.e. the transactional, operational and strategic levels; 2) the facilitating role of IT for firm capability for intra-/interfirm process integration; and 3) the improvement of FP delivered by IT flexibility and process integration. Therefore, the target respondents are employees involved in supply chain processes who are familiar with the different uses of IT for interorganisational business activities and have the proper level of understanding of their effects on firm capability and performance.

In interorganisational research, researchers often confront a lack of interfirm level data and interests (Kumar et al. 1993), where there are unclear ownerships of the business process and shared resources/responsibilities in the network (Anderson et al. 1994). As a result, research topics on interorganisational relationships mainly rely on key informant surveys because such informants are supposedly knowledgeable about the issues in interfirm network (Kumar et al. 1993). A key informant survey is an appropriate approach when the research question requires in-depth, complete information from informants who can generalise about patterns of behaviour after summarising actual or expected intereorganisational relationships (Seidler 1974; Phillips 1981; John and Reve 1982). Targeting senior executives as key informants is a typical data collection technique to ensure the reliability and credibility of responses (e.g. Sanders 2007; Liu et al. 2003). However, it should be stressed that the present study requires specific respondents. The respondents need to be qualified to adequately address divergent uses of IT at different organisational levels (transactional, operational and strategic levels) and their effects on supply chain integration and FP. Therefore, this study needs respondents at all levels for a balanced view of IT flexibility dimensions, i.e. employees handling transactional activities (usually clerks/junior level employees), operational activities (usually middle managers) and strategic activities (senior managers or executives). It is considered that although senior executives understand strategic issues well, they may not have hands-on experience of the IT system operations. A knowledgeable/experienced respondent, such as a transport/production planner, often knows how IT systems affects their key performance indicators (KPIs) much better than senior executives as he/she handle such IT activities on a daily basis. Indeed, during the pilot test and peer review, practitioners consider it is desirable to involve respondents at all levels.

This idea is supported by the arguments provided in the following. Gosain et al. (2004) acquired reliable data not only from senior level key informants, but also from managers or lower level informants to incorporate the perceptions from the employees involved in day-to-day transactions. Ravichandran and Lertwongsatien (2005) argued that such broadness of target respondents is necessary as there is a recognition of dispersed IT capability within a firm. They stated that respondents from multiple levels or areas will "allow for a richer measurement of the construct" (p. 259). Rai et al. (2012) identified the role of interfirm IT capability in supply chain management by arguing that senior level employees are not in charge of routine problem resolution and that the primary roles of the executives are more strategic in nature than those of junior level employees. Therefore, they included data from operators in logistics to include standardised operations at the transactional level.

5.6.2 Sampling Strategy

There are two categories of sampling methods, namely probability and nonprobability sampling. The technique used in this study falls into the category of nonprobability sampling. Probability sampling relies on randomly collected samples and includes simple random, systematic random, stratified random and cluster random techniques; in contrast, nonprobability sampling covers quota, purposive, snowball and convenience sampling (Bryman and Bell 2012; Saunders et al. 2012). In most case, it is not possible to collect data from the entire population. Therefore, researchers need to select an appropriate sampling method that should support the achievement of research objectives in a practical and efficient way under time and budget constraints (Saunders et al. 2012).

With the given required characteristics of respondents, on the one hand, it will be difficult to collect responses from qualified respondents for this study because the qualifications are complex. Such qualifications reduce the availability of suitable respondents and limit the collection of a sufficient amount of data for hypothesis testing. On the other hand, the acquired data should be reliable and credible for use in empirical analysis. Because of the limited resources available for the research and the requirements of reliable data, this study decided to adopt nonprobability sampling.

Nonprobability sampling is adopted when the population is not completely known (Bryman and Bell 2012) as in the present research, but the researcher has sufficient information on the informants to able to select the informants with relevant knowledge on the research topic (Saunders et al. 2012). According to Freeman (1986) and Thomas (2004), randomly selected samples are frequently the exception rather than the rule; thus, nonprobability sampling is the practical alternative adopted when there are given constraints regarding data collection (Thomas 2004; Bryman and Bell 2012), as is the case of this research. Moreover, nonprobability sampling is preferred for exploratory studies in which the focus is on theory development rather than creating a basis for generalisation (Thomas 2004; Sekaran and Bougie 2010). This is also consistent with this study's theory-building, exploratory approach to IT flexibility for SCM.

Specifically, a combination of purposive sampling and convenience sampling was selected for the present study. Purposive sampling was chosen because it uses the knowledge and experience of the researcher to obtain representative/knowledgeable informants from the population based on the researcher's evaluation (Bryman and Bell 2012; Saunders et al. 2012). With this technique, researchers can specify the characteristics of a population of interest and try to identify individuals who have those characteristics. Given the exploratory nature of the research and the difficulties in accessing different levels of informant groups, convenience sampling was considered to be a practical solution for collecting reliable data (Thomas 2004). In convenience sampling, research participants are asked to identify one or more respondents, as a focal point, who meet certain characteristics and may be willing to participate in the research (Bryman and Bell 2012). This technique is emphasised because the existing network can be used to gain access and develop it incrementally, thereby creating new networks (Saunders et al. 2012). The combination of purposive and convenience sampling is conducted as follows.

① The researcher accessed the professional network at the author's university, which includes industrialists who have worked with the university for a number of years through joint research projects, knowledge transfer projects, academic advisory boards, as well as established alumni expected to be knowledgeable about the research topic. Moreover, they were encouraged to circulate the questionnaire to their colleagues or business partners to participate in the survey.

② This study required all the respondents to have a sufficient level of organisational and functional experience at all levels to evaluate every variable in the questionnaire. In order to determine if the respondents met the inclusion criteria and to assess their competency, an additional formal check was administered with a section of the questionnaire (questions 2, 3 and 4 in section A; Kumar et al. 1993). Specifically, the three questions assessed the respondents' familiarity with IT use at the transactional, operational and strategic levels. Only informants who were able to fully answer these questions were retained for data analysis. Even in a single firm, individuals' knowledge concerning IT use will differ according to their job positions and types. Senior directors may have a more strategic view, but they may not necessarily have in-depth information or experience about current operating systems in practice. The intention in selecting the key informants was to approach respondents who are knowledgeable in IT implementation in all organisational areas.

The employment of nonprobability sampling is further justified by empirical research in OM/SCM fields, which argue that when there are limited resources for the research or uncertainty in getting the required number of samples, nonprobability sampling needs to be used (Li et al. 2009; Biloslavo et al. 2013; Liu et al. 2013; Fayezi et al. 2015). In fact, with its suitability for exploratory research (Thomas 2004; Sekaran and Bougie 2010), nonprobability sampling is used in many SCM studies to resolve the difficulties in collecting data due to the specific characteristics of the data or constraints related to the research topics in SCM (Beuckelaer and Wagner 2013).

Moreover, in the research of IT use for SCM, several studies have used nonprobability sampling techniques. For example, Devaraj et al. (2007), Closs and Savitskie (2003), Mouzakitis (2009), Tian et al. (2010) and Williams et al. (2013) used purposive sampling. Gosain et al. (2004), Malhotra et al. (2005), Su and Yang (2010) and Ye and Wang (2013) used a combination of purposive and convenience sampling. This study understood that such nonprobability approaches were made, in part, due to the requirements of knowledge about IT and IT use for interfirm operations, which would not be easily identifiable when accessing a broad, general pool of respondents.

Since data were collected from respondents who are invited to participate in the survey, the results from this study may be limited in terms of wide generalisation. However, considering the difficulties related to the limited access to heterogeneous groups of respondents, as well as time and budget constraints (Saunders et al. 2012), nonprobability sampling seems like the most practical and efficient way to collect reliable data.

5.6.3 Questionnaire Development

The design of a questionnaire should consider the content and formulation of individual questions and the survey structure as a whole (Thomas 2004). Following the questionnaire development checklist recommended by Churchill and Iacobucci (2002), this study prepared the questionnaire according to the steps described below.

1) Seeking information

The present study adopted a questionnaire-based survey to test the conceptual framework of IT flexibility and the hypothesised relationships; thus, the information sought was closely related to the constructs of research model. In particular, the measurement instruments which would be included in the questionnaire were determined by the characteristics of the five following measurement constructs: 1) TR flexibility, 2) OP flexibility, 3) STR flexibility, 4) PIC and 5) FP. Information on the characteristics and measurement indicators are documented in Chapters 2 and 4.

2) Types of questionnaire

The measurement instruments aimed to elicit the perceptions of respondents regarding the five conceptual constructs. To collect the data from the respondents, this study used a self-administered postal questionnaire supplemented by email and an online questionnaire. Self-administered questionnaires tend to have benefits like cost effectiveness, quick administration, an absence of interviewer effects (characteristics of interviewers may affect the answers that respondents give) and convenience for respondents (Brayman 2012). Moreover, as this study adopted PLS SEM as the data analysis method, the usefulness of collecting data with closed questions led to the selection of a self-administered questionnaire (Saunders at al 2012). Closed questions are questions for which respondents are given a limited choice of possible answers. Therefore, compared to open questions – which require the interviewer to record as much of what is said as possible and then examine and classify the contents – closed questions allow easy quantification of a large number of collected data, such as those required for PLS SEM in this study. Part 4 below explains how this study utilises the closed questionnaire.

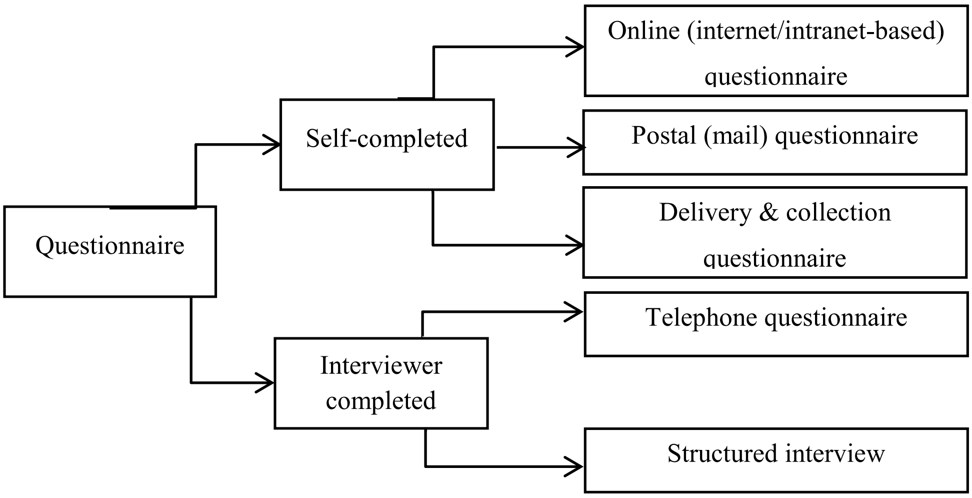


Figure 5.14 Types of questionnaire.
Source: Saunders et al. (2010)

3) Contents of individual questions

The contents of the questions are can be classified into five areas. First, to determine the competency of the respondents, three questions were asked regarding their use of IT at three different levels. Second, to investigate the dimensions of IT flexibility and their interrelationships, opinions regarding the 14 attributes of IT flexibility at three different levels were elicited. Although the dimensions of flexibility can be classified into types of IT flexibility (i.e., TR flexibility, OP flexibility, STR flexibility), the attributes were listed without any distinctions to reduce the possibility of common response bias. Third, to identify the influential mechanism of the mediator, PIC was investigated by asking how respondents perceived the PIC level for intra-/interfirm process integration. Fourth, to examine the impact of IT flexibility and PIC, items on FP related to cost, speed, value, quality and service were included. Finally, to conduct the descriptive analysis, questions about the background of respondents, such as job position, job area, firm revenue and service types were included.

The investigated area and required variables are summarised in Table 5.16 in the form of a data requirement table, as recommended by Saunders et al. (2012).

Investigative area	**Variable(s) required**	**Details of data measurement**	**Sections included in questionnaire**
Competency of respondents	Factual IT types or IT use for the supply chain management process	IT for network arrangement, IT for interfirm process improvement IT for strategic collaboration/ innovative practice	Section A
Independent variable (TR flexibility, OP flexibility, STR flexibility)	Opinion of respondents on the provision of their network connectivity and maintenance capability enabled by IT Opinion of respondents on the provision of their interfirm information sharing and process improvement enabled by IT Opinion of respondents on the provision of their supply chain collaboration and innovative practices enabled by IT	Level of IT flexibility supporting current supply chain network infrastructure and connectivity Level of IT flexibility supporting quality, visibility, speed and streamlining, optimisation in the supply chain interfirm process Level of IT flexibility enabling reconfiguration/product or service offerings to customers.	Section B
Mediator variable (process integration capability)	Opinion of respondents on the provision of process integration enabled by IT	Level of internal process integration capability (in sourcing, distribution and service) Level of external integration capability (in sourcing, distribution and service) Level of customer integration capability (in sourcing, distribution and service)	Section C

Dependent variable (firm performance)	Opinion of respondents on the provision of firm performance improved by IT flexibility Opinion of users on current business process integration	Level of improvement in firm performance regarding cost, speed, value, service and quality	Section D
Descriptive analysis	Demographic information of respondents	Respondents' position, working experience, firm annual revenue	Section E

Table 5.16 Data Requirement Table

Source: Author.

4) Form of the response to each question

For the relationship analysis between variables, this study adopted a Likert scale in the form of closed responses where respondents indicated how strongly they agreed or disagreed with items on the questionnaire in which the opinion variables recorded what respondents thought about something (Saunders et al. 2012). In the first two parts questions were measured using a 7-point scale from 'strongly disagree' to 'strongly agree'. FP was measured using a 7-point scale with end points from 'much worse' to 'much better.' Open questions supplemented the questionnaire, allowing the respondents to answer using their own words when they were unable to find appropriate answers from the examples (Bryman 2012).

5) Wording of each question

Prior to data collection, the questions used in a questionnaire need to be defined precisely (Saunders et al. 2012). According to Bryman (2012), questionnaires should be designed to avoid ambiguous, general, lengthy and leading questions. To address this issue, each part of questionnaire was followed by section headings and terms were revised several times with supervisors. The use of technical terms is undesirable in questionnaire design (Bryman 2012), but this was unavoidable due to the technology-oriented approach of the present study. However, such terms also acted as an indicator to assess the qualifications of the respondents and determine whether they met the inclusion criteria for the survey.

6) The physical characteristics and sequence of questions

The background of this research was covered in the introductory part of the questionnaire to give a clear idea about the research and invite respondents to participate (Saunders et al. 2012). Anonymity/confidentiality protection was mentioned and the usefulness of this research was highlighted to reduce respondents' evaluation apprehension (Podsakoff and Organ 1986; Podsakoff et al. 2003).

The sequence of questions was considered in relation to common method bias. As each survey was completed by a single informant, such concerns needed to be addressed. To minimise the likelihood of common method bias, procedural remedies were applied as proposed in the literature (Podsakoff and Organ 1986; Podsakoff et al. 2003; Chang et al. 2010). For example, questions on IT flexibilities were asked in different sections of the questionnaire, and they were separated from PIC and FP to create division between the predictor and criterion variables. The sequence of topics was as follows:

① Questions related to respondents' competency;

② IT flexibility indicators (without distinguishing between the three types);

③ PIC;

④ FP and general background; and

⑤ Demographic questions regarding the respondents' backgrounds.

7) Re-examination and the pilot-test questionnaire and revision

To ensure the validity of the measurement models and clarify the instructions and flow of the questionnaire, prior to its full implementation, the survey was peer reviewed by a panel of 3 academics from the field of logistics/SCM and 10 practitioners in the same field; it also piloted. The 13 academics/practitioners were asked to assess the measurement constructs to examine whether the measurement models were sufficiently represented by the indicators. Furthermore, the supply chain practitioners were asked to pilot-test the questionnaire with their colleagues and to identify any required modifications regarding format, appearance, terminology, clarity of instructions and response formats. Six supply chain practitioners completed the pretest. Table 5.17 summarises the peer review for the questionnaire. In carrying out this step, it was possible to minimise respondents' problems in answering the questionnaire and ensure the validity and reliability of the instrument (Thomas 2004; Saunders et al. 2012); furthermore, any suggested area of improvement could be identified. Pilot testing is also important for self-administered questionnaires, as there is no help to clear up confusion when the respondents complete the questionnaire independently (Saunders et al. 2012).

Reviewer	Service type	Pilot test	Time of peer review	Review
1	Manufacturing	X	02/04/2014 & 05/04/2014	Face to face
2	Purchasing and distribution		03/04/2014	Email
3	Third-party logistics (road freight)	X	03/04/2014	Email
4	Ocean shipping (tanker)	X	03/04/2014	Telephone
5	Third-party logistics (warehousing and distribution)		07/04/2014	Email
6	Supply chain manager	X	07/04/2014 & 17/04/2014	Face to face
7	Export operations manager		07/04/2014	Telephone
8	Director of supply chain services	X	11/04/2014	Telephone
9	Third-party logistics (integrated logistics)	X	11/04/2014	Email
10	Logistics operations manager		14/04/2014 & 17/04/2014	Face to face
11	Academia		21/04/2014	Face to face
12	Academia		21/04/2014	Face to face
13	Manufacturing/academia		21/04/2014	Email

Table 5.17 Peer-review Process for the Questionnaire
Source: Author.

As a result of this step, several items and questions were modified. For example, in terms of TR and OP flexibility, three practitioners pointed out that some of the technical terms were ambiguous. To resolve this issue, examples of specific technologies were provided to the questions for TR and OP flexibility. A definition of the reconfiguration of information linkages in STR flexibility was also provided to enhance the questionnaire's explicitness. Moreover, similar terminologies were unified into a single term. The wordings used before and after the modification of the questionnaire are shown in Table 5.18.

Before peer review	After peer review
We can access external firms effectively by using our advanced hardware	We can effectively transact with external firms by using our advanced hardware (e.g. Computer, field devices, sensors, meters, servers etc.)
We can access partner firms effectively by using our advanced software and applications	We can effectively transact with external firms by using our advanced software and applications (e.g. logistics portals, email systems)
We can access partners firms effectively by using our advanced network	We can effectively transact with external firms by using our advanced network (e.g. internet, LAN, telephone, text, email)
We can access our IT network properly and securely to communicate with partner firms	We can effectively access our IT network properly and securely to communicate with external firms (e.g. internet/LAN access anytime anywhere)
We can access a wide range of partner firms through our IT network	We can access a wide range of external firms through our IT network (e.g. *number of external firms* we can access through our portal)
We can work together with our partner firms through standardised information format	We can effectively transact with our external firms through standardised information format e.g. Excel, PDF, HTML, EDI
We can have partnership with existing external firms e.g. customers, suppliers and third party logistics providers	We can easily build and alter our information linkages to our *existing* supply chain partners e.g. customers, suppliers and third party logistics providers in response to changes in the business environment
Use of partner firms, existing external firms, supply chain stake holders interchangeably	Use of external firms and partners

Table 5.18 Modification of Questionnaire after Peer Review
Source: Author.

The final questionnaire distributed is presented in Appendix 1 with the ethical approval form for this study. Questionnaire in English is the main questionnaire but on request of respondents, questionnaires in different language is also supplemented (in Chinese and Korean). Native speakers translated the questionnaire. The translated questionnaire is peer reviewed by 3rd party native speakers and the key informants who requested the different version of questionnaire.

5.7 SUMMARY

This chapter focussed on the research method applied in this study. Based on the positivistic approach, research strategy and approach, it was determined that this research would take an abductive approach to IT flexibility research model, as this study seeks to formulate a new theory from an observation, test hypotheses using a quantitative approach and conduct further empirical tests to generalise the research model. Several research methods were explored that had the following characteristics: 1) capability to quantify the perceptions on IT flexibility in multiple dimensions, 2) capability to analyse the mediating affect and 3) capability to prioritise the dimensions. Finally, PLS SEM was selected as the best approach. In particular, the importance–performance matrix was discussed as an appropriate tool to prioritise the multiple dimension of flexibility by supplementing PLS SEM. To collect data for hypothesis tests, considering the required qualifications for inclusion in the study, a key informant survey was proposed as an appropriate method. Finally, considering the research object, methods and design, the questionnaire development process were presented. Chapter 6 focusses on the empirical data analysis.

CHAPTER 6. EMPIRICAL ANALYSIS

6.1 INTRODUCTION

This chapter presents the empirical data analysis result according to three themes, namely descriptive analysis, hypothesis testing and the application of the model. First, in section 6.2, the overall picture of the responses from the questionnaire survey and the basic statistics regarding the general trends of the constructs investigated are presented. Here, the data are elucidated using descriptive statistics via their central tendency and dispersion. Statistical tools like descriptive statistics enable researchers to describe and compare variables regarding research questions and objectives in a numerical fashion (Saunders et al. 2012).

Section 6.3 examines the research model through hypothesis testing, for which PLS SEM is employed. After the hypothesis test results are provided, this section develops an alternative model test to confirm whether the proposed IT flexibility research model presents the characteristics of the IT flexibility structure better than other models.

Finally, in section 6.4, the three IT flexibility dimensions are prioritised, and an approach to allocating resources in an efficient manner is suggested. To accomplish this, first, the PLS SEM result is extended to the IPA matrix. Then, the most important dimension of the three dimensions – that which should show the highest performance – is identified. Next, a specific firm's data is applied to the IT flexibility research model and the performance and importance scores of the IT flexibility dimensions are analysed by again extending the PLS SEM results to the IPA matrix. Finally, by examining whether the dimensions show a proper level of performance according to their importance, any flexibility requiring immediate investment or downsizing of the current investment is identified.

6.2 DESCRIPTIVE ANALYSIS

Using the list of companies and professionals, 35 key informants were identified. The questionnaires were distributed to these informants, who were formally instructed to distribute the questionnaire to colleagues that were also expected to have proper experience and knowledge on the use of IT in SCM. The distribution began in May 2014 and continued for 16 weeks. 132 questionnaires which answered to all competency related questions (question 2, 3, 4 in section A) were acquired. 4 questionnaires which had more than 15 % of missing values are removed based on the recommendation provided by Hair et al. (2013) so ultimately, 128 valid responses were acquired. Treatment on missing values will be further discussed in section 6.3.1.

Three themes are discussed in this section to provide an overview of responses. First, in section 6.2.1, common method and nonresponse bias test results are provided. These two tests are recommended as part of the PLS SEM process, as discussed in section 5.4.2. In section 6.2.2, demographic profiles of respondents are presented. In this section, the characteristics of respondents are initially discussed, and then responses to the questions included to identify the competency of respondents in this study are also analysed. Finally, in section 6.2.3, descriptive analysis of the five research constructs – TR flexibility, OP flexibility, STR flexibility, PIC and FP – is presented.

6.2.1 The Common Method Bias and Nonresponse Bias Tests

As the survey was completed by single informants, concerns related to common method bias should be addressed. The effect of common method bias is generally recognised as an element threatening the validity of behavioural research (Podsakoff et al. 2003). To minimise the likelihood of common method bias, procedural remedies were applied as proposed by Podsakoff and Organ (1986), Podsakoff et al. (2003) and Chang et al. (2010). For example, questions on IT flexibilities were asked in different sections of the questionnaire, and they were separated from PIC and FP to create division between the predictor and criterion variables. Scales of IT flexibility, PIC and FP were differentiated, as IT flexibility dimensions were measured with values from ‘strongly disagree’ to ‘strongly agree’. PIC was measured with values from ‘much worse’ to ‘much improved’, whereas FP was measured with values from ‘much worse’ to ‘much better’. The present research used concise and clear items, and anonymity/confidentiality were assured and protected. The usefulness of this research was highlighted to reduce respondents’ evaluation apprehension.

As the dependent and independent variables were measured using the same instrument and the concept of IT flexibility also covers employees perception regarding the use of IT, where potential causes of common method bias may exist (Podsakoff et al. 2003), two tests were performed to identify whether common method bias was a cause for concern. First, Harman’s single factor test was performed evaluate whether the majority of the variance is explained by a single factor. The nonrotated solution exploratory factor analysis extracted four factors with an eigenvalue above 1.0, as opposed to a single factor, and they accounted for 60% of the total variance. Moreover, as the first factor (23%) did not account for a majority of the variance, a considerable amount of common method variance did not present in the current study (Podsakoff and Organ 1986; Podsakoff et al. 2003).

In this research a test proposed by Pavlou et al. (2007) and Siponen and Anthocy (2010) was also conducted; here, the construct correlation matrix computed with PLS was used to examine whether any construct correlated highly (Table 6.1). This was done because extremely highly correlated (more than .90) variables means the possibility of common method bias. In this research, no constructs were so highly correlated. Therefore, it can be concluded that common method bias was not a significant problem in the study.

Latent variables	Process integration capability	Firm performance	Operational flexibility	Strategic flexibility	Transactional flexibility
Process integration capability	**0.867**				
Firm performance	0.685	**0.789**			
Operational flexibility	0.556	0.465	**0.843**		
Strategic flexibility	0.490	0.483	0.795	**0.842**	
Transactional flexibility	0.540	0.461	0.742	0.668	**0.753**

Table 6.1 Fornell–Larcker Criterion Analysis.
Source: Author.

Due to the limitation of the data collection method used to invite qualified respondents to participate in the survey, the conventional response rate calculation was not allowed (Gosain et al. 2004, Li et al. 2003; Su and Yang 2010; Williams et al. 2013). Thus, this study used respondent data to assesse non response bias. A non-response bias test was conducted using the recommendations suggested by Armstrong and Overton (1997). The last quartile of respondents were assumed to be the most similar to nonrespondents, as their replies took the longest time to gather; so the respondents from the last quartile were compared with those acquired in the first quartile (Armstrong and Overton 1997). Two types of nonparametric tests of difference, namely the Mann–Whitney test and Wilcoxon matched-pairs signed-ranks test, were used to determine whether the two data samples were different (Brace et al. 2006). The test result indicated that there was no significant difference between the two groups ($p > 0.05$) of the first quartile ($n = 32$) and last quartile ($n = 32$). Only one variable (COST) is recognised had a p-value (0.054) close to the threshold of 0.05. Therefore, it was assumed that nonresponse bias was not a significant issue in this research. The results of the nonresponse bias test are presented in Appendix 2.

6.2.2 Demographic Profiles of the Respondents

This section will report the demographic characteristics related to two categories, namely characteristics of respondents and characteristics of their firms.

1) IT use for supply chain wide activities—Three qualifying questions

As discussed in section 5.6, three questions were prepared to screen the respondents' competency for this questionnaire. Due to the widely dispersed use of IT for supply chain operations and value-creation activities, only respondents who were knowledgeable in various types of IT use and IT capabilities at different levels were selected as appropriate candidates. Therefore, respondents who filled in all three qualifying questions were included in this study. The respondents not only completed the questions, but they also showed consistency and reliability in answering the questionnaire; this intensified the validity of the survey.

By providing multiple answers, respondents were asked to indicate what kinds of IT are used for their supply chain operations. Three questions derived from the characteristics of the three IT flexibility dimensions included on the questionnaire. The first question asked about the use of IT for interfirm connectivity and networks. This question is in line with TR flexibility. The second question was about the use of IT for information sharing and interfirm operations for efficiency gains; this is in line with OP flexibility. The third questions regarded the use of IT for supply chain–structure reconfiguration for service and product offerings according to the market requirements; this is in line with STR flexibility.

The responses to the first question showed that the respondents were using a range of IT technologies and applications to connect to their trade partners. Specifically, networking with Web-based emailing and mobile messenger services represented the most common IT (n = 81) used to access supply chain partners. Hardware, such as LANs, GPS, satellite systems, which were frequently used in the transportation process, also showed higher frequency (n = 67). Software, such integrated logistics portals, also exhibited higher frequency (n = 57), while access through an intranet (n = 56) and RFID applications as an interoperable IT were also observed (n = 28). Table 6.2 and Figure 6.1 summarise the types of IT used for interfirm connectivity and physical network arrangements.

Context	Types	Frequency
Interfirm connectivity and network	Web-based email and mobile messenger services	81
	Local area network (LAN), global positioning system (GPS), satellite systems	67
	Integrated logistics portal	57
	Intranet	56
	RFID applications	28
	Other (ERP, SAP)	2

Table 6.2 Types of IT for Connectivity at the Transactional Level
Source: Author.

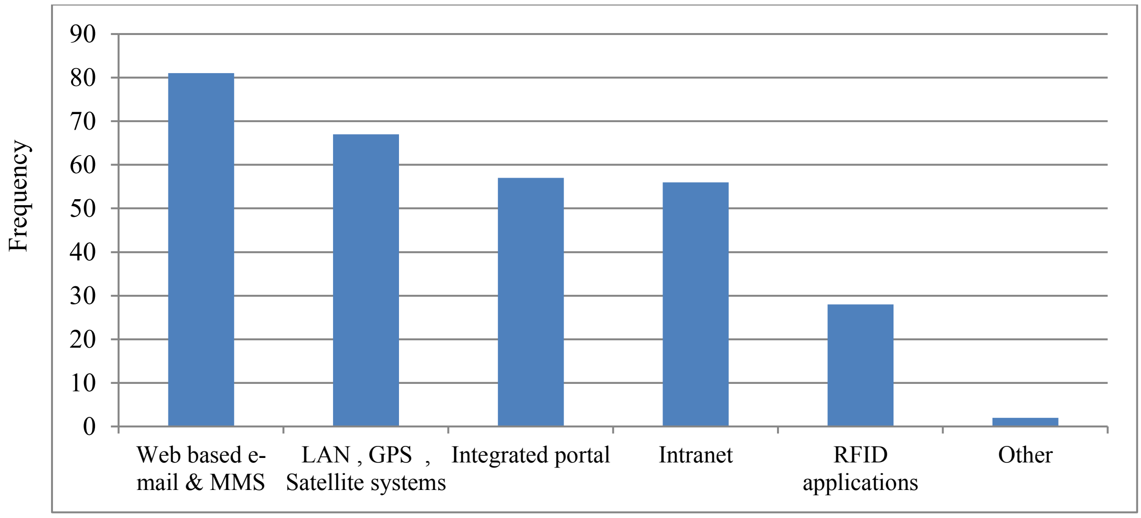


Figure 6.1 Types of IT for connectivity at the transactional level.
Source: Author.

In terms of the second question, IT for interfirm coordination and process automation via a higher level of information visibility were suggested as exemplars. TMS (*n* = 73), which compute the best way to ship the materials according to the order, were identified as the most widely used application from the question. It is known that, by using TMS, distribution processes are improved through fleet utilisation and streamlining reporting on transport process. WMS (*n* = 69), material requirement planning (*n* = 59) and real-time tracking and tracing systems (*n* = 46), which are closely related to material handling, were also identified as widely used applications. In general, such applications are interlinked to allow operators to have real-time views of material flows and storage within the warehouse and to allow firms to coordinate all of the transactions in material handling (Mason et al. 2003; Helo and Szekely 2005).

IT and IT applications were identified in more supplier-side interfirm operations, such as procurement and freight-auctioning systems ($n = 34$) and electronic invoice and fund-transferring systems ($n = 30$), were identified. Market-side applications, such as retail and sales management systems ($n = 18$) also captured. Relatively newly emerged applications, such as enterprise social network and decision-support systems, were also observed, but they were not as common as material handling and supplier management–related IT applications. Overall, although not all of the respondents filled in all of the questions, they also showed a reasonable level of consistency regarding this question, as the answers mirrored supply chain practices. Table 6.3 and Figure 6.2 summarise the types of IT used for information sharing and interfirm operations in supply chains.

Context	Types	Frequency (*n*)
Information sharing and interfirm operations for efficiency gains	Transport management systems	73
	Warehouse management systems	69
	Material requirement planning	59
	Real-time tracking and tracing systems	46
	Procurement and freight-auctioning systems	34
	Electronic invoice and fund-transferring systems	30
	Retail and sales management systems	18
	Enterprise social networks, such as Yammer	13
	Decision-support systems	11
	Other (drivers' Facebook pages, drivers' Twitter pages)	3

Table 6.3 Types of IT for Information Sharing and Process Improvement
Source: Author.

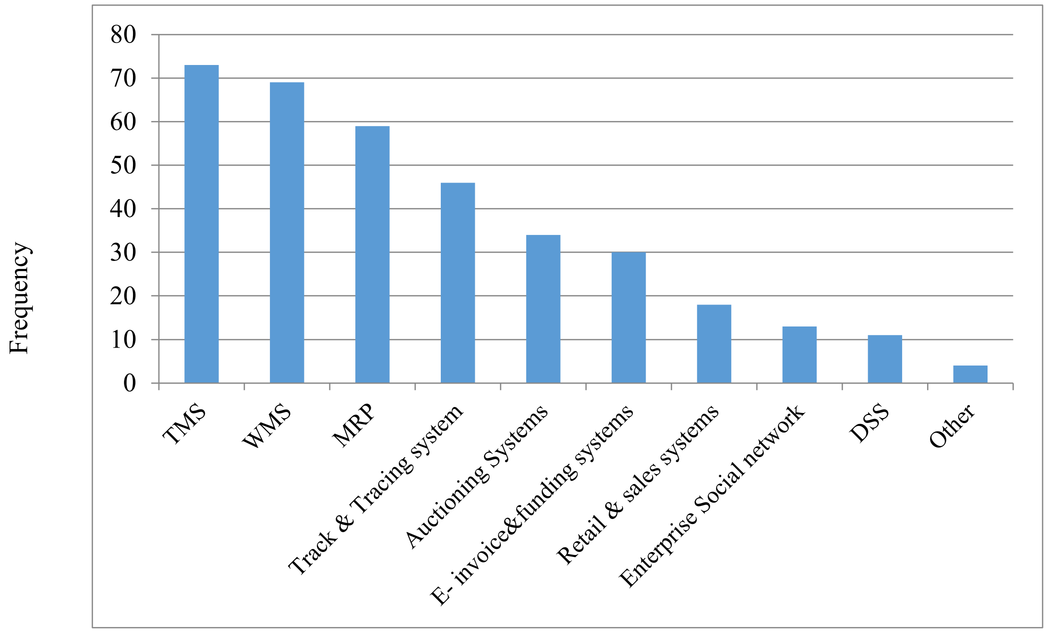


Figure 6.2 Types of IT for information sharing and process improvement.
Source: Author.

In terms of IT for supply chain configuration, the CRM system (n = 60), which is used to build close relationships with customers and produce future strategies, was identified the most widely IT application in service and product offerings. SRM (n = 47), which is used for partnership building and the development of purchasing strategy, was also observed as an application to (re)configure the supply chain relationships. VMI (n = 46), which enables shred ownership of the inventory and supports partnership configuration, was also identified. Collaboration portals (n = 45), sales/demand forecasting systems (n = 36) and electronic logistics networks (n = 33), which intensify the strategic and collaborative supply chain activities, were also observed. Table 6.4 and Figure 6.3 summarise the types of IT used for supply chain reconfiguration and offerings.

Context	Type	Frequency (n)
Supply chain structure reconfiguration and service/ product offering	Customer relationship management (CRM) systems	60
	Supplier relationship management (SRM) systems	47
	Vendor-managed inventory (VMI) systems	46
	Collaboration portal	45
	Sales/demand forecasting systems	36
	Electronic logistics network/marketplaces	33
	Other (remote access via Citrix, SAP ID sharing, electronic order management)	3

Table 6.4 Types of IT for Supply Chain Reconfiguration
Source: Author.

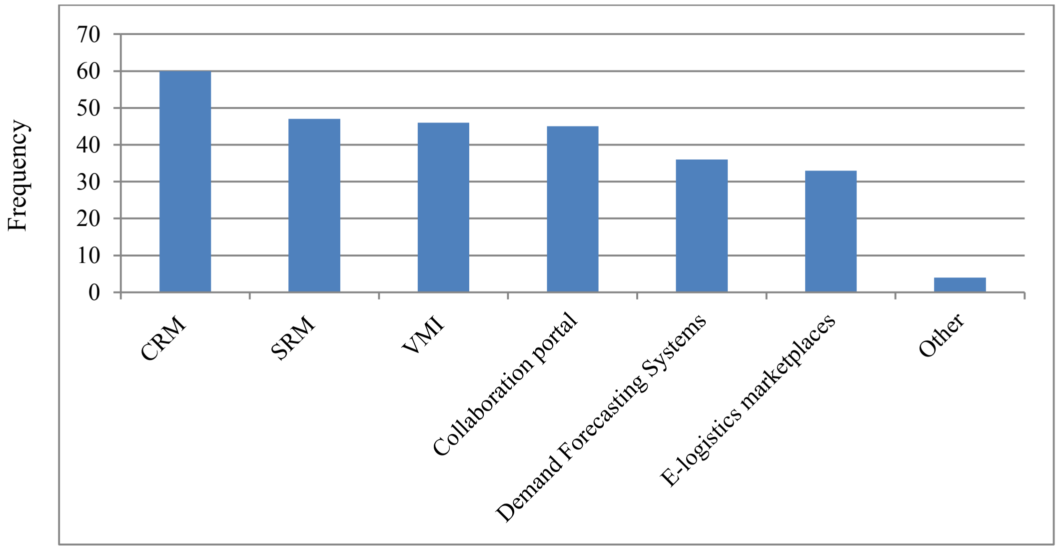


Figure 6.3 Types of IT for supply chain reconfiguration and innovative activities

Source: author

2) Characteristics of respondents' firms

As determined in section 5.6.1, the target respondents for this study were employees involved in the supply chain process who are familiar with the use of IT for interorganisational business activities. To cover supply chain-wide interfirm operations and value creation activities, this study intended to collect data throughout the upstream and downstream supply chains.

First, owing to the large scope of supply chain operations, the types of services they provide were identified to ensure that the firms supply chain operations cover the whole business process from manufacturing and distribution. This question (what type of services do you provide) was also required to ensure that the questionnaire was delivered to the right respondents and reliable data were acquired. Firms involved in supply chains provide several or integrative services covering manufacturing to logistics, so it is difficult to characterise the types of services that firms provide with one or two service types. However, by allowing respondents to indicate several answers, the overall image of the respondents' firm operation area was acquired. The analysis of the questionnaire showed that it was completed by representatives from manufacturing firms (*n* = 29), warehousing service providers (*n* = 36), integrated logistics providers (*n* = 38) and logistics intermediaries such as 3PL companies (*n* = 20). The distribution of services in the respondents' firms indicated that the questionnaires were collected from heterogeneous companies covering manufacturing to distribution; therefore, the responses could apply to this study with confidence (Figure 6.4).

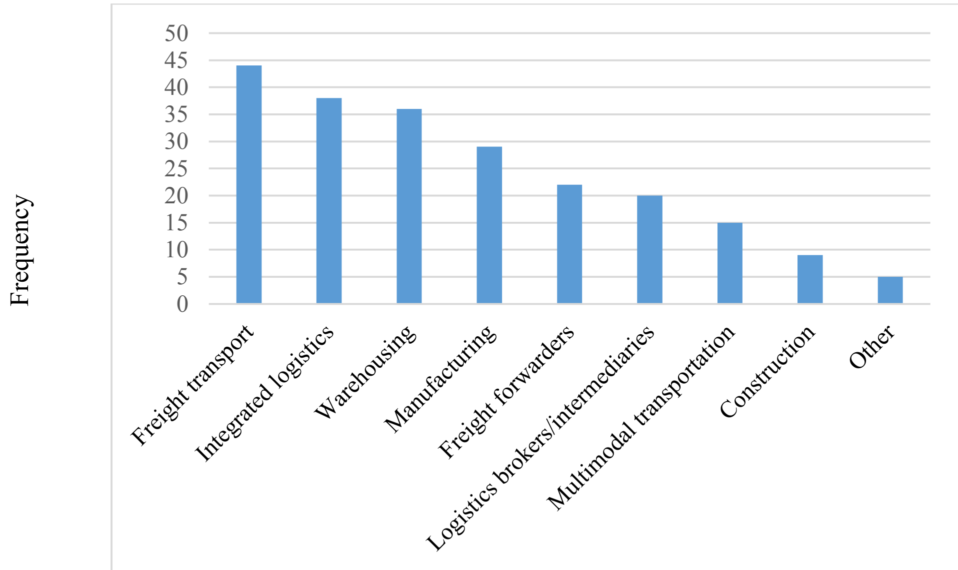


Figure 6.4 Operations and services provided by the respondents' firms.
Source: Author.

Second, the number of employees and the company age were considered to assess the general background of the respondents' firms. It was revealed that 15.6% of the firms employed fewer than 50 workers (*n* = 20), 31.3% employed 51–300 workers (*n* = 40), 21.1% employed 301–500 workers (*n* = 27), 14.4% employed 501–1000 workers (*n* = 18) and 15.6% had more than 1000 employees (*n* = 20). The samples were obtained from a wide variety of firms thus avoiding the large firm bias present in supply chain studies (Williams et al. 2013). In terms of company age, it was found that 20.3% of the respondents' firms had been operating for 1–5 years (*n* =26), 22.7% were 6–10 years old (*n* = 26), 23.4 % were 11–20 years old (*n* = 30) and 33.6% had been established for more than 21 years (*n* = 43).

From the widely-dispersed patterns of distribution in company age and number of employees, it is suggested that the sample is representative of heterogeneous companies in the industry. The firms employing a small number of workers were often logistics brokers and intermediaries, which are able to operate with a small business comprising a relatively low number of workers. Although the firm sizes of such intermediaries are small, to maintain their work—which involves interlinking service providers and service users—they also used IT services intensively, including CRM, email, standardised document formats and shared service portals. Figure 6.5 and Table 6.5 depict these characteristics of the profiles of respondents' firms in terms of company age and number of employees.

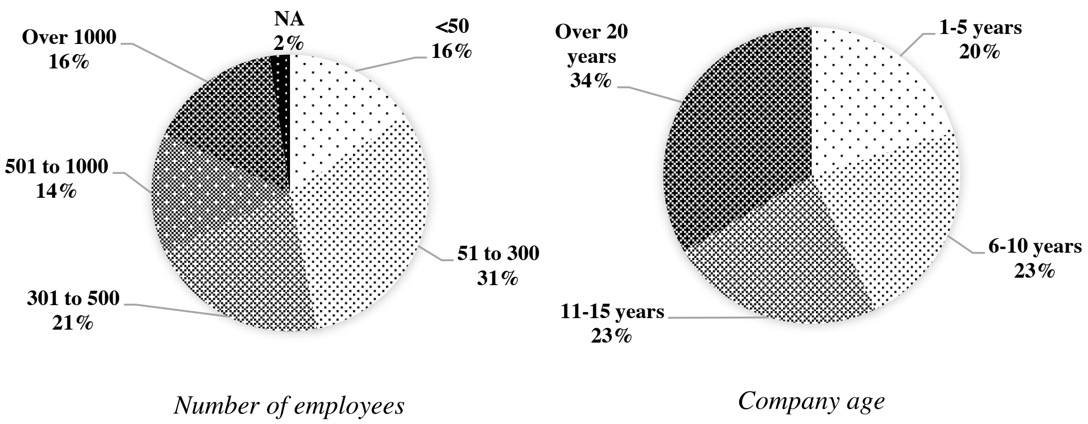


Figure 6.5. A pictorial profile of the respondents' firms: Number of employees (left) and Company age (right).
Source: Author

Respondent variable	Category	Frequency (*n*)	%	Cumulative %
Number of employees	<50	20	15.6	15.6
	51–300	40	31.3	46.9
	301–500	27	21.1	68.0
	501–1000	18	14.1	82.0
	Over 1000	20	15.6	97.7
	Not available	3	2.3	***100.0***
	Sum	***128***	***100.0***	
Company age	1–5 years	26	20.3	20.3
	6–10 years	29	22.7	43.0
	11–20 years	30	23.4	66.4
	Over 21 years	43	33.6	***100.0***
	Sum	***128***	***100.0***	

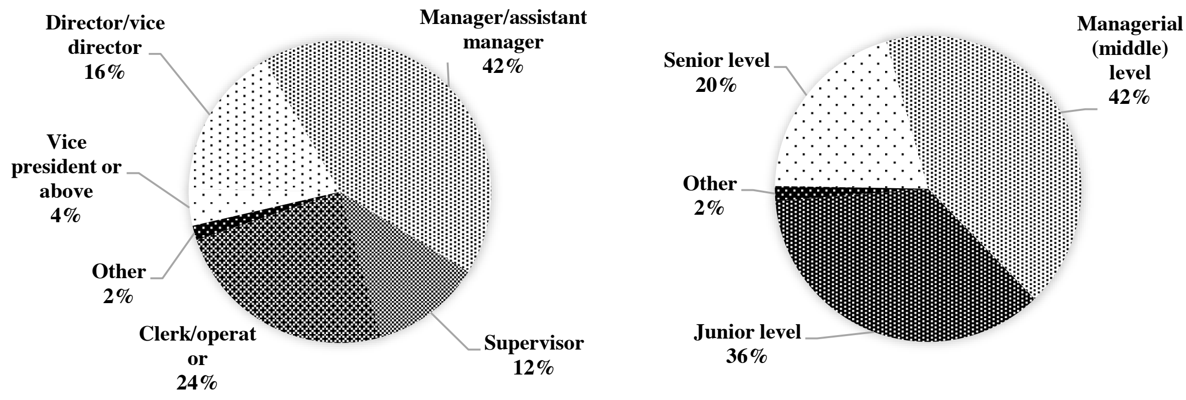
Table 6.5 Overall Descriptive Statistics for Respondents' Firms: Company Age and Number of Employees.

Source: Author.

3) Characteristics of respondents

This study's target respondents cover senior executives at the strategic level and employees at the operational and transactional level. This is because a knowledgeable respondent, such as a logistics operator, often has much better knowledge about IT use and skills for critical transactional and operational indicators than senior level employees as such individuals directly acquire their knowledge from the supply chain practices. Therefore, the respondents' levels of responsibility should be highlighted.

The sample tends to meet the requirements of this study because the proportion of each group showed that the questionnaire adequately reached the target respondents, including senior, junior, and mid-level employees. The samples covers vice president or above (3.9%, $n = 5$), director/vice director (16.4%, $n = 21$), manager/assistant manager (42.2%, $n = 54$), supervisor (11.7%, $n = 15$) and clerk/operator (24.2%, $n = 31$). Therefore, it was demonstrated that the managerial level employees are accessed (manager and assistant manager 42.2%, n = 54), and the data also includes a senior level share at 20.3% (director/vice director 16.4%, vice president or above 3.9%, n = 26) and junior level of employees at 35.9% (supervisor 11.7%, clerk/operator 24.2%, n = 46). The composition of the different respondents' positions indicates that knowledge about IT flexibility, which is dispersed across supply chain-wide operations and covers transactional, operational and strategic level activities, can be demonstrated from the acquired sample. Figure 6.6 and Table 6.6 highlight the composition of the final sample regarding the levels of responsibility.



Level of responsibility in five levels *Level of responsibility in three levels*

Figure 6.6 A pictorial profile of the survey respondents: Level of responsibility in five levels (left) and in three levels (right).
Source: Author.

Respondent variable	Category	Frequency *(n)*	%	Cumulative %
Level of responsibility	Vice president or above	5	3.9	3.9
	Director/vice director	21	16.4	20.3
	Manager/assistant manager	54	42.2	62.5
	Supervisor	15	11.7	74.2
	Clerk/operator	31	24.2	98.4
	Other	2	1.6	***100.0***
	Sum	***128***	***100.0***	

Table 6.6 Descriptive Statistics for Respondents: Level of Responsibility.
Source: Author.

Moreover, the area of responsibility that identified whether the respondents' knowledge fell into the category of supply chain related activities, supported the competency of the respondents. More than 83.6% of the respondents reported that they were responsible for supply chain and logistics (*n* = 107), as presented in Figure 6.7 and Table 6.7. It is expected that other respondents responsible for marketing and IT are also involved in supply chain operations, as customisation and product offerings are closely related to marketing activities with the support of IT (Baradwaj 2007; Kim et al. 2011).

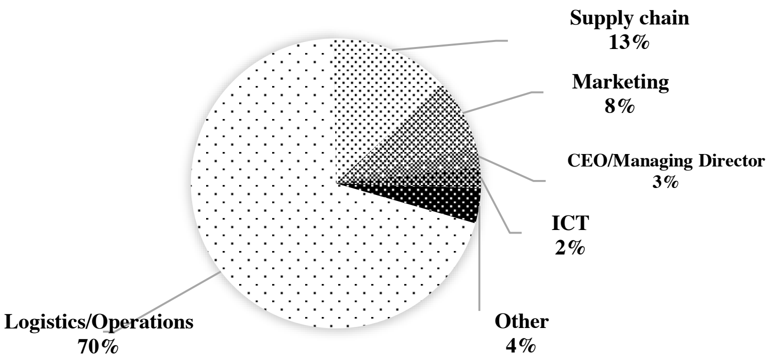


Figure 6.7 A Pictorial profile of the survey respondents: Area of responsibility

Source: Author

Respondent variable	Category	Frequency (*n*)	%	Cumulative %
Area of responsibility	CEO/managing director	3	2.3	2.3
	Logistics/operations	90	70.3	72.7
	Supply chain	17	13.3	85.9
	IT	3	2.3	88.3
	Marketing	10	7.8	96.1
	Other	5	3.9	***100.0***
	Sum	***128***	***100.0***	

Table 6.7 Descriptive Statistics for Respondents: Area of Responsibility.

Source: Author.

It should be noted that the questionnaire reached respondents around the world working for multinational companies. Unfortunately, a post hoc discussion with some informants identified that the comparison of samples between different countries was not possible. This was because, first, their locations were not traceable by language as the English version of the questionnaire was widely selected regardless of the geographical location of the respondent. Second, some respondents answered from the viewpoint of their headquarters in the mother country although they work in a branch (or subsidy) in a different country. Third, some informants failed to identify the geographical locations where the questionnaire were distributed.

6.2.3 Descriptive Statistics for the Main Questions

After investigating the demographic characteristics of the survey respondents and their firm backgrounds, the focus turns to the questions incorporated in the survey for the five measurement constructs, namely TR flexibility, OP flexibility, STR flexibility, PIC and FP. Abbreviation of items will be used from the following sections to simply the presentations of descriptive statistics. Table 6.8 contains abbreviation of the items.

<table>
<tr><th>Flexibility dimensions</th><th>Sub-dimensions</th><th>Indicators</th><th>Description</th></tr>
<tr><td rowspan="6">Transactional flexibility (TR flexibility)</td><td rowspan="3">IT infrastructure</td><td>Hardware (HW)</td><td>Advancement of hardware that enables information flow and facilitates decisions</td></tr>
<tr><td>Software (SW)</td><td>Advancement of IT applications that permit the hardware to enable information flow and facilitate decisions</td></tr>
<tr><td>Networks (NW)</td><td>Advancement of network enablement that allows the hardware to enable information flow and facilitate decisions</td></tr>
<tr><td rowspan="3">Connectivity</td><td>Access (ACC)</td><td>The ability of IT systems to legitimately access information resources</td></tr>
<tr><td>Linkages (LNK)</td><td>Level of reach (connection with a wide audience)/ range (sharing information across a variety of IT platforms)</td></tr>
<tr><td>Interoperability (INTP)</td><td>The ability of IT systems to enable firms to work together through mutually agreed-upon technical/operational standards</td></tr>
</table>

Operational flexibility (OP flexibility)	Information sharing	Quality (QLT)	Timeliness and accuracy of information
		Visibility (VIS)	The level of knowledge about where materials and parts are at any given time
		Speed (SPD)	How quickly transactions are conducted and information is exchanged
	Process improvement	Streamlining (STRM)	The level of automation and integration of business processes for better monitoring and control
		Optimisation (OPT)	Business intelligence, what-if, dynamic rerouting
Strategic flexibility (STR flexibility)	Partnering	Partnering with existing partners (PTN 1)	The ability of interfirm systems to build and alter linkages to existing supply chain players
		Partnering with changing partners (PTN 2)	The ability of interfirm systems to build and alter linkages to new supply chain players
	Offering	Offering improved services or products (OFF)	The ability of interfirm linkages to support changes in product or service offerings to customers
Process integration capability (PIC)	Process integration capability 1 (PIC1)		The ability to integrate sourcing, transport and service processes internally
	Process integration capability 2 (PIC2)		The ability to integrate sourcing, transport and service processes with external firms
	Process Integration Capability 3 (PIC3)		The ability to integrate processes with customers
Firm performance (FP)	Cost (CST)		Transaction cost of business operations
	Service (SVC)		Level of service provided to customers
	Speed (SPD_P)		Speed of business operations
	Quality (QLL_P)		Quality of service provided to customers
	Value (VAL)		Value creation in the supply chain

Table 6.8 Abbreviations of Items

Source: Author.

In an attempt to assess TR flexibility, respondents were asked to rate how well their IT infrastructure performs for interfirm network arrangements with external partners in supply chains. TR flexibility, as discussed above, was divided into two subsections – IT infrastructure and connectivity. These were measured with three items each (HW, SW and NW for IT infrastructure; ACC, LIK and INTP for connectivity) using 7-point scales ranging from ‘strongly disagree’ (1) to ‘strongly disagree’ (7). Table 6.9 presents the percentage frequencies for all items and their central tendency, that is, the mean and dispersion (standard deviation [SD]) of TR flexibility (Saunders et al. 2012).

Construct	Items	Response scale (%)								Mean	SD
		1.0	2.0	3.0	4.0	5.0	6.0	7.0	Missing		
TR flexibility	HW	1.6	2.3	3.1	10.2	16.4	42.2	24.2	0.0	4.61	1.13
	SW	0.8	1.6	2.3	10.9	16.4	41.4	26.0	0.8	4.70	1.20
	NTW	0.8	0.0	0.8	9.4	17.2	45.3	26.6	0.0	4.84	1.03
	ACC	0.8	2.3	2.3	14.1	20.3	35.9	23.4	0.8	4.54	1.27
	LNK	2.3	2.3	3.1	14.1	32.0	21.1	23.4	1.6	4.32	1.32
	INTP	0.8	0.0	3.1	8.6	16.4	38.3	32.0	0.8	4.85	1.14

Table 6.9 Descriptive Statistics for TR Flexibility
Source: Author.

The assessment of TR flexibility indicated the following:

1) 66.4% of the respondents agreed that they can effectively transact with external firms using their advanced hardware (HW: Mean = 4.61; SD = 1.13);
2) 67.4% agreed that they can effectively transact with external firms by using their advanced software and applications (SW: Mean = 4.70; SD = 1.20);
3) 71.9% agreed that they can effectively transact with external firms by using their advanced network (NTW: Mean = 4.84; SD = 1.03);
4) 59.3% agreed that they can effectively access their IT network properly and securely to communicate with external firms (ACC: Mean = 4.54; SD = 1.27);
5) 44.5% agreed that they can access a wide range of external firms through their IT network (LINK: Mean = 4.32; SD = 1.32); and
6) 70.3% agreed that they can effectively transact with their external firms through standardised information (INTP: Mean = 4.85; SD = 1.14).

Overall, most respondents perceived that TR flexibility was significantly above the midpoint. In particular, NW (network: advancement of network enablement that allows the hardware to enable facilitate decision) and INTP (interoperability: the ability of IT systems to enable firms to work together through mutually agreed-upon technical/operational standards) were considered significantly above the midpoint in relation to the other indicators. In contrast, LINK (linkage: the level of reach [connection with a wide audience]/range [sharing information across a variety of IT platforms]) showed a relatively lower average of 4.32. The mean value of items ranged from 4.32 to 4.85.

The respondents were also asked to assess their agreements according to OP flexibility, which consists of two subdimensions – information sharing and process improvement. Three indicators (QLT, VIS, SPD) for information sharing and two indicators (STRM, OPT) for process improvement were used to measure OP flexibility. A 7-point Likert scale ranging from 'strongly disagree' to 'strongly agree' was used. Table 6.10 represents the descriptive statistics for OP flexibility.

Construct	Item	Response scale (%)								Mean	SD
		1.0	2.0	3.0	4.0	5.0	6.0	7.0	Missing		
OP flexibility	QLT	0.0	1.6	2.3	11.7	13.3	43.8	26.6	0.8	4.76	1.14
	VIS	1.6	2.3	1.6	11.7	27.3	26.6	28.1	1.6	4.55	1.33
	SPD	0.0	.8	2.3	11.7	25.0	35.9	23.4	.8	4.65	1.09
	STRM	.8	.8	6.3	10.2	22.7	35.9	21.1	2.3	4.51	1.24
	OPT	.8	1.6	3.1	15.6	24.2	38.3	15.6	.8	4.40	1.19

Table 6.10 Descriptive Statistics for OP Flexibility
Source: Author.

The assessment of OP flexibility indicated the following:

1) 70.4% of respondents agreed that they can share accurate and timely information with their external firms (QLT: Mean = 4.76; SD = 1.14);
2) 54.7% agreed that they can gain good visibility of logistics processes with their external firms (VIS: Mean = 4.55; SD = 1.33);
3) 59.3% agreed that they can complete transactions rapidly with their external firms (SPD: Mean = 4.65; SD = 1.09);

4) 57.0% agreed that they can integrate and automate logistics process with their external firms (STRM: Mean = 4.51; SD = 1.24); and

5) 53.9% agreed that they can optimise the logistics processes with external firms (OPT: Mean = 4.40; SD = 1.19).

Although the indicators for process improvement (STMR, OPT) showed relatively lower average than the indicators for information sharing (QLT, VIS, SPD), the overall mean value of OP flexibility indicators were well above midpoint level. The mean value of items ranged from 4.40 to 4.76.

Third, the respondents were asked their views on STR flexibility focussing on supply chain reconfiguration and product/service offering, which was composed of two subdimensions – partnering and offering. Three indicators were used to measure the STR flexibility, namely PTN 1 and PTN 2 for partnering and OFF for offering. To measure STR flexibility, a 7-point Likert scale ranging from 'strongly disagree' (1) to 'strongly agree' (7) was used. Table 6.11 represents the descriptive statistics for STR flexibility.

Construct	Items	Response scale (%)								Mean	SD
		1.0	**2.0**	**3.0**	**4.0**	**5.0**	**6.0**	**7.0**	**Missing**		
STR flexibility	PTN 1	1.6	0.8	3.1	11.7	23.4	34.4	23.4	1.6	4.56	1.26
	PTN 2	.8	3.1	8.6	9.4	35.2	28.9	13.3	.8	4.17	1.29
	OFF	.8	1.6	0.0	12.5	28.1	32.0	24.2	.8	4.61	1.16

Table 6.11 Descriptive Statistics for STR Flexibility
Source: Author.

The assessment of STR flexibility indicated the following:

1) 57.8% of the respondents agreed that they can easily build and alter information linkages to *existing* supply chain partners (e.g. customers, suppliers and third-party logistics providers) in response to changes in the business environment (PTN1: Mean = 4.56; SD = 1.26);

2) 42.2% agreed that they can easily build and alter information linkages to *new* supply chain partners (PTN2: Mean = 4.17; SD = 1.29); and

3) 56.2% agreed that they are actively exploring innovative ways of using IT in offering new products or services to customers (OFF: Mean = 4.61; SD: 1.16).

All of the indicators of STR flexibility were above the midpoint level. A notable observation in this construct was that, compared to the other two IT flexibility dimensions, STR flexibility indicators showed a relatively lower average value. Particularly, PTN2 showed the lowest mean value among the 13 indicators of IT flexibility. The mean value of items ranged from 4.17 to 4.61.

Fourth, respondents were asked to indicate their opinions on the PIC. PIC was measured with three indicators, namely PIC1, PIC2 and PIC3. TR flexibility was measured through a 7-point Likert scale ranging from 'much worse' (1) to ' much improved' (7). Table 6.12 provides the descriptive statistics for PIC.

Construct	**Items**	**Response scale (%)**								**Mean**	**SD**
		1.0	**2.0**	**3.0**	**4.0**	**5.0**	**6.0**	**7.0**	**Missing**		
PIC	PIC1	0.0	0.0	0.0	10.9	27.3	40.6	19.5	1.6	4.70	.915
	PIC2	0.0	0.0	0.0	15.6	27.3	43.8	13.3	0.0	4.55	.912
	PIC3	0.0	0.0	0.0	17.2	25.8	44.5	12.5	0.0	4.52	.922

Table 6.12 Descriptive Statistics for PIC.
Source: Author.

The assessment of PIC with three indicators suggested the following:

1) 60.1% of respondents perceived that their capability to integrate sourcing, transport, service process and other areas internally had improved (PIC 1: Mean = 4.70; SD = 0.92);
2) 57.1% perceived that their capability to integrate sourcing, transport, service process and other areas with suppliers had improved (PIC 2: Mean = 4.55; SD = 0.91); and

3) 57.0% perceived that their capability to integrate sourcing, transport, service process and other areas with customer had improved (PIC 3: Mean = 4.52; SD = 0.92).

Overall, respondents perceived that PIC was well above the midpoint; the mean value of items ranged from 4.52 to 4.70.

Finally, the respondents were asked to indicate their opinions of FP, which was measured with five indicators, namely COST, SVC, SPD_P, QLT_P, VAL. FP was measured through a 7-point Likert scale ranging from 'much worse' (1) to 'much better' (7). Table 6.13 presents the mean and dispersion (SD) of FP.

Construct	Items	Response scale (%)								Mean	SD
		1.0	2.0	3.0	4.0	5.0	6.0	7.0	Missing		
FP	COST	0.0	0.0	.8	10.9	28.1	45.3	14.8	0.0	4.63	.896
	SVC	0.0	0.0	1.6	7.0	30.5	39.8	21.1	0.0	4.72	.930
	SPD_P	0.0	0.0	0.0	9.4	25.0	39.8	25.0	.8	4.81	.924
	QLT_P	0.0	0.0	.8	7.8	31.3	41.4	18.8	0.0	4.70	.892
	VAL	.8	0.0	0.0	19.5	28.1	37.5	13.3	.8	4.42	1.035

Table 6.13 Descriptive Statistics for FP
Source: Author.

The assessment of FP with three indicators suggested the following:

1) 60.1% of respondents perceived that their transaction costs for supply chain operations were reduced (COST: Mean = 4.63; SD = 0.90);
2) 60.9% thought that their level of service provided to customers had improved (SVC: Mean = 4.72; SD = 0.93);
3) 64.8% viewed that their speed of logistics operations had improved (SPD_P: Mean = 4.81; SD = 0.92);

4) 60.2% thought that their quality of service to customers had improved (QLT_P: Mean = 4.70; SD = 0.89); and

5) 50.8% perceived that the value creation in their supply chains had improved (VAL: Mean = 4.42; SD = 1.04).

It can generally be stated that respondents perceived that FP was well above the midpoint level. The mean of items for FP ranged from 4.42 to 4.81. The highest item was SPD_P (speed: speed of business operations) and the lowest value was VAL (value: value creation in the supply chain).

6.2.4 Summary of the Descriptive Analysis

This chapter has presented the basic profiles and statistics from an initial analysis of the data acquired from the questionnaire survey. Through the analysis of the respondents' background, IT use and descriptive statistics, an overall picture of the responses can be summarised as follows:

1) One hundred and twenty-eight valid responses were collected after discarding unusable responses. The responses were collected from a heterogeneous group of services, and therefore they provided good confidence for the hypotheses testing.

2) The competency of respondents for the questionnaire was screened by three questions regarding the types of IT employed for different interorganisational purposes. The responses showed good confidence by mirroring the actual use of IT for interfirm business operations with consistency. For the interfirm connectivity, Web-based email and mobile messenger services, LANs, GPS, satellite systems, integrated logistics portals/e-marketplaces were indicated as the commonly used IT. For information sharing for process improvement, TMS, WMS, manufacturing resource planning (MRP) and tracking and tracing systems were identified as the most commonly used IT. CRM, SRM, VMI and collaboration portals are viewed as the mostly common IT for external collaboration and value-adding practices. This

also supports the idea that the IT flexibility should be viewed from multiple dimensions.

3) Although the competency of respondents was assessed, respondents' backgrounds were also checked. The respondents were mainly mid-level workers within the firm, and 42% of them were managers/assistant managers. As intended, the respondents comprised senior, middle-level and junior employees, so the questionnaire acquired information concerning different levels of interfirm operations (i.e. transactional, operational and strategic activities). Most respondents were from the supply chain and logistics field of firm services. The company age and number of employees were also identified as well distributed. Overall, the questionnaire collected reliable and credible data with a proper sample size.

4) The mean of the items revealed that the respondents' perceptions of IT flexibility dimensions – TR flexibility, OP flexibility and STR flexibility – were well above the midpoint. Moreover, the respondents recognised PIC and FP as well above the midpoint. The respondents demonstrated that they had relatively positive attitudes concerning the support of IT and IT capability for supply chain–wide activities. Moreover, they revealed that their capability to integrate supply chain process internally and externally (PIC) and their performance were positively supported by IT.

5) As this study recruited only knowledgeable informants who were familiar with the use of IT for interfirm relationships, informants were more likely to present their opinions given the technical characteristics of IT research, which uses more fact-based indicators compared to other research areas. In section 6.3, data analysis adopting PLS SEM is conducted with hypothesis testing. Moreover, the application of the model test using the importance–performance matrix is performed.

6.3 DATA ANALYSIS: HYPOTHESIS TESTING AND ALTERNATIVE MODEL TESTING – ADDRESSING RESEARCH QUESTION 1 AND RESEARCH QUESTION 2

In sections 6.3.1 and 6.3.2, the measurement models and structural model are assessed. The results of hypotheses testing are then discussed in section 6.3.3. In section 6.4, alternative models of the proposed IT flexibility model are tested to determine whether the proposed model appropriately represents the characteristics of IT flexibility in its multiple dimensions.

The IT flexibility model hypotheses on the impact from TR flexibility to OP and STR flexibility and the impact from OP flexibility to STR flexibility to identify the relationships between IT flexibility dimensions. Moreover, the model hypothesises on the influence of the three dimensions of IT flexibility on PIC and FP. Finally, it suggests that PIC will affect FP. The general process of PLS SEM analysis is discussed in Chapter 5.

6.3.1 Measurement Model Assessment

1) Data preparation – Missing data, outliers and normality

When data are missing, an appropriate treatment should be carried out. It is noted that PLS SEM is highly robust, so if the number of missing values is below a reasonable level (i.e. less than 5% per indicator), it is recommended not to delete them to avoid a bias owing to the decrease in variances; instead of deleting them, a missing value treatment should be used (Hair et al. 2013). In this study, mean replacement is used; this involves replacing the missing values with the mean values of the valid indicators when the data exhibits very low of missing data (Hair et al. 2013) as is the case of this study. Table 6.14 shows the number of missing values in the responses. None of the variables exhibited missing data of more than 5% indicating very low level of missing data per indicator.

Construct	Sub-dimensions	Indicators	Count	Percentage	Construct	Indicators	Count	Percentage
TR flexibility	IT infrastructure	H/W	-	-	Process integration capability	PIC1	2	1.6%
		S/W	1	0.8%		PIC2	-	0.0%
		NW	-	0.0%		PIC3	-	0.0%
	Connectivity	ACC	1	0.8%	Firm performance	COST	-	0.0%
		LINK	2	1.6%		SVC	-	0.0%
		INTP	1	0.8%		SPD_P	1	0.8%
OP flexibility	Information sharing	QLT	1	0.8%		QLT_P	-	0.0%
		VIS	1	0.8%		VAL	1	0.8%
		SPD	1	0.8%				
	Process improvement	STMR	3	2.3%				
		OPT	1	0.8%				
STR flexibility	Partnering	PTN1	2	1.6%				
		PTN2	1	0.8%				
	Offering	OFF	1	0.8%				

Table 6.14 Percentage of Missing Data
Source: Author.

Outliers can be defined as observations with a unique combination of characteristics that are distinctly different from those of the other observations (Hair et al. 2009). A case with such an extreme value on one variable is called a univariate outlier; a strange combination of scores on two or more variables is called a multivariate outlier (Tabachnick and Fidell 2001). Outliers occur from procedural error (incorrect data entry), extraordinary events with unique observed phenomena or unique data combinations (Hair 2009). In this study, outliers were retained, as recommended by Byrne (2009) and Hair et al. (2009). According to Byrne (2009) the outliers can be supported by the bootstrapping resampling technique (used for PLS SEM), as outliers are considered to assist in generating the implications to the empirical research (Byrne 2009). According to Hair et al. (2009), outliers should be retained to ensure generalisability to the entire population. Such utilisation of bootstrapping is related to the issue of normality.

Normality refers to the "[d]egree to which the distribution of the sample data corresponds to a normal distribution" (Hair 2009, p. 72). As discussed in section 5.4.1, it is necessary, when using CB SEM, owing CB SEM's requirements of normally distributed data, which are linked to estimation of parameters like MLE (Byrne 2009; Hair et al. 2013). However, as discussed in section 5.4.1 and 5.4.2 an attractive characteristic of bootstrapping is that it does not rely on normally distributed data in significance testing (Efron and Tibshirani 1993; Hair et al. 2013). Instead, bootstrapping creates multiple subsamples from the original samples so that one can examine parameter distributions relative to each of the generated samples (Byrne 2009). Therefore, a bootstrap distribution is a reasonable approximation of an estimated coefficient's distributions, and its standard deviations can also be used a proxy for the parameter's standard error in the populations without relying on normal distribution (Hair et al. 2013). Therefore, the bootstrapping technique covers outlier and normality issues (Byrne 2009) in this research.

2) Measurement model evaluation

As discussed in section 5.4.2, to validate the measurement models, four types of validity tests need to be conducted. These are indicator reliability, internal consistency reliability, convergent validity and discriminant validity. The measurement model assessment results are presented below.

Internal consistency reliability represents a form of reliability analysed to assess the consistency of results across variables on the same test. PLS employes composite reliability for the internal consistency reliability. In addition, Cronbach's alpha can be used for conservative criteria related to this reliability. Composite reliability and Cronbach's alpha values of 0.60 and 0.70 are acceptable in exploratory research, while 0.708 or higher is a recommended value for a reliable construct. It was found that the composite reliability values of the research construct (0.879 to 0.925) and Cronbach's alpha values (0.792 to 0.898) satisfied the threshold, as presented in Table 6.15.

Convergent validity is used to determine the extent to which a measure correlates positively with alternative measures of the same variable. AVE measures convergent validity on the construct level with a criterion of 0.50 or higher, which indicates that the construct explains more than half of the variance of its indicators. The analysis indicated that the AVE values of the research constructs ranged from 0.567 to 0.752, thereby meeting the threshold, as shown in Table 6.15.

Indicator reliability indicates how many of the variations in an item are explained by the constructs. Outer loading of each item represents the estimated relationship in a reflective construct model so outer loading determines an item's absolute contribution to its assigned construct. As discussed in section 5.4.2, outer loadings of 0.708 or higher are required. In this study, all items' outer loading values were higher than 0.708, with the exceptions of INTP (0.665) and ACC (0.688) in TR flexibility, as shown in Table 6.15 and Table 6.16. However, if we consider that present research employed an exploratory approach, a loading higher than 0.4 is also acceptable (Hulland, 1999). Table 6.15 summarises the validity test results for the measurement models, while Table 6.16 represent the factor loadings for each measurement model.

Latent variables	Number of indicators	Internal consistency reliability		Convergent validity	Indicator reliability
		Composite reliability	Cronbach's alpha	AVE	Factor loadings
TR flexibility	6	0.887	0.846	0.567	0.665 to 0.813
OP flexibility	5	0.925	0.898	0.710	0.814 to 0.894
STR flexibility	3	0.879	0.792	0.709	0.734 to 0.895
PIC	3	0.901	0.836	0.752	0.834 to 0.890
FP	5	0.891	0.846	0.622	0.722 to 0.879

Table 6.15 Summary of Validity Test Results of the Measurement Model
Source: Author.

	TR flexibility	OP flexibility	STR flexibility	PIC	FP
HW	0.813				
SW	0.780				
NW	0.801				
ACC	0.688				
LINK	0.760				
INTP	0.665				
QLT		0.816			
VIS		0.837			
SPD		0.851			
STMR		0.894			
OPT		0.814			
OFF			0.734		
PTN1			0.888		
PTN2			0.895		
PIC1				0.834	
PIC2				0.890	
PIC3				0.878	
COST					0.750
SVC					0.804
SPD_P					0.722
QLT_P					0.879
VAL					0.780

Table 6.16 Factor Loadings of Measurement Models
Source: Author.

Discriminant validity is also verified; this uses two methods to measure the extent to which a construct is truly distinct from other constructs. First, as recommended by Fornell and Larcker (1981), the square root of the AVE for each construct need be greater than its highest correlation with any other model construct. As Table 6.17 indicates, all of the square roots of AVE values (in bold) were greater than the values from the correlation with other constructs.

Latent variables	PIC	FP	OP flexibility	STR flexibility	TR Flexibility
PIC	**0.867**				
FP	0.685	**0.789**			
OP flexibility	0.556	0.465	**0.843**		
STR flexibility	0.490	0.483	0.795	**0.842**	
TR flexibility	0.540	0.461	0.742	0.668	**0.753**

Table 6.17 Fornell–Larcker Criterion Analysis

Source: Author.

Second, as a part of the discriminant validity test, this study examined cross-loading, which specifies that each construct shares larger variance with its own measures than with other measures. Therefore, an indicator's outer loadings (in bold) need be higher than all of its cross-loadings with other constructs. Table 6.18 shows that the research model meets the cross-loading requirements.

	TR flexibility	OP flexibility	STR flexibility	PIC	FP
HW	**0.813**	0.614	0.545	0.431	0.346
SW	**0.780**	0.593	0.486	0.365	0.280
NW	**0.801**	0.521	0.480	0.389	0.389
ACC	**0.688**	0.487	0.458	0.413	0.345
LINK	**0.760**	0.634	0.588	0.473	0.383
INTP	**0.665**	0.480	0.434	0.352	0.335
QLT	0.574	**0.816**	0.552	0.425	0.295
VIS	0.650	**0.837**	0.691	0.414	0.380
SPD	0.561	**0.851**	0.632	0.511	0.352
STMR	0.704	**0.894**	0.751	0.520	0.477
OPT	0.624	**0.814**	0.700	0.467	0.433
OFF	0.451	0.461	**0.734**	0.383	0.439
PTN1	0.616	0.734	**0.888**	0.442	0.467
PTN2	0.605	0.780	**0.895**	0.412	0.325
PIC1	0.423	0.399	0.375	**0.834**	0.557
PIC2	0.488	0.568	0.543	**0.890**	0.594
PIC3	0.490	0.471	0.349	**0.878**	0.630
COST	0.388	0.343	0.451	0.536	**0.750**
SVC	0.333	0.307	0.296	0.534	**0.804**
SPD_P	0.251	0.340	0.331	0.491	**0.722**
QLT_P	0.411	0.394	0.380	0.558	**0.879**
VAL	0.414	0.440	0.431	0.572	**0.780**

Table 6.18 Analysis of Cross-loadings
Source: Author.

Coupled with validity assessment, multicollinearity was examined due to the relatively high correlations among some variables. The VIF values for all of the constructs were at acceptable levels (i.e. below 5), as presented in Table 6.19.

Latent variables	OP flexibility	STR flexibility	PIC	FP
TR flexibility	1.000	2.228	2.311	2.311
OP flexibility		2.228	3.486	3.486
STR flexibility			2.823	2.823
PIC				1.532

Table 6.19 Variation Inflation Factor Analysis Results
Source: Author.

6.3.2 Structural Model Analysis: Hypothesis Testing

Following the validity tests on the measurement models, this study conducted an assessment of the structured model and tested the hypotheses to examine the relationships between the measurement constructs. Furthermore, the mediating effect of PIC on FP was examined. Bootstrapping, a resampling technique, is adopted as discussed in section 5.4.2.

Table 6.20 summarises the structural model tested using PLS SEM analysis. This table delivers the explained variance (R^2), the standardised path coefficient and the *t*-values produced with the level of significance using the bootstrapping method. It also presents the results with and without the mediating effects of PIC to discuss its mediating role within the relationship between IT flexibility dimensions and FP.

Effects on endogenous variable with hypotheses	Path coefficient β (*t* value)		Variance explained (R^2)	
	Non-mediated model	Fully mediated model	Non-mediated model	Fully mediated model
Effects on OP flexibility			0.552	0.551
H1a: TR → OP	0.743***(15.482)	0.742***(15.550)		
Effects on STR flexibility			0.649	0.646
H1b: TR → STR	0.167**(2.326)	0.172** (2.347)		
H1c: OP → STR	0.673***(10.498)	0.668***(10.175)		
Effects on PIC				0.347
H2a: TR → PIC		0.270**(2.119)		
H2b: OP → PIC		0.297** (2.066)		
H2c: STR → PIC		0.073(0.581)		
Effects on FP			0.275	0.500
H3a: TR → FP	0.215*(1.695)	0.051(0.391)		
H3b: OP → FP	0.097(0.571)	-0.078(0.530)		
H3c: STR → FP	0.266*(1.896)	0.221**(2.010)		
H4: PIC → FP		0.592***(5.682)		

Table 6.20 Effects and Variance Explained for All Endogenous Variables

*** $p < .0.01$; ** $p < 0.05$; * $p < 0.1$ (all two-tailed)

Source: Author.

1) IT flexibility dimensions and their relationships (H1a, H1b and H1c) – Response to Research question 1

In the full mediation model, the test results supported hypotheses H1a (β = 0.742, $p < 0.01$), H1b (β = 0.172, $p < 0.05$) and H1c (β = 0.668, $p < 0.01$) for the IT flexibility dimensions. This clarifies that TR flexibility significantly affected OP flexibility, which explained 55.1% (R^2) of the OP flexibility variance. This indicates that a firm's investment in TR flexibility will increase the level of OP flexibility. Both TR flexibility and OP flexibility affect STR flexibility significantly, accounting for 64.6% of STR flexibility variance. This implies that a firm's investment in TR and OP flexibility will affect the accumulation of STR flexibility. This test supports the idea regarding the role of TR flexibility as a pivotal construct, because the notion that TR flexibility supports the other two flexibility dimensions is supported. Consequently, the structure of IT flexibility that this study proposed in the conceptual model was also supported.

Together with the partial answer to RQ 1 – What are the key dimensions of IT flexibility for SCM? – in section 3.4, the construct of IT flexibility with the relationships between its dimensions is identified in this section. There was a positive effect of TR flexibility on OP and STR flexibility. Moreover, OP flexibility also affected STR flexibility significantly. Although the impact scale of OP flexibility was greater than that of TR flexibility, it should be remembered that the impact of OP flexibility was also supported with the impact of TR flexibility. This relationship between the dimensions highlights the critical role of TR flexibility, which enhances the influence of the other two flexibility dimensions for greater FP, thereby playing a pivotal role. In sum, the different types of dimensions constructing the concept of IT flexibility for SCM were identified with the relationships among the dimensions. Therefore, RQ 1 was addressed. Figure 6.8 depicts the relationships between IT flexibility dimensions.

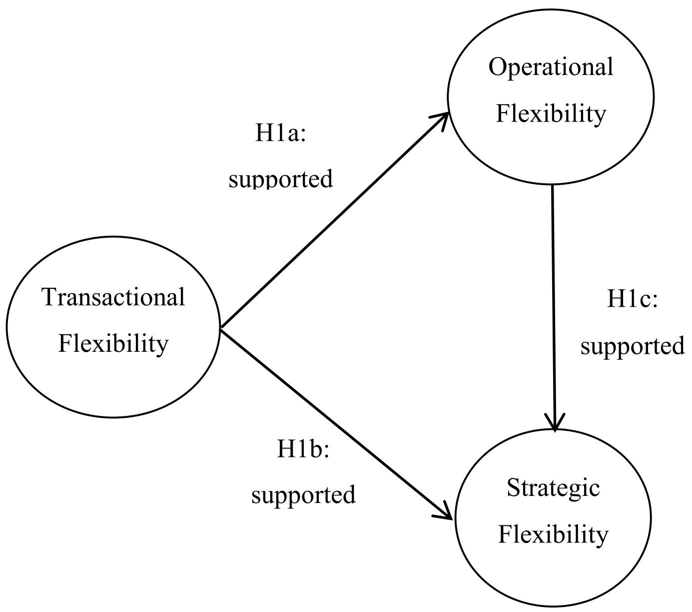


Figure 6.8 Relationships between IT flexibility dimensions (H1a, H1b and H1c).
Source: Author.

2) The impact of IT flexibility dimensions on process integration capability (H2a, H2b and H2c)

Regarding the effect of IT flexibility on PIC, the test supported H2a (β = 0.270, $p < 0.05$) and H2b (β = 0.297, $p < 0.05$), representing the positive impact of TR flexibility and OP flexibility on PIC. In contrast, the link between STR flexibility and PIC (i.e. H2c; β = 0.073, $p < 0.1$) was not supported. TR flexibility and OP flexibility significantly affected PIC, explaining 34.7% of variance, which means a reasonable level of prediction accuracy (Hair et al. 2013). It was found that aspects of TR flexibility, such as capability of advanced level of infrastructure, connectivity and technical interoperability, were positively associated with a firm's capability to integrate business processes internally, externally and even with customers. Furthermore, OP flexibility was positively associated with PIC. Although the role of OP flexibility has not been adequately addressed in existing IT flexibility literature, this test indicated that there was an obvious impact of OP flexibility on a firm's PIC, where information sharing and process improvement were emphasised. In contrast, the hypothesis test did not show a significant level of impact of STR flexibility on PIC. Figure 6.9 summarises the relationships between IT flexibility dimensions and PIC.

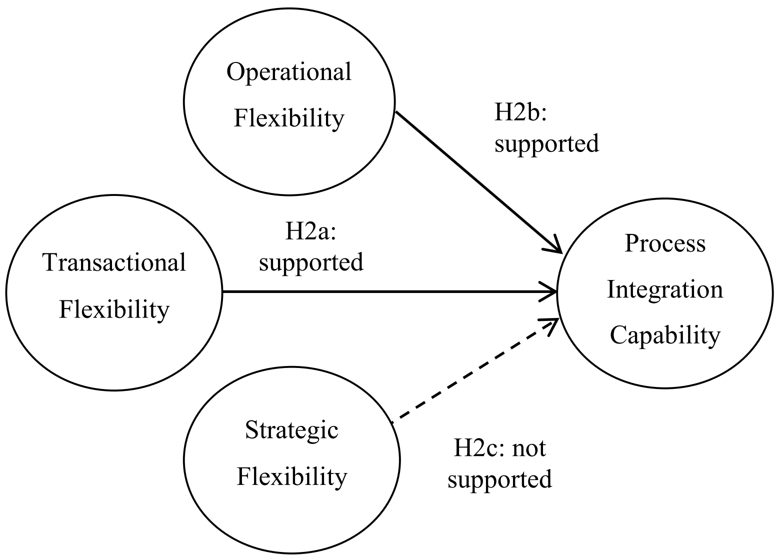


Figure 6.9 The impact of IT flexibility dimensions on process integration capability (H2a, H2b and H2c).
Source: Author.

3) The impact of IT flexibility dimensions on firm performance (H3a, H3b and H3c)

In terms of the impact of IT flexibility dimensions on FP, TR flexibility and OP flexibility did not have a direct impact on FP; that is, H3a (β = 0.051, $p < 0.1$) and H3b (β = -0.078, $p < 0.1$) were not supported. However, STR flexibility affected FP significantly, meaning that H3c was supported (β = 0.221, $p < 0.05$). This test result indicates that TR and OP flexibility did not affect FP directly, but STR flexibility did affect FP directly. Therefore, the necessity of mediating effect analysis emerges, as TR and OP flexibility may affect FP only via PIC, while STR flexibility affects FP without any associated impact with PIC. This is discussed in part 5. Figure 6.10 presents the relationships between IT flexibility dimensions and FP.

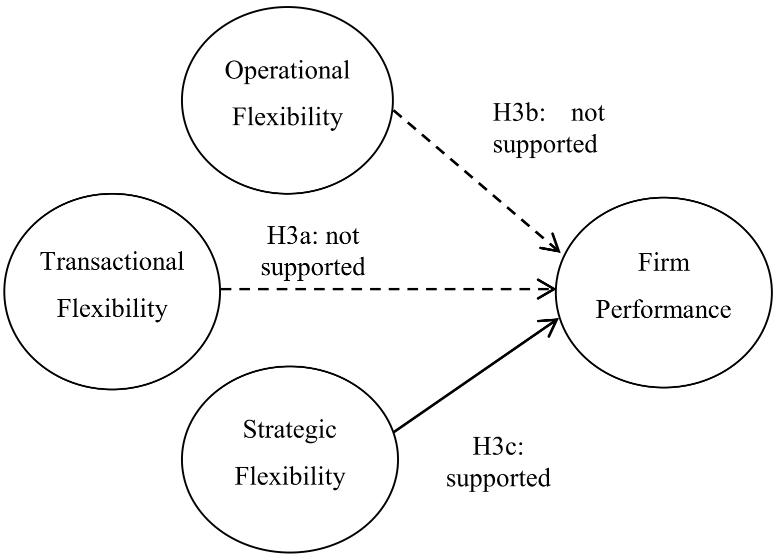


Figure 6.10 The impact of IT flexibility dimensions on firm performance(H3a, H3b and H3c).
Source: Author.

4) The impact of process integration capability on firm performance (H4)

Finally, PIC affected FP positively; thus, H4 (β = 0.592, $p < 0.01$) was supported. Figure 6.11 illustrates the relationship between PIC and FP. The test results indicate that PIC affects FP significantly, which implies that a firm whose goal is greater FP in an interorganisational setting cannot ignore PIC development. In other words, a firm with a greater capability to integrate business processes with trade partners and customers across firm departments will perform better.

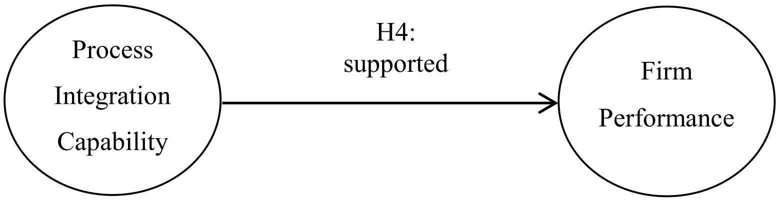


Figure 6.11 The impact of process integration capability on firm performance (H4).
Source: Author.

The hypothesis test results of the IT flexibility research model are depicted in Figure 6.12.

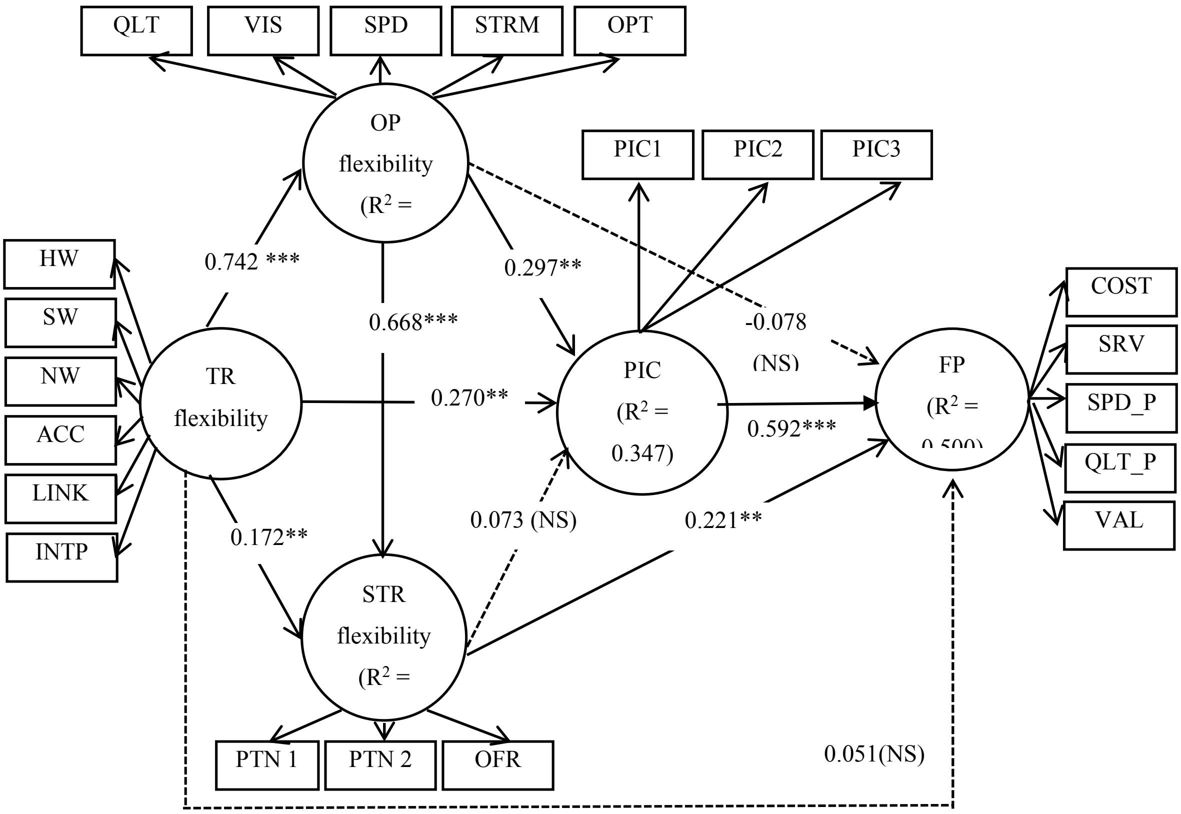


Figure 6.12 Results of path analysis.
** $p < 0.05$, *** $p < 0.01$, NS: nonsignificant.
Source: Author.

5) Mediating effect analysis – Response to Research question 2

The test identified that 50.0% of variance of FP was explained by IT flexibility dimensions and PIC, as presented in Table 6.20 and Figure 6.12. This indicates strong prediction accuracy (Hair et al. 2013). Although STR flexibility was not associated with PIC, the test result showed that STR flexibility significantly and directly affects FP performance. TR flexibility and OP flexibility do not affect FP directly. However, they do affect FP via PIC. This indicates that TR and OP flexibility tend to affect FP indirectly. In contrast, the impact of STR flexibility is directly associated with FP.

To elucidate this issue, this study examined the mediating role of PIC capability between TR and OP flexibility and FP by comparing the unmediated model to the full-mediation model (Baron and Kenny 1986; Iacobucci et al. 2007; Preacher and Hayes 2008) based on the values presented in Table 6.18. When the mediator, PIC, was incorporated to the research model, the direct impact of TR flexibility on FP decreased ($\beta = 0.215$ to $\beta = 0.051$). Further, TR flexibility's impact on PIC ($\beta = 0.270$, $p < 0.05$) and PIC's impact on FP ($\beta = 0.592$, $p < 0.01$) were identified as significant. This indicates that TR flexibility was positively associated with FP via PIC. In terms of OP flexibility, the direct impact of OP flexibility on FP decreases ($\beta = 0.097$ to $\beta = -0.078$) in the mediated model, while the impact path of OP flexibility on PIC was identified as significant ($\beta = 0.297$, $p < 0.05$), and the impact of PIC on FP was also significant ($\beta = 0.592$, $p < 0.01$). Thus, the indirect impact of OP flexibility on FP through PIC is demonstrated.

While comparing the direct and indirect effects of flexibility dimensions on FP, it was identified that the prediction accuracy (R^2) of FP increased from 27.5% to 50.0%. Therefore, the proposed mediated IT flexibility model had stronger predictive power with a higher level of prediction accuracy (Hair et al. 2013) than the non-mediated model; thus, the research hypothesis that the IT flexibility dimensions supports supply chain execution in the context of PIC was supported.

In sum, TR and OP flexibility affect FP via PIC. STR flexibility affects FP directly. Therefore, the influential mechanism of IT flexibility dimensions in the SCM context (using PIC) was identified. This finding answers RQ 2 – How do IT flexibility dimensions impact FP in the context of supply chain execution? This influential mechanism is also depicted in Figure 6.13; in the figure only significant paths in the research model are shown to highlight the mediating effect of PIC in the IT flexibility research model.

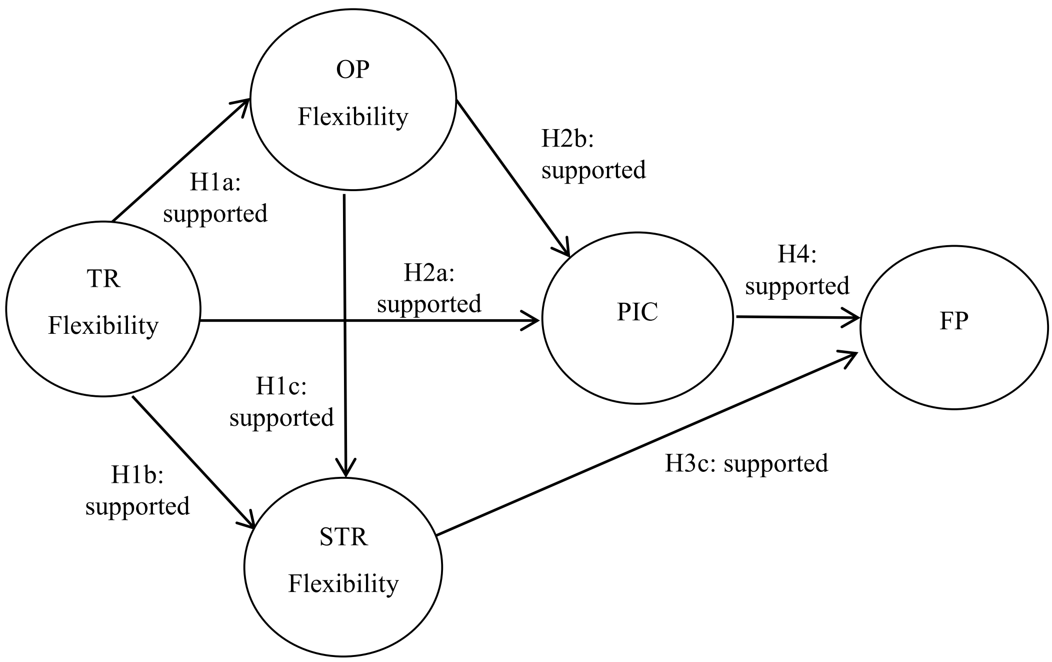


Figure 6.13 Indirect impact of OP and STR flexibility on firm performance and direct impact of STR flexibility on firm performance.
Source: Author.

Scales of the indirect impact of each dimension on FP were computed using SmartPLS 3.0 to identify the total effect of the IT flexibility dimensions on FP. The results showed differences between the dimensions' impacts. TR flexibility was the most influential aspect of these dimensions, OP flexibility the next most influential aspect and STR flexibility the least influential aspect, as presented in Table 6. 21.

Exogenous variables	Endogenous variables (firm performance)		
	Direct effect	Indirect effect	Total effect
Transactional flexibility	0.051	0.409	0.460
Operational flexibility	-0.078	0.353	0.275
Strategic flexibility	0.221	0.043	0.264

Table 6.21 Total Effects of Exogenous Variables on Endogenous Variables
Source: Author.

6.3.3 Findings from Hypotheses Testing – Responses to Research Question 1 and Research Question 2.

The objective of this section is to deliver a clear understanding of the relationships between the IT flexibility dimensions and the effect of IT flexibility dimensions on FP with hypothesis testing. The theoretical conceptualisation of the relationships between the model constructs was supported, as it was recognised that the IT flexibility dimensions were related to each other, showing the pivotal role of TR flexibility in supporting the other two IT flexibility dimensions. From these test results, the three dimensions comprising IT flexibility for SCM were confirmed along with their relationships, thereby addressing RQ 1 regarding the structure of IT flexibility for SCM. Moreover, it was identified that there is a mediating role of PIC associated to the impact of IT flexibility on FP. That is, TR and OP flexibilities affect FP via PIC, and therefore indirectly, while STR flexibility affects FP directly. This finding addresses RQ 2 regarding the influential mechanism of IT flexibility on FP.

The IT flexibility for the SCM structure is now in line with flexibility as multidimensional concept encompassing a range of heterogeneous change options (Koste and Malhotra 1999). Thus, the number of change options has been adequately extended to a higher level of IT use to accommodate the divergent use of IT to adapt to a changing business environment (Bernandes and Hanna 2009).

With the findings regarding the effects of each flexibility on FP, the IT flexibility research model has identified that the three IT flexibility dimensions have uniformity to FP. Uniformity means that to be flexible, although the flexible dimensions are different from each other, their performance outcomes need to show similarity to contribute to the overall system (Upton 1994; Koste and Malhotra 1999). Specifically, the notable finding of this research with regard to the uniformity is that the impact of the IT flexibility dimensions can be direct or indirect, as evidenced by the mediation analysis. Moreover, this study identified that such uniformity can be applied to the SCM context because the IT flexibility research model incorporated PIC to provide the SCM context, as discussed in section 4.3.2. Moreover, the FP was also constructed by considering interfirm operational efficiency and customer satisfaction, as discussed in section 4.3.3.

6.3.4 Alternative Model Testing

1) Hierarchy in IT flexibility dimensions

Throughout the empirical tests, this study has explored the relationships between the three IT flexibility dimensions and their combined effects on FP. The empirical results show that the three IT flexibility dimensions are interrelated and their interrelation generates positive effects on FP. Specifically, in terms of the total effect of each dimension on FP, the test identified that TR flexibility had the biggest effect on FP. OP flexibility had the second biggest effect and STR flexibility had the least effect.

At this stage, a critical question regarding the relationships between the flexibility dimensions arises, as follows: If the relationships are hierarchical and affect FP created from TR flexibility, does the effect of each flexibility dimension accumulate according to the impact path from TR flexibility to OP flexibility to STR flexibility? In the proposed research model, owing to the pivotal role of TR flexibility and the mediating effect of PIC associated with TR and OP flexibility, the possibility of such accumulation could not be addressed. If the impact accumulates in the hierarchy, it will be another characteristic of

IT flexibility dimensions for SCM. To explore this issue, this study conducted alternative model testing. This testing is used to compare research models and then identify the model that explains characteristic relationships between constructs in an effective way (Swafford et al. 2008).

First, this study tested the IT flexibility hierarchical model. This model considers TR flexibility's direct impact on OP flexibility; OP flexibility's direct impact on STR flexibility; and STR flexibility's direct impact on FP (i.e. hypotheses H1a, H1c and H3c; Figure 6.14). If the hierarchical relationship is identified – that is, if the total impact of IT flexibility dimensions on FP increases according to the impact path – then the accumulation of the impact will be identified.

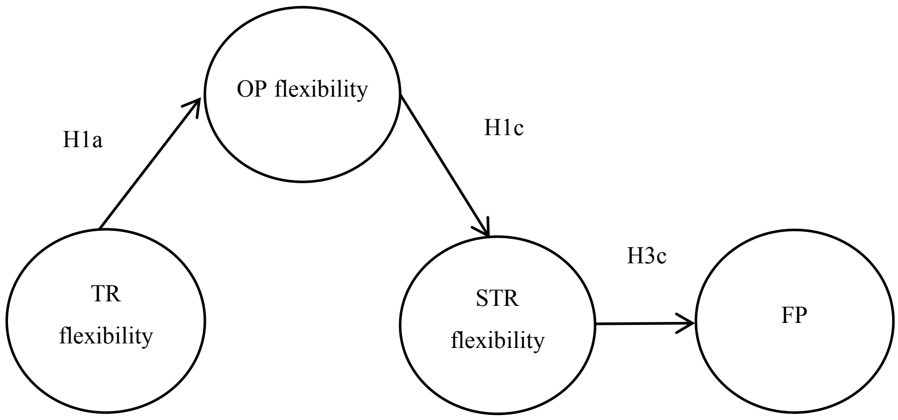


Figure 6.14 Hierarchical IT flexibility model.
Source: Author.

Second, this study tested the extended linear model. This model is the same as the linear model but incorporates the mediator (PIC); if there is a linear relationship generating the effect accumulation in the IT flexibility dimensions, it should also be validated within the same setting, that is, the SCM context as in the proposed model (the fully mediated model). Therefore, extended linear model tests were carried out for H1a, H1c, H2a, H2b, H2c, H3a, H3b, H3c and H4 (without H1b), as shown in Figure 6.15.

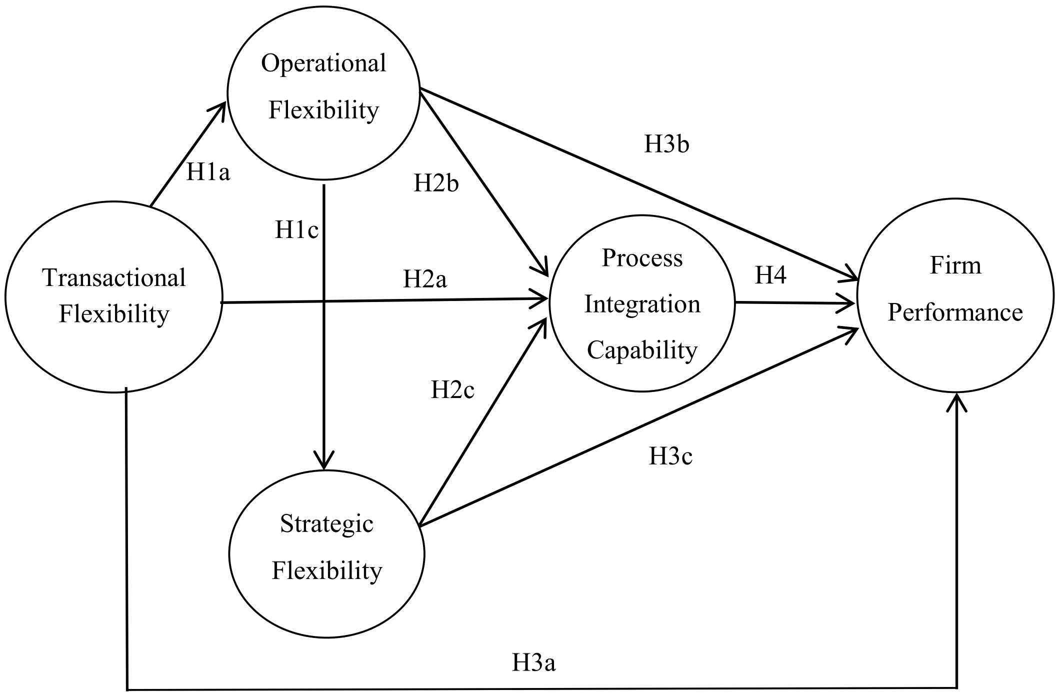


Figure 6.15 Extended hierarchical model.
Source: Author.

If the hierarchical model identifies the impact accumulation throughout the path and the test result of the extended hierarchical model maintains the same mediating effects of PIC, then the advantage of the proposed IT flexibility model (the original fully mediated model) presenting the pivotal role of TR flexibility (with H1b) and the accumulation of effects in linear relationships will be confirmed.

2) Model test results

✓ The hierarchical model

In this model, the test results showed that hypotheses H1a ($\beta = 0.744$, $p < 0.01$), H1c ($\beta = 0.798$, $p < 0.01$) and H3c ($\beta = 0.489$, $p < 0.01$) were supported[13], confirming a positive

[13] A summary of the validity test results of the measurement constructs of the hierarchical model is provided in Appendix 3.

impact from TR flexibility to OP flexibility, OP flexibility to STR flexibility and STR flexibility to FP, as shown in Figure 6.16.

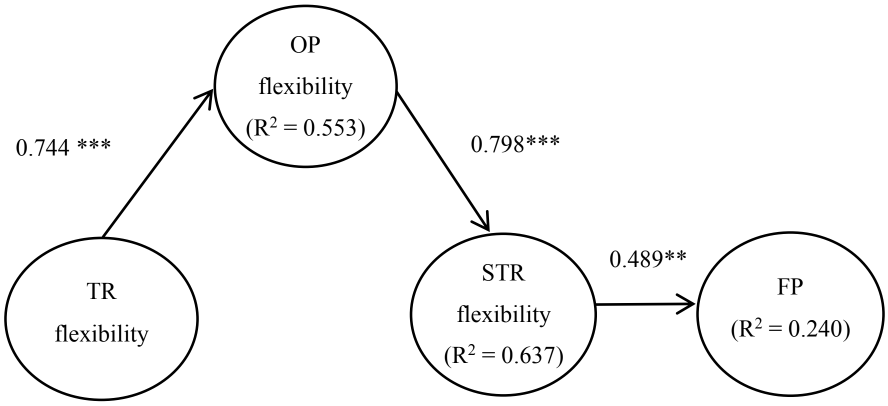


Figure 6.16 Results of path analysis of hierarchical model.
** $p < 0.05$, *** $p < 0.01$ NS: nonsignificant
Source: Author.

The total effect of each dimension specified that STR flexibility (0.489) was the most influential aspect, followed by OP flexibility (0.391) and TR flexibility (0.291), as shown in Table 6.22. This supports the idea of the accumulated effects of IT flexibility dimensions, as it indicates that the effects increase according to the linear impact path from TR flexibility to OP flexibility to STR flexibility. Therefore, the accumulation of the effects of IT flexibility dimensions is identified.

Exogenous variables	Endogenous variables (firm performance)		
	Direct effect	Indirect effect	Total effects
Transactional flexibility		0.291	0.291
Operational flexibility		0.391	0.391
Strategic flexibility	0.489		0.489

Table 6.22 Total Effects of Each Flexibility Dimensions on Firm Performance: Hieararchical Model
Source: Author.

✓ **Extended hierarchical model**

In the extended hierarchical model, hypotheses H1a (β = 0.742, $p < 0.01$), H1c (β = 0.796, $p < 0.01$), H2a (β = 0.271, $p < 0.05$), H2b (β = 0.298, $p < 0.05$), H3c (β = 0.219, $p < 0.1$) and H4 (β = 0.593, $p < 0.01$) were supported. In contrast, H2c (β = 0.072, $p < 0.1$), H3a (β = 0.052, $p < 0.1$), and H3b (β = -0.078, $p < 0.1$) were not supported[14]. This also shows that there was a positive effect from TR flexibility to OP flexibility and OP flexibility to STR flexibility, which also demonstrates a hierarchical impact path, as illustrated in Figure 6.17.

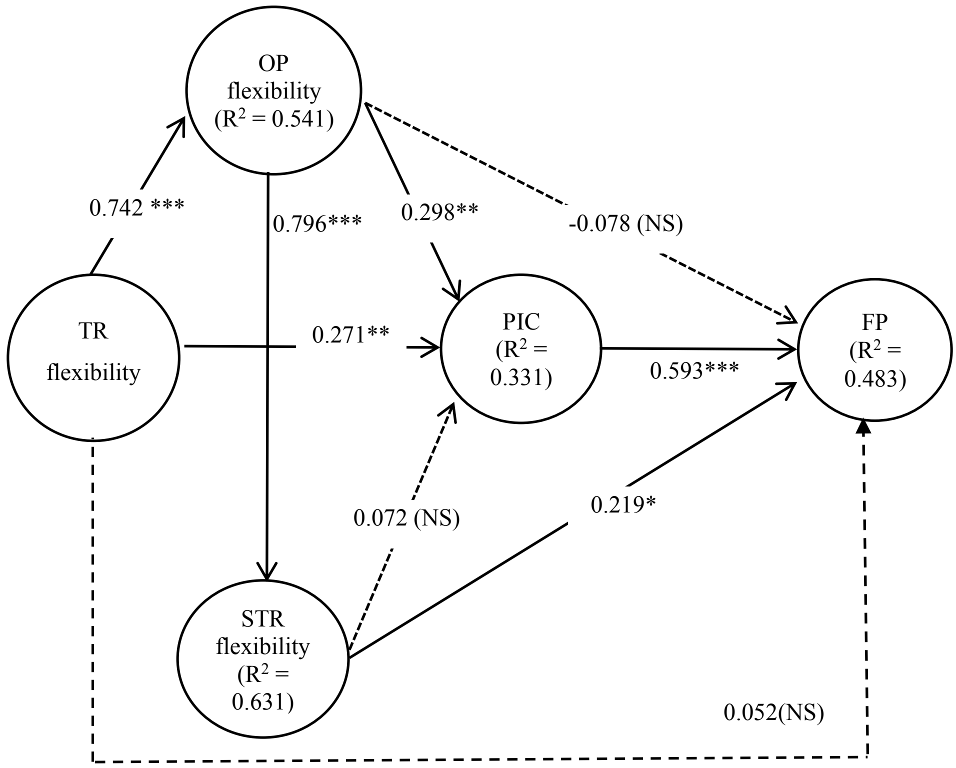


Figure 6.17 Results of path analysis of extended hierarchical model.
** $p < 0.05$, *** $p < 0.01$ NS: nonsignificant
Source: Author.

[14] A summary of the validity test result of the measurement constructs of the extended hierarchical model is provided in Appendix 4.

Table 6.23 summarises the test results for each model. The mediating effect of PIC was also identified. Regarding TR flexibility, its effect on FP decreased (from β = 0.215 to β = 0.052) in the mediated model, while its effect on PIC was significant (β = 0.271, $p < 0.05$), and the effects of PIC on FP were significant (β = 0.593, $p < 0.01$). In terms of OP flexibility, its effects on FP decreased (β = 0.098 to β = –0.078) in the mediated model, while the impact of OP flexibility on PIC was significant (β = 0.298, $p < 0.01$). Thus, it was identified that the mediating role of PIC for TR flexibility and OP flexibility was also identified as in the proposed full-mediation model.

Effects on endogenous variables with hypotheses	Path coefficient β (*t*-value)			Proposed (fully mediated) model
	Hierarchical model	Extended Hierarchical model		
		Non-mediated	Mediated	
Effects on OP flexibility				
H1a: TR → OP	0.744***(16.151)	0.743***(15.551)	0.742***(15.636)	0.742***(15.550)
Effects on STR flexibility				
H1b: TR → STR				0.172** (2.347)
H1c: OP → STR	0.798***(21.166)	0.799***(21.298)	0.796***(20.829)	0.668***(10.175)
Effects on PIC				
H2a: TR → PIC			0.271**(2.144)	0.270**(2.119)
H2b: OP → PIC			0.298**(2.068)	0.297** (2.066)
H2c: STR → PIC			0.072(0.564)	0.073(0.581)
Effects on FP				
H3a: TR → FP		0.215*(1.692)	0.052(0.397)	0.051(0.391)
H3b: OP → FP		0.098(0.590)	-0.078(0.531)	-0.078(0.530)
H3c: STR → FP	0.489***(6.149)	0.264*(1.866)	0.219*(1.997)	0.221**(2.010)
H4: PIC → FP			0.593***(5.592)	0.592***(5.682)

Table 6.23 Alternative Model Test Results
Source: Author.

6.3.5 Findings from Alternative Model Testing

The test of the hierarchical model identified that the effects of IT flexibility dimensions accumulate linearly. Moreover, the extended hierarchical model that incorporates the hierarchical relationship without the effect from TR flexibility to STR flexibility identified the same mediating effects of PIC. Therefore, by synthesising the above findings and the test results of the full-mediation model, it was identified that the full-mediation model presented not only the hierarchical relationships between the IT flexibility dimensions but also picked up the impact path of TR flexibility to STR flexibility, which the extended linear model does not cover.

With regard to the explained variance (R^2) of FP, R^2 improved in the full mediation model throughout latent variables shown in Table 6.24. To elaborate, R^2 of OP flexibility increased from 0.547 to 0.551, R^2 of STR flexibility increased from 0.631 to 0.646, R^2 of PIC increased from 0.331 to 0.347 and R^2 of FP increased from 0.483 to 0.500. This indicated that the full-mediation model has better predictive power than the extended hierarchical model. Therefore, it is concluded that the full mediation model is the most appropriate model for explaining the characteristics of IT flexibility dimensions with its combined impact of the flexibility dimensions on PIC and FP.

Explained variance (R^2)	**Linear model**	**Extended linear model**	**Proposed (full-mediation) model**
OP flexibility	0.553	0.547	0.551
STR flexibility	0.637	0.631	0.646
PIC		0.331	0.347
FP	0.240	0.483	0.500

Table 6.24 Explained Variance (R^2) of the Alternative Models and the Proposed Model
Source: Author.

6.4 APPLICATION OF THE MODEL TO IMPORTANCE AND PERFORMANCE MATRIX – ADDRESSING RESEARCH QUESTION 3

As discussed in Chapter 5, the IPA matrix is a useful tool for visualising the importance and performance of indicators. By extending the PLS SEM result (based on the proposed IT flexibility research model) to the IPA matrix, this study will examine how firms can prioritise the multiple dimensions of IT flexibility and suggest a way to allocate the resources to the different types of IT flexibility in a strategic manner. By doing so, this section addresses RQ 3.

6.4.1 Prioritisation of the IT Flexibility Dimensions

As introduced in section 5.5, the IPA matrix uses two scores, namely importance and performance. Importance on the X axis represents the estimation of direct, indirect and total relationships of latent variables. They are calculated from the inner and outer coefficients. Performance on the Y axis follows average values of the latent variable scores. The combination of importance and performance scores for each construct is presented in a plot.

1) Prioritisation of IT flexibility dimensions with industry-level data

The scores of importance and performance for each IT flexibility type in the industry-level data (n = 128) are shown in Table 6.25. TR flexibility had the highest importance score (0.369), while OP flexibility had the second highest (0.201). The importance of STR flexibility had the lowest score (0.186) among the three flexibility types. This implies that TR flexibility's performance score should be the highest among the three constructs, as this construct had the highest importance, and therefore it should be working best. TR flexibility's performance score was 26.276, which was the highest, while OP flexibility's performance score came second (23.835) and STR flexibility's performance was ranked in third (20.459).

Constructs	Importance	Performances
TR flexibility	0.369	26.276
OP flexibility	0.201	23.835
STR flexibility	0.186	20.459
Mean	***0.252***	***23.523***

Table 6.25 Importance–Performance Analysis of Industry: Construct Scores
Source: Author.

The scores are combined in a plot and presented in Figure 6.18. The distribution patterns of the IT flexibilities show a line going up and to the right, implying that the most important construct (TR flexibility) for FP showed the highest performance; the second most important construct (OP flexibility) exhibited the second highest performance; and the least important construct (STR flexibility) showed the lowest performance.

In this analysis, the ranks among the three dimensions were arranged according to the level of importance of the target construct. Moreover, it was inferred that performance levels of each IT flexibility were appropriate to the level importance of each flexibility. In other words, at the industry level, the resource allocation for the three types of IT flexibility was managed properly.

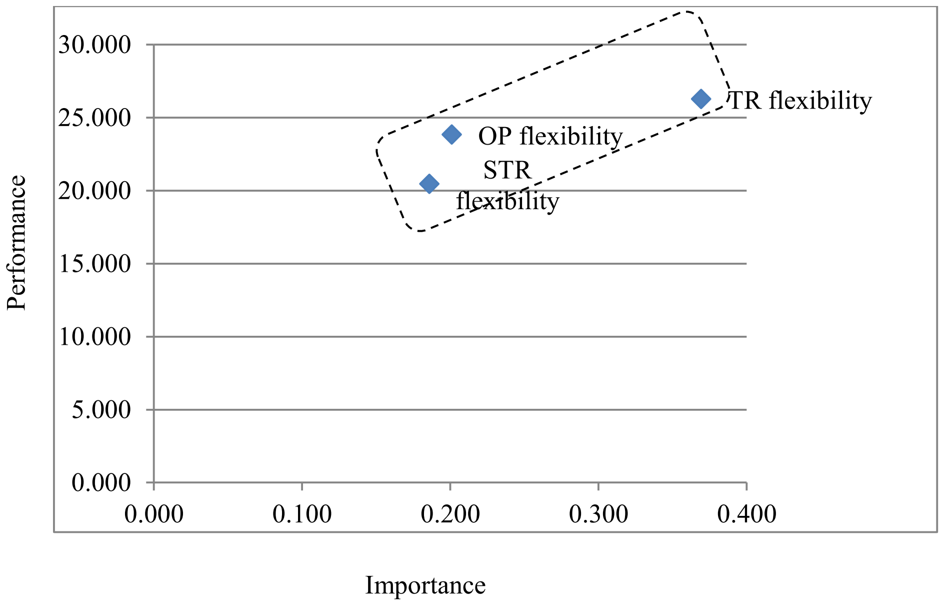


Figure 6.18 Importance–performance analysis of industry: construct matrix.
Source: Author.

2) Analysis of a client firm

A specific firm called Company A was considered in this analysis. Company A (a label given to preserve the company's anonymity, as requested) operates in the logistics industry and provides diverse types of 3PL services, such as warehousing, freight shipping and freight forwarding. With its mandate to transmit a large amount of information and exchange this information with customers and partners, the role of IT has been treated as a critical area to successfully execute Company A's operations.

Before the IPA matrix was employed, the full-mediation model – including the total impact path of the three IT flexibility dimensions for FP – was applied to Company A's data[15]. As a result, all of the conditions of Company A's IT flexibility measurements were set to be the same as the measurement conditions of IT flexibility at the industry level.

✓ **Construct-level analysis**

Table 6.26 provides Company A's scores for importance and performance at the construct level. TR flexibility had the highest importance score (0.635), while OP flexibility's importance was the second highest (0.384). The importance of STR flexibility had the lowest score (0.142) among the three flexibilities. Such levels of importance are consistent with the findings from the full research model. Moreover, this implies that TR flexibility's performance score should be the highest among the three constructs, as this construct has the highest importance, as discussed in terms of the industry-level data (n = 128). However, in this case of Company A, TR flexibility had a performance score of 39.013, representing the lowest score, while OP flexibility's importance scores was the second highest (40.184), and STR flexibility's performance was ranked first (45.363).

Construct	Importance	Performance
TR flexibility	0.635	39.013
OP flexibility	0.384	40.184
STR flexibility	0.142	45.363
Mean	***0.387***	***41.520***

Table 6.26 Importance–Performance Analysis of Company A: Construct Scores
Source: Author.

[15] The PLS SEM analysis result for Company A is provided in Appendix 5.

The scores are combined in a plot and presented in Figure 6.19. The order of importance is the same as for the industry-level analysis. However, in terms of their performance, TR flexibility showed the lowest score, while STR flexibility had the highest performance. Thus, the distribution pattern of the IT flexibilities shows a line going down and to the right.

Steps should be taken to resolve this issue; that is, more investment should be made in TR flexibility first, as this is the most important construct and should therefore be showing the highest performance. Moreover, resources from STR flexibility should be reallocated to other areas, as it shows the lowest importance level but high performance.

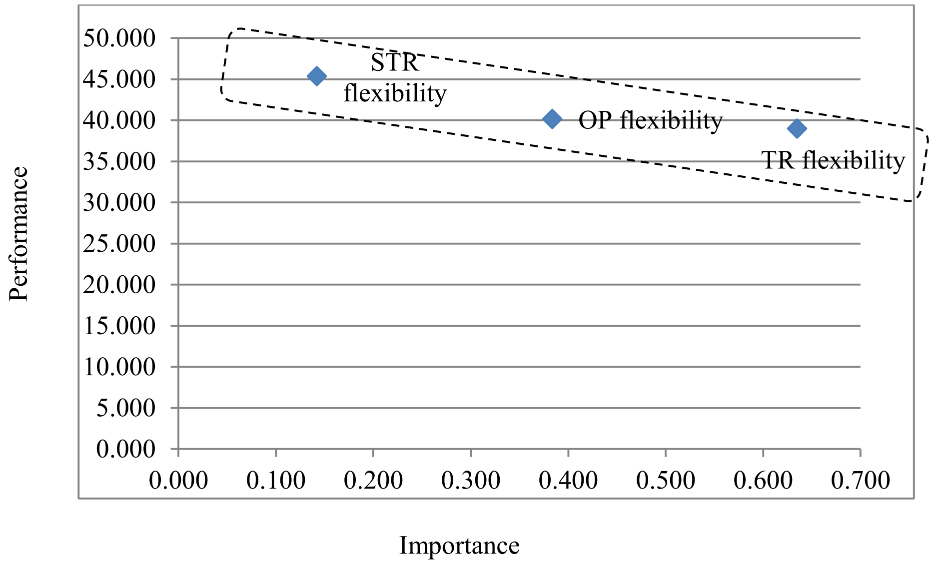


Figure 6.19 Importance–performance analysis of Company A: construct matrix.

Source: Author.

6.4.2 Resource Allocation to the IT Flexibility Dimensions

✓ Indicator-level analysis

To identify which indicator of TR flexibility should be treated preferentially with more resource input or which indicator is consuming resources that could be reallocated to other indicators, the IPA matrix at the indicator level was developed as follows. Table 6.27 provides the importance and performance scores of each indicator, while Figure 6.20 shows the scores in the form of a plot.

Indicator	Importance	Performance
HW	0.107	40.952
SW	0.106	37.619
NW	0.076	28.095
ACC	0.109	34.706
LINK	0.131	45.455
INTP	0.105	42.857
QLT	0.078	37.255
VIS	0.080	39.524
SPD	0.082	40.476
STMR	0.076	46.667
OPT	0.068	36.667
PTN1	0.042	40.000
PTN2	0.052	48.095
OFF	0.049	47.059
Mean	***0.080***	***40.238***

Table 6.27 The Results of Importance–Performance Analysis for Company A: Indicator Scores

Source: Author.

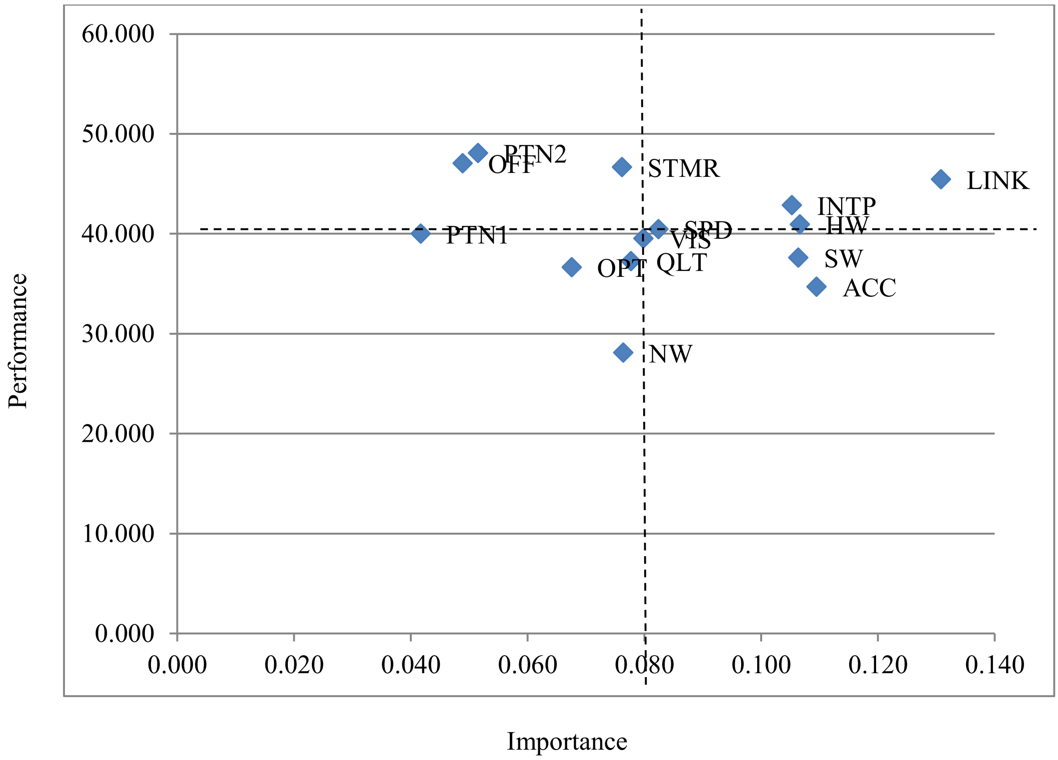


Figure 6.20 Importance–performance analysis of Company A: indicator scores in quadrants

Note: the mean of importance scores is 0.080. The mean of performance scores is 40.238).

Source: Author

✓ ***Resource allocation suggestion 1: Immediate investment in SW and ACC is required***

In the matrix, the TR flexibility indicators are located on the right side, showing higher importance (HW SW, ACC, INTP, LINK). However, their performance is not high compare to other indicators (i.e. OFF, PTN2, STMR). Particularly, SW (software: advancement of IT applications that permits the hardware to enable information flow and facilitate decisions) and ACC (the ability of IT systems to legitimately access information resources) need to be treated as indicators requiring immediate treatment, as the analysis indicates they are located in quadrant 4. Here, there is sufficient potential for future improvement that can lead to higher FP. This suggests that relatively high importance appears to be the key issue for improving FP. HW, INTP and LINK are categorised as showing relatively high performance according to the quadrants, implying that more investment in SW and ACC should be made to improve TR flexibility will be made and lead to the overall improvement of FP.

✓ ***Resource allocation suggestion 2: Downsizing investment in OFF, PTN2 and STMR***

As OFF and PTN2 from STR flexibility and STMR from OP flexibility showed lower importance but higher performance, the resources for these indicators need to be reduced and reallocated to indicators requiring more investments and treatment, possibly SW and ACC, as discussed above.

The PLS SEM test results for Company A showed consistency with the above results. In the test results, four impact paths were different from those of the industry model test results, as follows: ① TR flexibility does not directly support PIC; ② OP flexibility directly supports FP; ③ STR flexibility does not directly support FP; and ④ PIC does not directly support FP.

Based on the findings from the IPA matrix, one can propose that the reason for ①, ③ and ④ is the lack of TR flexibility due to the lower performance in SW and ACC. From the industry level analysis, it is known that TR flexibility directly affects STR flexibility and PIC. Moreover, STR flexibility and PIC also directly affect FP. The lack of TR flexibility may result in a lack of performance of PIC and STR flexibility.

The PLS SEM test results of Company A indicate that OP flexibility directly affects FP. This is consistent with the result of the IPA matrix. Indicators of OP flexibility were clustered around the middle of the matrix, apart from STMR in quadrant 1, which showed high performance. The overinvestment in STMR could be a clue concerning the additional effect of OP flexibility on FP (as pointed out in ②). Therefore, resource reallocation from STRM to other candidates, such as SW or ACC, could be a more efficient way to improve overall FP.

6.4.3 Findings from the Application of the Research Model to the IPA Matrix – Response to Research Question 3

The reversed IT flexibility importance and performance score distribution patterns between the industry level (going up to the right) and Company A (going down to the right) are presented in Figure 6.21.

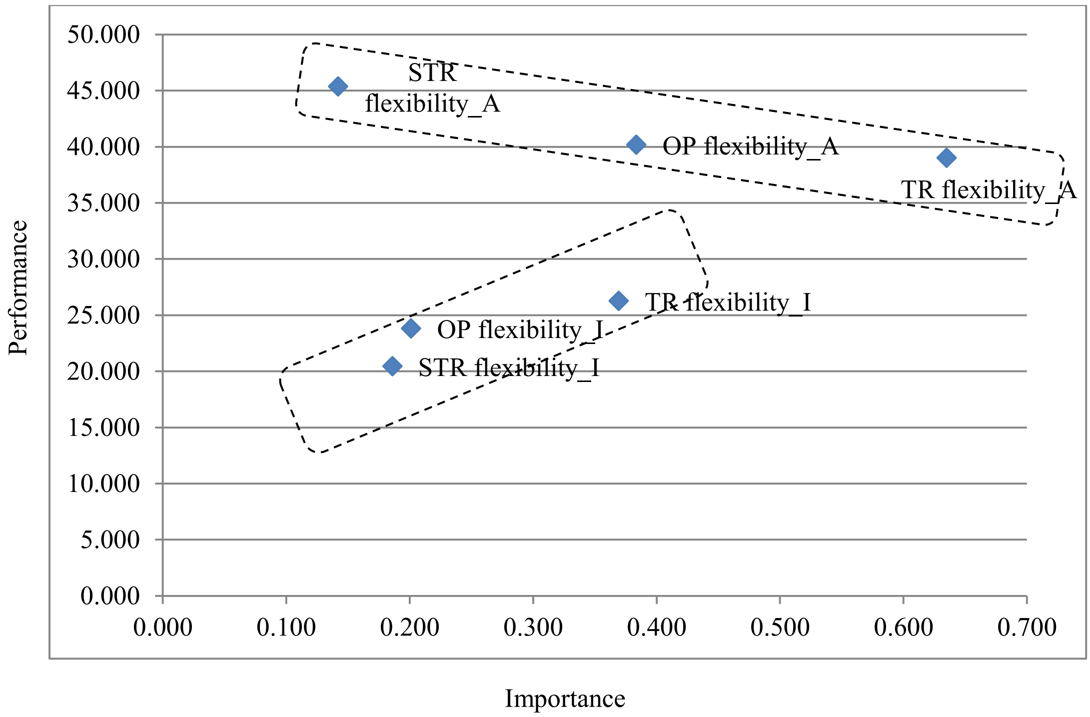


Figure 6.21 Importance–performance analysis: industry (I) and Company A (A) at the construct level.
Source: Author.

It can be expected that Company A's IT flexibility can be improved by making more managerial, technical efforts concerning TR flexibility but downsizing the investment in STR flexibility. By formulating the indicator-level IPA matrix, it was identified that SW and ACC from TR flexibility require more resources to improve their performance and the overall TR flexibility performance (TR flexibility → TR flexibility* in Figure 6.22). In contrast, PTN2 and OFF from STR flexibility and STMR from OP flexibility were interpreted as having a too-high level of performance compared to their level of importance, so resource reallocations from these indicators are suggested (OP flexibility → OP flexibility*, STR flexibility → STR flexibility* in Figure 6.22). Then, the distribution of the combination of importance and performance will go up and to the right, as shown in Figure 6.22.

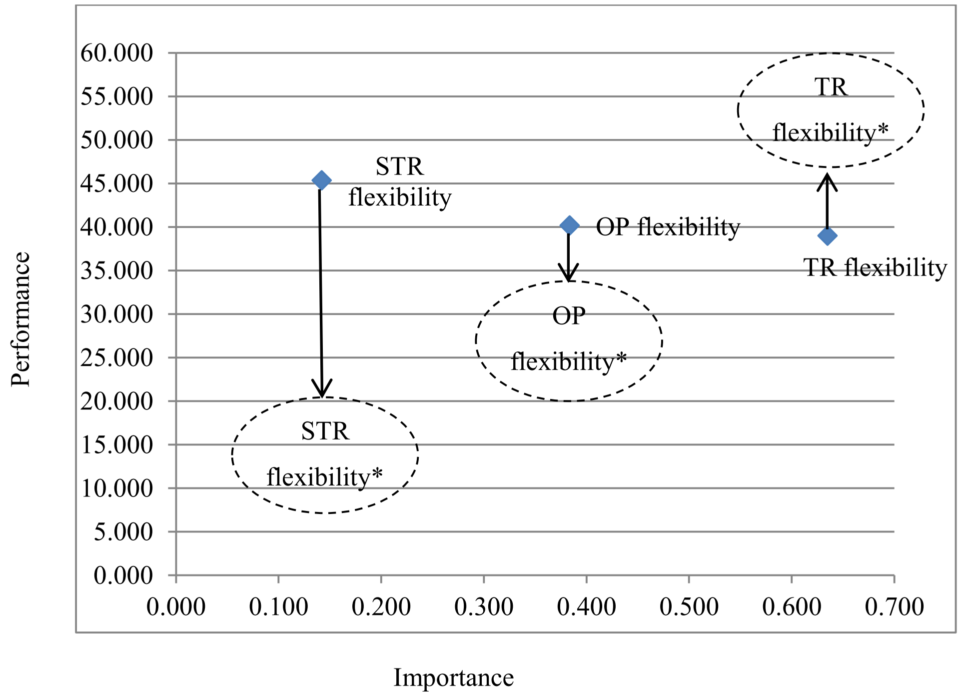


Figure 6.22 Resource allocation suggestions.
Source: Author.

Overall, by extending the PLS SEM results to the IPA matrix, this study prioritised the IT flexibility dimensions according to their levels of importance. TR flexibility is the most important dimensions, while OP flexibility is the second most important dimension and STR flexibility is the least important dimension. Moreover, it was identified that strategic resource allocation among the different flexibility dimensions is available. By analysing whether the dimension's performance level is appropriate to the level of importance, the identification of IT flexibility constructs that are most in need of improvement/downsizing of resources is possible. Thus, this section addresses RQ 3.

The identification of resource reallocation according to prioritised importance is closely related to the mobility of the flexibility concept proposed by Upton (1994) and Koste and Malhotra (1999). According to these authors, firms need to operate multiple dimensions with mobility, which is the capability move from one dimension to another at low cost. The resource reallocation suggestions made in this study contribute to such mobility, as they do not require additional cost penalty. Specifically, by applying objective measurement for different dimensions/types of flexibility (i.e. importance and performance; Upton 1995; Stevenson and Spring 2007), this study can enable firms to identify which dimensions require more resource input or a downsizing of input. Such an approach will allow firms to increase the level of FP without damaging the overall performance of the target construct as the strategy requires firms to transmit the resources from one specific dimension to another dimension without using additional resources. This resource allocation approach clarifies the concept of mobility by demonstrating how firms need to elastically operate multiple dimensions of flexibility in practice.

With regard to Company A's higher scores in relation to overall industry, it should be noted that this analysis is based on the respondents' perceptions on the use of IT. The perceptions will be different from company to company; moreover, they are affected by the circumstances in which companies operate. This is why the present study did not compare the IPA matrix of the industry and Company A directly with the estimated scores (score to score) but instead concentrated on comparison of the distribution patterns of the dimensions of importance and performance scores in each case.

In fact, Company A is a large, world-class firm that invests a large amount of financial resources in the IT area. Larger companies have more capital and technological resources to invest in IT, which may lead to a higher level of interfirm process performance (Bayraktar et al. 2009; Vanpoucke et al. 2013); however, they may also suffer from a lack of insights to allocate resources to IT flexibility in a strategic manner. Therefore, the overall higher score of Company A than the industry with its reversed distribution patterns of resource allocation can be explained.

In terms of measurement criteria, some issues need to be addressed as weaknesses of the employed method. First, data on cost – which are required for potential performance improvement – were not available. This is because the costs will differ from company to company, and they are determined by the specific characteristics of the process (where the IT flexibility attributes are used) used by the firm. Therefore, the IPA matrix allocation technique should be based on the assumption that the cost required to improve each flexibility is not significantly different from the others.

Second, it should be noted that this method uses relative measurement involving the distribution patterns of general features of a firm. In other words, the measurements of a firm's IT flexibility are based on relative comparisons among IT flexibility dimensions rather than using an absolute value. Although such an approach is consistent with the idea of flexibility as a relative attribute, where flexibility is to be examined as an alternative (Koste and Malhotra (1999), there may be a different view suggesting that the level of flexibility needs to be measured using universal absolute criteria.

With the samples acquired from this company, the present study applied the research model and IPA matrix to measure Company A's IT flexibility on two levels. The sample size was 35, which could be considered small. However, considering that this research involved exploratory analysis, a 10% significance level was regarded as theoretically sufficient. The sample size required was 34–53 with a minimum R^2 of 0.25–0.50 (Table 5.9). Considering that the R^2 identified from Company A's model test results was 0.261–0.735, the sample size of 35 theoretically meets the threshold.

CHAPTER 7. CONCLUSION AND IMPLICATIONS

7.1 INTRODUCTION

The continuous evolution of SCM along with the support from IT has encouraged the development of the proper management of IT flexibility in a changing environment. However, there has been disparate research streams on IT flexibility that do not correspond to the roles of IT for supply chain–wide activities. With such a unidimensional approach, it is difficult to make recommendations for supply chain practitioners to capitalise on the advantages generated by IT flexibility. However, with the recognition that IT flexibility need to be multidimensional to cover the divergent roles of IT in SCM, this study seeks to identify the best set of IT flexibility dimensions. The overarching objectives of this study, which were derived from the necessity for multidimensional IT flexibility in SCM, were as follows: 1) to reconceptualise the flexibility for SCM with multiple dimensions, 2) to identify the multiple dimensions' influencing mechanism on FP and 3) to prioritise the dimensions to enhance firms competitiveness and suggest a strategic way to allocate resources according to the prioritisation to provide competitive advantages to firms To achieve these research objectives, the following questions were developed:

RQ 1) What are the key dimensions of IT flexibility for SCM?

RQ 2) How do IT flexibility dimensions impact FP in the context of the supply chain execution?

RQ 3) How should firms prioritise different dimensions of IT flexibility and allocate resources to them in a strategic manner?

To develop the theoretical background of this research and to demonstrate the research motivation, literature regarding flexibility in OM/SCM and general IT flexibility was reviewed in Chapter 2. This chapter identified that IT flexibility needs to be classified and framed in an integrative format with multiple dimensions by incorporating the interfirm characteristics of SCM.

In Chapter 3, a systematic review was conducted to identify the dimensions of IT flexibility for SCM. By exploring and classifying the IT capabilities that enable a certain level of change, adjustment or development in supply chain operations to adapt to changes, the review identified three dimensions of IT flexibility. These were as follows: TR flexibility, which is responsible of interfirm network arrangement and connectivity; OP flexibility for information sharing and process improvement; and STR flexibility for strategic partnership reconfiguration and innovative product/service offering. In this chapter, RQ 1 was partially addressed.

Chapter 4 focussed on the research model development. Owing to the dominant theoretical lens of RBV, which showed a lack of explanation of the different dimensions of IT flexibility as relationship-specific resources in the interorganisational environment, the DC and RV theories were chosen as a theoretical lens for the IT flexibility research model. Based on the composition of the advantages of these two theories, a research framework linking IT flexibility and FP with the mediating concept of PIC was developed. Moreover, based on the research framework, an IT flexibility model hypothesising on the impact of the three dimensions on FP via the mediator PIC was developed.

To clarify the relationships between the five constructs and identify impact paths, Chapter 5 identified that this study would assume a positivistic and realistic view concerning the roles of IT flexibility and the SCM environment. Moreover, with this study's objective to develop a new theory via hypothesis testing and to generalise with further empirical study, it was determined that this study should take an abductive approach. Based on this methodological background and the research objective, PLS SEM was adopted as an appropriate method to test the proposed hypotheses. Considering the qualifications required for the questionnaire survey, a key informant survey was adopted as an appropriate data collection method.

In Chapter 6, a descriptive analysis of the survey responses and the demographic profile of the sample were presented and analysed. It was identified that the sample was selected from heterogeneous groups of respondents who were assessed as competent and knowledgeable about the questions. PLS SEM was performed to statistically test the 10 hypotheses, and 6 hypotheses were identified as significant. Table 7.1 summarises the results of hypotheses testing. From the hypotheses testing results, it was identified that TR flexibility supports OP flexibility and STR flexibility. Moreover, the positive impact of OP flexibility on STR flexibility was identified. Thus, the structure of IT flexibility with its multiple dimensions was validated. This also addressed RQ 1.

Hypothesis	Impact path	Result
H1a	TR flexibility → OP flexibility	Supported
H1b	TR flexibility → STR flexibility	Supported
H1c	OP flexibility → STR flexibility	Supported
H2a	TR flexibility → PIC	Supported
H2b	OP flexibility → PIC	Supported
H2c	STR flexibility → PIC	Not supported
H3a	TR flexibility → FP	Not supported
H3b	OP flexibility → FP	Not supported
H3c	STR flexibility → FP	Supported
H4	PIC → FP	Supported

Table 7.1 Summary of the Hypothesis Testing
Source: Author.

Mediating effect analysis was conducted to identify the influential mechanism of IT flexibility on FP. IT was found that TR and OP flexibilities affect FP indirectly via PIC, while STR flexibility affects FP directly. Therefore, RQ 2 was addressed.

Alternative model testing was conducted to identify whether the proposed IT flexibility research model described the characteristics of the IT flexibility dimensions. It was identified that the proposed research model not only presented the hierarchical relationships between the dimensions but also depicted the mediating effect of PIC in an efficient manner.

By extending the PLS SEM results to the IPA matrix, chapter 6 prioritised the IT flexibility dimensions according to the level of importance. Moreover, it suggested a way of allocating resources to the multiple dimensions by comparing the level of performance to the level of importance without a significant level of cost penalty. Therefore, RQ 3 was addressed.

In this chapter, the findings from the literature review and empirical tests are discussed along with their implications for the theory and practice. The chapter concludes by describing limitations of the study and directions for future research.

7.2 KEY RESEARCH FINDINGS

7.2.1 Response to Research Question 1: IT Flexibility Dimensions in SCM

The IT flexibility research model proposed in this study reflected and accommodated divergent areas in SCM research regarding the use of IT, resulting in comprehensive and explicit constructs of IT flexibility in three dimensions. These were TR flexibility, OP flexibility and STR flexibility. Each of these dimension has its own characteristics and responsibility to support firms in the supply chain. They were found to be involved in a hierarchical relationship.

TR flexibility is responsible for IT infrastructure and interfirm connectivity. By supporting firms to connect to a wide range of partner firms and IT platforms in widely dispersed areas, TR flexibility supports firms to establish and/or expand their network for successful interfirm transactions. OP flexibility focusses on quality information sharing and process improvement in the network, including elements like ordering, inventory, transport and distribution management. The purpose of OP flexibility is defined as exploitation, which refers to elastic utilisation of IT resources to support continuous process improvement and greater control over process execution in interorganisational relationships. STR flexibility is the capability of a firm to proactively explore its own and its supply chain partners' IT resources to create new, future-focussed business capabilities;

thus, its role can be defined as explorative. Moreover, its focus in SCM is the reconfiguration of IT resources for external partnering and new product and service offerings for the end customers.

The validity of each construct and the relationships among the constructs were identified by hypothesis testing. The hypotheses were that TR flexibility affects OP flexibility and the OP flexibility affects STR flexibility; therefore, hierarchical IT flexibility was identified. Moreover, it was found TR flexibility plays a pivotal role in supporting the two other types of IT flexibility, specifically OP and STR flexibility

7.2.2 Response to Research Question 2: Influential Mechanism

With the different responsibilities of the newly captured IT flexibility dimensions and conflicting identification regarding the impact of IT flexibility on FP, the influential mechanism that determines how different IT flexibility dimensions affect FP is an important issue to investigate. To capture the different roles of the three IT flexibility dimensions for FP, this study hypothesised that: first, the three IT flexibility dimensions affect FP directly; and second, that the three dimensions affect FP via PIC. PIC is incorporated into this research to test their roles in the context of SCM execution. Due to the lack of investigation into the mediating role of PIC in the current literature, the IT flexibility research model with PIC is expected to identify more process execution related evidences regarding the roles of IT flexibility dimensions. Ten hypotheses were developed into an IT flexibility research model and tested with PLS SEM analysis. Due to the incorporation of PIC as a mediator, mediating impact analysis was conducted to identify the influential mechanism of IT flexibility for FP.

Synthesis of the mediating effect analysis revealed that there are two different types of impact paths. On the one hand, TR flexibility which is responsible for interfirm network arrangement and connectivity configuration, and OP flexibility which is responsible for interfirm information sharing and process improvement positively affects FP only indirectly. The indirect effects were found to be mediated by PIC, which consisted of internal (intrafirm) process integration, process integration with suppliers and customers while supporting the idea of indirect impact of IT flexibility for FP (e.g. Ravichandran and Lertwongsatien 2005; Saraf et al. 2007; Fink and Neumann 2009; Bhatt et al. 2010; Ngai et al. 2011; Liu et al. 2013). While intra-/interfirm process integration has been argued as a key factor in successful SCM, it is rarely examined within the context of IT flexibility. However, this research identified the mediating role of PIC in executing IT flexibility.

On the other hand, STR flexibility, which is in charge of partnering reconfiguration and service offering, is identified as having direct impact on FP. This finding is in line with the direct impact of value creation focused IT flexibility to FP which is identified from the current literature (e.g. Armstrong and Sambamurthy 1999; Byrd and Turner 2001; Ray et al. 2005; Tian et al. 2010), indicating the explorative use of IT for innovative and potential value creation affect FP directly.

Overall, this study shows that the three dimensions are positively associated with FP in SCM but according to their roles, their impacts materialise in two different forms, namely direct and indirect impact. Moreover, in contrast to TR flexibility which can be viewed as closely related to an infrastructure focused view and STR flexibility which is in line with the value creation focussed view of the existing IT flexibility literature, OP flexibility is a newly captured flexibility dimension. Therefore, the identification of the impact mechanism of OP flexibility for FP is another notable finding that should be considered as another type of influential mechanism of IT flexibility for FP.

7.2.3 Response to Research Question 3: Prioritisation of IT Flexibility Dimensions

Owing to the lack of an objective and general measure for the flexibility concept, the prioritisation among different dimensions of flexibility has been regarded as an issue to be resolved in the literature. By employing the IPA matrix, which extends the result of PLS SEM, this study prioritised IT flexibility dimensions according to the level of importance of each dimension. Moreover, this study provided a way to initiate strategic resource allocation to the flexibility dimensions. Specifically, based on the idea that the most important construct shows the highest performance, as confirmed by the industry-level data (n = 128), this study applied the IPA matrix to a specific firm's PLS SEM test results. In this case, STR flexibility, which was expected to show the lowest performance, showed the highest performance. Moreover, TR flexibility, which was expected to show the highest performance, showed the lowest performance. By investigating the indicator-level IPA matrix of this firm, this study identified which indicators need more investment and which indicators need less investment. By prioritising IT flexibilities according to the importance levels and analysing the performance of each construct against its importance level, strategic resource allocation can be carried out for different types of IT flexibility.

7.3 IMPLICATIONS

7.3.1 Theoretical Implications

The major theoretical implication of this study is the reconceptualisation of IT flexibility for SCM. This study achieved an integrative format of IT flexibility via a comprehensive review. The model was further tested and validated through a large-scale questionnaire survey and applied to another empirical study. By reviewing and integrating the relevant literature, the current research provided a synthesis of the knowledge on IT flexibility for SCM, which will be useful for supply chain researchers and future research on IT flexibility.

The research model, which reconceptualised the roles of IT flexibility with its multiple dimensions, is different from the current models of IT flexibility in several ways. First, existing IT flexibility models are frequently skewed towards IT infrastructure–related flexibility (e.g. Duncan 1995; Byrd and Turner 2001). In contrast, the IT flexibility model developed in this study is more exhaustive, as this study covered two disparate research approaches, namely infrastructure-focussed view and the potential value-seeking–focussed view of IT flexibility. By providing a multidimensional concept of IT flexibility, this study demonstrated how IT flexibility for SCM should be developed so that supply chain–participating firms can develop different types of flexibility at the supply chain level for improved performance.

By identifying the interrelations between types, this study identified the roles of different dimensions of IT flexibility that are hierarchically related. TR flexibility has the central role, so firms are supported to flexibly exploit (with OP flexibility) and explore (with STR flexibility) business opportunities with a broader vision on the potential role of different IT flexibility dimensions. Such findings address the request of Kumar and Stylianou (2013), who called for research that systematically integrates different types of IT flexibility. Moreover, the research model established an extended view of IT flexibility based on the SCM philosophy and the transition to a strategic supply chain configuration.

This study also clarified the influential mechanism of IT flexibility for FP by identifying both direct and indirect effects on FP. The current literature has provided conflicting evidence on this topic. Few models have explicitly investigated the clear relationships between IT flexibility and organisational performance; rather, they have generally used other constructs, such as IT integration (Swafford et al. 2008) and IT-enabled information-sharing capabilities (Jin et al. 2014). This research showed that TR and OP flexibility affect FP indirectly, while STR flexibility affects FP directly.

The proposed model incorporates internal and external process integration in SCM – a gap overlooked by existing IT flexibility literature. Current research models do not articulate how IT flexibility enhances FP through process integration, which is regarded as an essential way to implement supply chain operations. For example, some studies found that IT flexibility is one of the preconditions for a higher level of organisational capability (Ravichandran and Lertwongsatien 2005; Ngai et al. 2011; Jin et al. 2014); others ascertained that IT flexibility is a moderator for an organisational capability that affects performance (Bush et al. 2010). Therefore, existing studies provide limited evidence on how IT flexibility affects FP in the context of SCM. The proposed model classified IT flexibility into three dimensions – TR flexibility, OP flexibility and STR flexibility – and demonstrated how these types of IT flexibility interact with each other and PIC to enhance FP.

This study employed DC and RV to explain the role of IT flexibility for SCM, thereby overcoming the conventional RBV. It was identified that, in the literature review process, RBV has been the dominant theoretical lens in IT flexibility research. However, this study pointed out that the RBV overlooks the characteristics of multidimensional contemporary IT capabilities, particularly their strong complementary nature when it comes to interacting with other IT resources located beyond the firm boundaries. This study extends RBV to incorporate further relational and dynamic dimensions to support the theory of IT flexibility for SCM. The combined theory proves effective in explaining how IT flexibility affects FP in a supply chain.

Finally, this research identified three flexibility elements, namely heterogeneity, mobility and uniformity. First, the multiple dimensions of IT flexibility that cover supply chain–wide operations from the transactional to strategic level signified that the IT flexibility dimensions are heterogeneous. The contribution of this study was to show that the integrative format can be developed by identifying a wide range of change options to cover the divergent use of IT and adapt to a changing business environment. Second, the positive impact of all of the dimensions on FP indicates that the IT flexibility dimensions have uniformity. Particularly, this study identified that uniformity can materialise in two ways, namely direct and indirect effect, as different IT dimensions shows different impact paths. Moreover, this study identifies that such uniformity can be realised in the SCM context, as the research model incorporated the PIC and FP, which were constructed by considering interfirm process integration and operational efficiency. Third, the strategic resource allocation developed from the IPA matrix indicates that firms can switch their focus from one option to another so representing the concept of mobility. The contribution of this strategy to the concept of mobility is that the resource allocation strategy allows firms to increase the level of FP without harming overall performance, even if they do not have any additional resources to invest. Therefore, this resource allocation approach demonstrates the concept of mobility by suggesting how firms need to elastically operate multiple dimensions in practice without cost penalties.

7.3.2 Practical Implications

This study provided an integrative view of IT flexibility for SCM and an explicit pathway to construct competitive advantages with such flexibility. These practical implications can be categorised in three ways, as described below.

First, this study's findings highlighted the importance of infrastructure flexibility building at the transactional level as a foundation that supports OP and STR flexibility. Moreover, investment in OP flexibility will allow firms to exploit existing IT resources skills, thereby causing efficiency in interfirm processes to improve. Such investment is particularly appropriate for companies that operate in a relatively stable market; here, frequent configuration of relationships is not required, but operations need to be carried out in a routine and standardised manner to meet customers' requirements. In contrast, this study stressed that that investment in STR flexibility will be result in innovative and potential value creation–based performance improvement, resulting in longer term, explorative capability that is highly desired for firms operating in a volatile market.

Second, this study provided a way to develop an action plan to allocate resources and investment in an efficient manner. Due to the lack of measures that can be used for different types of flexibilities, it was hard to identify the best priority for investment among the three IT flexibility dimensions. However, by extending PLS SEM to the IPA matrix, this study identified that the most important construct (TR flexibility in this study) should have the highest performance. Therefore, if the most important construct shows lower performance, investment needs to be made in the construct with the highest priority given the resources available within a firm. This approach led to improved understanding of how to extract the best value in an organisation's investment in IT resources. By taking general features to measure flexibility (Upton 1994), this study was able to identify the optimal level of flexibility (Sethi and Sethi 1990; Upton 1994; Upton 1995). Thus, it suggested the appropriate route for strategic resource allocation with the given amount of resources in a firm.

Given the above considerations, this study encourages managers to recognise the importance of IT flexibility with a more explicit and comprehensive perspective to understand how to strategically coordinate and use their IT flexibility dimensions to deal with current and upcoming environmental changes with the given resources. It is probably difficult to distinguish the types of IT flexibility to supply chain practitioners, as this requires a fundamental change in managerial thinking regarding the roles of IT, which are currently under their control. Moreover, the required understanding of the critical components of IT flexibility in supporting different objects may need more effort due to the traditional idea that IT flexibility is an independent, internally controlled technical resource for data interconnection and exchange (Shi and Daniels 2003). However, as IT has evolved and emerged as a crucial enabler of process transformation with divergent forms of capabilities in the interconnected business environment, it is important to pay attention to the diversity of roles carried out by IT at the network level. This study provided a framework of such integrative IT flexibility for SCM and tools to review the resource allocation to IT flexibility. Therefore, this approach delivers implications that are inherent to the IT flexibility dimensions; thus, supply chain practitioners should be encouraged to review their current IT flexibility dimensions and examine them according to their interorganisational business requirements.

7.4 LIMITATIONS AND FUTURE RESEARCH DIRECTIONS

Despite its significant contributions, the current study has several limitations. These are explained in conjunction with suggestions for future research below.

This study investigated the role of IT flexibility in dyadic relationships, primarily from the focal company's perspective, using the survey technique. This method is frequently used in supply chain IT-related research due to the limitations in capturing respondents interacting as pairs with too many variables in a complex supply chain environment (Kembro and Näslund 2014). However, since the supply chain network is normally a complex web comprising various types and numbers of companies, a triadic or extended level of interorganisational relationship could be ideal for the context of supply chain networks. In line of this idea, extending the survey beyond the focal company to cover two or more firms in a supply chain can be suggested as another direction of future research (Kembro and Näslund 2014).

As discussed in section 5.6.2, nonprobability sampling is preferred for exploratory research rather than as a basis for generalisation. Moreover, it is a good alternative when a study has limited resources or uncertainty in gathering the required number of samples. With the exploratory nature of this study and the need for access to specialised respondents, the selection of nonprobability sampling was justified. However, as all data were collected from respondents who were invited to enter the survey, it is limited in generalising the findings widely. In order to improve generalisability, future research should adopt a more rigorous sampling technique such as probability sampling. Moreover, it should be noted that, although this research made every effort to screen the competency of respondents, there could be respondents who might have entered without the required competency (in cases where the competency screening questions did not work). Therefore, in line with the issue of nonprobability sampling, more attention should be paid to generalisation.

While an IT flexibility measuring system (i.e. the IPA matrix) adopted in this research, this represented a purely relative measurement approach. According to Koste (1999), the flexibility concept is a relative attribute. Therefore, measuring IT flexibility with an absolute value or criteria that directly measure the level of flexibility may not be possible because the notion is always examined with respect to an alternative to assess its magnitude (Koste and Malhotra 1999, p. 78). Based on this idea, there needs to be a consensus related to using these relative criteria, which measure the level of flexibility in comparison of other flexibility constructs in the same population.

This study adopted perception-based FP measurement indicators. To characterise performance more objectively, the survey questions also need to incorporate performance, for example, in comparison to the industry average or actual performance measures, such as return on investment (ROI) and profits. It should be noted that the author made every effort to acquire a large sample for application of the model to the client firm; however, the application of the model was conducted with a relatively small sample size (n = 35) due to the limited access to the respondents. Reaching a sample of more than 100 individuals from a single company was not an easy task. Furthermore, the nature of the research subject, which required key respondents who were knowledgeable about overall IT use, interfirm process integration and FP dimensions, limited the ability to contact a large sample from a specific company, where the sample pool would be relatively narrower than in overall industry. The sample size falls into the statistically acceptable range if one considers the exploratory nature of the current study (Hair et al. 2013). However, if more samples were acquired, the test results would achieve extra validity.

Another future research direction can be identified from this study. This research developed the concept of IT flexibility based on the flexibility literature in OM/SCM; it then developed a method of prioritising different flexibility dimensions. By using the general and objective measures, this study identified (i.e. importance and performance) flexibility literature in OM/SCM that may be able to attempt to measure the level of manufacturing or supply chain flexibility with existing dimensions and identify the optimal level of flexibility. In particular, a trade-off between different flexibility types has been an issue in OM/SCM to be resolved with a view to adapting to the changing environmental conditions (Beach and Muhlemann 2000; Tiwari et al. 2015). The use of an IPA matrix for resource allocation may be useful in such a trade-off, as the matrix suggests, transmitting resources from one dimension to another. However, one of the preconditions of the IPA matrix is to disregard the resources required to improve each flexibility (or the amounts are the same for each flexibility). Thus, to use the IPA matrix for trade-offs, a clear measurement of the resources required to improve a specific flexibility should be supplemented by future research. Moreover, further empirical case studies will also help to shed further light on this subject; for example, longitudinal data may be used to examine the dynamics between the time when the information linkages are built and the time when the economic and environmental effects materialise.

There could be a concern with the inclusion of junior level employees in the survey. To identify whether and how different the research model would be if the clerks and operators were taken out, a stratified analysis was carried out. The model test without the clerks and operators (n = 97) generates a very similar result to the test with the full sample (n = 128), while keeping its good prediction accuracy (R^2 from 0.327 to 0.597) as presented in Appendix 6. The only difference is that the former model does not support H2a (H2a: TR flexibility positively affects process integration capability). As discussed in section 4.4.2, existing literature outlines the positive impact of TR flexibility to PIC but the stratified analysis without the clerks and operators does not capture the impact of TR flexibility for PIC. It suggests that the involvement of junior level employees does not have a detrimental effect on the model and the inclusion of information at all levels is required to develop a more comprehensive and robust IT flexibility model. Appendix 6 shows the results of a stratified analysis.

Although some limitations were identified above, this research contributed to the existing body of literature on IT and SCM by filling the research gaps identified concerning the role of IT flexibility for SCM using a multidimensional approach.

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APPENDICES

APPENDIX 1. ETHICAL APPROVAL FORM AND QUESTIONNAIRES

- **Ethical approval form**

APPLICATION APPROVED
Research Ethics Committee
Cardiff Business School
Cardiff University

ETHICS 1

Cardiff Business School Cardiff University | Ysgol Fusnes Caerdydd Prifysgol Caerdydd

STANDARD ETHICAL APPROVAL FORM

This form should be completed for every research project that involves human participants. It can also be used to identify whether a full application for ethics approval needs to be submitted. The researcher or, where the researcher is a student, the supervisor, is responsible for exercising appropriate professional judgement in this review. This checklist must be completed **before** potential participants are approached to take part in any research.

SECTION 1 - RESEARCH CHECKLIST

1.1	Does the study involve holding personal information (names, attributable information or personal identifiers of any form) on a database?	NO
1.2	Does the study involve participants who are particularly vulnerable or unable to give free and informed consent (children, people with learning disabilities, students in academically dependent relationships)?	NO
1.3	Will it be necessary for participants to take part in the study without their full knowledge and explicit consent (perhaps through covert observation)?	NO
1.4	Will the study involve discussion of sensitive topics (political or religious views, illegal activities, sexual activity, drug use and so forth) that could be uncomfortable to participants or harmful if divulged to others?	NO
1.5	Will the study involve potentially harmful procedures of any kind or be conducted in a hazardous environment that could expose the researchers or participants to higher risk than is encountered in normal life? http://www.cf.ac.uk/osheu/index.html	NO
1.6	Will financial inducements (cash, vouchers or a prize draws) be offered to participants?	NO
1.7	Will the study involve patients or patient data in the NHS?	NO

If you have answered 'NO' to all questions 1.1 to 1.7 above, please complete this form and submit TWO copies to Lainey Clayton in room F43. Both forms will be stamped as evidence of submission. One copy will be retained by the School for audit/office purposes and the other by the researcher/s. Undergraduate and postgraduate students should include/bind their copy of the form with their research report or dissertation.

If you have answered 'YES' to any of the questions above, you will need to complete a full ethical review form (ETHICS 2, available on Learning Central – CARBS RESEARCH ETHICS)

SECTION 2 PROJECT DETAILS

Title of Project:	Re-conceptualization of IT flexibility for Supply Chain Management: A multi-dimensional approach
Name of Lead Researcher:	Jeong Hugh HAN
Status (please circle) :	Post Graduate Researcher (PhD)
Names of other Researchers:	
Department:	Cardiff Business School
Email:	HanJH@cardiff.ac.uk

Contact Address:	D46, Cardiff Business School, Aberconway Building, Colum Drive, Cardiff, UK, CF10 3EU
Telephone number:	02920875704
Start and Estimated End Date of Project:	Start Date: 30/09/2013 Estimated End Date: 30/09/2016

SECTION 3 STUDENTS ONLY

Module name and number	PhD in Business Studies
Supervisor's or Module Leader's name	Dr. Yingli Wang
Email address	WangY14@cardiff.ac.uk

SECTION 4

<u>Briefly</u> describe the study design to be applied in the project including <u>methods of data collection and data analysis</u>

The aim of this study is to construct a multi-dimensional structure of IT flexibility for supply chain management and to identify how does IT flexibility affects firm performance. To do so, this study develops a research model that links IT flexibility to firm performance. Partial Least Squares Structural Equation Modelling is adopted to test the research model. Data for the model test were collected by distributing questionnaire to key informants who meet the criteria of involvement, (i.e., to employees who are involved in logistics / supply chain process, and also knowledgeable and familiar with the use of IT for inter-organizational business activities together with proper level of understanding on its impact on firm capability and performance.

SECTION 5 DECLARATION

I/we hereby confirm that we have answered these questions to the best of our knowledge and will take all reasonable steps to ensure the independence and transparency of this research.

SIGNED: [signature] **Jeong Hugh HAN** **DATE:**

PRINCIPAL RESEARCH INVESTIGATOR

SIGNED: [signature] **DATE:**

SUPERVISOR (WHERE APPROPRIATE)

APPLICATION APPROVED
Research Ethics Committee
Cardiff Business School
Cardiff University

- Questionnaire in English

CARDIFF UNIVERSITY
PRIFYSGOL CAERDYDD

Cardiff Business School
Cardiff University
Ysgol Fusnes Caerdydd
Prifysgol Caerdydd

Information Technology Flexibility
Does IT matter to your business?

Title of Project: Defining and Measuring IT Flexibility in Supply Chain Management

Invitation to join the IT flexibility study

You are cordially invited to take part in the IT Flexibility research project. The study is for companies who utilise information technology (IT) in their interactions with external parties in supply chains. Before you take part in, please read the following information and ask us if there is anything that is not clear or if you would like more information. You are under no obligation to participate in the survey and you may decline to answer any given question.

What is the purpose of this study?
The aim of this research is to develop a IT flexibility model in a supply chain management context. Moreover, in utilising the IT flexibility model we will provide a tool to measure a firm's IT flexibility, assess its impact on firm performance and determine ways to instigate improvements.

Why am I being asked to take part in the study?
In order to measure the impact of IT flexibility on firm performance, a survey is a potentially useful way to generalise research. Every participants' responses will be contributing to developing the IT flexibility model structure. Also, the survey will be analysed to give insights on measuring the impact of IT flexibility and how to improve it.

Who is undertaking the survey?
A PhD student Jeong Hugh Han in the Logistics and Operations Management Section, Cardiff Business School, Cardiff University is undertaking this research.

Will my taking part in the study be kept confidential?
All information we collect about you and your company will be treated confidentially. Identities will be kept anonymous in any reports papers subsequently published as a result of the survey findings.

Where can I find the results of the study?
The results of the study expected to be published in open access journals which means anyone in the world can read them without payment either through a journal's own website or our University's repository. When available we can send you links to these publications upon request.

Is there a contact point where I can seek further information about this study?
You can ask to speak to the research associate responsible for the research, Jeong Hugh Han by sending him an email to HanJH@cardiff.ac.uk or calling him on +02920875704 (UK). Alternatively, you may contact the academic accountable for the research, Prof. Mohamed Naim, via e-mail – NaimMM@cardiff.ac.uk.

Section A: Background Information on the use of IT

Please tick or fill in the answer that best describes you and your organization.

1. What types of operations/services do you provide? (Select all that apply)
□ Manufacturing □ Warehousing □ Construction □ Freight transport □ Integrated logistics
□ Multimodal transportation □ Freight forwarders □ Logistics brokers/intermediaries
□ Other (please specify):

2. Which types of IT do you deploy to access your network? (Select all that apply)
□ Integrated logistics portal/ E-market place □ RFID applications
□ LAN (Local Area Network), GPS (Global Positioning System), Satellite systems
□ Web based e-mail and mobile messenger services
□ Intranet □ Other (please specify):

3. Which types of IT do you deploy to manage your supply chain processes? (Select all that apply)
□ Material Requirement Planning □ Enterprise Resource Planning
□ Procurement and freight auctioning systems □ Warehouse Management Systems
□ Transport Management Systems □ Decision support systems
□ Real time Track and Tracing Systems □ Retail and sales management systems
□ Enterprise Social network such as Yammer □ Electronic Invoice and Fund Transferring Systems
□ Other (please specify):

4. Which types of IT do you deploy for external collaboration? (Select all that apply)
□ Sales/demand Forecasting Systems □ Customer Relationship Management Systems
□ Supplier Relationship Management Systems □ Vendor Managed Inventory Systems
□ Collaboration portal □ Electronic logistics network/marketplaces
□ Other (please specify):

Section B: IT and inter-firm information sharing

Please tick or fill in the answer that best describes you and your organization.

5. How do you assess your ability to communicate with external firms at supporting by the current IT?

Level of Agreement	Strongly disagree	Disagree	Slightly disagree	Neither	Slightly agree	Agree	Strongly agree
We can effectively transact with external firms by using our advanced hardware (e.g. Computer, field devices, sensors, meters, servers etc.)	1	2	3	4	5	6	7
We can effectively transact with external firms by using our advanced software and applications (e.g. Logistics portals, email systems etc.)	1	2	3	4	5	6	7
We can effectively transact with external firms by using our advanced network (e.g. internet, LAN, telephone, text, email)	1	2	3	4	5	6	7
We can effectively access our IT network properly and securely to communicate with external firms (e.g. internet/LAN access anytime anywhere)	1	2	3	4	5	6	7
We can access a wide range of external firms through our IT network (e.g. *Number of external firms* we can access through our portal)	1	2	3	4	5	6	7
We can effectively transact with our external firms through standardized information format e.g. Excel, PDF, HTML, EDI	1	2	3	4	5	6	7

Level of agreement	Strongly disagree	Disagree	Slightly disagree	Neither	Slightly agree	Agree	Strongly agree
We can share accurate and timely information	1	2	3	4	5	6	7
We can gain good visibility of supply chain processes	1	2	3	4	5	6	7
We can complete transactions rapidly	1	2	3	4	5	6	7
We can integrate and automate supply chain processes	1	2	3	4	5	6	7
We can optimize the supply chain processes with external firms	1	2	3	4	5	6	7
We can easily build and alter our information linkages to our ***existing*** supply chain partners e.g. customers, suppliers and third party logistics providers in response to changes in the business environment	1	2	3	4	5	6	7
We can easily build and alter our information linkages to ***new*** supply chain partners	1	2	3	4	5	6	7
We are actively exploring innovative ways of using IT in offering new products of services to customers	1	2	3	4	5	6	7

Section C. Process Integration Capability

Please circle one number on each scale, to indicate the level of your capability to integrate business process internally and externally.

6. How is your firm's capability for process integration improved by using IT?

Level of agreement	Much worse	worse	Slightly worse	Neutral	Slightly improved	Improved	Much improved
Capability to integrate sourcing, transport, service process and other areas ***internally***	1	2	3	4	5	6	7
Capability to integrate sourcing, transport, service process and other areas ***with suppliers***	1	2	3	4	5	6	7
Capability to integrate sourcing, transport, service process and other areas ***with customers***	1	2	3	4	5	6	7

Section D. Firm performance
Please circle one number on each scale, to indicate the level of your firm's performance

7. In the following areas how is your firm's performance improved by using IT?

Level of agreement	Much worse	worse	Slightly worse	Neutral	Slightly better	better	Much better
Transaction costs for your supply chain operations	1	2	3	4	5	6	7
Level of service provided to customers	1	2	3	4	5	6	7
Speed of supply chain operations	1	2	3	4	5	6	7
Quality of product/service to customers	1	2	3	4	5	6	7
Value creation in the supply chain	1	2	3	4	5	6	7

Section E. General Background Information
Please tick or fill in the answer that best describe you and your organization.

8. What is your level of responsibility within your company?

☐ Vice president or above
☐ Manager/assistant manager
☐ Director/vice director
☐ Supervisor
☐ Clerk/operator
☐ Other (please specify):

9. What is your area of responsibility within your company?

☐ CEO / Managing Director
☐ Logistics / Operations
☐ Supply chain
☐ IT
☐ Marketing
☐ Other (please specify):

10. How long has your company been established?

☐ 1-5 years
☐ 6-10 years
☐ 11-15 years
☐ 16-20 years
☐ Over 20 years

11. Approximately, please indicate the number of employees in your company.
Total of ……………….employees

12. Please give an estimate of your firm's annual revenue in 2013
Total of ………………. revenue (in monetary unit in your country)

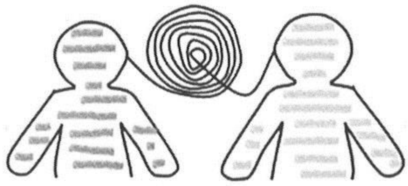
13. What types of IT are you considering investing in, or implementing, in the next 3-5 years?
……

14. Date of completion of survey
Day……………Month……………Year……..

Thank you for your participation in this important study

- **Questionnaire in Korean**

CARDIFF UNIVERSITY PRIFYSGOL CAERDYDD



Cardiff Business School Cardiff University

Ysgol Fusnes Caerdydd Prifysgol Caerdydd

Information Technology Flexibility
Does IT matter to your business?

공급사슬 운영을 위한 IT 유연성 연구

본 연구에 참여해 주셔서 깊은 감사를 드립니다. 이 연구는 공급사슬 및 물류서비스를 제공하고 있는 기업들을 위한 연구입니다. 참여하시기 전에 이 글을 잘 읽어 보시고 궁금한 점이나 더 필요한 정보가 있으시면 연락 주시기 바랍니다. 이 설문에 의무적으로 참여하실 필요는 없으며 답변을 거절하실 수 있습니다.

연구의 목적

이 연구의 목적은 공급사슬 및 물류 기업들의 IT 유연성 개념을 정립하고 일반화 하는데 있습니다. 또한 이 개념을 사용, 기업의 IT 유연성이 기업성과에 어떠한 영향을 미치는지 측정하고, 또한 기업의 IT 유연성을 발전시킬 수 있는 방법을 도출할 계획입니다.

설문조사의 필요성

IT 도입이 기업성과에 미치는 영향을 측정하고 그 영향력을 일반화하기 위해 설문조사가 진행되고 있습니다. 설문답변 내용은 IT 유연성 개념을 정립하기 위해 분석될 예정이며 또한 개별기업의 IT 유연성을 어떻게 발전시키기 위한 연구에 소중히 사용될 예정입니다.

연구진행 기관

영국 카디프 경영대학원의 물류 및 운영관리학과 박사과정 한정휴가 본 연구를 실시하고 있습니다.

설문의 익명성

응답에 관련된 모든 정보는 유출이 금지될 것이며 연구결과 역시 모든 부분에 있어 익명성이 보장됩니다.

연구결과

연구결과는 학술논문집에 수록될 예정이며 인터넷 및 교육기관의 시설을 통해 전세계 누구나 비용 부담없이 볼 수 있도록 할 예정입니다. 연구결과를 열람하시길 요청하시면 차후 연구논문의 링크를 이메일로 보내 드리겠습니다.

연락처 정보

본 연구와 관련하여 궁금하신 점은 한정휴 (HanJH@cardiff.ac.uk)에게 메일을 보내시거나 +442920875704 (영국)로 전화하실 수 있습니다. 또한 본 연구의 학문적 책임에 관해 궁금하신 점은 Mohamed Naim (교수, NaimMM@cardiff.ac.uk.)에게 메일을 보내실 수 있습니다.

Section A: IT 사용에 대한 질문 (귀하 및 귀사가 해당하는 곳에 표기하여 주시기 바랍니다.)

1. 귀사가 제공하는 공급사슬/물류서비스는 무엇입니까? (해당사항 모두선택)
□ 제조업 □ 창고업 □ 건설업 □ 화물운송업 □ 통합물류서비스 □ 복합운송업
□ 포워딩 □ 물류서비스 브로커 □ 기타 (설명해주세요):

2. 귀하는 회사 네트웍에 접속하기 위해 어떤 정보통신기술을 사용하고 계십니까? (해당사항 모두선택)
□ 통합물류포탈/ e-마켓 □ RFID 관련 기술 □ LAN (근거리 통신망), GPS (글로벌 포지셔닝 시스템), 위성 시스템 □ 인터넷 기반 email 시스템/메신저 시스템 □ 인트라넷 (사내 통신망) □ 기타 (설명해주세요)

3. 귀하는 공급사슬/물류서비스 운영을 위해 어떠한 정보통신 기술을 사용하십니까? (해당사항 모두선택)
□ 자재소요계획 시스템 (MRP) □ 조달 및 운송 경매 시스템 □ 창고운영시스템(WMS)
□ 운송 운영 시스템 (TMS) □ 기업 의사결정 시스템 □ 실시간 위치 추적 시스템
□ 소매 및 매출관리 시스템 □ 기업 소셜 네트워 (예를 들어 Yammer) □ 전자 결제시스템
□ 기타(설명해 주세요):

4. 귀하는 타기업과의 협업을 위해 어떠한 정보통신 기술을 사용하고 있습니까? (해당 사항 모두 선택)
□ 매출 및 수요예측 시스템 □ 고객관리 시스템 □ 공급자관리 시스템 □ 판매자 운영방식의 재고시스템 □ 타기업과 연결된 포탈시스템 □ 전자물류네트웍 시스템/ e-market □ 기타 (설명해 주세요):

Section B: 정보통신 기술과 기업간 의사소통 (귀하 및 귀사가 해당하는 곳에 표기하여 주시기 바랍니다.)
5. 정보통신 기술을 사용, 귀사가 타기업과 소통할 수 있는 능력에 대해 어떻게 평가하십니까?

동의하는 정도	매우 그렇지않음	그렇지 않음	약간 그렇지않음	중립	약간 동의함	동의함	매우 동의함
우리는 우수한 장비를 통해 타기업과 효과적으로 거래 할 수 있다. (e.g. 컴퓨터, 센서, 서버 및 기타 실무장비 등),	1	2	3	4	5	6	7
우리는 우수한 소프트웨어 및 어플리케이션을 통해 타기업과 효과적으로 거래할 수 있다. (e.g. 물류포탈, email 등)	1	2	3	4	5	6	7
우리는 우수한 네트웍을 통해 타기업과 효과적으로 거래할 수 있다. (e.g. 인터넷, 랜(LAN), 이메일, 전화, 문자메세지 서비스 등)	1	2	3	4	5	6	7
우리는 타기업과 안전하고 안정적으로 거래하기 위해 우리의 네트워크에 효과적으로 접속할 수 있다. (e.g. 시간과 장소에 관계없이 인터넷 및 랜을 통한 회사 네트웍 접속)	1	2	3	4	5	6	7
우리는 회사 네트워크를 통해 많은 수의 기업에 접속할 수 있다. (e.g. 회사포탈을 사용하여 접속할 수 있는 외부기업의 수)	1	2	3	4	5	6	7
우리는 표준화된 양식을 통해 타기업과 효과적으로 거래할 수 있다. (e.g, Excel, PDF, HTML, EDI 등등)	1	2	3	4	5	6	7

동의하는 정도	매우그렇지않음	그렇지않음	약간그렇지않음	중립	약간 동의함	동의함	매우동의함
우리는 공급사슬/물류 관련 정보를 정확하게, 그리고 제시간에 공유할 수 있다	1	2	3	4	5	6	7
우리는 공급사슬/물류 진행과정을 한눈에 알아볼 수 있다.	1	2	3	4	5	6	7
우리는 공급사슬/물류관련 거래를 빠르게 진행 할 수 있다	1	2	3	4	5	6	7
우리는 공급사슬/물류서비스 진행 과정을 통합하고 자동화 할 수 있다	1	2	3	4	5	6	7
우리는 타기업과 함께 공급사슬/물류운영과정을 최적화할 수 있다.	1	2	3	4	5	6	7
우리는 현재의 공급사슬 파트너기업과 함께 정보시스템을 쉽게 연결/조정할 수 있다. (e.g. 경영환경 변화에 적응하기 위한 고객사, 공급자, 3 자물류회사간의 정보교환의 방식의 변화)	1	2	3	4	5	6	7
우리는 새로운 공급사슬파트너기업과 함께 정보시스템을 쉽게 연결/조정할 수 있다	1	2	3	4	5	6	7
우리는 새로운 공급사슬/물류서비스 제공을 위해 정보통신을 사용한 혁신적인 방법을 적극적으로 찾고 있다.	1	2	3	4	5	6	7

Section C. 물류과정통합 역량

다음 기술하고 있는 물류과정통합역량 지표와 관련, 귀하가 동의 하는 정도를 표시해 주시기 바랍니다.

6. 귀하는 정보통신기술 사용을 통해 향상된 귀사의 물류 수행 능력을 어떻게 평가하십니까?

동의하는 정도	매우 악화됨	악화됨	약간 악화됨	중립	약간 발전됨	발전됨	매우 발전됨
내부적으로 구매, 운송, 서비스 및 다른 분야를 통합하여 운영할 수 있는 역량	1	2	3	4	5	6	7
공급자와 함께 구매, 운송, 서비스 및 다른 분야를 통합하여 운영할 수 있는 역량	1	2	3	4	5	6	7
고객과 함께 구매 운송, 서비스 및 다른 분야를 통합하여 운영할 수 있는 역량	1	2	3	4	5	6	7

Section D. 물류기업성과

다음 기술하고 있는 물류기업성과 지표와 관련, 귀하가 동의 하는 정도를 표시해 주시기 바랍니다.

7. 정보통신기술의 사용이 물류기업성과에 미치는 영향

동의하는 정도	매우 악화됨	악화됨	약간 악화됨	중립	약간 향상됨	향상됨	매우 향상됨
물류서비스 제공에 대한 거래 비용	1	2	3	4	5	6	7
고객에게 제공되는 서비스의 수준	1	2	3	4	5	6	7
물류 운영의 속도	1	2	3	4	5	6	7
고객에게 제공되는 서비스의 품질	1	2	3	4	5	6	7
공급사슬운영시 부가가치 창조	1	2	3	4	5	6	7

Section E. 일반적인 사항에 대한 질문

귀하 및 귀사가 해당하는 곳에 표기하여 주시기 바랍니다.

8. 귀하의 사내 직위는 무엇입니까?

□ 부사장 혹은 그 이상
□ 부장/차장
□ 과장/대리
□ 관리자
□ 사원/오퍼레이터
□ 기타 (설명해주세요):

9. 귀하의 사내 직무는 무엇입니까?

□ CEO / 고위관리직
□ 물류 / 운영관리
□ 공급사슬 관리
□ 정보통신 관리
□ 마케팅
□ 기타 (설명해주세요):

10. 귀하가 근무하는 회사는 설립된 지 얼마나 되었습니까?

□ 1-5 년 □ 6-10 년 □ 11-15 년 □ 16-20 년 □ 20 년 이상

11. 귀하가 근무하는 회사의 종업원수는 대략 몇 명입니까?

전체 약....................명

12. 귀하가 종사하는 회사의 2013 년도손익은 대략 얼마입니까?

전체 약 ....원

13. 향후 3~5 년간 어떤 종류의 정보통신 기술을 도입하거나 투자할 생각이십니까?

....

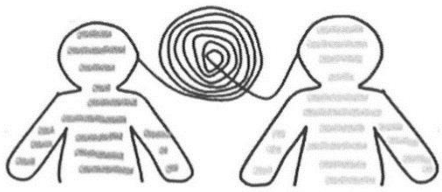
14. 설문지 작성일

............년...............월.................일

소중한 시간 내어 주셔서 감사합니다.

- **Questionnaire in Chinese**

CARDIFF UNIVERSITY PRIFYSGOL CAERDYDD



Information Technology Flexibility

Does IT matter to your business?

Cardiff Business School Cardiff University

Ysgol Fusnes Caerdydd Prifysgol Caerdydd

项目名称：界定和测量物流业通信灵活性

邀请您完成问卷调查

尊敬的先生/女士：

您好！首先感谢您能抽出宝贵时间协助我们完成本研究项目的这份调查问卷，此次问卷调查目的是为完成采用信息通信技术开发一个在物流领域的通信灵活性模型，评估其对物流绩效的影响，并确定改进的方法。请您根据贵单位客观实际情况，协助完成以下问题的问答。本项研究是由英国卡迪夫大学商学院和中国江苏师范大学商学院项目研究团队合作开展的 研究经费是由英国工程和物理科学研究委员会 资助的，这份调查问卷是为完成本项目而进行的纯属学术研究，您所提供的资料将绝对保密，当然您也可以拒绝完成回答问题。

关于本项目的更多信息，您可以通过以下方式联系：

英国研究员：英国卡迪夫大学商学院本项研究对外联系的研究员：Jeong Hugh Han，联系方式：HanJH@cardiff.ac.uk 或拨打 02920875704（英国）。

第一部分：关于使用信息和通信技术的背景资料

请勾选或填写最能描述您和您的组织的答案。

1 你们提供什么类型的操作/物流服务？（选择所有适用）

□制造业 □仓储 □建设 □货运 □综合物流

□多式联运 □货运代理 □物流经纪/中介

□其他（请注明）：

2 您使用哪些类型的信息和通信技术用来访问您的网络？（选择所有适用）

□综合物流门户网站/电子市场 □RFID 应用

□LAN（局域网），GPS（全球定位系统）卫星系统

□基于 Web 的电子邮件和移动信使服务

□内联网 □其他（请注明）：

3 您使用哪种类型的信息和通信技术来管理您的物流流程？（选择所有适用）

□物料需求计划　□采购和货运竞价系统
□仓库管理系统　□运输管理系统　□决策支持系统
□实时跟踪和追踪系统　□零售及销售管理系统
□企业社交网络如 Yammer　□电子发票和资金转移系统
□其他（请注明）：

4 外部协作方面，您使用了哪些类型的信息和通信技术？（选择所有适用）
□销售/需求预测系统　□客户关系管理系统
□供应商关系管理系统　□供应商管理库存系统
□协作门户系统　□电子物流网络/交易市场
□其他（请注明）：

第二部分：信息和通信技术与企业间的沟通

请勾选或填写最能描述您和您的组织的答案。

5 您如何评价您目前利用所使用的信息和通信技术与外部机构进行交流的能力？

一致性水平	非常不同意	不同意	比较不同意	无所谓	比较同意	同意	非常同意
我们可以通过使用我们先进的硬件有效地与外部企业进行交易（如电脑，现场设备，传感器，仪表，服务器等）	1	2	3	4	5	6	7
我们可以通过使用我们先进的软件和应用程序有效地与外部企业进行交易（如物流门户网站，电子邮件系统）	1	2	3	4	5	6	7
我们可以通过使用我们先进的网络有效地与外部企业进行交易（例如互联网，局域网，电话，文本，电子邮件）	1	2	3	4	5	6	7
我们可以通过适时而安全地访问我们的信息和通信技术网络有效地与外部机构进行通信（如随时随地接入互联网/局域网）	1	2	3	4	5	6	7
我们可以通过我们的信息和通信技术网络访问广泛的外部企业（例如，我们可以通过我们的门户访问一大批外部企业）	1	2	3	4	5	6	7
我们可以通过标准化的信息格式有效地与我们的外部企业进行交易（例如 Excel，PDF，HTML，EDI）	1	2	3	4	5	6	7
我们可以分享准确，及时的信息	1	2	3	4	5	6	7
我们可以得到可视化的物流过程	1	2	3	4	5	6	7

我们可以迅速完成交易	1	2	3	4	5	6	7
我们可以集成和自动化物流流程	1	2	3	4	5	6	7
我们可以与外部企业优化物流流程	1	2	3	4	5	6	7
在应对变化的业务环境时，我们可以轻松地构建和改变我们与现有的供应链合作伙伴（如：客户，供应商和第三方物流供应商）之间的信息联系	1	2	3	4	5	6	7
我们可以轻松地构建和改变我们与新的外部机构间的信息联系	1	2	3	4	5	6	7
我们正在积极探索利用现有信息和通信技术的创新方式	1	2	3	4	5	6	7

第三部分：物流执行能力

请圈上的每行刻度中一个数字，用来说明您执行内部和外部物流过程的能力水平。

6 您的企业是如何利用信息和通信技术提高物流执行能力的？

一致性水平	大为变差	变差	略变差	中性	略改善	改善	大为改善
在企业内部整合采购，运输，服务流程和其他相关领域的能力	1	2	3	4	5	6	7
面对供应商整合采购，运输，服务流程和其他相关领域的能力	1	2	3	4	5	6	7
面对客户整合采购，运输，服务流程和其他相关领域的能力	1	2	3	4	5	6	7

第四部分：物流绩效

请圈上最能描述您和您的组织的答案，用来说明您公司的物流绩效水平。

7 在以下几个方面是如何贵公司的物流绩效提高利用信息和通信技术？

一致性水平	极大变差	变差	略微变差	中性	略有改善	有改善	极大改善
物流业务的交易成本	1		3	4	5	6	2
为客户提供的服务水平	1	2	3	4	5	6	7
物流作业速度	1	2	3	4	5	6	7
为客户服务的质量	1	2	3	4	5	6	7
供应链的价值创造	1	2	3	4	5	6	7

第五部分：一般背景资料

请勾选或填写最能描述您和您的组织的答案。

8 您在公司内部职务等级是？

□副总裁或以上　□经理/经理助理　□主任/副主任

□监理　□文员/操作员　□其他（请注明）：

9 您在公司内部的职责范围是？

□CEO /总经理　□物流/营运　□供应链

□信息通信技术　□市场　□其他（请注明）：

10 您公司已经成立多长时间？

□1-5 年　□6-10 年　□11-15 年　□16-20 年　□20 年以上

11 您公司的职员一共大概有多少人？

员工总数为：

12 请您估算在 2013 年的年收入是？

总收入 ______（以您所在国家的货币单位计量）

13 您是否正在考虑在未来的 3-5 年内投资或实施某种类型的信息和通信技术，有哪些类型？

14 调查问卷完成日期

______ 年__ 月___ 日

再次感谢您参与完成本调查问卷！

APPENDIX 2. NONRESPONSE BIAS TEST RESULTS

	Mann–Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
HW	475.0	1003.0	-0.523	0.601
SW	462.5	958.5	-0.475	0.635
NW	378.5	906.5	-1.900	0.057
ACC	469.0	965.0	-0.386	0.699
LINK	495.5	1023.5	-0.007	0.994
INTP	435.5	963.5	-1.089	0.276
QLT	487.0	1015.0	-0.131	0.896
VIS	381.0	909.0	-1.640	0.101
SPD	399.5	927.5	-1.400	0.162
STMR	397.5	893.5	-1.016	0.309
OPT	362.5	890.5	-1.916	0.055
PTN1	377.5	905.5	-1.687	0.092
PTN2	374.0	902.0	-1.723	0.085
OFF	488.0	984.0	-0.114	0.909
PIC1	454.5	982.5	-0.826	0.409
PIC2	394.5	922.5	-1.664	0.096
PIC3	411.0	939.0	-1.466	0.143
COST	377.5	905.5	-1.924	0.054
SVC	451.0	979.0	-0.869	0.385
SPD_P	472.0	1000.0	-0.580	0.562
QLT_P	475.0	1003.0	-0.529	0.597
VAL	505.0	1033.0	-0.099	0.921

APPENDIX 3. PLS SEM TEST RESULTS FOR THE HIERARCHICAL MODEL

- Summary of the validity test results for the measurement model

Latent variables	Number of indicators	Internal consistency reliability		Convergent validity	Indicator reliability
		Composite reliability	Cronbach's alpha	AVE	Factor loadings
Transactional flexibility	6	0.887	0.846	0.567	0.660 to 0.823
Operational flexibility	5	0.925	0.898	0.710	0.813 to 0.893
Strategic flexibility	3	0.879	0.792	0.709	0.725 to 0.899
Firm Performance	5	0.890	0.846	0.620	0.719 to 0.874

- Factor loadings of the measurement models

	TR flexibility	OP flexibility	STR flexibility	Firm performance
HW	0.822			
SW	0.793			
NW	0.798			
ACC	0.676			
LINK	0.756			
INTP	0.660			
QLT		0.817		
VIS		0.840		
SPD		0.849		
STMR		0.893		
OPT		0.813		
OFF			0.725	
PTN1			0.890	
PTN2			0.899	
COST				0.771
SVC				0.781
SPD_P				0.719
QLT_P				0.874
VAL				0.783

- Fornell–Larcker criterion analysis

	Firm performance	**OP flexibility**	**STR flexibility**	**TR flexibility**
Firm performance	0.787			
OP flexibility	0.469	0.843		
STR flexibility	0.489	0.798	0.842	
TR flexibility	0.462	0.744	0.668	0.753

- Analysis of cross-loadings

	TR flexibility	**OP flexibility**	**STR flexibility**	**Firm performance**
HW	**0.822**	0.615	0.549	0.356
SW	**0.793**	0.594	0.490	0.282
NW	**0.798**	0.521	0.481	0.389
ACC	**0.676**	0.487	0.458	0.344
LINK	**0.756**	0.635	0.587	0.385
INTP	**0.660**	0.481	0.432	0.339
QLT	0.575	**0.817**	0.553	0.298
VIS	0.650	**0.840**	0.692	0.382
SPD	0.561	**0.849**	0.634	0.351
STMR	0.706	**0.893**	0.753	0.483
OPT	0.625	**0.813**	0.704	0.437
OFF	0.445	0.462	**0.725**	0.447
PTN1	0.617	0.733	**0.890**	0.474
PTN2	0.607	0.780	**0.899**	0.332
COST	0.388	0.344	0.450	**0.771**
SVC	0.329	0.307	0.295	**0.781**
SPD_P	0.249	0.339	0.329	**0.719**
QLT_P	0.409	0.394	0.379	**0.874**
VAL	0.410	0.439	0.428	**0.783**

APPENDIX 4. PLS SEM TEST RESULTS FOR THE EXTENDED HIERARCHICAL MODEL

- Summary of validity test results for the measurement model

Latent variables	Number of indicators	Internal consistency reliability		Convergent validity	Indicator reliability
		Composite reliability	Cronbach's alpha	AVE	Factor loadings
Transactional flexibility	6	0.887	0.846	0.567	
Operational flexibility	5	0.925	0.898	0.710	
Strategic flexibility	3	0.879	0.792	0.709	
PIC	3	0.901	0.836	0.752	
Firm performance	5	0.891	0.846	0.622	

- Factor loadings of the measurement models

	TR flexibility	OP flexibility	STR flexibility	Process integration capability	Firm performance
HW	0.812				
SW	0.780				
NW	0.801				
ACC	0.689				
LINK	0.759				
INTP	0.666				
QLT		0.816			
VIS		0.837			
SPD		0.851			
STMR		0.894			
OPT		0.814			
OFF			0.732		
PTN1			0.888		
PTN2			0.896		
PIC1				0.834	
PIC2				0.890	
PIC3				0.878	
COST					0.750
SVC					0.804
SPD_P					0.722
QLT_P					0.879
VAL					0.780

- Fornell–Larcker criterion analysis

	Process integration capability	Firm performance	OP flexibility	STR flexibility	TR flexibility
Process integration capability	0.867				
Firm performance	0.685	0.789			
OP flexibility	0.556	0.465	0.843		
STR flexibility	0.490	0.483	0.796	0.842	
TR flexibility	0.540	0.461	0.742	0.668	0.753

- Analysis of cross-loadings

	TR flexibility	OP flexibility	STR flexibility	Process integration capability	Firm performance
HW	**0.812**	0.614	0.546	0.431	0.346
SW	**0.780**	0.593	0.487	0.365	0.280
NW	**0.801**	0.521	0.480	0.389	0.389
ACC	**0.689**	0.487	0.458	0.413	0.345
LINK	**0.759**	0.634	0.588	0.473	0.383
INTP	**0.666**	0.480	0.434	0.352	0.335
QLT	0.574	**0.816**	0.553	0.425	0.295
VIS	0.650	**0.837**	0.692	0.414	0.380
SPD	0.561	**0.851**	0.633	0.511	0.352
STMR	0.703	**0.894**	0.752	0.520	0.477
OPT	0.624	**0.814**	0.701	0.467	0.433
OFF	0.451	0.461	**0.732**	0.383	0.439
PTN1	0.615	0.734	**0.888**	0.442	0.467
PTN2	0.604	0.780	**0.896**	0.412	0.325
PIC1	0.423	0.399	0.375	**0.834**	0.557
PIC2	0.488	0.568	0.543	**0.890**	0.594
PIC3	0.490	0.471	0.349	**0.878**	0.630
COST	0.388	0.343	0.451	0.536	**0.750**
SVC	0.333	0.307	0.296	0.534	**0.804**
SPD_P	0.251	0.340	0.330	0.491	**0.722**
QLT_P	0.411	0.394	0.380	0.558	**0.879**
VAL	0.414	0.440	0.430	0.572	**0.780**

APPENDIX 5. PLS SEM TEST RESULTS FOR COMPANY A

- Summary of validity test results of the measurement model

Latent variables	Number of indicators	Internal consistency reliability		Convergent validity	Indicator reliability
		Composite reliability	Cronbach's alpha	AVE	Factor loadings
TR flexibility	6	0.918	0.894	0.655	0.619 to 0.898
OP flexibility	5	0.940	0.920	0.758	0.831 to 0.898
STR flexibility	3	0.919	0.868	0.792	0.854 to 0.945
Process integration capability	3	0.911	0.856	0.773	0.869 to 0.888
Firm performance	5	0.954	0.940	0.807	7.848 to 0.953

- Factor loadings of the measurement models

	TR flexibility	OP flexibility	STR flexibility	Process integration capability	Firm performance
HW	0.904				
SW	0.880				
NW	0.815				
ACC	0.709				
LINK	0.876				
INTP	0.604				
QLT		0.839			
VIS		0.892			
SPD		0.867			
STMR		0.899			
OPT		0.831			
OFF			0.863		
PTN1			0.862		
PTN2			0.946		
PIC1				0.873	
PIC2				0.886	
PIC3				0.877	
COST					0.845

SVC					0.913
SPD_P					0.915
QLT_P					0.955
VAL					0.860

- Fornell–Larcker criterion analysis

Latent variables	Process integration capability	Firm performance	Operational flexibility	Strategic flexibility	Transactional flexibility
Process integration capability	**0.879**				
Firm performance	0.422	**0.898**			
Operational flexibility	0.498	0.757	**0.871**		
Strategic flexibility	0.361	0.715	0.739	**0.890**	
Transactional flexibility	0.401	0.689	0.692	0.805	**0.809**

- Analysis of cross-loadings

	TR flexibility	OP flexibility	STR flexibility	Process integration capability	Firm performance
HW	**0.898**	0.715	0.759	0.446	0.588
SW	**0.889**	0.603	0.785	0.208	0.584
NW	**0.817**	0.331	0.544	0.168	0.349
ACC	**0.724**	0.404	0.514	0.341	0.638
LINK	**0.870**	0.762	0.874	0.474	0.678
INTP	**0.619**	0.312	0.287	0.173	0.397
QLT	0.550	**0.854**	0.556	0.404	0.700
VIS	0.633	**0.897**	0.711	0.448	0.671
SPD	0.565	**0.872**	0.677	0.543	0.732
STMR	0.678	**0.898**	0.742	0.376	0.603
OPT	0.582	**0.831**	**0.508**	0.389	0.584
PTN1	0.588	0.710	**0.851**	0.227	0.576
PTN2	0.810	0.635	**0.945**	0.337	0.661
OFF	0.783	0.640	**0.871**	0.385	0.665

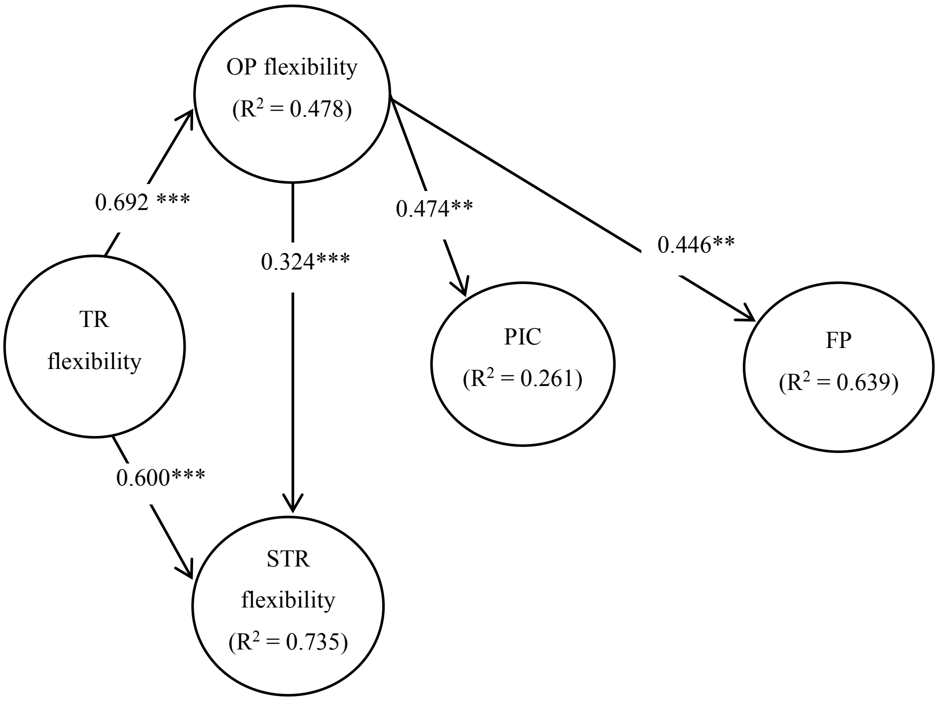
PIC1	0.428	0.439	0.412	**0.869**	0.430
PIC2	0.215	0.314	0.178	**0.888**	0.224
PIC3	0.363	0.509	0.309	**0.880**	0.401
COST	0.590	0.751	0.680	0.351	**0.848**
SVC	0.694	0.663	0.637	0.399	**0.913**
SPD_P	0.589	0.684	0.628	0.304	**0.917**
QLT_P	0.685	0.673	0.685	0.429	**0.953**
VAL	0.523	0.619	0.570	0.415	**0.856**

- Effects and variance explained for all endogenous variables

Effects on endogenous variable with hypotheses	Path coefficient β (*t* value)	Variance explained (R^2)
Effects on OP flexibility		0.478
H1a: TR → OP	0.692*** (7.718)	
Effects on STR flexibility		0.735
H1b: TR → STR	0.600***(5.418)	
H1c: OP → STR	0.324***(3.020)	
Effects on PIC		0.261
H2a: TR → PIC	0.203(0.659, NS)	
H2b: OP → PIC	0.474**(2.123)	
H2c: STR → PIC	–0.157(0.397, NS)	
Effects on FP		0.639
H3a: TR → FP	0.179(0.921 NS)	
H3b: OP → FP	0.446**(2.224)	
H3c: STR → FP	0.220(0.971, NS)	
H4: PIC → FP	0.049(0.320, NS)	

Note: *** $p < .0.01$; ** $p < 0.05$; * $p < 0.1$ (all two-tailed)

- Result of path analysis



Note: ** $p < 0.05$, *** $p < 0.01$ NS: nonsignificant

APPENDIX 6. PLS SEM TEST RESULTS FOR THE RESEARCH MODEL WITHOUT CLERKS AND OPERATORS

- Summary of validity test results of the measurement model

Latent variables	Number of indicators	Internal consistency reliability		Convergent validity	Indicator reliability
		Composite reliability	Cronbach's alpha	AVE	Factor loadings
TR flexibility	6	0.894		0.587	
OP flexibility	5	0.920		0.698	
STR flexibility	3	0.878		0.708	
Process integration capability	3	0.904		0.760	
Firm performance	5	0.901		0.646	

- Factor loadings of the measurement models

	TR flexibility	OP flexibility	STR flexibility	Process integration capability	Firm performance
HW	0.773				
SW	0.778				
NW	0.813				
ACC	0.787				
LINK	0.816				
INTP	0.590				
QLT		0.778			
VIS		0.826			
SPD		0.832			
STMR		0.907			
OPT		0.789			
OFF			0.740		
PTN1			0.881		

PTN2			0.874		
PIC1				0.823	
PIC2				0.886	
PIC3				0.892	
COST					0.760
SVC					0.830
SPD_P					0.869
QLT_P					0.760
VAL					0.780

- Fornell–Larcker criterion analysis

Latent variables	Process integration capability	Firm performance	Operational flexibility	Strategic flexibility	Transactional flexibility
Process integration capability	**0.872**				
Firm performance	0.682	**0.804**			
Operational flexibility	0.548	0.451	**0.836**		
Strategic flexibility	0.498	0.475	0.767	**0.841**	
Transactional flexibility	0.491	0.475	0.740	0.629	**0.766**

- Analysis of cross-loadings

	TR flexibility	OP flexibility	STR flexibility	Process integration capability	Firm performance
HW	**0.776**	0.555	0.465	0.338	0.304
SW	**0.780**	0.613	0.471	0.342	0.287
NW	**0.816**	0.542	0.472	0.394	0.407
ACC	**0.790**	0.579	0.542	0.416	0.424
LINK	**0.818**	0.670	0.560	0.472	0.391
INTP	**0.592**	0.412	0.348	0.253	0.367

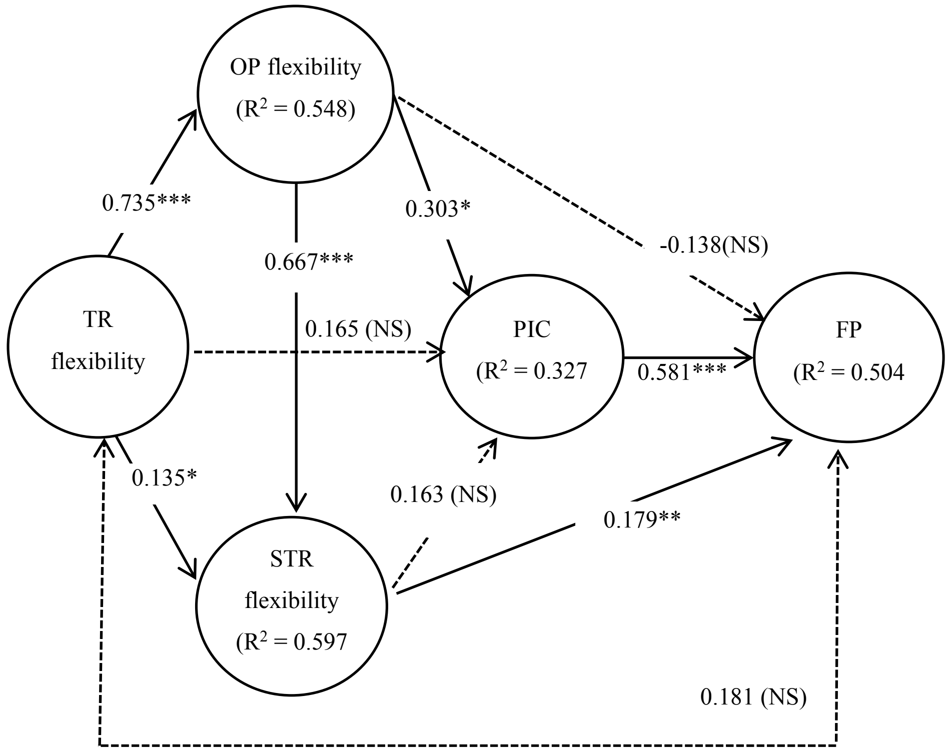
QLT	0.531	**0.786**	0.508	0.387	0.237
VIS	0.647	**0.834**	0.632	0.376	0.316
SPD	0.541	**0.840**	0.603	0.527	0.352
STMR	0.758	**0.916**	0.753	0.562	0.481
OPT	0.586	**0.797**	0.672	0.413	0.452
PTN1	0.398	0.430	**0.746**	0.441	0.465
PTN2	0.606	0.713	**0.889**	0.424	0.464
OFF	0.565	0.765	**0.881**	0.399	0.276
PIC1	0.355	0.385	0.377	**0.827**	0.539
PIC2	0.444	0.536	0.517	**0.890**	0.587
PIC3	0.472	0.496	0.397	**0.896**	0.652
COST	0.431	0.352	0.458	0.582	**0.763**
SVC	0.354	0.325	0.288	0.563	**0.833**
SPD_P	0.295	0.351	0.404	0.507	**0.762**
QLT_P	0.435	0.379	0.361	0.560	**0.872**
VAL	0.377	0.399	0.382	0.518	**0.783**

- Effects and variance explained for all endogenous variables

Effects on endogenous variable with hypotheses	**Path coefficient β (*t* value)**		**Variance explained (R^2)**	
	Without clerk/operator (*n* = 97)	**Fully mediated Model (*n* = 128)**	**Without clerk/operator (*n* = 97)**	**Fully mediated Model (*n* = 128)**
Effects on OP flexibility			0.548	0.551
H1a: TR → OP	0.735***(13.941)	0.742***(15.550)		
Effects on STR flexibility			0.597	0.646
H1b: TR → STR	0.135*(1.730)	0.172** (2.347)		
H1c: OP → STR	0.667***(8.475)	0.668***(10.175)		
Effects on PIC			0.327	0.347
H2a: TR → PIC	0.165(1.265)	0.270**(2.119)		
H2b: OP → PIC	0.303*(1.821)	0.297** (2.066)		
H2c: STR → PIC	0.163(1.291)	0.073(0.581)		
Effects on FP			0.504	0.500
H3a: TR → FP	0.181(1.454)	0.051(0.391)		
H3b: OP → FP	-0.138(1.229)	-0.078(0.530)		
H3c: STR → FP	0.179**(1.837)	0.221**(2.010)		
H4: PIC → FP	0.581***(5.204)	0.592***(5.682)		

Note: *** $p < .0.01$; ** $p < 0.05$; * $p < 0.1$ (all two-tailed)

- Result of path analysis



Note: ** $p < 0.05$, *** $p < 0.01$ NS: nonsignificant