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# BUYER-SUPPLIER RELATIONSHIPS IN ADVANCED MANUFACTURING TECHNOLOGY ACQUISITION AND IMPLEMENTATION: A STUDY IN MALAYSIA

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## Abstract

This thesis reports the results of research into the connections between transaction attributes and buyer-supplier relationships (BSR) in advanced manufacturing technology (AMT) acquisition and implementation. It also examines the impact of the different patterns of BSR on performance. Specifically, it addresses the issues of how the three transaction attributes; namely level of complexity, level of asset specificity, and level of uncertainty, can affect the relationships between the technology buyer and supplier in AMT acquisition and implementation, and then to see the impact of different patterns of BSR on the two aspect of performance; namely technology and implementation performance. In understanding the phenomena, the study mainly draws on and integrates the literature of transaction cost economics theory, buyer-supplier relationships, and advanced manufacturing technology as a basis of theoretical framework and hypotheses development. Data were gathered through a questionnaire survey with 147 responses and seven semi-structured interviews of manufacturing firms in Malaysia. Quantitative data were analysed mainly using the AMOS (Analysis of Moment Structure) package for structural equation modeling and SPSS (Statistical Package for Social Science) for analysis of variance (ANOVA). Data from interview sessions were used to develop a case study with the intention of providing a richer and deeper understanding on the subject under investigation and to offer triangulation in the research process. The results of the questionnaire survey indicate that the higher the level of technological specificity and uncertainty, the more firms are likely to engage in a closer relationship with technology suppliers. However, the complexity of the technology being implemented is associated with BSR only because it is associated with the level of uncertainty that has direct impact upon BSR. The analysis also provides strong support for the premise that developing strong BSR could lead to an improved performance. However, with high levels of transaction attribute, implementation performance suffers more when firms have weak relationships with technology suppliers than with moderate and low levels of transaction attributes. The implications of the study are offered for both the academic and practitioner audience. The thesis closes with reports on its limitations and suggestions for further research that would address some of these limitations.

Keywords: Advanced Manufacturing Technology; buyer-supplier relationships; technology implementation; transaction cost economics theory; Malaysia

# Dedication

I dedicate this thesis to my parents who have always encouraged me in furthering my education. To my beloved mother, who sadly did not live to see me complete my research. To my husband Azizan and sons Emir and Farish, thank you for being patient and understanding throughout my educational pursuit. I love you all!

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## LIST OF ABBREVIATIONS

| | |
|---|---|
| AMOS | Analysis of moment structure |
| AMT | Advanced manufacturing technology |
| ANOVA | Analysis of variance |
| BU | Business understanding |
| BSR | Buyer-supplier relationships |
| CFA | Confirmatory factor analysis |
| CFI | Comparative fit index |
| CI | Committed involvement |
| COMMIT | Commitment |
| COMMU | Communication |
| CR | Critical ratio |
| EFA | Exploratory factor analysis |
| GFI | Goodness-of-Fit Index |
| H | High |
| INVO | Involvement |
| IP | Implementation performance |
| IS | Information sharing |
| KA | knowledge acquired |
| L | Low |
| LAS | Level of asset specificity |
| LOC | Level of complexity |
| LOU | Level of uncertainty |
| M | Moderate |

| | |
|---|---|
| MI | Modification index |
| PCA | Principle component analysis |
| RM | Malaysian Ringgit |
| RMSEA | Root Mean Square of Approximation |
| SEM | Structural equation modeling |
| SPSS | Statistical package for social science |
| Std. error | Standard Error |
| Std. Load. | Standard Loading |
| TBU | Trust and Business understanding |
| TCE | Transaction cost economics |
| TLI | Tucker Lewis Index |
| TP | Technology performance |

# CHAPTER ONE
# INTRODUCTION

## 1.1 BACKGROUND

In an increasingly competitive environment, manufacturing firms have continued to acquire and implement new and advanced technologies aimed at improving plant performance as well as achieving or sustaining competitiveness in the marketplace. Advanced manufacturing technology (AMT) is becoming an important competitive factor in global markets. Since its inception in the 1970s, AMT has been praised for enabling greater process control and flexibility indicative of "high-performance manufacturing" (Boyer et al., 1997). The use of AMT enables a firm to gain earlier entrance to markets, respond more quickly to changing customer needs and offer higher quality products with improved consistency and reliability (Small and Yasin, 1997a). AMT has been heralded as a new way for manufacturing companies to gain a competitive advantage (Dangayach and Deshmukh, 2005; Pagell et al., 2000). Its use in manufacturing operation is becoming crucial to remain competitive in today's business environment. Consequently, firms that adopt AMT in their manufacturing operation have grown significantly.

The performance of companies using AMT not only depends on the technology itself, but to a large extent on how well they implement it (Efstathiades et al., 2000). In any new technology adoption, implementation remains the biggest issue, having been recognised by practitioners and widely reported by researchers, as a major source of project failure. Results of several empirical studies reveal that implementing AMT has often not been either as successful or as straightforward as expected. Many firms are still struggling with AMT implementation (Chen and Small, 1996; Hottenstein et al., 1999; Sambasivarao and Deshmukh, 1995). In the process of adopting the technology, users are confronted with various problems that arise during the implementation process as many firms learn by doing (Baldwin and Lin, 2002).

Within the body of AMT research, several studies have been undertaken to identify critical success factors for technology acquisition and implementation. As a result of this research, many factors have been found to have a significant impact on the success or failure of AMT implementation, and on the potential enhancement of the implementation process. One important factor in the enhancement of the success of technology acquisition and implementation, was the role of the technology supplier (Udo and Ehie, 1996; Zairi, 1998; Zhao and Co, 1997), since lack of vendor support has been associated with impediments to technology acquisition and implementation (Baldwin and Lin, 2002).

Transaction cost economics (TCE) theory has frequently been used to explain buyer-supplier relationships (Dyer, 1997; Ellegaard et al., 2003). This theory is concerned with the selection of effective governance mechanisms in order to reduce the transaction costs. While the theory is clearer with respect to pure forms of governance, various intermediate forms have also been conceptualised, which as noted by Grover and Malhatra (2003), can be represented by the extent of co-operative behaviour in the relationships. "TCE has been applied to alliances, specifically how to structure relationships to try to mitigate the transaction hazards that are present in a relationship" (Norman, 2004, p.611). Strong supplier relationships can reduce transaction cost (Dyer, 1997; McCutcheon and Stuart, 2000; Sako, 1992), through for instance, trusting relationships, since in these the specification and monitoring of the contract could be minimised, thus reducing the transaction cost (Hill, 1990).

Applying the concepts of TCE to BSR in AMT implementation, potentially offers useful insights. In the case of AMT implementation, not only do different technologies have varying degrees of complexity, but the same technology can also be viewed by firms in different ways. This is due to the uniqueness of each firm and its environment. A similar situation occurs concerning the view of technology specificity to the firm as well as the level of uncertainty surrounding the entire process of acquisition and implementation. Therefore, transaction cost economics (TCE) theory sheds valuable light on this issue. This theory describes these aspects as the transaction attributes surrounding the acquisition, and these in turn have an impact on the governance arrangement, which is related to the development of technology buyer-supplier relationships (Dyer, 1996b; Robertson and Gatignon, 1998). Consequently, one of the critical concerns in accessing the governance of technology buyers and technology suppliers in AMT acquisition and implementation, is the firm's perception of the level of asset specificity, level of technological uncertainty and level of technological complexity of the acquired technology.

## 1.2 RESEARCH AIM AND OBJECTIVES

From the technology buyer perspective, the study explores the governance of buyer and supplier relationships in advanced manufacturing technology acquisition and implementation. The aim of this research is to examine how the transaction attributes of the implemented technology affect the pattern of relationships between the technology buyer and the technology suppliers, and then to see the impact of different patterns of buyer-supplier relationships on the performance of AMT.

A transaction is defined as the exchange of goods or services across organisational boundaries (Williamson, 1975; Williamson, 1979). In this present research investigation, a transaction refers to the acquisition and implementation of the technology into the firm. Transaction attributes in this study were based on those proposed by transaction cost economics (TCE) theory. Thus, the three attributes surrounding the acquisition and implementation of the technology are the level of complexity, the level of asset specificity, and the level of uncertainty. Technology in this study refers to advanced manufacturing technology. Generally, AMT is a term that covers a broad spectrum of computer-based automated process technologies (Dangayach and Deshmukh, 2005)

In light of the aim of the study, a number of objectives were identified and outlined below. In meeting these objectives, and thus the overall aim of this study, it is proposed that this research contributes to the TCE, AMT, and BSR literatures in a number of significant ways.

Research objectives:

1. To understand how the level of complexity affects the strength of technology buyer and supplier relationships

2. To understand how the level of asset specificity affects the strength of technology buyer and supplier relationships
3. To understand how the level of uncertainty affects the strength of technology buyer and supplier relationships
4. To explore a link between technology buyer-supplier relationships and technology performance
5. To explore a link between technology buyer-supplier relationships and implementation performance

## 1.3 RESEARCH CONTEXT: MALAYSIAN MANUFACTURING INDUSTRY

Malaysia is a developing country where the manufacturing sector is the main contributor to the country's economic growth and gross domestic product. In 2005, the Malaysian economy expanded by 5.3% with manufacturing remaining the strongest sector that steered the nation's economic growth. Malaysia is also one of the world's largest exporters of semi-conductor devices, electrical goods, and appliances. Foreign direct investment (FDI) is actively welcomed and encouraged, and steps have been taken by the Malaysian government to further liberalise foreign investment regulation, particularly in the manufacturing sector. From June 2003, the requirements for FDI have been relaxed to allow 100% foreign equity holdings for all investments in new manufacturing projects, including expansion/diversification by existing companies.

Through the Second Industrial Master Plan (IMP2) 1996-2005, the Malaysian manufacturing sector has been moving along the value chain from assembly-based and low value-added activities towards higher value-added activities, such as R&D and Product Design. The Industrial Master Plan is also responsible for moving to a higher level the whole value chain in the Malaysian manufacturing sector through productivity-driven growth achieved by the use of advanced technologies such as automation and robotisation. The Malaysian government has also continued to play a key role in the promotion and execution of newer technologies among local manufacturing companies. For instance, under the Malaysian Technology Development Corporation Sdn Bhd (MTDC), the government has facilitated the acquisition of strategic and relevant technology by Malaysian industry through various incentives such as the Technology Acquisition Fund (TAF), and the Technology Acquisition Fund for Women (TAF-W). TAF and TAF-W provide partial grants to further promote efforts by the private sector to enhance their technology levels and production processes. To supplement these efforts to promote investment in newer technologies, the Advanced Manufacturing Technology Centre (AMTC) was established in January of 1990, with a mandate to enhance the global competitiveness of small and medium-scale industries through upgrading their industrial technological capabilities.

Thus, advanced manufacturing technology (AMT) is being more widely used in the Malaysian manufacturing sector, consistent with the government's vision for the country to achieve higher levels of technological competitiveness. In a survey of implementation and justification on the usage of AMT amongst local manufacturing companies in Malaysia. Teng and Seetharaman (2003) found 94.5% of the responding firms have been using AMT in their manufacturing operation. The country's manufacturing demand for the latest technologies is currently valued at RM30 billion a year (Business Times. Kuala Lumpur, 24 April 2006, p.45). However, during this phase of accelerated industrialisation, most of the technology has been acquired from overseas through various transfer arrangements, and Malaysia remains a net importer of machinery and equipment to meet its industrial needs. In 2004 alone, imports of machinery and equipment into Malaysia amounted to RM33.1 billion (Malaysia Economic Report, 2004/2005).

Efstathiades et al. (2000) cautioned that the process of technology transfer is very complicated and requires skills and managerial know-how of the acquiring firm. In their study of technology transfer in developing countries, Saad et al. (2002) found that the dependence on external/foreign assistance for management and skilled operations is still significant and that the technology buyer remains entirely dependent on suppliers from overseas. Difficulties such as breakdowns, delays in delivery of spare parts, and repairs that have to be dealt with by foreign experts located abroad, lead to long delays in production schedules. These explain the chronic gaps between the forecast and actual rates of production due to under-utilisation of the technology. This issue is related to the implementation problems of AMT where many studies found that despite the many advantages offered by advanced technology, most firms still fail to reap its full benefits (Baldwin and Lin, 2002; Lei et al., 1996; Meredith, 1987; Moller et al., 2003; Sohal, 1996; Udo and Ehie, 1996; Zammuto and O'Connor, 1992).

Therefore, in the context of a developing country like Malaysia, where the local technological capabilities are relatively low and most of the technology has been acquired and transferred from a foreign country, the problem of not fully realising the benefits of acquired technology could be even more apparent. According to Zhao and Co (1997), barriers in the transfer of technology, lower wage rate, size of the firms and paradigm of competition may be some of the compelling reasons to suspect that the factors affecting AMT adoption in industrialised countries may be different from those applicable to newly-industrialised countries. More often than not, the buyer of technology is in a weak position, especially when dealing with a stronger and more experienced supplier from an industrialised country (Efstathiades et al., 2000).

Hipkin and Bennett (2003) highlight the fact that technology acquiring organisations in developing countries must take the initiative to use suppliers and networks to reap the full range of benefits from the new technologies. Thus, referring to the research objectives introduced in the earlier section, the Malaysian manufacturing sector has provided the researcher with a suitable context in which to investigate how the attributes surrounding the acquisition and implementation of the specified technology affects buyer-supplier relationships, and how such relationships could impact on the technology and implementation performance. To date, very few studies on AMT have been conducted in Malaysia, despite its wide usage. This circumstance, therefore, provides further motivation for the researcher to seek evidence from the Malaysian manufacturing industry.

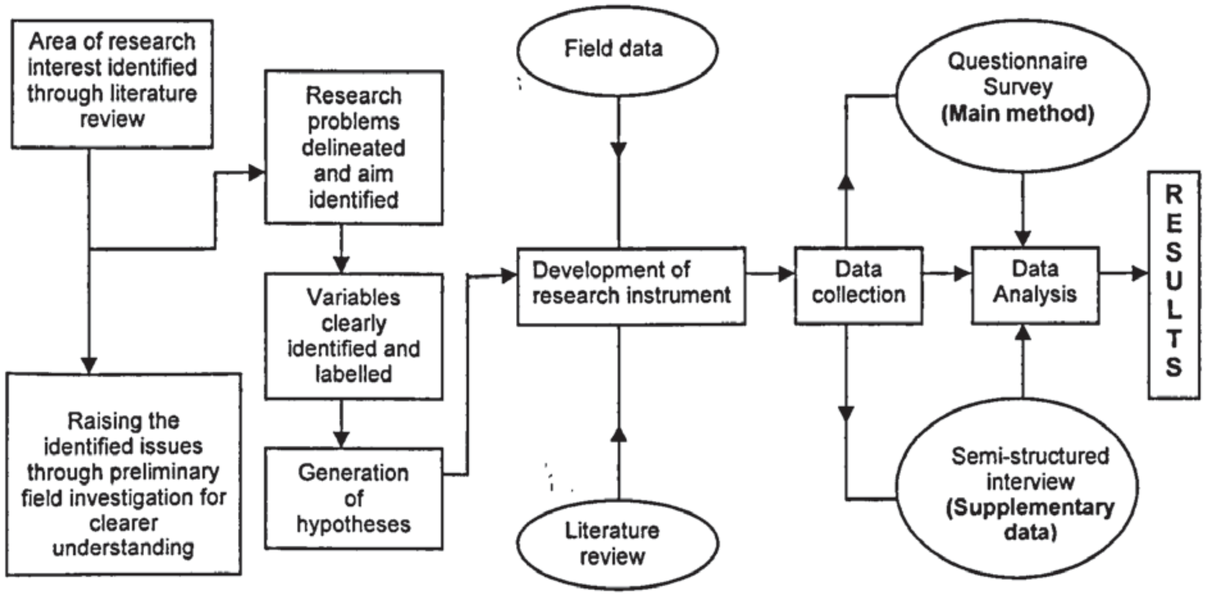
## 1.4 INVESTIGATIVE PROCESS

At the initial stage of the research, problems were identified from the preliminary review of the literature and anecdotal evidence sought from the practising organisations. This process involved stages of revision of the original ideas until gaps were identified within the area of the research interest. Then, several potential research questions were generated from the research problems. The literature was thoroughly checked to determine whether those questions had been answered. The research aim was then identified based on the final selection of research questions, and the research objectives were derived from the main aims, being refined several times in the process.

To answer the research questions, a literature (Chapter two) was further studied to establish an appropriate theory. Key concepts or variables involved in the subject of research were identified. The literature review concentrated on several areas. Firstly, it considers advanced manufacturing technology, secondly, it focuses on the issues surrounding buyer-supplier relationships, and thirdly, it explores transaction attributes which involves the levels of asset specificity, uncertainty, and complexity. Thereafter, the hypotheses were constructed (Chapter Three), and measurements of each variable of interest were developed according to the extensive review of the literature, along with information and suggestions from the practising organisation.

The data collection exercise involved a quantitative approach using a questionnaire survey as the main data gathering method, and qualitative interviews as a supplementary data source. The data was primarily collected through the structured questionnaire survey from a representative sample of the research population, and around the same time, semi-structured interviews were conducted, and seven case studies were analysed as a supplement to the survey findings. Quantitative data was analysed mainly using the AMOS package for structural equation modelling (SEM) and SPSS packages for descriptive statistics and analysis of variance (ANOVA). On the other hand, data from the interviews were used to develop snapshot case studies. In this study, quantitative data were used primarily to examine any correlation or association between the variables under investigation (Chapter Five). The results obtained were then strengthened or weakened by findings from the qualitative data (Chapter Six). Figure 1.1 provides an overview of the investigative process.

**Figure 1.1: Investigative process**




## 1.5 OUTLINE OF THE THESIS

This thesis is divided into seven major chapters. Following this introduction, Chapter Two provides the reader with a critical review of the existing AMT, BSR and TCE literature. This starts by providing a working definition of AMT used throughout this study and highlights how AMT has been widely defined and classified. The discussion continues to the review of research that has been conducted on AMT implementation and management, with the objective of identifying the frequently-cited benefits associated with AMT implementation. Hence, this information can be used to gauge the aspect of technology performance that should be measured in the present research. Then AMT implementation and success factors are reviewed in order to highlight where buyer-supplier relationships are positioned within this subject.

Within the area of BSR, a wider overview of previous research within the various research streams is presented to provide a basic understanding of a different perspective of how BSR has been studied and to critically review how the literature has been dominated by an understanding of the relationships with industrial/parts suppliers as opposed to capital equipment suppliers. Then, BSR specific to AMT implementation is reviewed and finally, previous research in the area of "buyer-supplier relationships" is critically reviewed to equip the reader with the working description of the term 'BSR' as used in the present research. Within the area of TCE, a basic definition and explanation is presented to provide the reader with better background comprehension about the usage of this theory later in this research. Previous research studies that apply TCE theory are then reviewed in order to highlight the wide use of this theory in the organisational research field. The TCE literature is then is critically explored and BSR is presented as a governance mechanism to bring together much of the currently separate work within these two fields (BSR and TCE). Finally, the three transaction attributes within TCE theory are reviewed and attention is given to how these are related to the issues of AMT acquisition and implementation.

Chapter Three presents the readership with a critical perspective on the framework and development of the hypotheses for the present research. The chapter begins with an outlined of the research gaps drawn from the previous chapter (Literature review), and proceeds to demonstrate the framework for this study. From here, a graphical representation of each important variable in the research and the flow of expected relationships, is presented in a theoretical model. Finally, the chapter ends with the key arguments supporting the introduction and development of the five main hypotheses and the three sub-hypotheses developed in the study.

Chapter Four begins with a critical perspective on the quantitative and qualitative approaches in research methodology and the justification for the choice of the methodological approach employed in the present research. The detail of both data collection methods is then presented. Part one considers the quantitative data collection method, and part two discusses the qualitative data collection method. In terms of the quantitative data, issues regarding the measurement/operationalisation, sampling methods, scale development and analysis techniques used in this study are presented in detail. With regard to the qualitative data, the sample selection procedure, interview protocol, and approach for analysis are discussed.

Chapters Five and Six present the results of this research. Chapter Five focuses on the findings of the questionnaire survey and considers three main issues. Firstly, the demographic detail - profile and characteristics of the responding companies are presented, thereby highlighting the representative nature of the sample. This presentation is followed by the final dataset assessment for reliability and validity in order to ensure the data were fit for further analysis. Finally, the chapter presents the results of the main hypotheses after subjecting the data to the various tests. The chapter concludes with a summary of the key findings of the survey.

Chapter Six provides the reader with the findings of the qualitative semi-structured interviews. This chapter is divided into two main sections. Using Yin's approach of data analysis (Yin, 2003), case studies were developed based on semi-structured interviews and company documentation data. Section one presents an in-depth analysis of each individual case company. This is followed by cross-case analysis where key issues arising from the individual case analysis, which pertain to the main hypotheses of the study were identified and discussed. The chapter ends with insight gained from the case analysis uncovering more understanding towards BSR and transaction attributes in AMT acquisition and implementation.

Chapter Seven provides more in-depth discussions of the findings from both quantitative and qualitative data collection and analysis. This chapter is divided into three main sections. Section one attempts to bring both findings together in order to provide a richer understanding of the result presented in Chapter Five and Chapter Six. From this discussion, the main conclusions of the study are presented. The implications of the study are then offered for both the academic and practitioner audience. Finally, this chapter indicates the limitations of the study and, as a result directions for future research are also proposed.

# CHAPTER TWO
# LITERATURE REVIEW

## 2.1 INTRODUCTION

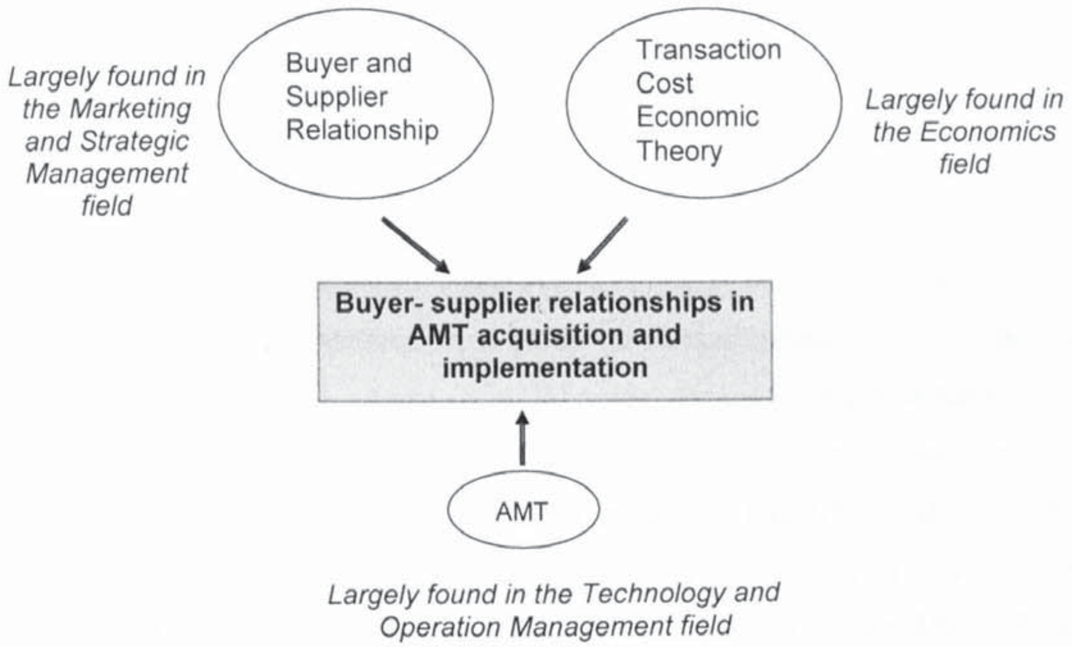
This chapter introduces the related theories linked to the issues under investigation as described in Chapter One. The overall review was carried out using three dominant and important literature streams, which when linked together, clearly delineate the research issues. These three bodies of literature are concerned with: advanced manufacturing technology; buyer-supplier relationships; and transaction cost economic theory.

The first sets out to build up a fundamental understanding of the research context, which is that of advanced manufacturing technology implementation. For that reason, initially, the definition and classifications of AMT are explored to provide the reader with an appreciation of how AMT is conceptualised in the current research study. The review then considers how this subject has been studied previously, but consistent with the context of the current research, this review confines itself to previous studies on AMT implementation and management. Apart from ensuring whether the intended investigation has been previously explored, this aspect of the review provides knowledge of the benefits offered through the adoption of AMT and how this issue has continued to gain importance, and is, therefore, worth investigating. Finally, reviews are carried out on AMT implementation and its success factors. This important section leads to the identification of the importance of buyer and supplier relationships as one of the critical success factors in this area. Additionally, the overall literature reviews on this first aspect, reveal that despite the recognition of the importance of developing good relationships with the technology supplier in AMT implementation, research in this area remains scarce.

The second body of literature comes from the corpus of knowledge on buyer and supplier relationships, and from this it can be seen that such relationships have been studied from various research disciplines such as marketing, purchasing, strategy, and supply chain management. Consequently, the main thrust in this area has not been established within the context of AMT acquisition and implementation, but is largely focused on buyer-supplier relationships with parts/industrial suppliers. However, this whole literature stream still provides a useful theoretical implication and techniques for the subject of this enquiry, especially on the dimension used to measure the strength of buyer and supplier relationship. The last part of this area of literature highlights how buyer-supplier relationships are even more critical in advanced manufacturing technology acquisition and implementation.

The third theoretical stream is on transaction cost economics and governance structure. Basically this part introduces how transaction cost economic theory relates to the choice and the management of governance structure and how a buyer-supplier relationship is also considered as one form of that structure. Following the transaction cost economic theory, it is possible to identify three transaction attributes, these being the level of asset specificity, uncertainty, and complexity, as important determinants of governance structure (in this case the governance or management of buyer-supplier relationships). In fact, these three attributes have different influences in different firms in the process of technology acquisition and implementation. The third part provides an explanation of why transaction attributes cannot be isolated from the issues of buyer-supplier relationships in AMT implementation. Figure 2.1 illustrates the integration of disciplines and the literature focus for this research investigation.

**Figure 2.1: The integration of disciplines and literature focus**




## 2.2 ADVANCED MANUFACTURING TECHNOLOGY (AMT)

### 2.2.1 The definition and classification of AMT

AMT involves new manufacturing techniques and machines combined with information technology, microelectronics and new organisational practices in the manufacturing process (Teng and Seetharaman, 2003). In general AMT is defined as an application of computer-enhanced, applied science to a firm's production system (Tracey et al., 1999). Youssef (1992) and Udo and Ehie (1996) defined AMT as a group of integrated hardware-based and software-based technologies, which if properly implemented, monitored, and evaluated, will lead to improving the efficiency and effectiveness of the firm in manufacturing a product or providing a service. Udo and Ehie (1996) further illustrated that these technological innovations include, numerical control (NC) machine tools, cellular manufacturing, machining centres, industrial robots, computer-aided design and manufacturing (CAD/CAM) systems, and automated storage and retrieval systems (AS/RS) .

Defining AMT as manufacturing process technologies that use computers to store and manipulate data, Beaumont et al. (2002) also refer to electronic mail, decision support systems, knowledge-based systems, and office automation as part of AMT, as long as they are used to give administrative support to the factory and integrate its operations with the rest of the organisation. Park (2000), on the other hand, defines AMT as a comprehensive collection of technologies for enhancing the efficiency and flexibility of manufacturing systems.

Despite the existence of numerous definitions of AMT, the literature generally agrees that it has been widely defined as a group of computer-based technologies, which includes computer-aided design (CAD), computer-aided manufacturing (CAM), manufacturing resources planning (MRPII), robotics, group technology, flexible manufacturing systems (FMS), automated materials handling systems, computer numerically controlled (CNC) machine tools, and bar-coding or other automated identification techniques (Cook and Cook, 1994; Lewis and Boyer, 2002; Millen and Sohal, 1998; Sambasivarao and Deshmukh, 1995; Stock and McDermott, 2001; Zairi, 1992; Zammuto and O'Connor, 1992). This study applies the existing definition of AMT but extends this to include any technology, which is new or advanced to a company when compared to its previous or current manufacturing technology. The study focuses on the hard form of AMT, and also soft technologies when they are embedded in hardware rather than being transferred independently.

Apart from the variety of ways that AMT has been defined, the literature also indicates that various classifications of AMT have been offered. To distinctively classify AMT into several groups is not an easy task since the set of AMT is hybrid and complex in terms of technological background and industrial origin (Park, 2000). Amongst the available classifications are those discussed in the following paragraphs.

Kotha and Swamidass (2000) classified the various manufacturing technologies into four groups on the basis of the embedded information processing capabilities. The four groups are:

1. *Product design technologies.* This group includes technologies such as computer-aided design (CAD), computer-aided engineering (CAE), and automated drafting technologies that focus primarily on product definition, and design-related information processing functions.

2. *Process technologies.* This group includes technologies such as flexible manufacturing systems (FMS), numerically controlled (NC) machines, and programmable controllers that focus on the process aspects of manufacturing.
3. *Logistics/planning technologies.* This group helps facilitate the storage and exchange of information among process, product, and logistics technologies identified above. Such technologies are common databases, systems translators, and data transfer protocols.

Park (2000) on the other hand, offers three classifications of AMT, which are firstly, the scheme based on industry-technology linkage; secondly, the scheme based on system-technology linkage; and thirdly, the scheme based on process-technology linkage, as illustrated in Table 2.1, Table 2.2, and Table 2.3.

**Table 2.1: Classification scheme based on industry–technology linkage**

| Major category | Minor category | Representative technologies |
|---|---|---|
| Sole-industry technology | Mechanics industry technology | Hydraulic, pneumatic |
| | Electric-industry technology | Motor |
| | Electronic-industry technology | Sensor |
| | Software-industry technology | CAD/CAPP, MRP |
| | Info./comm.-industry technology | LAN, MAP |
| Composite-industry technology | Mechanics-electronics technology | NC machines, robotic, AGV, AR/RS |
| | Electronics-software technology | PLC |

**Table 2.2: Classification scheme based on system–technology linkage**

| Category | Representative technologies |
|---|---|
| Protocol development technology | Simulation |
| Component software technology | CAD, CAPP |
| Component hardware technology | NC machines, robotics, control devices |
| System control technology | MRP, Controller |
| System integration technology | LAN, MAP, AGV, AS/RS |
| Base technology | Sensor, hydraulic/pneumatics, electrical motor |

**Table 2.3: Classification scheme based on process–technology linkage**

| Category | Representative technologies |
|---|---|
| Product/process design technology | CAD, CAPP |
| Fabrication/assembly technology | NC machines, robotics |
| Material handling technology | AS/RS, AGV |
| Testing/inspection technology | Inspection robots, sensor |
| Control/communication technology | MRP, LAN, MAP |

Small and Yasin (1997) introduce three technology classifications known as stand-alone systems, intermediate systems, and integrated systems, as illustrated in Table 2.4.

**Table 2.4: AMT classification based on system groups**

**Stand-alone systems**
*Design and engineering:*
Computer-aided design (CAD)
Computer-aided process planning (CAPP)

*Machining/fabricating and assembly:*
Numerical control machines (NC/CNC/DNC)
Pick-and-place robots (PPR)
Other robots (ROB)
Materials working lasers

*Logistics related:*
Material requirements planning (MRP)

**Intermediate systems**
*Automated material handling technologies:*
Automated storage/retrieval systems (ASRS)
Automated material handling systems (AMHS)

*Automated inspection and testing technologies:*
Automated inspection and testing equipment (AITE)

**Integrated systems**
*Flexible manufacturing systems:*
Flexible manufacturing cells/systems (FMC /FMS)

*Computer-integrated manufacturing:*
Computer-Integrated Manufacturing (CIM)

*Logistics-related technologies:*
Just-in-time (JIT)
Manufacturing requirement planning (MRP)
Manufacturing resource planning (MRPII)

The core observations from the above discussions are firstly, although these varieties of definitions and classifications make valuable contributions to understanding AMT, there is no one absolute way that AMT can be classified. Secondly, previous studies have frequently classified the technology consistent with the main objective of the study. For instance, consistent with the main objective of their study, which is to investigate the strategy-AMT fit and its implication on performance, Kotha and Swamidass (2000)(2000) claimed that the broader conceptualisation of AMT used in their study permits the many dimensions of AMT to be matched against several possible business-level strategies.

Similarly, in the study relating to the hierarchical classification scheme of AMT and the policy formulation process, Park (2000) identified three different categorisations of AMT which are: the classification scheme based on industry-technology linkage, the classification scheme based on system-technology linkage, and the classification scheme based on process-technology linkage. The industry-technology linkage is primarily associated with policy-makers in government who take charge of national industrial policy. The system-technology linkage is primarily associated with the researchers and engineers who account for the technology development capacity. And finally, the process-technology linkage is primarily associated with the end-users in manufacturing firms. In their study investigating effective planning for the implementation of AMT, Small and Yasin (1997) combined technologies that offer similar organisational benefits into the same category. The reason behind this categorisation is that technologies that offer similar benefits are conducive to similar planning and installation approaches.

### 2.2.2 Research on AMT implementation and management

AMT has generated a great deal of interest and been widely researched from various aspects. Examples include, research on addressing the factors that determine success or failure in the acquisition and implementation of AMT (Fynes and Voss, 2002; Sohal and Singh, 1992; Zhao and Co, 1997), on benefits associated with AMT implementation (Beaumont et al., 2002; Efstathiades et al., 2002; Efstathiades et al., 1999; Kotha and Swamidass, 2000; Lewis and Boyer, 2002; Tracey et al., 1999), and on planning associated with AMT implementation (Efstathiades et al., 2002; Millen and Sohal, 1998; Small and Yasin, 1997; Sohal, 1997).

Recently, researchers have begun to study AMT implementation and various organisational variables such as organisational culture (McDermott and Stock, 1999), organisational structure (Gupta et al., 1997), organisational culture and operations strategy (Stock and McDermott, 2001), participation of managers in strategic formulation (Tracey et al., 1999), buyer-supplier relationships (Youssef and Zairi, 1996; Youssef et al., 1996; Zairi, 1992; Zairi, 1992; Zairi, 1998), and organisational characteristics such as size and ownership (Schroder and Sohal, 1999).

A large body of academic research has been undertaken on the benefits associated with the adoption of AMT. Small (1998) identified 15 benefits associated with the implementation of 12 investigated AMT types. The list of benefits is as follows:

1. decreasing labour cost;
2. improving labour productivity;
3. reducing per unit production costs;
4. reducing set-up time;
5. reducing manufacturing lead-times;
6. reducing scrap and rework;
7. improving product quality;
8. developing management expertise;
9. developing an integrated organisation;
10. improving engineering expertise;
11. reducing engineering/design lead times;
12. improving responsiveness to competitors' actions;
13. gaining earlier entrance to market/reduced new product development time;
14. increasing market share;
15. improving responsiveness to changing customer needs.

Generally, with the benefits associated with the adoption, AMT enable firms to gain or sustain competitive advantage in the marketplace (Gupta et al., 1997; MacDougall and Pike, 2003; Millen and Sohal, 1998). This is because the use of AMT permits more flexibility in terms of product design and manufacturing processes, with fewer flaws at lower costs. Previous empirical research has found support for the ability of AMT to offer an extensive range of benefits to the adopting firm. Table 2.5 shows a selection of previous studies on AMT issues, together with the performance achieved as a result of its adoption or successful implementation and management.

**Table 2.5: Selected previous studies of AMT concerning performance**

| Author | Issue | Performance achievement |
|---|---|---|
| McDermott and Stock (1999) | Effect of organisational culture on AMT implementation | - Operational Performance<br>- Managerial Performance<br>- Competitive Performance<br>- Satisfaction Performance |
| Gupta et al. (1997) | Effect of organisational structure on AMT performance | - Manufacturing Performance<br>- Growth performance |
| Beaumont et al. (2002) | Effect of Planning effort in AMT investment on AMT performance | - Organisational Performance<br>- Operations performance |
| Lewis and Boyer (2002) | Factors impacting AMT Performance | - Financial performance |
| Zhao and Co (1997) | Adoption and Implementation of AMT | - Reduction in labour cost<br>- Manufacturing performance<br>- marketing performance |
| Efstathiades et al. (2002) | Strategic planning associated with AMT implementation | - Technical Success<br>- Manufacturing success<br>- Business success |
| Stock and McDermott (2001) | Effect of organisational culture and operations strategy on AMT implementation | - Manufacturing performance<br>- Competitiveness |
| Tracey et al. (1999) | Manufacturing technology and strategy formulation | - Competitive capabilities<br>- Overall customer satisfaction<br>- Market Performance |
| Shepherd et al. (2000) | Technology radicalness and the assessed benefit | - Operational benefit<br>- Organisational benefit<br>- Satisfaction |
| Boyer et al. (1997) | Unlocking the potential of AMT technologies | Business level performance (Growth, profit, flexibility) |
| Small and Yasin (1997) | AMT Implementation plan and performance | - Time-based competition<br>- Operational performance<br>- Manufacturing cost<br>- Quality |
| Das and Narasimhan (2001) | Implication of Process- technology fit on performance | - Manufacturing performance<br>- Firms performance |
| Pagell and Krause (1999) | The relationship between environmental uncertainty and manufacturing flexibility | Improvement of manufacturing performance over the past 3 years |

### 2.2.3 AMT implementation and its success factors

Despites the advantages, the implementation of AMT does not guarantee that a firm will reap all the potential benefits being offered (Gupta et al., 1997; Meredith, 1987; Small and Yasin, 1997). Indeed, a number of research studies indicate that the benefits from such investments have not been fully realised (Baldwin and Lin, 2002; Lei et al., 1996; Meredith, 1987; Moller et al., 2003; Sohal, 1996; Udo and Ehie, 1996; Zammuto and O'Connor, 1992). In some cases, firms that reported successful implementation of AMT were not exploiting the full benefits offered by the system (Inman, 1991). Likewise Udo and Ehie (1996) noted that despite the numerous benefits of AMT, only a small proportion of companies adopting AMT have taken full advantage of these.

Boer et al. (2003) reported that manufacturing companies are not benefiting from AMT owing to technical difficulties, such as problems with standardisation, and the integration of hardware and software after installation. Park (2000) proposed the lack of absorptive capabilities to internalise AMT due to managerial deficiencies and organisational obstacles, as one of the reasons. Additionally, Park (2000) suggested that the structural discrepancy between technology generation (supply) and technology application (demand) is a more serious reason for failure in performance. Udo and Ehie (1996), on the other hand, attributed poor performance to the lack of appreciation of the degree of complexity and challenge that such implementation might entail. In a broader sense, Saraph and Sebastian (1992) referred to AMT implementation failure as due to the neglect of critical human resource factors. And on a similar theme, Sohal (1996) claimed that firms that enlist technology champions (individuals who provide a continual driving force throughout the initiative), are more likely to achieve successful AMT implementation. Babbar and Rai, (1990) reported that the problem lies not in the level of technology, but rather in its implementation.

In short, most firms still struggle with AMT implementation (Gupta et al., 1997; Hottenstein et al., 1999; Sambasivarao and Deshmukh, 1995). Meredith (1987) observed that implementing AMT is one of the most lengthy, expensive and complex tasks a firm can undertake. Consistent with Hayes and Jaikumar (1985), Frohlich (1999) warned practitioners that the threatening obstacles associated with AMT implementation are not decreasing and may even be increasing. Many managers assume that since their organisations have already adopted early-generation AMT, all future implementations of even more advanced automation will be relatively straightforward. The author then claims that has not been the case, primarily due to the tremendous change in complexity of technologies, and that difficulties related to AMT implementation are as severe today as they were in the 1980s, when many forms of automation first appeared.

Since the success of AMT in achieving competitive advantage depends primarily on correctly selecting and properly managing AMT projects (Cook and Cook, 1994), enormous amounts of research have been undertaken, from which various factors have been found to affect the success of AMT acquisition and implementation. For instance, Frohlich (1999) found that information systems adaptation during the course of AMT implementation is the most important action to enhance AMT success. Zammuto and O'Connor (1992), on the other hand, recognised the importance of firm design and culture to the potential outcomes of an AMT investment. Zhao and Co (1997) highlighted that project team integrity, strategic planning and project championship, and technical knowledge, were found significant in the successful use of AMT. Small and Yasin (1997), Millen and Sohal (1998), and Efstathiades et al. (2002) drew attention to the importance of planning to the success of AMT implementation. Small and Yasin (1997) found that firms using both formal business and manufacturing planning, or formal business planning alone, had achieved significantly higher levels of performance from their implementation projects than those firms that were using neither business nor manufacturing planning.

In light of the above discussion of the relevant literature, it can be seen that much of the previous research on examining critical success factors has been identified and carried out with regard to the factors internal to the firm (see Efstathiades et al., 2000; Frohlich, 1999; Millen and Sohal, 1998; Small and Yasin, 1997; see Zammuto and O'Connor, 1992; Zhao and Co, 1997). In addition to the various internal factors applicable to the users themselves, there are other factors which tend to inhibit or facilitate the implementation process, and which are external to the users, pertaining mainly to the suppliers of AMT (Zairi, 1992). Studies by Udo and Ehie (1996) and Zhao and Co (1997), indicate that supplier support and/or relationship with the technology supplier are the only factors external to the organisation that were found to be significant in terms of the success of AMT implementation. This factor was, no doubt, found to be significant in determining AMT implementation success. Indeed, the need to establish good links with suppliers has been reported to be of paramount importance in successful AMT implementation (Bessant, 1994; Burgess et al., 1997; Fynes and Voss, 2002; Gupta et al., 1997; Kaighobadi and Venkatesh, 1994; Sohal, 1999; Sohal and Singh, 1992), yet very few studies have been conducted in relation to this issue.

In a comprehensive study regarding the critical success factors in the adoption and implementation of AMT, Udo and Ehie (1996) classified the critical success determinants for AMT implementation into four broad categories which are: triple 'C' factors, self-interest factors, housekeeping factors, and literacy factors (see Table 2.6). Each of these determinants was found to be a significant determinant of success factors. It can be seen that quality of support from the vendor, which was classified under the housekeeping factors, was found to directly affect the benefits of improved quality and quick response to customers.

**Table 2.6: Critical success determinants for AMT implementation (Adopted from Udo and Ehie, (1996)**

| **Determinants** | |
|---|---|
| **Triple 'C' factors** | **Self-interest factors** |
| Effective communications | Employees' morale |
| Sound co-ordination | Employees' satisfaction with the project |
| Strong co-operation from everyone | Belief that the AMT is for general interest |
| Strong commitment | Quick response to workers' concerns |
| | Appropriate reward system |
| **Housekeeping factors** | |
| Quality plan of action | **Literacy factors** |
| Teamwork | Clear understanding of AMT capabilities |
| *Quality vendor support** | Clear understanding of the business principles |
| Quality technical support | Understanding of the business system |
| Detailed cost/benefit report | Effective training |
| AMT cost justification | Clarity of AMT goals and objectives |
| Business functions integration | Appropriate level of expectations of the AMT |
| Effective facilitator | |

* Issue relates to buyer-supplier relationships

In another comprehensive study concerning the critical success factors in AMT adoption and implementation, Zhao and Co (1997) listed 27 such factors in order of importance, as identified by the adopting firm (see Table 2.7 ). For instance, of 27 critical success factors identified by Zhao et al. (1997), selecting the appropriate technology supplier(s) was ranked 9th in importance and the nature or relationships with the technology supplier(s) was ranked 13th. The comparatively high rank of these factors indicates the importance of technology suppliers in enhancing the success of AMT adoption and implementation.

**Table 2.7: Critical success determinants for AMT implementation (Adopted from Zhao and Co, 1997)**

| Critical success factor |
|---|
| 1. Degree of financial support |
| 2. Degree of alignment of the core organisational systems with the corporate strategy |
| 3. Understanding the potential contribution of AMT to current operations |
| 4. Degree of management commitment and support |
| 5. Well-defined objectives of AMT adoption |
| 6. Degree of effective alignment of employee attitudes with corporate objectives |
| 7. Degree of willingness of top management to take short term-risks for long-term improvement |
| 8. Pace of implementation |
| *9. Selecting the appropriate technology supplier(s)* * |
| 10. Position of AMT champion in the organisation |
| 11. Existence of an AMT champion |
| 12. Degree of top-down planning and bottom-up implementation |
| *13. Nature of the relationship between the technology supplier(s) and user firm* * |
| 14. Degree of turnover of the project team members |
| 15. Degree of availability of hands-on training program to employees after implementation |
| 16. Active participant by in-house engineer |
| 17. Degree of specialised technical training is very important |
| 18. Need for long-term automation objective |
| 19. Training programs must be maintained throughout the process of implementation |
| 20. Do not disband the project team until the new technology is absorbed by the organisation |
| 21. Need for team members to be familiar with the new technologies |
| 22. Organisation and composition of the project team |
| 23. Existence of an employee education program prior to AMT implementation |
| 24. Degree to which organisations obtained experience with a pilot project prior to implementation |
| 25. Need to reorganise |
| 26. Need to revise policies and procedures |
| 27. Need for external consultants |

* Issue relates to buyer-supplier relationships

The overall discussions from this section recognise that the adoption of AMT does not necessarily guarantee success to the firm. In fact, most firms still struggle with problems in its implementation. Various factors have been found to facilitate, as well as to hinder the implementation success, most being internal to the firm. A good relationship with the technology supplier was found to be one of the most important external factors that can facilitate implementation success. Despite recognising the importance of this factor, the literature nevertheless indicates the lack of research particularly on exploring aspects of technology buyer-supplier relationships in AMT acquisition and implementation.

## 2.3 BUYER-SUPPLIER RELATIONSHIPS (BSR)

### 2.3.1 Areas of previous research into buyer-supplier relationships

Since the 1990s, research in buyer-supplier relationships has received increasing attention, especially as it has become widely known that various benefits can be enjoyed by developing closer relationships with the suppliers. As noted by Tang et al. (2001), buyer- supplier relationships have evolved towards a new form in order to respond to intensified competition in industry. The movement towards closer co-operation between buyers and suppliers also results from the global and competitive market place that focuses on cost, quality, delivery, flexibility, and technology, which subsequently create a greater need to emphasise inter-firm collaboration with various business partners. Dwyer et al. (1987) described a continuum of different types of buyer-supplier relationship, believing that firms engage in co-operative buyer-supplier relationships because they expect to benefit from them. Only as long as the firms perceive a benefit from the relationship do they continue in a co-operative fashion.

Since the initial recognition from practitioners and scholars on the important role of suppliers, research in this area is gaining importance and has been studied in a wide range of research fields. Ellegaard et al. (2003) distinguished six main areas in which buyer-supplier relations have been studied, namely: organisational studies, industrial economics, industrial and relational marketing, strategic supply chain management, purchasing, and strategic development. Within these six main areas, the literature on buyer-supplier relationships has been dominated by three main areas, these being, industrial and relational marketing, supply chain management, and purchasing areas.

In industrial and relational marketing areas, buyer-supplier relations are generally viewed as one of the inter-organisational exchange relationships. Close to exchange relationships, strategic supply chain management areas view buyer-supplier relations as one of the crucial networks in a business process in delivering excellent product or service. Research in both areas extends from the model for the development of buyer-supplier relationships (Dwyer et al., 1987; Lau and Goh, 2005), to building and maintaining close buyer-supplier relationships (Johnson et al., 2004; McCutcheon and Stuart, 2000), and towards how the use of information technology (Humphreys et al., 2006; Ryssel et al., 2004; Stump and Sriram, 1997; Tang et al., 2001) and advanced manufacturing technology (Burgess et al., 1997) has altered the nature of buyer and supplier relationships.

Within purchasing areas, research is more concerned with the development of a more effective purchasing strategy. Noordewier et al. (1990)(1990) stated that purchasing performance is an important determinant of a firm's competitiveness, and they empirically prove that long-term co-operative agreements with suppliers have a positive impact on purchasing performance, subsequently suggesting that developing close relationships with the suppliers could enhance firm competitiveness. Studies in the purchasing area have ranged from supplier selection procedures and criteria (Ellram, 1990; Ellram, 1995; Humphreys et al., 2003; Motwani et al., 1999; Youssef and Zairi, 1996), to the linking of strategic purchasing strategy with other variables like buyer-supplier relationships evaluation system (Carr and Pearson, 1999). These studies are associated with the development of a more effective purchasing strategy.

In the area of strategic development, researchers have focused on the importance of buyer-supplier relations and management as a strategic tool for creating competitive advantage (Cusumano and Takeishi, 1991; Kotabe et al., 2003). Similar evidence on how buyer-supplier relations bring competitiveness can be found in Zeller and Gillis (1995), who demonstrated how the Ford Motor company, under total quality management (TQM), has transformed its buyer-supplier relationships from being adversarial to collaborative in nature. Ford's success indicates that businesses can increase their competitiveness by implementing co-operative supplier relationships.

Evidence from various field of BSR research indicate that the need for firms to engage into strong or close relationships with suppliers is crucial, as it links to various aspects of performance. A range of benefits can be derived from the management of good relationships with the technology supplier. Generally, partnerships and alliances between firms and their suppliers are one important manifestation of core competency leading to knowledge-based competitive advantage (Dyer, 1997; Johnson et al., 2004). Specifically, the outcomes for partnerships between buyers and suppliers are improved process technology adoption (Johnston and Linton, 2000), improvements in conformance quality, and risk reduction and reductions in capital investments (Lado et al., 1997) to operating performance measures such as on-time delivery and responsiveness (Stanley and Wisner, 2001).

Johnson et al.(2004) found that trusting buyer-supplier relationships lead to high co-operative behaviour in terms of shared planning (sharing of strategic plans and schedule information) and flexibility in arrangements (the willingness to alter conditions and expectations to suit unanticipated situations). This co-operative behaviour has been found to link positively with aspects of performance such as long term profitability, net profits over past year, growth, innovation of product/services, lower long-term and short-term costs, and an increased product/service base.

Partnership sourcing, when appropriately and selectively used (Bensaou, 1999), has been directly linked to objective financial performance measures. For instance, Carr and Pearson (1999) in their empirical study, found that buyer-supplier relationships have a positive impact on a firm's financial performance with respect to return on investment, profits as a percentage of sales, firm's net income before taxes, and present value of the firm. Based on the results of their study, they proposed that through collaborative relationships with their suppliers, which involve communication, co-operation, and co-ordination of all activities associated with the production of goods and services, firms can anticipate some improvement in their financial performance through reductions in costs.

From the above review of the literature, three main observations, which are paramount to this research can be drawn. Firstly, there is increased evidence that suggests buyer-supplier relationships are of paramount importance for firms because such relationships can create value for both parties involved. Secondly, while the issues surrounding supplier alliances have been discussed in the purchasing and marketing fields, they have been less frequently addressed in the Operations Management (OM) field (McCutcheon and Stuart, 2000). Finally, although buyer-supplier relationships have been studied from various research streams, efforts have been concentrated on the relationships with industrial suppliers rather than on those with the capital equipment suppliers. In fact, within the limited BSR research in the OM field, investigations are still predominantly on the relationships with industrial suppliers, and hence, knowledge on buyer-supplier relations in the procurement of capital equipment, remains limited and inadequate.

### 2.3.2 Buyer-supplier relationships in AMT implementation

The issue of developing close relationships with suppliers is equally important with regard to capital equipment suppliers. Sako (1992) highlighted that technology transfer and training is one of the three major areas where supplier relationships may not be strictly arm's length, but may require some moderate to extreme extensions from the traditional arm's length relationships. Referring to technology transfer as the movement of technology from one organisation to another, that is across the organisational boundaries of the source and recipient, Stock and Tatikonda (2000) observed that even when the technology is functional in its present form and less complex, due to the lack of expertise or experience, the recipient may not know how to immediately utilise it.

Therefore, there is more communication, co-ordination and co-operation between the recipient and the technology supplier than in the arm's-length purchase transfer mode. Stock and Tatikonda (2000) also argued that when the technology is much more complex, unfamiliar to the recipient, and must be customised to some extent and is not in its completed form when it arrives at the recipient's facility, greater communication, co-ordination, and co-operation are required. In this respect, a well-established, close relationship may make the inter-firm boundaries more permeable, allowing technology to be transferred more easily into the organisation (Heide and John, 1990). If they perform as intended, closer supplier relations can reduce transaction cost (Dyer, 1997).

The limited literature in buyer-supplier relationships for the procurement of capital equipment is mostly found in the area of advanced manufacturing technology research. A review of the available body of knowledge in the area indicates that the implementation of advanced manufacturing technology requires significant involvement and support from the technology supplier (Gupta et al., 1997; Kaighobadi and Venkatesh, 1994; Saleh et al., 2001; Sohal, 1999; Sohal and Singh, 1992; Youssef and Zairi, 1996; Zairi, 1992; Zairi, 1992; Zairi, 1998; Zhao and Co, 1997). By its nature, AMT is a complex technology especially for firms that have no previous experience in automation, and even with previous experience, each technology embodies specialised know-how that differentiates the product. Not all firms possess the ability and the know-how on the technology, especially when it is not the type of product that firm purchase on a regular basis, such as in the purchase of parts and components. Zairi (1998) noted that the complex nature of the technology and the limited knowledge and experience of users, led to difficulties for users in specifying their own technical requirements, without a close involvement of suppliers.

Saleh et al. (2001) reported that even the process of justification for its investment is a complex and critical task. Swanson (1997) highlighted how an increase in automation as in the environment of AMT, means that the equipment is more intricate, making the diagnosis of equipment problems more difficult, thus emphasising the importance of maintenance management for this type of technology. Both Saleh et al. (2001) and Swanson (1997) indicated how the technology supplier can add value to the overall success of technology implementation. Kakati (1997) claimed that given the complexity of AMT and the high technical and economic risk associated with its implementation, effective planning and evaluation requires an extensive database containing information about the technical, which includes process plan, drawings, and part description. This information helps firms in understanding the AMT consequence for manufacturing. As previously mentioned, not all firm possess the ability and the know-how of the acquired technology, and thus, stronger support from the technology supplier is always needed in the process.

Chen and Small (1996) asserted that adopting AMT requires more complex relationships and greater integration with the organisation's key environmental constituencies (i.e. customers, parts suppliers and technology suppliers). Sohal and

Singh (1992) suggested that close links with suppliers are among the critical factors for both technical and business success in implementing AMT. In a case study of the introduction and implementation of new manufacturing technologies by a small Australian manufacturer, Sohal (1999) found that one of the factors leading to successful implementation of AMT is a close relationship with the technology supplier. According to the operations manager in charge in the implementation in the case, the quick response from the technology supplier when there was a problem with the new technology, helped very much in the success of the implementation.

Bessant (1994) and Chen and Small (1997) maintained that closer relationships between buyers and suppliers are very important in order to implement AMT more successfully. More collaborative relationships with suppliers can be argued to contribute positively to success in AMT implementation (Burgess et al., 1997). Zhao and Co (1997), in their study of the adoption and implementation of advanced manufacturing technology in Singapore, found that supplier selection criteria and developing close relationships with the technology vendor ranked number nine and 13 respectively, out of the 27 factors that determine the success of AMT implementation.

In the study involving ten suppliers and 20 users of AMT innovation, Zairi (1992) identified various indicators on the degree of success/failure in AMT implementation, attributable to the supplier factors. The criteria considered by the users, to facilitate AMT implementation were:

- Supplier ability to relate AMT products to user requirements.
- Supplier competitiveness in product range, price, and performance.
- Supplier ability to provide a whole range of support services during the various stages of the implementation process.
- The ability of users and suppliers to work closely during the implementation process
- The ability of people to relate to one another for joint problem solving and knowledge/information sharing.
- External criteria which were specially focused on, were those relating to the suppliers of AMT innovation, and the dynamics involved in determining interaction processes between the suppliers and users of AMT.

- Supplier commitment in implementation by resource allocation, and determination to solve all problems.
- Degree of commitment from both suppliers and users in enhancing existing relationship an in planning jointly for a long-term future.

The criteria which users considered to inhibit AMT implementation were:

- Poor choice of equipment in terms of reliability.
- Supplier inability to solve problems/poor technical knowledge.
- Supplier inability to provide good support and back-up services.
- Poor supplier communication with customer.
- Limited supplier involvement during implementation.
- Lack of supplier interest in users' future requirements.
- Lack of supplier progressiveness.

The above study by Zairi (1992) provides a rich insight into how suppliers can add significant value to the overall success of technology implementation and at the same time how the lack of certain provisions on the supplier side can hinder the overall implementation success. Given the nearly inevitable, and the vital involvement of the technology supplier to the implementation process, it stands to reason that close relationships with the technology supplier play a pivotal role in AMT success.

The work of Zairi (1992) also provides some indication that most of the success factors attributable to the aspects internal to the firm, could be further enhanced by developing closer relationships with the technology supplier. For instance, Udo and Ehie (1996), suggested clear understanding of AMT capabilities, clear understanding of the business principles, understanding of the business system, effective training, clarity of AMT goals and objectives, and the appropriate level of expectations of the AMT, as being among the critical success determinants for AMT implementation success, and categorised these under the literacy factors. However, to achieve what is suggested by Udo and Ehie (1996), firms must first acquire the knowledge about, and the capabilities of AMT, to be implemented. This type of competency however, is not automatically and necessarily possessed by the firms, especially when each technology offers its own set of differentiated operational, strategic, and marketing capabilities (Zairi, 1992). These signify that closer relationships with the technology supplier are even more critical.

Especially with new adopters, technology suppliers can help in the clarification of AMT goals and objectives as well as educating their customers in terms of appropriate expectations of the benefits of the AMT being implemented, in order to avoid over-expectation and disappointment at a later stage. Reflecting on what has been outlined by Zairi (1992) relating to the supplier's ability to relate AMT products to user requirements and the ability to provide a whole range of support services during the various stages of the implementation process that further facilitate AMT implementation, it stands to reason that in this particular case, firms involving the supplier at every stage of planning associated with AMT implementation could further enhance the overall success of the exercise.

However, despite the widely claimed crucial role of technology suppliers in AMT implementation (Kaighobadi and Venkatesh, 1994; Saleh et al., 2001; Sohal and Singh, 1992; Udo and Ehie, 1996; Zairi, 1992; Zhao and Co, 1997), very limited knowledge in this area has been gained as only few studies have specifically focussed on this issue. The claim that the technology supplier is imperative in AMT implementation was identified through the wide investigation of factors that facilitate or hinder the implementation process. Studies by Youssef and Zairi (1996) and Zairi (1992), however, are two that have particularly examined factors that inhibit or facilitate the implementation process and which pertain mainly to suppliers of AMT. Nonetheless, although these studies offer insightful understanding on buyer-supplier relationships in the AMT acquisition and implementation process, they remain limited, leaving gaps in the literature concerned with the following:

1. Since buyer-supplier relationships in technology implementation are important to implementation success, there is a need to investigate the antecedents that lead to the development of stronger or weaker relationships with the technology supplier.
2. Despite the wide claim that strong relationships with suppliers could enhance the adoption process, no studies have systematically tested the impact of BSR on performance. Previous research that examines factors affecting the AMT

adoption success often take a broader view of performance achievement when in fact; performance associated with the technology supplier should be associated more closely to the monitoring of implementation performance, in addition to the assessment of manufacturing or business performance as a whole.

3. To date, most of the empirical results on the effect of the technology user and supplier relationship in AMT implementation have been supported by case studies (Sohal and Singh, 1992; Zairi, 1992; Zairi, 1992; Zairi, 1998), and evidence from survey research is rather limited. Consequently, there has not yet been any development of a quantitative research instrument to assess the strength of BSR in AMT acquisition and implementation and for this reason, its association with performance remains difficult to explore. Therefore, there is a need to further investigate this issue from another methodological perspective.

### 2.3.3 The terms and dimensions of "close/strong" BSR

From the time that the nature of buyer-supplier relationships underwent dramatic changes in the late 1980s, various terms have been used by researchers to describe "closer ties" with the technology supplier. Terms such as "alliance" (Ellram, 1995; McCutcheon and Stuart, 2000; Stuart, 1997) , "partnerships" (Heide and John, 1990), "collaboration" (Humphreys et al., 2003) or "co-operative" (Carr and Pearson, 1999) are being used to contrast "closer ties" with the traditional "arm's length" type of interaction with the supplier. A more recent empirical study also indicates that, within the body of research that measures the extent to which buyer and supplier have developed closer relationships, many different terms have been used to describe close relationships. For instance, Guimaraes et al. (2002) used the term "depth of supplier relations" to investigate the depth of company relationships with suppliers. Joshi and Campbell (1998) referred to the buyer and seller relationships in their study as "relational governance". Fynes and Voss (2002) used the term "relationships strength" to denote close buyer-supplier relationships. Burgess and Gules (1997) and Tang et al. (2001), on the other hand, looked at buyer and supplier relationships in terms of whether they demonstrated more collaborative or adversarial patterns of interaction.

Kern (2000) recognised the necessity of working closely with suppliers, terming this as a "partnership". In a similar vein, Lee and Kim (1999) used the term "partnership quality" to denote the extent that the service receiver and service provider in information system outsourcing develop quality relationships with each other. Goffin et al. (2006) proposed the term "partnership-like relationships", to indicate a relationship not based on legal definition. This is because relationships between manufacturer and suppliers are a form of business relationship, which does not have the same legal basis as a formal business partnership, or alliance. Goffin et al. (2006) also conclude that partnership-like relationships are close co-operations between buyers and their suppliers, which bring many advantages including better quality, lower costs and reliability delivery.

However, despite the various terms used to describe buyer-supplier relationships in past research, the principal aim has been to explore the extent of "closeness" between buyer and supplier, a feature which has been widely identified as an important characteristic of relationships. In fact, it has dominated how the supplier base has been viewed by both practitioners and academics over the last decade (Goffin et al., 2006). Nonetheless, although "closeness" has potential as a vehicle for investigating partnership-like relationships (Goffin et al., 2006), there is no one absolute standard relating to how close BSR should be defined, or should be measured. Table 2.8 indicates selected prior research studies that have used multiple indicators to measure the closeness of BSR, from which it can be seen that a wide variety of terms and dimensions have been used in this respect.

**Table 2.8: Selected previous research concerning the use of BSR term and measure**

| Author(s) | How the author(s) termed and measured buyer-supplier relations | Sample | Main research interest |
|---|---|---|---|
| Benton and Maloni (2005) | Buyer-seller relationships<br>1. Commitment<br>2. Trust<br>3. Co-operation<br>4. Conflict<br>5. Conflict resolution | President/CEO/Chairman of supplier of automotive industry | Investigate how different bases of power affect buyer-seller relationships |
| Ryssel et al.(2004) | Customer-supplier relationships<br>1. Trust<br>2. Commitment | Sales executive (supplier side) of various industry sectors | Investigate the impact of information technology deployment on inter-organisational relationships |
| Joshi and Campbell (1998) | Relational governance<br>Mutual understanding on various aspects | Purchasing managers in Manufacturing firms | Examine the conditions under which environmental dynamism and relational governance will be positively or inversely related |
| Fynes and Voss (2002) | Buyer-supplier relationships<br>1. Trust<br>2. Adaptation<br>3. Communication<br>4. Interdependence<br>5. Commitment<br>6. Satisfaction<br>7. Co-operation | Individual with a detailed knowledge of quality practices, quality performance, business performance and buyer-supplier relationships | Investigate the extent of the relationship between quality practices and quality performance contingent upon the nature of buyer–supplier relationships |
| Guimaraes et al.(2002) | Depth of relations<br>1. Degree of confidence and willingness<br>2. Degree of understanding with respect to behaviours, goals, and policies | Purchasing managers of manufacturing companies | Investigate the impact of the effective use of information technology and the depth of the company relationship with its |

| | | | |
|---|---|---|---|
| | 3. Degree of articulation and agreement on matters of benefit and risk between both.<br>4. Commitment<br>5. Willingness to participate together in activities<br>6. Communication process<br>7. Smoothly co-ordinate activities<br>8. Information sharing<br>9. Degree of each party to influence each other's decisions<br>10. Degree of shared values and belief between both | | suppliers on supplier network performance |
| Carr and Pearson (1999) | <u>Buyer-supplier relationships</u><br>1. Special agreements with suppliers who have improved performance<br>2. Loyalty to key suppliers<br>3. Frequency of face-to-face planning/communication with key suppliers<br>4. Level of Corporate level communication on important issues with key suppliers<br>5. Direct computer to computer links with key suppliers | High level of purchasing executives across various industry sector | Investigate the influence of strategic purchasing on supplier evaluation systems, buyer-supplier relationships, and firms' financial performance |
| Lee and Kim (1999) | <u>Partnership quality</u><br>1. Level of trust<br>2. Level of business understanding<br>3. Level of benefit and risk share<br>4. Level of conflict<br>5. Level of commitment | Representative from service receiver and service provider of information system functions | Investigate the determinants of partnership quality and the effect of partnership quality on outsourcing success |

| | | | |
|---|---|---|---|
| Burgess and Gules (1997) | <u>Buyer-supplier relationships</u><br>1. Length of trading<br>2. General sourcing practices<br>3. Procedure for giving orders<br>4. Types of communication channels and intensity<br>5. Level of technology transfer<br>6. Level of mutual dependence<br>7. Level of risk sharing<br>8. Level of inspection on purchased components<br>9. Method of solving conflicts<br>10. Method of reaching agreements | Senior managers of automotive industry | Investigate the link between buyer-supplier relationships, supplier evaluation criteria, and types of technology implemented |
| Stuart (1997) | <u>Supplier Alliance</u><br>1. Resource commitment<br>2. Benefits sharing<br>3. Joint problem solving | Senior buyers/Purchasing managers of various industry sectors matched with their corresponding supplier key contact | Investigate how the supplier alliance evolves over time and the predictors of alliance success and failure |
| Stump and Sriram (1997)(1997) | <u>Buyer-supplier relationships</u><br>1. Mutual trust<br>2. Information sharing with vendors<br>3. Frequency of disputes between you and your vendors<br>4. Overall co-ordination with vendors | Purchasing managers of various industry sectors | Investigate the extent of information technology investment and whether the degree of use in purchasing alters the nature of buyer-supplier relationships |

A clear definition of relationship closeness, and a way of measuring this are still lacking in the literature. Due to the variations in the dimensions identified by different researchers, Goffin et al. (2006) viewed close relationships (partnership-like relationships) as context-specific. Some empirical studies have also tended to focus on individual relational dimensions. For instance, Johnson et al. (2004) specially looked at trust in measuring buyer-supplier relationships. Kotabe et al. (2003) referred to buyer-supplier relationships or partnerships in terms of the duration links between the two. However, Fynes and Voss (2002) recognised that all relationships may be influenced by past, present, and future events, and therefore, a comprehensive set of measures is needed to assess such temporal dimensions. Most prior research studies have used multiple indicators of BSR because this strategy can better capture the extent of closeness or strength of relationships.

Based on these studies, it appears that the aspects of trust, business understanding, commitment, communication, and information sharing, have always been taken as dimensions of BSR. Trust has been defined as "the firm's belief that another company will perform actions that will result in positive actions for the firm, as well as not take unexpected actions that will result in negative outcomes for the firm" (Anderson and Narus, 1990, p.45). Trust plays a key role in any organisational relationship (Morgan and Hunt, 1994), because the presence of trust can reduce the specification and monitoring of contracts, provide material incentives for co-operation, and reduce uncertainty (Hill, 1990). Developing and maintaining a high level of trust has often been identified in the literature as an essential issue in relationships (Goffin et al., 2006). Related to the development of trust, researchers have also stressed the need for both parties in the relationships to clarify expectations carefully (Johnson et al., 2004). The present research refers to this expectation in terms of the supplier's understanding of the buyer's business or manufacturing operation and requirement.

Commitment has been defined as "an implicit or explicit pledge of relational continuity between exchange partners" (Dwyer et al., 1987, p.19). It refers to the trading partners' commitment to exerting effort on behalf of the relationship and the attempts to sustain the relationship even in the face of unanticipated problems (Fynes and Voss, 2002). On the other hand, communication has been defined as "the formal as well as informal sharing of meaningful and timely information between firms

(Anderson and Narus, 1990, p.44). Frequent and timely communication is important because it assists in resolving disputes and aligning perceptions and expectations (Morgan and Hunt, 1994). Effective communication is, therefore, essential for successful collaboration (Fynes and Voss, 2002). Information sharing refers to the extent to which the information exchange is effective in a partnership and includes the level and the quality of information sharing (Monczka et al., 1998). It is recognised as a key requirement for collaborative inter organisational relationships. Several studies (Guimaraes et al., 2002; Sheu et al., 2006; Stump and Sriram, 1997) have suggested that successful buyer-supplier relationships are associated with high levels of information sharing.

Knowledge acquisition refers to skills learned and knowledge acquired by the focal firm from a partner during an alliance (Norman, 2004). The use of knowledge acquisition as an indicator of close BSR is not frequent within the industrial marketing, purchasing or supply-chain management research areas. However, within strategic management or knowledge management area, knowledge transfer or knowledge acquisition is seen as one of the important outcomes of any form of alliance or partnership. In fact, collaborative experience was found to affect knowledge acquisition (Simonin, 1997). Knowledge transfer is strongly affected by the relationship between source and recipient (Albino et al., 2004). Therefore, if knowledge transfer is expected to affect the outcome of buyer-supplier relationships (Kotabe et al., 2003), then, the extent of knowledge acquired by the technology buyer from the technology supplier in the process of technology acquisition and implementation, should be taken as an indicator of close relationships.

Within research that used multiple indicators to gauge the strength of the relationship, "involvement" has not been frequently included. However, prior studies in supply chain management areas have frequently used "involvement" as a single construct that denotes supplier relationships and these in turn have an impact on various aspects of performance. For instance, Tracey and Tan (1999) found supplier involvement in product design teams and in continuous improvement programmes to have significant impact on customer satisfaction and firm performance. In product development, Liker et al. (1998) highlighted the importance of supplier involvement, especially for complex and new product design. Involvement can also be referred to as "participation" (Guimaraes et al., 2002) in terms of which, joint planning (Sheu et al., 2006) and/or joint problem solving (Stuart, 1997) are indicators of success. Similarly, in the context of technology acquisition and implementation, high supplier involvement throughout, or at any stage of technology implementation, signifies the existence of closer or strong relationships with the technology supplier. Therefore, involvement is taken an indicator of close BSR in the present research.

Hence, for the purpose of the present study, the researcher has chosen the multiple indicators of buyer-supplier relationships that measure relationships strength or the extent of closeness between buyers and suppliers, these being:

1. Level of trust
2. Level of business understanding
3. Level of commitment
4. Level of involvement
5. Level of communication
6. Level of information sharing
7. Level of knowledge acquired

These are the commonly-used dimensions of BSR in prior research and are judged to be highly appropriate for measuring buyer-supplier relationships in AMT acquisition and implementations. Hence, it is proposed that these dimensions are strong indicators of the higher order construct that will be referred to as relationship strength. Therefore, the terms "close BSR" and "strong BSR" will be used interchangeably throughout this thesis. Relationship strength will be defined as the degree to which the technology buyer has engaged in close and strong relationships with the technology supplier and has operationalised the construct, using the indicators of trust, business understanding, commitment, involvement, communication, information sharing, and knowledge acquired. Table 2.9 summarises prior research studies that have used each of these indicators to measure BSR.

These dimensions of buyer-supplier relationships are distinct but interrelated (Mohr and Speakman, 1994). For instance, trust encourages behaviour such as open communication (Goffin et al., 2006) and willingness to share. On the other hand, regular contact and sharing of information increases the chance that knowledge will be spread (Norman, 2004), thus enabling the technology buyer to learn more from the technology supplier, resulting in a higher level of knowledge acquisition. Morgan and Hunt (1994) found a high degree of correlation between commitment, trust and co-operation in inter-company relationships. Similarly, Monczka et al. (1995) found that such dimensions reinforce each other in terms of enhanced buyer-seller relationships. As such, the comprehensive measurement of buyer-supplier relationships should incorporate an aggregate measure of BSR (Fynes and Voss, 2002).

**Table 2.9: Indicators of BSR and supporting references**

| Indicators | References |
|---|---|
| **Trust** | Benton and Maloni, 2005; Burgess and Gules, 1998; Burgess et al., 1997; Dyer, 1997; Fynes and Voss, 2002; Guimaraes et al., 2002; Lee and Kim, 1999; McCutcheon and Stuart, 2000; Morgan and Hunt, 1994; Sako, 1991; Stump and Sriram, 1997; Tomkins, 2001 |
| **Business Understanding** | Guimaraes et al., 2002; Joshi and Campbell, 2003; Lee and Kim, 1999 |
| **Involvement** | Dyer, 1997; Guimaraes et al., 2002; Lee and Kim, 1999 |
| **Commitment** | Benton and Maloni, 2005; Burgess and Gules, 1998; Burgess et al., 1997; Dyer, 1997; Fynes and Voss, 2002; Guimaraes et al., 2002; Lee and Kim, 1999; Morgan and Hunt, 1994; Sako, 1991 |
| **Communication** | Burgess and Gules, 1998; Burgess et al., 1997; Carr and Pearson, 1999; Fynes and Voss, 2002; Guimaraes et al., 2002; Lee and Kim, 1999; Sako, 1991 |
| **Information Sharing** | Dyer, 1997; Fynes and Voss, 2002; Guimaraes et al., 2002; Lee and Kim, 1999; Stump and Sriram, 1997 |
| **Knowledge acquired** | Kotabe et al., 2003; Moller et al., 2003; Sako, 1991 |

## 2.4 TRANSACTION COST ECONOMICS (TCE)

### 2.4.1 Definition and explanation

Transaction cost economics was pioneered by Coase (1937) and developed by Williamson (1975; 1979; 1981). Transaction cost economic theory defines a transaction as the transfer or exchange of goods and services across an organisational boundary (Williamson, 1975; 1979). It focuses on the minimisation of opportunism as a means of minimising the transaction cost. Transaction costs are the customer's costs of being in the exchange relationship. Typical costs are those of setting up, negotiating and safeguarding the relationship and the costs of running, securing and correcting the relationship while it is working (Williamson, 1985).

Transaction costs arise because a transfer of goods and services takes place in an exchange context where information is imperfect, where parties have asset-specific investments, or either party may seek to promote its own interest at the expense of the other by engaging in strategic or opportunistic behaviour (Williamson, 1975). The purpose of transaction cost theory is to identify the sources, characteristics or dimensions of a transaction that make an exchange problematic or prohibitively expensive, and then to specify the governance mechanism that can most efficiently handle the transaction so as to economise on these costs.

Three important key dimensions or attributes of transactions that potentially determine the most appropriate governance structures are: 1) the condition of asset specificity required to support the transaction, 2) the frequency with which transaction recurs, and 3) the degree and type of uncertainty surrounding the transaction. The main relationship between these three attributes and the transaction cost is that as the three attributes increase, transaction costs also increase. All three dimensions have a heavy impact on the choice of governance structure, which is market, hybrid or hierarchy (Williamson, 1975, 1979, 1981, 1989).

TCE theory proposes that performance will be enhanced when there is congruence between the governance structure employed and the underlying attributes of the transaction. For instance, a study by Dyer (1996a) on a comparison between Japanese and US automakers' governance structure in facilitating exchange with suppliers, is amongst the prominent empirical research relating to governance structure and performance achievement of the firm. He found that Japanese automotive firms have been able to achieve a competitive advantage through the effective use of hybrid/alliance governance. The analysis suggests that governance influences the performance of the value chain because it affects the transaction cost, the level of relation-specific investments, and the strategic use of information.

Although this theory was mainly concerned with crafting an efficient governance structure, the broad scope and generality of the theoretical analysis have led to its usage across several research disciplines such as in economics, marketing, and strategic management. The application of this theory ranged from the analysis of outsourcing decisions (Coase, 1937; Ngwenyama and Bryson, 1999; Pisano, 1990; Poppo and Zenger, 1998; Rasheed and Geiger, 2001), to the organisation of exchange relationships (Dyer, 1997; Dyer, 1996; Noordewier et al., 1990), the choice of governance mode in technology development (Robertson and Gatignon, 1998) and in technology transfer (Davies, 1992), and the examination of governance within a single governance mode such as an alliance (Nordberg et al., 1996).

### 2.4.2 Transaction cost economics and governance structure

Governance structure denotes the organisational form in which a transaction takes place (Phan and Sommer, 1999). If the firm performs the task within its boundaries through bureaucratic control and co-ordination, the governance structure being utilised is a "hierarchy". If the task is performed outside the firm through market co-ordination and outsourcing, the governance structure being utilised is "market". If the task is performed jointly by economic units within the boundaries of the firm and economic units outside it, the governance structure being utilised is a "hybrid"(Williamson, 1991). The TCE basic premise is that the cost of doing transactions could be too high under certain conditions. In those cases, organising the economic transaction within the firm (hierarchy governance structure) might be superior to organising it as a market-based governance structure.

Transaction cost economics theory, is one of the dominant theoretical frameworks employed in the literature to model variations in governance structure (Bello et al., 1997). Governance structure can be matched to transactions in a manner that leads to lowered cost of exchange (Williamson, 1979). Each structure is associated with different levels of transaction cost. These costs arise from the set-up and running costs of the governance structures, as well as other costs, such as those due to renegotiation, arising from a shift in the alignment. Underlying this rationale is the central premise that the chosen governance structure will be the one that minimises transaction cost.

The basic tenets of this theory rely on two key assumptions about human behaviour, these being bounded rationality and opportunism. Bounded rationality refers to the limited ability of people to make decisions (Williamson, 1975; Williamson, 1985). In the organisational context, while decision-makers might want to act rationally, they are limited in their ability to receive, store, and communicate information without error. This restricts the extent to which rational behaviour can be conducted. Opportunism indicates that human actors in a relationship will be guided by considerations of self-interest with guile. This includes behaviour such as cheating, lying, and subtle forms of violation of agreements. TCE views bounded rationality and opportunism as a problem under conditions of high transaction attributes because it can lead to high transaction cost.

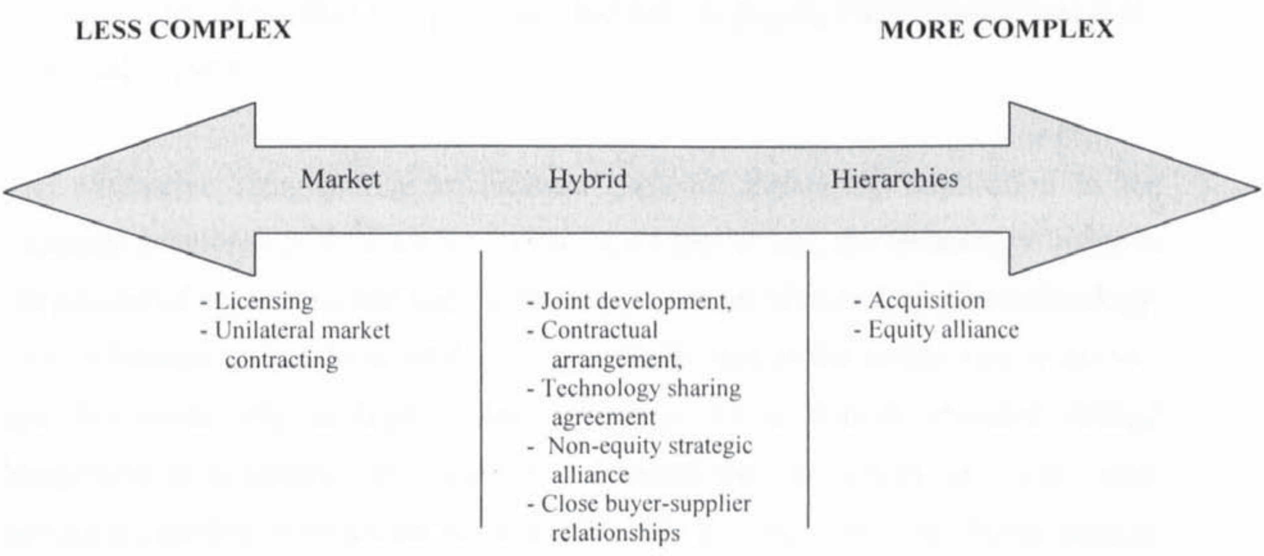
From the three discrete modes of governance structure initially introduced by Williamson, literature in governance structure and the application of the transaction economic perspective continue to treat the classification of governance structures in different ways. For instance, from a hierarchy-market perspective, Mowery et al. (1996) (1996)viewed a licensing agreement as a unilateral contract and a market arrangement where access to specific technology is purchased from an external source. In contrast to a licensing agreement, joint development is a more hybrid arrangement where two or more companies agree to share in developing and commercialising technology (Tyler and Steensma, 1995). Similarly, Thorelli (1986) considered collaborative development to take the middle ground between markets and hierarchies. Hagedoorn and Schakenraad (1994) on the other hand, viewed the governance mode along a continuum ranging from simple to complex. In their study on the effect of strategic technology alliances on performance, they indicate that technology agreements can range from fairly simple unilateral contracts, such as licensing, through to more complex contractually based arrangements, such as joint development agreements, to 'pure' equity joint ventures where ownership is through a separately incorporated entity shared by the partner firms. Table 2.10 indicates the treatment of the governance mode in some of the selected previous studies.

**Table 2.10: Selected previous studies on TCE and governance mode choice**

| Author | Issue | Governance structure under investigation | | | Major findings |
|---|---|---|---|---|---|
| | | **Market** | **Hybrid** | **Hierarchy** | |
| Robertson and Gatignon (1998) | Technology Development | - | Alliances | Internal R&D development | The usage of alliances for technology development is positively related to asset specificity, external uncertainty, and behavioural uncertainty. |
| Rasheed and Geiger (2001) | Outsourcing Decision | Outsource the IT function | | Internalise the IT function | Higher investment in human resources and technical infrastructure (high asset specificity) and higher level of transaction frequency lead to greater level of internalisation of the IT function |
| Davies (1992) | Choice of technology transfer | Licensing | | Internalised | The internalised mode of governance leads to the transfer of a much broader range of information and skills than licensed transactions |
| Dyer (1996a) | Comparative analysis between Japanese and US automakers of governance structure in facilitating exchange with suppliers | Arm's-length | Partner | Division | Japanese automakers effectively rely on hybrid governance (close relationships with the suppliers) whereas US automakers largely rely on markets and hierarchies to facilitate exchange.<br><br>Effectively aligning governance structures with transactions will result in efficiency advantage. |

Despite the various definitions that emphasise the discrete types of governance structure originally proposed by TCE, three important observations can be made, these being: firstly, the above research studies that utilise a transaction cost economics perspective indicate that transactions differ along the critical dimensions of transaction attributes (asset specificity, uncertainty, and frequency of transaction), which are then aligned with governance structures. Secondly, the right governance choice then has an implication on the various aspects of performance under investigation, through the reduction of transaction cost. Finally, despite of the many areas in which governance structure and TCE research have taken place, there has been increased argument and evidence that the right choice of governance arrangement leads to better performance. Rasheed and Geiger (2001) point out that the appropriate choice of corporate governance mechanisms for inter-organisational relationships within the value chain, is critical to the strategic objective of maximising firm performance. Based on a compilation of the past research, Figure 2.2 visualised the types of governance mode, along the continuum of governance structure in transaction cost economic theory.

**Figure 2.2: Governance arrangement along the 'market-hierarchy' continuum**




Although TCE was traditionally concerned with choices about whether activities were performed within a firm's organisational boundaries or in the marketplace, more recently, TCE has been applied to alliances, specifically how to structure relationships to try to "mitigate the transaction hazards that are present in a relationship" (Norman, 2004, p.611). The two key assumptions in this theory - bounded rationality (the capability of people to make decisions is limited), and opportunism (people tend to exploit a situation to their own advantage) - lead to many firms viewing the development of closer buyer-supplier relationships as a risk management tool that safeguards the transaction from various sources of failure.

### 2.4.3 Buyer-supplier relationships as a governance mechanism

As indicated earlier, the fundamental prediction of transaction cost economic theory is that when firms made a transaction with higher transaction attributes, they tend to safeguard the transaction by moving away from an arm's-length market relationship toward a vertically-integrated relationship and its associated bureaucratic control mechanism. While the most prominent safeguards employed from previous studies were in the form of legal contracts, such as through the establishment of a hierarchy or hybrid form of governance as described in the previous sections, alternative means have been offered by scholars from various fields. These alternative means include informal safeguards such as the use of relational elements between both parties involved in the transaction as a protection mechanism (Dyer, 1997; Noordewier et al., 1990; Sako, 1992).

The alternative safeguarding mechanisms pose an interesting implication in the exchange relationship between the technology supplier and the technology buyer in the process of acquisition and implementation of advanced manufacturing technology. This is because in certain technology acquisitions, even if the technology is specific and the uncertainty is higher, the technology buyer cannot consider vertical integration as a feasible alternative to safeguard the transaction. In some cases, vertical integration is irrelevant to, and unfeasible for, the technology buyer because the cost of establishing a bureaucratic control mechanism such as an alliance or joint venture, might be higher that the cost of the technology.

Similarly, vertical integration is also irrelevant to the technology supplier because it is the buyer's investment at risk, and the supplier firm does not see the need to vertically integrate. The question is then in this situation, how can the buyer firm protect the transaction? Noordewier et al. (1990) (1990), Sako (1992) and Dyer (1997), all found in their studies, that firms use informal safeguards such as the use of relational elements between both parties involved in the transaction as a protection mechanism. For instance, Noordewier et al. (1990)(1990) examined the relationship between the organisation of the buyer-seller interface and performance in repetitively-used items procurement. On the basis of transaction cost analysis, the buyer-vendor relationship is used as a measure of governance structure.

Although not all studies that use transaction cost economics perspectives explicitly emphasise the buyer and supplier relationship as a governance mechanism, TCE has been seen as one of the most influential theories on managing supplier relationships (Ellegaard et al., 2003). From a review of the literature, it can be seen that a great number of studies examine buyer and supplier relationships using the transaction cost economics perspectives (Dyer, 1997). Indeed, many scholars also study the supplier and user relationship within a single governance structure such as inter-firm knowledge transfer in strategic alliances (Mowery et al., 1996) and understanding the costs and benefits under short-term market-based contracting (Nordberg et al., 1996). This means that the principal issue within and between chosen modes of governance is the relationship development between parties involved in the transaction.

In another view of intra and inter-organisational relationships, buyer and supplier relationships can also be classified as one of the many forms of governance structure. Exchange theories, which consider co-operation as a means of maximising economic or psychological benefits (Blau, 1964), can be used to explain co-operative relationships (Smith et al., 1995). The specific theories of exchange include transaction cost theory (Smith et al., 1995). Related to this issue, Stuart (1997) stressed that the supplier alliance is one form of inter-organisational relationship similar to alternate forms of inter-organisational relationships like joint ventures, mergers, acquisitions, and licence agreements.

In a theoretical argument of hybrid organisational arrangements, Borys and Jemison (1989) classified supplier arrangements as one of the five major types of hybrid forms of governance structure comparable to mergers and acquisitions, joint ventures, and the licensing agreements. Focusing on their common elements and purpose, the authors further indicate that in the supplier arrangement, the management of boundary permeability and the value creation process is the primary determinant of success, and the performance of supplier arrangements is determined primarily by its ability to create and manage reciprocal interdependencies between buyer and supplier.

Dyer (1997) described the term 'safeguard' as an alternative to the term governance structure, which are both further defined as control mechanisms which have the objective of bringing about the perception of fairness or equity among transactors. According to the author, many of the arguments that claim a close relationship with suppliers is efficient, arise from more effective and more complete information sharing (Fruin, 1992), and 'trust' as a highly efficient governance structure which minimises transaction cost (Sako, 1992) lies within transaction cost economics.

There are varieties of safeguards that can be employed by the transactors (Dyer, 1997). For instance, in a comparison study between the US and Japanese automobile firms, Dyer (1996a) claimed that the Japanese manufacturing industry owes its competitive advantage to its "Vertical Keiretsu" (Supplier partnership). This term refers to the close and trusting patterns of relationships between firms and their suppliers. Dyer (1996a) further explained that Japanese firms rely largely on "hybrid governance" or supplier alliances, whereas their US counterparts largely depend upon market and hybrid types of governance. However Japanese automotive value chains are characterised by greater inter-firm asset specificity than US chains. This gives an indication that in the event of greater asset specificity, close partnerships with suppliers act as a powerful governance mechanism for Japanese firms.

Therefore, since a close and trusting supplier relationship is capable of minimising the transaction cost (Barney and Hansen, 1994; Sako, 1992), it is reasonable to expect that the buyer and supplier relationship, which is one of the types of hybrid governance (Borys and Jemison, 1989), also operates as a powerful form of governance mode that controls the exchange. This research characterises the relationship between buyers and suppliers in AMT acquisition and implementation as part of a collaborative arrangement, and thus, part of governance structure, and as operating as a tool to reduce transaction cost by increasing efficiency and minimising the effect of opportunism.

### 2.4.4 Transaction attributes

The degree of transaction cost has been previously measured in terms of the attributes associated with the transaction. As described in section 2.4.2, previous research studies have provided evidence that the cost-effective choice of governance form is seen to vary systematically with the attributes of the transactions. The three primary types of attribute offered by transaction cost economic theory in describing a transaction are the condition of asset specificity, the degree and type of uncertainty surrounding the transaction, and the frequency of the transaction.

#### 2.4.4.1 Asset specificity

An early and basic definition of a firm's specific assets offered by Williamson (1985), are human and physical assets, as well as, routines and knowledge that are not transferable to alternative uses. Similarly, Robertson and Gatignon (1998) referred to transaction specific assets as transactions that involve investments in human and physical capital that cannot be redeployed without losing productive value. The authors further explained that these assets may be in plant and equipment uniquely suited to producing a specific product or serving a particular customer, in brand name capital, or in terms of specific knowledge and expertise. Wang (2002) further extended the definitions of asset specificity to the products, services or investments that are customised to the transaction.

Since its inception, the term asset specificity has been widely defined and operationalised to suit the context of the research. In the comparative study between Japanese and US car manufacturers' governance structures, Dyer (1996; 1997) further expanded asset specificity into four major categories which are: site-specificity which refers to the transactors' locating facilities; physical asset specificity which refers to capital investment in customised machinery, tools, dies etc; human asset specificity which refers to relation–specific know-how developed between transactors; and dedicated asset specificity which refers to the percentage of the supplier's total sales to the particular automaker (buyer). On a sample of service organisations, Jones (1987) measured transaction specificity in terms of the nature of the work provided by employees to customers. High specificity occurs when each customer has different needs and the work is different for every customer.

In the study on principal-agent relationships, Heide and John (1988) referred to asset specificity as the time and effort spent on learning about the principal's organisation and the selling techniques used by the principal, time and effort spent in working closely with the principal's people, and effort given to developing sales territories for the principal's line. In their study of the outsourcing decision of an Information Technology function, Rasheed and Geiger (2001) referred to the number of web employees and the investment made in web-based hardware and software, as the measure of asset specificity.

In the context of AMT acquisition and implementation, an acquired manufacturing technology is a highly-firm-specific asset when the technology represents a core competence to its business operations and requires idiosyncratic human capital and skills. If the technology represents a core competence to the firm, it gives that particular AMT investment a high asset specificity because huge amounts of production value need to be sacrificed in case the technology fails to work as expected. To implement the technology, firms must incur specific investment in learning and training in order to perform the task adequately. Additionally, if the investment in the technology is considered by the firm to be major, the more likely it will feel the need to secure the investment from various sources of failure. Thus, in this study, transaction specific investment is defined as the tangible and intangible assets that are devoted to the acquisition and implementation of the particular AMT innovation and to support the transaction.

#### 2.4.4.2 Uncertainty

Uncertainty is another important principal factor in the transaction cost economic perspective that can impact upon the choice of governance structure. Amongst an early form of uncertainty highlighted by Williamson (1979), is parametric or environment uncertainty, which complicates writing and enforces contingency claims contracts. Previous research has found that the level of uncertainty influences the selection of governance structure adopted by firms. A study by Jones (1987) indicated that uncertainty affects the governance structure of firms, showing that in high certainty situation, firms tend to adopt more sophisticated control practices by increasing the number of levels in their hierarchies and reducing spans of control in order to increase employee accountability.

Like asset specificity, uncertainty can come in various forms (Wang, 2002). In the context of technology development, Robertson and Gatignon (1998) investigated the factors explaining the choice of governance, dividing uncertainty into two types, these being, external uncertainty and behavioural (internal) uncertainty. The two sources of external uncertainty employed in their study are demand uncertainty and technological uncertainty. The former refers to the volatility or the difficulty of predicting demand whereas the latter relates to changes in technology in the product category. On the other hand, two sources of behavioural (internal) uncertainty employed in their study are the ability to measure innovation performance and the firm's prior experience with alliances.

In the context of the procurement of external technical know how, Steensma and Fairbank (1995) discussed how the level of uncertainty associated with the technology can affect the choice of governance arrangement on whether to internalise or outsource the technical know how. The three pertinent questions associated with uncertainty related to the technology are: will the technology work as intended, will there be market acceptance, and will the technology continue to be of value in the midst of a changing competitive environment? In the analysis of the implications of transactions attributes on the consequences of customised software outsourcing practice, Wang (2002) defined uncertainty as the inherent characteristics of specific software outsourced in terms of the difficulties of prescribing specifications, scheduling delivery dates and estimating costs at the contracting stage.

Nevertheless, reflecting on the above reviews, in general, uncertainty refers to any disturbance related to the transaction that is not definitely or precisely known. In the process of acquisition and implementation of advanced manufacturing technology, uncertainties are more concerned with the technology being acquired and the firm's own capability to implement it. Before investing in a new technology, firms will normally be uncertain about whether the invested technology would be able to achieve its investment goals. Due to the newness of the technology, firms might also have some doubt with regard to the technical expectations and in the technology's ability to satisfy their high customer demand. Whether or not the technology will work as intended, cannot be determined until the implementation is complete and the technology is being used for the daily production task. Uncertainty also surfaces from a firm's own technological capability. Thus, a firm's prior experience in implementing similar types of technological innovation and the availability of expertise to handle the technology, can affect the uncertainties associated with the acquisition and implementation of advanced manufacturing technology. Therefore, these two aspects are included in assessing the uncertainty level in this study.

#### 2.4.4.3 Transaction frequency

Transaction frequency is the sequence and the regularity of a transaction. When transactions are carried out frequently, both buyer and seller will probably value repeat business and will not wish to tarnish their reputations by acting opportunistically. As information becomes more infrequent, the incentive to act opportunistically and to exploit any informational asymmetries that may be present, increases (Hobbs, 1996). Compared to the procurement of industrial/parts component, the acquisition of capital equipment such as AMT is distinct, generally it is a one-time event, and a rarely occurring transaction. The measure of transaction frequency is not applicable in this context and is excluded in this study. However, the infrequent nature of AMT procurement assumes the presence of a high risk of bounded rationality and opportunism in the transaction process of AMT acquisition and implementation between buyer and supplier, which signifies the need to develop close relationships with the technology supplier.

#### 2.4.4.4 Complexity

Although three primary transaction attributes are originally offered in the transaction economics model, the literature identifies that the attributes that lead to variations in transaction cost, vary significantly from one study to another. For instance, Dyer

(1996; 1987), is only concerned with the asset specificity aspect of the transactions, whereas Jones (1987) takes transaction uncertainty and performance ambiguity as the two important attributes of the transactions, since they affect the amount of information that has to be processed to complete the transactions.

Globerman (1980) argues that the complexity involved in different technological innovations must also be acknowledged in the transaction cost reasoning, since it is predicted to directly increase the complexity of the appropriate governance structure. According to Dodgson (1993), another technological dimension or consideration for firms pursuing a collaborative relationship with the technology supplier is when the breadth and depth of expertise required exceeds the capability of an individual firm. Firms are at a disadvantage when the technology contains a level of complexity that is unfamiliar to them. These disadvantages will not only create the possibility for opportunistic behaviour by the technology provider, but will also cause firms to be more dependent on the supplier.

By its nature, advanced manufacturing technology is complex (Zairi, 1998) in terms of technical profiles and participating actors (Park, 2000). Thus, the implementation of AMT is much more complicated and difficult to undertake (Cook and Cook, 1994). The increased automation imbedded in the technology places new demands on the knowledge of a particular computer software technology, and requires continuous attention to the maintenance function. The benefits associated with its adoption and the changes it brings to the entire manufacturing practices and performance, produce a greater need for firms to be more meticulous in its adoption. Firms with the newly-adopted technology firstly have to bear substantial investment in the physical value and the costs associated with its implementation such as training, learning, change required in the organisation and time dedicated for such process. Coupled with various feelings of uncertainty surrounding the acquisition of the technology, firms also have to face another challenge, which is to effectively install the technology. Even after successful installation, there is no guarantee that the technology will work perfectly and harmoniously during the daily production task, and failure of a single component or piece of equipment may halt the entire production line.

Advanced manufacturing technology is used in production technology that produces small quantities of a large number of different products (job shop) to the production of large volumes of either a single product or a very limited range of product (continuous processes). Many of the previous research studies have classified AMT by its use and three sub-categories have emerged, which are: stand-alone systems, intermediate systems, and integrated systems (Small and Yasin, 1997). Although technically, the integrated systems can be considered as the most complex range of technology compared to the other two systems, it must be noted that, due to the various nature of technology and organisational environment, the perception of complexity is very subjective from the view of the firm. For instance, within the same technology categorisation, the level of complexity of the technology can be different from firm to firm. As evidence from the case studies show, firms that acquired the CNC technology for the first time might consider the technology and the whole adoption process as complex compared to firms that have previously adopted and used the CNC technology. Similarly, firms that adopt integrated technology might not find it very complex as they have the previous automation experience compared to firms that adopt a stand-alone robotic system for the first time.

Reflecting on the above, it is reasonably important to assess the complexity of the technology from the view of the firm when studying the patterns of relationships with the technology supplier. Thus, complexity is taken as another dimension that affects the governance of buyer and supplier relationship in this study. Consistent with Kogut and Zander (1993), complexity is defined as the number of critical and interacting elements embraced by an entity or activity. Simple technology is easy to learn and use, and the embodied knowledge is usually explicit. Complex technology on the other hand cannot be codified in full, even if it is mature. Complex technology contains a much higher tacit knowledge element than simple technology (Tsang, 1997). These perceptions of complexity vary from firms to firms.

### 2.4.5 Section summary

TCE theory is concerned with the arrangement of governance structures consistent with the attributes of the transaction. According to this theory, transaction attributes are associated with transaction cost and therefore, the attributes of the transaction and the governance arrangement should always be matched. The theory suggests that efficient governance will result in better performance. The application of this theory has been widely used in studies related to: governance arrangements such as alliances in technology development (Robertson and Gatignon, 1998) , whether to internalise or to outsource information technology (Rasheed and Geiger, 2001) , and whether to use joint venture and acquisition in acquiring the technology (Moon, 1998)

On a separate issue, there have been claims that BSR is also part of the governance arrangement, similar to other types of governance structure like partnership, joint venture, and merger and acquisition (Dyer, 1997; Noordewier et al., 1990; Sako, 1992). As part of the governance mechanism, BSR can be argued to be capable of protecting the transaction from various sources of failure. However, since existing research in the area of TCE and governance has only focused on the types of governance structure like joint venture, acquisition, licensing and merger, a considerable gap in the area of TCE remains in the following areas:

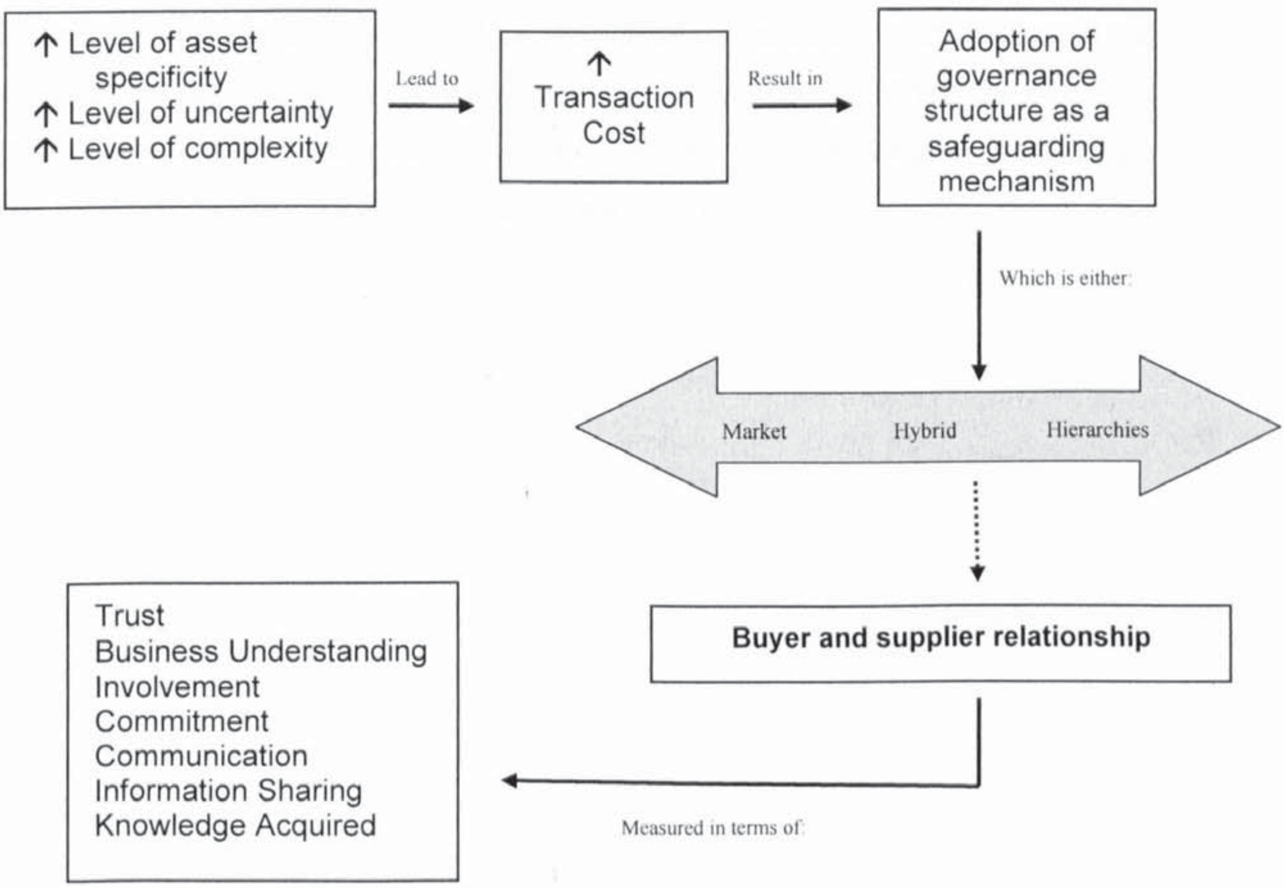
1. In a situation where it is neither possible nor feasible to form a higher governance arrangement (from the technology buyer perspective), the question remains of how firms protect their investment from opportunistic behaviour which TCE highlights as a possibility.
2. If BSR has been regarded by some scholars as similar to other inter-organisational relationships that exist beyond the boundary of the firm, there is a possibility that the attributes surrounding the specific transaction could affect the development of BSR, especially in the situation where a high level of governance arrangement is not feasible, as mentioned before.
3. If there is a possibility that BSR can act as a governance mechanism, then strong BSR can be regarded as a higher level of governance arrangement, and should have an impact on performance.

These issues have not been adequately addressed in the TCE literature, especially in relation to BSR in technology acquisition and implementation. This study will use TCE theory in understanding the development of BSR in AMT acquisition and implementation.

## 2.5 CHAPTER SUMMARY

This chapter has brought together the streams of literature on AMT, BSR and TCE. Having evaluated and integrated these three areas of research and theory, Figure 2.3 presents the inter-relationships between BSR, TCE, and governance structure, and how these will be used to study AMT acquisition and implementation.

**Figure 2.3: The inter-relationships between TCE, Governance structure, and BSR**




The figure demonstrates that according to transaction cost economic theory, the higher the transaction attribute (asset specificity, uncertainty, and complexity), the higher the transaction cost, and the more firms tend to adopt appropriate organisational forms or governance structures to lower the transaction cost and increase transaction value. The three discrete modes of governance structure initially offered are market, hybrid, and hierarchy. A growing stream of literature also recognises these modes as part of the inter-organisational relationship, thus considering buyer-supplier relationships as another governance mechanism, capable of lowering the transaction cost and increasing the transaction value. Within the transaction cost economic literature, buyer-supplier relationships are also considered as one of the five major types of hybrid forms of governance structure comparable to mergers and acquisitions, joint ventures, and licensing agreements. The BSR literature recognises that the elements of trust, business understanding, involvement, commitment, communication, information sharing, and knowledge acquired, are frequently used to gauge an understanding of BSR. In the area of AMT, despite the claims that the technology supplier plays an important role in project success, there has been a great lack of research that has specifically investigated this issue. Therefore, this research will explore the effect of transaction attributes on the development of BSR in the acquisition and implementation of AMT. The following chapter provides the reader with the research model and to be adopted in this study, and the development of clusters of hypotheses to be tested.

# CHAPTER THREE

# RESEARCH FRAMEWORK AND THE DEVELOPMENT OF HYPOTHESES

## 3.1 INTRODUCTION

The literature review presented in the preceding chapters, has helped to frame the research problem, identify the relevant concepts, and define each of the variables of interest in the study. This chapter outlines the main conclusions and gaps drawn from this exercise, which lead to the construction of the research model and the development of the hypotheses to be tested in the study.

## 3.2 OUTLINE OF RESEARCH GAPS

- Despite the recent surge of research interest in buyer and supplier relationships and the advancement in manufacturing technology, knowledge about the development and role of technology suppliers in AMT implementation, remains limited. A review of the AMT literature reveals that, despite the wide claim that a close relationship with the technology supplier is one of the main ingredients of the successful implementation of AMT, very few studies have been conducted on this issue. Limited empirical attention has been devoted to the role of technology supplier in the implementation process.
- A review of the BSR literature indicates that research in this area is vastly expanding. A growing number of firms are now shifting towards a more collaborative form of relationship with their suppliers in order to attain and sustain competitive advantage in their business. However, although much attention has been directed toward understanding the relationship between buyer and supplier for the industrial/parts purchases (repetitively used items), the relationship between buyer and supplier in terms of capital equipment purchases (e.g. the procurement of AMT) has been scarcely examined.
- In the area of TCE and governance structure, there has been a lack of research exploring the effect of transaction attributes in understanding the development

of buyer-supplier relationships despite the recognition that the supplier arrangement emerges as one of the five major types of hybrid forms of governance structure, being comparable to mergers and acquisitions, joint ventures, and licensing agreements.

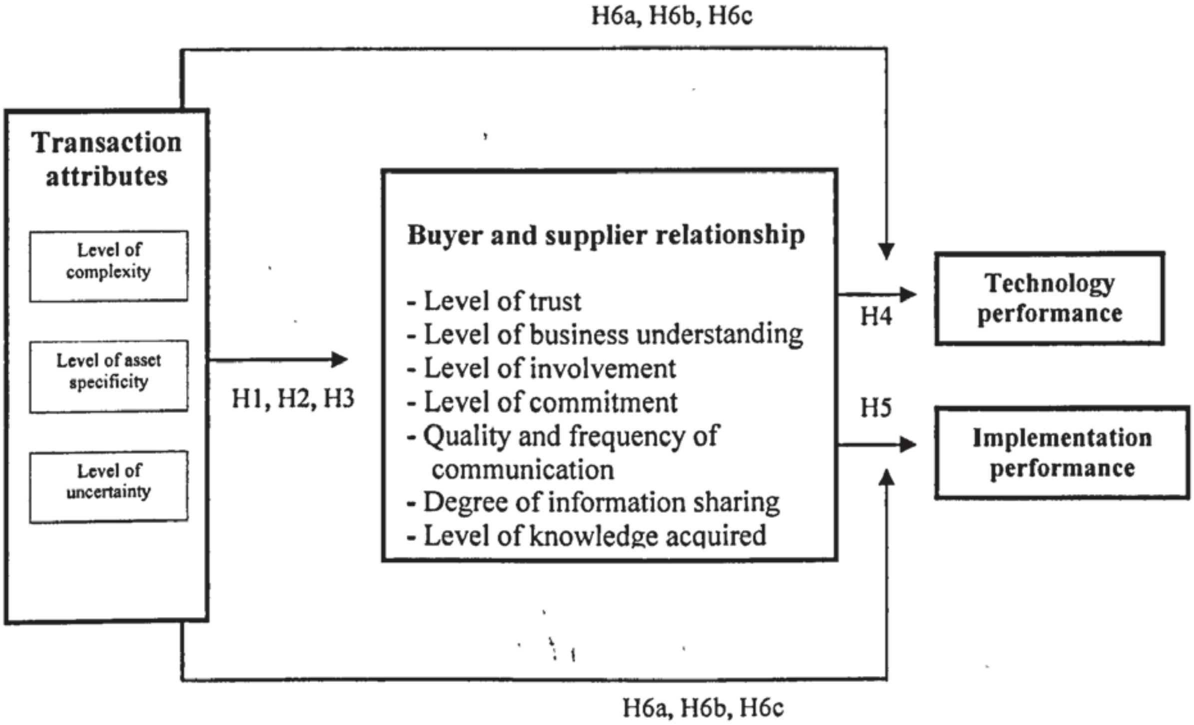
- Although the appropriate choice of corporate governance mechanisms for inter-organisational relationships has been recognised as critical to firm performance, an unknown and unexplored area is the understanding of how the buyer and supplier relationship, which is considered as one form governance structure, could make a difference in terms of performance achievement in AMT acquisition and implementation.
- To date, no empirical studies or theoretical model explain how the transaction attributes surrounding the acquisition and implementation of a particular technology could affect the choice of a particular governance mode, nor of how the chosen governance structure influences the performance of a particular technology acquisition and implementation.
- There has been no established measure to test the elements of complexity, asset specificity, and uncertainty in AMT acquisition and implementation environment.

These gaps were perceived to require further investigation. The research will empirically explore this issue and consistent with the research objectives, as stated in chapter one, the aim of the research is to examine how the transaction attributes of the implemented technology affect the pattern of relationships between the technology buyer and the technology suppliers, and then to see the impact of different patterns of buyer-supplier relationships on the performance of AMT.

## 3.3 THE RESEARCH FRAMEWORK

Figure 3.1 illustrates the conceptual framework investigated in the present study. Basically, the model envisages that the level of asset specificity, level of uncertainty, and level of complexity of the particular AMT innovation, will have an impact on the relationship between technology buyer and supplier, which then will influence performance.

**Figure 3.1: Framework to investigate relationships between variables**




This research characterises the relationship between buyers and suppliers in AMT acquisition and implementation as part of a collaborative arrangement, and thus, part of governance structure, operating as a tool to reduce transaction costs by increasing efficiency and minimising the effect of opportunism. The premise underlying this study is that, the pattern of relationship between the technology buyer and the technology supplier in AMT implementation is more likely to be different on the basis of the transaction attributes of the technology being acquired. Drawing from transaction cost economic theory reasoning, in combination with exploratory interviews and semi-structured interviews with managers involved in AMT implementation, the factors leading to the differences in the technology user and the technology supplier relationships in AMT implementation, were investigated in terms of the level of asset specificity, level of uncertainty, and the level of complexity of the technology. Since it has been widely cited in the literature that the relationship with the technology supplier is crucial for AMT success and that such an appropriate governance arrangement could improve firm performance, in this study, the different pattern of the technology buyer and the technology supplier relationship is predicted to have a different impact on the technology and implementation performance.

In the study, the performance of the particular AMT innovation is evaluated using firms' self-assessments of changes in manufacturing performance since the adoption of AMT, whereas implementation performance fundamentally concerns the implementation issues. As the study utilises transaction cost economics theory, the transaction refers to the firm's acquisition and implementation of AMT innovation. The term buyer and supplier relationship is defined as the governance mechanism or interaction between the technology user and the technology supplier in the process of technology implementation. Firms are considered to develop closer buyer and supplier relationships when there is a higher level of trust, business understanding, involvement, commitment, communication, information sharing, and knowledge acquisition between the buyer and the supplier during the relationship. Technology acquisition and implementation refers to the three implementation processes as proposed and used by Voss (1988) and Small and Yasin (1997a), which are:

1. Pre-installation (Planning and Justification)
2. Installation and commissioning (Acquisition, installation and start up)
3. Post-commissioning (operating, monitoring and evaluating)

The following section provides key arguments supporting the introduction and development of the research framework and hypotheses.

## 3.4 TRANSACTION ATTRIBUTES AND BSR

In determining the factors affecting the management of the buyer and supplier relationship in the acquisition and implementation of a particular AMT innovation, this study uses transaction cost theory to hypothesise how the level of asset specificity, level of uncertainty, and level of complexity, influence the strength of the relationship between the buyer and the supplier of the technology. This perspective was chosen because it has provided a dominant explanation in research on governance mode choice research (Masten, 1993; Moon, 1998). This theory is also a major theoretical framework employed in the literature to model variations in governance structures (Bello et al., 1997), and consistent with the literature review, this study takes buyer-supplier relationships as one form of governance mechanism. Thus, variations in the patterns of buyer and supplier relationships could be attributable to differences in the transaction attributes. This perspective has been seen as one of the most influential in managing supplier relationships (Ellegaard et al., 2003). The literature indicates that many studies examine buyer and suppliers relationship using the transaction cost economics lens (Dyer, 1997).

### 3.4.1 Asset specificity and buyer-supplier relationships (BSR)

Transaction cost economics theorists have long argued that governance structures are necessary due to the 'opportunism' problem when transactors make specialised investments (Klein et al., 1978). According to this theory, transaction costs increase as the level of asset specificity increases, thus hybrid relational contracting becomes more optimal for transactions until high asset specificity results in internalisation (Nordberg et al., 1996). The probability for individuals engaging in the transaction to behave opportunistically increases as investments in specific assets increase (Hill, 1990). The party making significant investment in transaction-specific assets is placed at risk of exploitation by the other party as a consequences of the latter's opportunistic behaviour. Accordingly, the transaction costs incurred in establishing safeguards for such market transactions can exceed the bureaucratic costs of internal organisation, which then lead to a change in governance structure from market to hierarchy (Chiles and McMackin, 1996).

Highly specific assets are also hypothesised to damage the performance of a simple governance arrangement as a result of costly contractual safeguards to protect from opportunistic behaviour (Williamson, 1981, 1985). For instance, Robertson and Gatignon (1998) found that a firm's specific commitments in finance, plant, equipment, and marketing at the product category, core competencies represented by the technology, and the firm's collective learning at the product category, are significant predictors of whether to use an alliance or to develop the technology internally. In the context of the automotive industry, Dyer (1997) found that specialised investment by Japanese automakers resulted in closer and more trusting relationships with the supplier (hybrid relational governance). In the analysis of the impact of transaction attributes on the consequences of customised software outsourcing practice, Wang (2002) found that specific investments tend to create a mutual dependence and bilateral monopoly relationships, which have an effect on constraining the opportunistic behaviour between each party involved in the transaction. In sum, support has been found for the key explanation of the relationships between asset specificity and the choice of governance arrangement, that being that increasing asset specificity leads to the adoption of suitable governance arrangements as a safeguarding mechanism.

The above arguments demonstrate how different levels of asset specificity require the adoption of different types of governance structure by firms. According to Williamson (1985) and Heide (1995), the development of stronger relationships is partly in response to the presence of uncertainty and transaction specific assets. As mentioned earlier, close buyer-supplier relationships act as a powerful governance mechanism. In the process of AMT acquisition and implementation, it could be even more crucial. As the technology requires major monetary and human investment and represents a core competence to the acquiring firm's business operation, the more likely it is that firms develop close ties with their technology suppliers, to safeguard the investment from various sources of failure.

The technology supplier sometimes tends to manipulate the true information about the technology in the interests of selling it; thus, a firm that regards the technology as highly specific will initially have to develop a high level of trust in the relationship. Also in the early stage of the relationship, close contact with the supplier can enhance the supplier's understanding of the firm's business requirement, with the result that mis-specification of the technology provision can be minimised. Thereafter, the firm continues to work closely with the suppliers to ensure efficiency in the entire process. In this case, developing close buyer-supplier relationships is not only targeted at minimising the transaction cost, but also aims to maximise the transaction value, as proposed by Zajac and Olsen (1993).

The explanation also lies in the contention that, apart from operating as a mechanism to safeguard the transaction, specific assets create value in a relationship. Based on the result of his empirical study, Dyer (1996a) pointed out that higher human asset specificity results in superior co-ordination, information sharing, and learning which is critical in complex-product industries. This implies that specific assets require greater effectiveness and efficiency from both parties in the transaction. As higher asset specificity demands a more complex governance form it indirectly provides a powerful signal of commitment and participation to the technology supplier. This is especially important if the technology is new and unfamiliar to the buyer firm. Therefore, it is anticipated that different levels of asset specificity for the investment in advanced manufacturing technology will have different patterns of relationship with the technology supplier. Thus, the first hypothesis to be developed and tested is:

**H1**: The higher the level of asset specificity, the more likely it is that a firm will engage in a closer relationship with the technology supplier during the acquisition and implementation of AMT.

### 3.4.2 Level of uncertainty and buyer-supplier relationships (BSR)

Many previous studies have found support for the idea that the level of uncertainty affects the choice of governance structure (Anderson and Schmittlein, 1984; John and Weitz, 1988; Jones, 1987; Klein et al., 1990; Noordewier et al., 1990; Robertson and Gatignon, 1998; Wang, 2002). Amongst the earliest studies, Jones (1987) empirically found that the level of uncertainty between an organisation and its clients affects the organisational governance structure in terms of organisational control and co-ordination. He suggested that organisational control and co-ordination appear to be the two main governance mechanisms that emerge in response to monitoring problems that transaction uncertainty produces.

In a similar argument, Robertson and Gatignon (1998) found that technological uncertainty was associated with an increased incidence of forming alliances for technology development. The authors claim that it is unlikely that a single company has the full range of expertise needed to bring advanced products to market in a timely and cost effective fashion, and thus, when firms experience high technology uncertainty, engaging in strategic alliances is likely to be more cost effective. The authors also found that as the ability to measure an innovation's performance increases, the likelihood of forming an alliance to develop innovation increases also.

Following the transaction cost economics reasoning, the authors claim that the more firms are uncertain about the performance of the particular innovation, the greater is the likelihood of opportunistic behaviour. Thus, the development of the technology internally rather than forming an alliance with an external partner acts as a safeguarding mechanism to lower the transaction cost and minimise the opportunistic behaviour.

Steensma and Fairbank (1999) claimed that uncertainty about the technology can be expected to partially affect the governance mode pursued by the firm. In the context of technology development, the authors empirically found that when firms are uncertain about whether the technology will work as intended, and whether it will be accepted in the market, they are more likely to choose the governance mode that can reduce the transaction cost. Previous findings relating to uncertainty and governance structure provide evidence that different levels of uncertainty require different patterns of governance arrangements in order for firms to be more effective.

In the context of acquisition and implementation of advanced manufacturing technology, the issue of uncertainty is similarly crucial. Saleh et al. (2001) claimed that investment in advanced manufacturing technology involves high capital investment and a high degree of uncertainty. In fact, it has been well reported in the literature that the adoption of this technology, whether to automate or to replace production facilities, has proven to be ineffective to many organisations. Different firms deal with different kinds of uncertainty, especially before the acquisition process. Amongst the uncertainties involved in the process of technology acquisition are whether the technology will meet the manufacturing objectives or whether it will fit the current manufacturing layout. The source of uncertainty also surfaces from the firm's own technological capability. Firms that have previous experience in implementing similar types of technological innovation and have enough expertise in handling the technology, may possess a low level of technological uncertainty. Thus, the more complex the technology and the less experience firms have in handling a similar type of technological innovation, the higher the level of uncertainty surrounding the transaction. In this context, developing close relationships with technology suppliers has the potential to reduce the feelings of uncertainty surrounding the transaction.

Following Robertson and Gatignon (1998), high uncertainty also means greater difficulty for the firm in trying to measure performance success. In research assessing the effect of performance measurement in a transaction cost economics framework, Anderson and Schmittlein (1984) showed that as the difficulty of measuring performance increases, so too does the likelihood of vertical integration. Similarly, John and Weitz (1988) confirmed that difficulties in performance assessment increase the likelihood of direct, rather than indirect, channels of distribution. Both studies indicated that integration, whether in channels or R&D development, provides the firm with readier access to information. In the same line of argument, in the context of acquisition and implementation of advanced manufacturing technology, it is reasonable to expect that the higher the level of uncertainty, the more likely firms are to develop closer relationships with their technology suppliers because of the possibility of readier access to information and the entire range of support from the suppliers.

Jones (1987) claimed that transaction uncertainty is a function of transaction infrequency, that the more infrequent the exchange between the buyers and the suppliers, the higher the uncertainty and costs of transactions. Unlike the procurement of industrial parts and components, the acquisition of capital equipment such as advanced manufacturing technology, is a non-recurring event. Thus, the infrequent exchange in the acquisition of advanced manufacturing technology leads to a higher level of transaction cost since each party lacks experience in dealing and negotiating with each other. Infrequent transactions also cause the buyer firm to have insufficient experience in handling the acquisition and implementation of the particular manufacturing technology, which subsequently leads to an increase in the level of transaction uncertainty.

The greater the level of such uncertainty, the greater the amount of information that firms have to process to complete a transaction efficiently, and thus the higher are its cost (Jones, 1987). In the acquisition of advanced manufacturing technology, firms may have to bear the information costs of ensuring equity in the exchange relationship and may incur information cost as they collect the data necessary to make the best decision. In high uncertainty transactions, firms also have to bear the monitoring cost of evaluating the quality of the product and service they receive. These situations increase the transaction cost that firms encounter and affect the way they develop relationships with the technology supplier. Since closer buyer-supplier relationships are capable of reducing the transaction cost and increasing the transaction value, it is reasonable to expect a relationship between the level of uncertainty surrounding the transaction and buyer-supplier relationships. Thus, another hypothesis to be developed and tested is:

**H2:** The higher the level of technological uncertainty, the more likely it is that a firm will engage in a closer relationship with its technology supplier during the acquisition and implementation of AMT.

### 3.4.3 Level of complexity and buyer-supplier relationships (BSR)

The complexity of the appropriate governance structure is also predicted to increase directly with the complexity involved in different technological innovations (Globerman, 1980). According to Dodgson (1993), another technological dimension or consideration for firms pursuing a collaborative relationship with the technology supplier, is the situation when the required breadth and depth of expertise exceeds the capability of an individual firm. Firms are at a disadvantage when the technology contains a level of complexity that is unfamiliar to them. These disadvantages may not only create opportunistic behaviour by the technology provider, but will cause firms to be more dependent on the technology provider.

There has been very little empirical research examining the impact of technological attributes on governance arrangements, especially in terms of complexity. One previous study that has used the technological context in determining the choice of governance mode is that of Steensma and Fairbank (1999), who investigated how the perceived technological attributes influence the governance mode used to procure external know-how. They found that the limited imitability and the dynamism of the technology significantly influence a firm's choice of governance mode for the procurement of external technical know-how.

As previously discussed in the literature review, advanced manufacturing technology is inherently complex. According to Saleh et al. (2001), the complexity surrounding this technology arises due to the large number of decision attributes and the existence of both tangible (usually financial), and non-tangible factors, and the interaction between those factors in its adoption. Many firms, seduced by the idea of a technical fix, adopted new and advanced technologies with very little real understanding about their complexity, with a resultant high level of failure (Swan and Clark, 1992; Wilson et al., 1994). Youssef et al. (1996) noted that the implementation of advanced manufacturing technology presents a variety of challenges to organisations that seek to automate and modernise their operations. The authors claim that the diffusions of AMT have intensified over the past two decades and the transfer and utilisation of AMT on a global basis is set to continue. The spread of the AMT innovation trend will be heavily dependent upon suppliers' abilities in ensuring the purchased technologies can efficiently meet the buyers' needs. Consequently, the development of close buyer-supplier relationships is critically important in a complex technology acquisition and implementation.

It has been widely reported in the literature that the implementation of advanced manufacturing technology requires significant involvement and support from the technology supplier (Chen and Small, 1996; Kaighobadi and Venkatesh, 1994; Saleh et al., 2001; Sohal, 1999; Sohal and Singh, 1992; Youssef and Zairi, 1996; Zairi, 1992b; Zairi, 1992a, 1998; Zhao and Co, 1997). Supplier roles are even more crucial when firms consider the technology to be highly complex, since such firms will have a greater dependence on the technology supplier. Zairi (1998) noted that the complex nature of the technology and the limited knowledge and experience of users, led to difficulties in user specification of their technical requirements, if there was no close involvement of suppliers. Firms normally seek a great amount of information from various technology suppliers even before the technology is acquired. They are also highly dependent on the technology supplier for the technology installation, and critically need the technology supplier to respond quickly and efficiently, especially on any production breakdown associated with the technology. When the implementation of the technology reflects major changes to the buyer's manufacturing layout, process, or performance, the supplier has to gain a deep understanding of the buyer's overall manufacturing plant and processes so that the right technology specification can be provided. In the process, effective communication and information sharing between both parties is essential.

As evidence from the case study in this research, when firms view the technology as complex, they make an effort to ensure that the technology supplier being selected can really provide the full support throughout the implementation process. Some firms choose to pay the full installation cost and extra maintenance cost to ensure a smooth installation and overall success in the technology adoption. Also, when firms view the technology being acquired as complex, they tend to develop even closer relationships with the technology supplier, especially during the early process of technology implementation. This is to ensure that the suppliers will give them the correct and complete information and respond quickly to any enquiries or problems encountered during the implementation process.

From the transaction cost economics perspective, it can be argued that firms are at a disadvantage when the technology contains a level of complexity that is unfamiliar to them. These disadvantages may then create opportunistic behaviour by the technology provider. For instance, in the interests of selling the technology, the supplier can make exaggerated claims which result in the buyer firm believing that it is simple to implement the technology, or in the buyer firm investing in technology that is far too advanced for its current manufacturing operation (therefore not fully utilising the technology), or in the buyer firm being "locked into" the supplier's technology and being obliged to invest in unexpected upgrading.

As the 'transaction' in this study refers to the process of acquisition and implementation of advanced manufacturing technology, a small mistake or failure at any stage of the transaction means an increase in the transaction cost. Hence, it can be seen that there is a close connection between the complexity of the technology and the need to develop close relationships with the technology supplier. Drawing from the transaction cost perspectives, developing closer relationships with the technology supplier in highly complex transactions will minimise the overall transaction cost and maximise the transaction value. Thus, a further hypothesis to be developed and tested is:

**H3:** The higher the level of complexity, the more likely it is that a firm will engage in a closer relationship with the technology supplier during the acquisition and implementation of AMT.

## 3.5 THE RELATIONSHIPS BETWEEN THE STRENGTH OF BSR AND PERFORMANCE

Matching governance structure with transactions is the key to efficiency (Williamson, 1991), and a firm may achieve efficiency advantage if it is effective in aligning transactions, which differ in their attributes, with governance structures that differ in their costs and competencies. In a similar vein, Masten (1993) claimed that the appropriate choice of corporate governance mechanisms for inter-organisational relationships is critical to the firm's performance. Dyer (1997) found that the competitive advantage achieved by the Japanese automakers is partly due to these companies' effective hybrid governance (close relationships with suppliers).

Based on the results of their study, Rasheed and Geiger (2001) suggested that critical to the strategic objective of maximising firm performance, is the appropriate choice of corporate governance mechanisms for inter-organisational relationships within the value chain. The choice of appropriate governance arrangements has been widely recognised in the literature to have an impact on performance. As discussed earlier, buyer-supplier relationships form part of a firm's governance mechanism, and hence, it is expected that close buyer-supplier relationships also have an influence on various aspects of performance.

Close BSR lead to better performance because they function as powerful governance mechanisms, being able, as observed by Williamson (1975), to safeguard the transaction from bounded rationality and opportunism. As proposed by Dyer (1997) the term "safeguards" or alternatively "governance structure" can be defined as a control mechanism which has the objectives of bringing about the perception of fairness or equity among transactors. Referring to Williamson (1985), the purpose of safeguards is to provide, at minimum cost, the control, and 'trust' that is necessary for transactors to believe that engaging in the exchange will make them better off. Dyer (1996a) claimed that the Japanese manufacturing industry owes its competitive advantages to its "Vertical Keiretsu" (Supplier partnership), a term that refers to the close and trusting patterns of relationships between firms and their suppliers. Dyer (1996a) further explained that Japanese firms rely largely on "hybrid governance" or supplier alliances to achieve competitive advantage through the minimisation of the transaction costs.

In addition to the benefit of cost minimisation, close buyer-supplier relationships can also maximise transaction value through value creation initiatives, as noted by Zajac and Olsen (1993). These authors further argue that the transactors' choice of governance structure, in this case, the development of close buyer-supplier relationships, influence the incentives of the transactors to engage in value creation behaviour for 'non-contractibles' such as innovation, quality, and responsiveness. In the process of acquisition and implementation of advanced manufacturing technology, the development of close buyer-supplier relationships can create value creation initiatives, which will positively impact on the technology and implementation performance, by influencing the extent to which suppliers willingly demonstrate higher level of favourable conduct towards the buyers.

In this case, value creation behaviour by both parties arguably benefits the buyer firm because, for instance, a high level of trust and business understanding helps both parties to understand each other's business and results in the provision of the correct technology specification as needed by the supplier firms. Through true and complete information sharing, unnecessary cost especially from the buyer's side, can be avoided. Then, committed involvement from the suppliers can facilitate even a complex technology implementation. All these aspects are extremely important to the technology buyers because just a small mistake in the process or slight delays in the suppliers' responsiveness can be very costly to them.

Considering the role of the technology supplier in the process of technology implementation, it can be seen that developing closer relationships enables buyers to depend on suppliers to effectively meet their needs. The key stages of help and support include: the ability to help users to develop skills in relation to the innovation concerned; giving solutions to technical bottlenecks; facilitation of the implementation process; and post-implementation back-up and continued support (Youssef and Zairi, 1996). Previous studies also indicated that closer relationships with suppliers lead to successful AMT implementation (Chen and Small, 1996; Sohal and Singh, 1992; Zairi, 1992a). Therefore, it is reasonable to expect that that there is a link between close buyer-supplier relationships and both aspects of performance measured in this study, which are technology performance and implementation performance. The related sub-hypotheses that are developed for testing are:

**H4**: There is a link between the technology buyer and supplier relationship and technology performance.

**H5**: There is a link between the technology buyer and supplier relationship and implementation performance.

If there is a link between the buyer and supplier relationship and performance, and the transaction attributes of the implemented technology play a vital role in shaping the pattern of that relationship with the technology suppliers, then the transaction attributes must also have an impact on the interaction between the BSR and performance level. It is also important to control the effect of transaction attributes when exploring whether firms that develop strong relationships with their technology suppliers are significantly different in term of performance achievement. On the basis of transaction attributes, three further sub-hypotheses related to performance were developed, as follows:

**H6a**: Within the same level of complexity, performance will vary depending on the pattern of relationships with the technology suppliers.

**H6b**: Within the same level of asset specificity, performance will vary depending on the pattern of relationships with the technology suppliers.

**H6c**: Within the same level of uncertainty, performance will vary depending on the pattern of relationships with the technology suppliers.

## 3.6 CHAPTER SUMMARY

This chapter has outlined the significant gaps in the literature in respect of the three broad areas under investigation, namely AMT, BSR, and TCE. In relation to these gaps, the cluster of hypotheses to be tested in this research was developed and presented. A systematic framework for exploring the hypothesised links between transaction attributes, buyer-supplier relationships, and performance was depicted. The following chapter provides the reader with a detailed description, explanation and evaluation of the methodological approaches considered and taken by the researcher in order to best meet the aim and objectives of the research.

# CHAPTER FOUR
# METHODOLOGY

## 4.1 INTRODUCTION

This chapter describes the overall approaches to the research process in respect of the issues under investigation, and is divided into three main sections. The first discusses general matters in the formulation of research methodology, and includes a discussion of qualitative and quantitative approaches. It then provides a justification for the method chosen for this study. Subsequently, both data collection methods adopted by the research, which are the questionnaire survey and the case study, are presented.

The second section is devoted to the quantitative aspect of the work, and includes sampling design and procedure, measurement/operationalisation used in the present research, questionnaire design and scale development, and an overview of structural equation modeling (SEM), a technique which will be used in analysing the survey data. Finally, the last section focuses on the qualitative data collection, and considers the case study design, sample selection method, interview protocol, and approach for analysing the data.

## 4.2 RESEARCH METHODOLOGY: QUALITATIVE VERSUS QUANTITATIVE APPROACHES

Quantitative and qualitative methods are quite distinct in their approach to the data (Stake, 1995), and the two methods have been an important feature of discussions on social science methodology since the mid 20$^{th}$ century, both challenging and revitalising the assumptions of social science (Bryman, 1988). By definition, quantitative research is the numerical representation and manipulation of observations for the purpose of describing and explaining the phenomena that those observations reflect, while qualitative research is described as the non-numerical examination and interpretation of observations, for the purpose of discovering underlying meanings and patterns of relationships (Babbie, 1998).

Denzin and Lincoln (2000) state that "the word qualitative implies an emphasis on processes and meanings that are not rigorously examined or measured (if measured at all), in terms of quantity, amount, intensity, or frequency. Qualitative researchers stress the socially constructed nature of reality, the intimate relationship between the researcher and what is studied, and the situational constraints that shape inquiry. In contrast, quantitative studies emphasise the measurement and analysis of causal relationships between variables, not processes. Inquiry is purported to be within a value-free framework" (p.4).

Following this, it can be understood that there are differences between quantitative and qualitative methods and techniques, and Table 4.1 summarises the kinds of distinctions often made concerning the use and value of both methods.

**Table 4.1: Predispositions of Quantitative and Qualitative Modes of Inquiry**



Source: (Glesne and Peshkin 1992 p.7)

Reviewing the definitions of what is meant by quantitative and qualitative research helps identify the reasons for the separate use of each method and the continuing debate among researchers concerning the relative value of each approach. However, the arguments can be complicated and often are philosophical, referring, as noted by Collis and Hussey (2003), to the basic beliefs about the world, which then reflect the way research is designed, data is collected and analysed, and even the way findings are reported. Quantitative techniques are often referred to as falling with the positivistic paradigm whereas qualitative techniques reflect an affiliation with the phenomenological paradigm. The positivistic approach seeks the facts about, or the cause of social phenomena, paying little regard to the subjective state of the individual, whereas the phenomenological approach is concerned with understanding human behaviour from the participant's own frame of reference (Collis and Hussey, 2003).

Given the fact that these two different philosophical paradigms each have their own strengths and weaknesses, the question of how a researcher should choose between quantitative and qualitative research approaches, must be answered. In this respect, some researchers maintain that the choice between these two approaches actually has less to do with methodologies than with positioning oneself within a particular discipline or research tradition. Choices about which approach to use may reflect the interests of those conducting or benefiting from the research and the purposes for which the findings will be applied. Such decisions may also be based on the researcher's own experience and preference, the population being researched, the proposed audience for the findings, the time, money and other resources that are available (Hathaway, 1995).

According to Bryman (1988) and Hammersley (1992), it is the concrete research problem or aim, rather than the philosophical position, which determines the design (or overall strategy) of the study, and depending on the nature and complexity of the problem, the design can be either qualitative or quantitative, or a combination of both. Even though some social science researchers (Lincoln and Guba, 1985; Schwandt, 2001) perceive qualitative and quantitative approaches as incompatible, others (Patton, 1990; Reichardt and Cook, 1979) believe that the skilled researcher can successfully combine them. Indeed, although the positivist and the interpretivist paradigms rest on different assumptions about the nature of the world, and require different instruments and procedures to find the type of data desired, this does not mean, as noted by Glesne and Peshkin (1992), that the positivist never uses interviews or that the interpretivist never uses a survey.

### 4.2.1 Methodological approach for the present research

The research objectives in the present study provided a well-defined focus for the research and allow the researcher to specify the kind of data to be gathered. Therefore, referring to the investigative process in the next section, this research is basically deductive in nature, attempting to provide evidence for or against a pre-specified hypothesis (building theories from data). The logic of this approach is that, a conceptual and theoretical structure is developed and then tested by empirical observation (Collis and Hussey, 2003; Gill and Johnson, 2002).

The main data collection was carried out through the survey method, which has been chosen because it is the most appropriate technique when the main aim and objectives of a study are to determine the associations between specific variables. The large sample obtained from using a survey allows the researcher to examine the relationships between the variables in question, and to establish whether any associations or correlations are significant or whether they are simply random effects (Fisher, 2004). The questionnaire survey also allows the researcher to test quantitatively, the generalisability of the TCE framework for assessing BSR within the (previously untested) AMT acquisition and implementation context.

Quantitative methods are also consistent with the deductive nature of the research approach. The research aims at testing a theory deductively by revealing a pattern of relationships as opposed to building a theory. Furthermore, the theories and variables of interest investigated in this study have also been used and measured in previous studies using a quantitative technique, except in a different setting and context. Accordingly, a quantitative approach, which requires a clear operationalisation of each specific variable, was chosen as the main method for the empirical work.

Apart from employing a questionnaire survey as the main data collection method, a few semi-structured interviews were also conducted to accompany the survey data. According to Collis and Hussey (2003) it is perfectly possible, and even advantageous, to use both qualitative and quantitative methods for collecting data. They further exemplify that a questionnaire survey providing quantitative data could be accompanied by a few in-depth interviews to provide qualitative insights and illuminations. Sekaran (2003) also argues that both qualitative and quantitative data can allow hypothesis testing. Another benefit of the interviews was the opportunity presented to the researcher to explore contextual factors that may help provide new perspectives and explanations on the findings of the questionnaire survey, thus again uncovering a more detailed picture of BSR in AMT acquisition and implementation. Therefore, both qualitative and quantitative techniques were adopted in the data collection aspect of this research. The multi-method approach was considered as the most appropriate research strategy to obtain as complete a picture as possible regarding the antecedents and impact of BSR in AMT implementation.

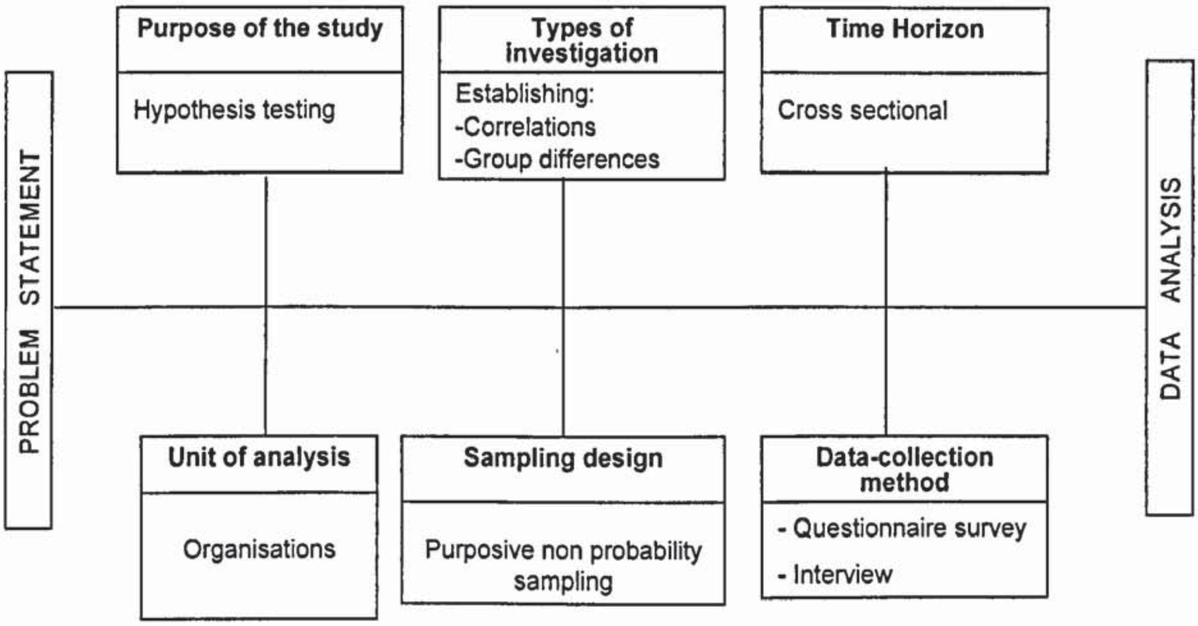
Having recognised the design of an investigative process as described earlier (Chapter One) and the belief that quantitative and qualitative methods are complementary and should be used as, and when appropriate, depending on the focus, purpose and circumstances of research (Ghauri et al., 1995), a mixed-methodology approach was employed in this research. There are a few crucial aspects in justifying such a design for this study. Firstly, single methodology approaches (qualitative only and quantitative only) have their own strengths and weaknesses. A combination of methodologies, however, can focus on their relevant strengths. Secondly, the use of a combination of research methods within a single study can permit a richer and deeper understanding of the area under investigation than would otherwise be possible. Furthermore, a mixed approach to data collection could enhance the overall result of the study and improve the overall understanding of the phenomenon.

Collis and Hussey (2003) emphasise that it is not unusual in business research to take a mixture of approaches, particularly in the methods of collecting and analysing data as that allows for broader, and often complimentary, view of the research problem or issue. As the primary goal of the interviews in this study is to elicit the respondent's views and experiences in his own terms, rather than gaining an answer from among pre-established response categories, more insight can be gained from the process. In this case, a few interviews conducted with the managers involved concerning their experience with the technology supplier in the process of technology acquisition and implementation, were thought to give an in-depth understanding of capital equipment buyer-supplier relationships, which is quite lacking in the literature.

Apart from that, semi-structured interview sessions can provide a deeper explanation on why such patterns of relationships exist. As described by Fisher (2004), the positivist approach might uncover an association between variables of interest in the study, but having identified the pattern, it can say little more, and does not explain why the pattern is there. However, interpretivist approaches (which use qualitative techniques), can be used to create a quasi-causal account of how two or more variables interact. Fisher (2004) further suggests that a researcher may start off with a piece of positivist research that identifies an association between two variables, and then use an interpretative approach to understand the causal connection, which shows in all complexity how the different aspects interact. The ways in which the interviews provide a deeper understanding of the areas under investigation are revealed in more detail in Chapters Seven.

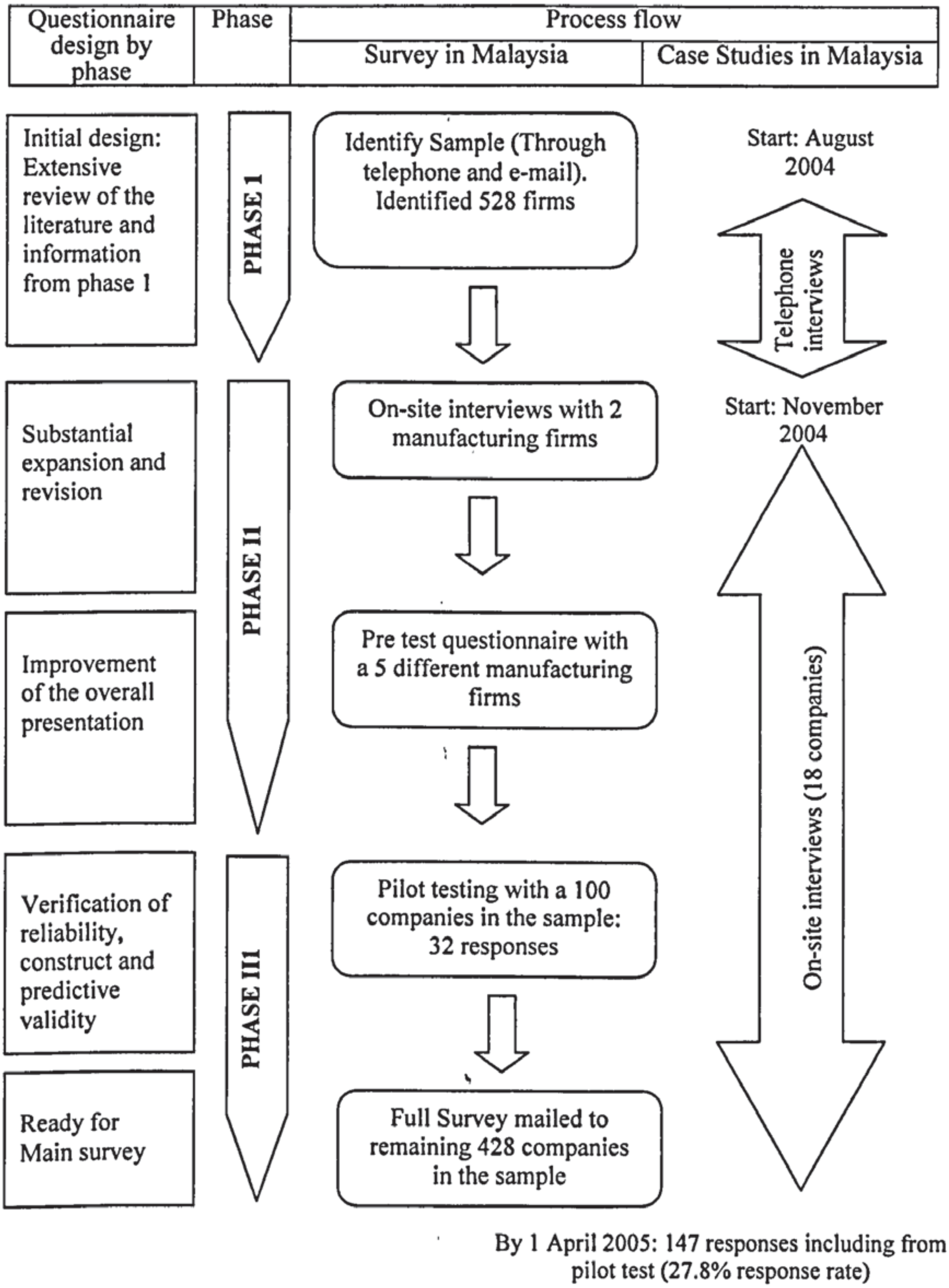
Finally, the use of both quantitative and qualitative methods of data collection permits methodological triangulation (Easterby-Smith et al., 1991). Denzin (1974) who defines triangulation as the combination of methodologies in a study of the same phenomenon, argues that triangulation could lead to greater validity and reliability than a single methodological approach. Triangulation through multiple data collection methods can also provide stronger substantiation of constructs and hypotheses (Eisenhardt, 1989; Yin, 2003). Therefore, the use of a qualitative technique as a supplement to the quantitative technique was adopted as part of the strategy to enhance the construct validity and reliability of the research. Figure 4.1 demonstrates the various issues involved in the design of this research.

**Figure 4.1: Issues in research design and method adopted in this study**




The study employed cross-sectional design, which considered the organisation as a unit of analysis through the solicitation of information from a single respondent, that being the key manager involved in the area under investigation. Figure 4.2 summarises the stages of the questionnaire design and the data collection process used.

**Figure 4.2: Stages of the questionnaire design and the data collection process**



## 4.3 PART I: SURVEY METHODOLOGY

The following sections present a discussion of the methodology used for the survey part of the data collection employed in the present research. The first four parts in this section discuss the general issues in data collection for survey methodology. Then, the discussion focuses on the scale used for the study, beginning with a consideration of the measurement or operationalisation of each main variable, proceeding to indicate how the questionnaire was designed and how the scale was developed to meet the purpose of the study. The section ends with a brief description on the approach used for analysing the data (Detail on data analysis is presented in Chapter Five).

### 4.3.1 Sampling design and the selection procedure

A cross-sectional survey methodology was employed for this study. The population for the study was the Malaysian manufacturing sectors that have acquired advanced manufacturing technology within the past five years. These sectors were selected because they are engineering intensive and focus on designing new products and processes. The population frame, which lists all the elements in the population from which the sample is drawn (Sekaran, 2003), was the Federation of Malaysian Manufacturers (FMM) Directory of 2003. This directory is an official authoritative publication in Malaysia listing approximately 2,000 manufacturing organisations.

Burgess and Gules (1998) pointed out the importance of getting the right length of recall period in this type of measurement process. In their study of buyer-supplier relationships in firms adopting advanced manufacturing technology, they had used a period of five years, since as during the piloting process, the respondent had indicated that a period of five years is appropriate since the respondents can remember over that period, but if this were longer, it would pose problems in recollecting. Similarly, Frohlich (1999) who investigates the relationships between advanced manufacturing technology adaptation and performance has also used a five year period in his study. The author states that given the challenging nature of implementation, the manager interviewed had no difficulties in recalling the event. In fact, one manager described it as the most memorable six months of his 25 years in manufacturing. As a means of double checking, during the preliminary interviews and pre-testing stage, two managers were asked if a period of five years was recallable. They indicated that they would have no problems recalling the experience, especially if this was a major and challenging project.

Since the study targeted firms that had invested in AMT within the past five years, and the manufacturer database generated from the sampling frame did not provide this critical information, two options were available to generate an appropriate sample. The first was to mail the questionnaire to all firms listed in the directory, anticipating that only those who had made such an investment would respond. The second option was to identify in advance which companies had made an investment within the specified time frame. The second method is known as the "purposive sampling technique", since the sampling is confined to specific types of respondent who can provide the desired information, either because they are the only ones who possess it, or because they conform to some criteria set by the researcher (Sekaran, 2003).

Although the first option seems to be more convenient, the second method was deemed to be an optimal approach for a number of important reasons. Firstly, since it is important to have a reasonable number of cases to ensure sufficient power in the statistical analysis, the researcher needs to have a clear idea of the actual population size from which to estimate the sample. Additionally, there was also a concern at that time that due to the effect of economic downturn around the year 1997 and 1998, many companies might have delayed their investment in AMT. Secondly, since the study also considered the impact on performance from the buyer-supplier relationship patterns, it was decided during the pre-testing stage, that firms must have used the specified technology under a regular/normal production hour for a minimum period of one year to be eligible to participate in this study. Thus, this crucial information could only be obtained through some verification from the companies identified for the study.

Thirdly, the second method was thought to offer more control over the sample for the purpose of follow-up procedures and advantage in terms of time and budget. Additionally, it could be used as a pre-notification method as it is essential to request the firm's co-operation and commitment (Schlegelmilch and Diamantopoulos, 1991). Therefore, each company listed in the directory was contacted by telephone or/and email requesting it to indicate whether it had made an investment in AMT in the past five years. Firms without an email address were directly contacted via telephone. Those with an email address in the FMM directory were emailed requesting their information and agreement to participate. Firms that did not respond to the email were then contacted via telephone. The entire verification and pre-notification procedures were conducted with the assistance of four enumerators. The process was completed in less than two months and resulted in identifying 528 possible manufacturing companies for the study[1]. As mentioned earlier, apart from identifying respondents, the researcher also used this procedure to notify the respondents in advance about the forthcoming survey in an attempt to enhance the response rate (Dillman, 2000; Sekaran, 2003).

### 4.3.2 Questionnaire administration

As this study adopted a cross-sectional design, a wide geographical coverage was needed for the survey data collection. Given the resource constraint, administering the questionnaire personally or through telephone interview was ruled out as the main method for gathering the survey data. As Sekaran (2003) observes, the mailed questionnaire survey is the best suited and the only alternative open to the researcher when a substantial amount of information is to be obtained through structured questions, at a reasonable cost, and from a sample that is widely dispersed. Therefore, it was decided to use a mailed questionnaire, which also had the advantage of being relatively cheap, especially because the population was so widely dispersed. Additionally, this method allows respondents to complete the questionnaire at their own pace, or in their own leisure time. The regular mail, rather than email was chosen in order to standardise the method of data collection since not every company in Malaysia can be reached through electronic mail. Although some firms have access to this facility, it is limited for sales and support activities.

[1] Despite attempts to screen respondents in the pre-notification phone calls, some respondents simply cut short the conversation and requested sight of the questionnaire before deciding on their next action. These firms were automatically considered eligible and were sent the questionnaire to participate in the study. Hence, they were included in the response rate calculation because they were given the opportunity to participate in this study. Whereas, some respondents indicates negative feedback and refuse to participate and some respondents could not be contacted even after several attempts to do so. These respondents were not included in the total of 528 firms eligible for the study.

The questionnaire was mailed to all 528 firms in the target population, together with a cover letter, a return postage-paid envelope, and a postage-paid reply postcard with an identifying number/code of the actual respondent. Respondents were asked to return their completed surveys separate from the reply postcard, so that the researcher was able to learn which firms had participated, but did not know which questionnaires had been completed by which responding companies. Another advantage of using a separate identifier was that this allowed the researcher to track responses so that reminder materials could be sent or a further follow-up phone call made to non-responding firms only, thus, saving on costs and time. Additionally, this procedure increases respondent confidence since their anonymity in relation to the actual responses on the questionnaire is completely guaranteed.

Although the questionnaire was addressed to the Production Manager of each company, the covering letter indicated that it should be completed by the person in charge of the entire technology acquisition, implementation, and daily production, since it was recognised that in a minority of firms, this member of staff might not be the Production Manager. This was to ensure that the questionnaire respondent possessed the appropriate and adequate knowledge on the subject under investigation. Based on the information sought during the telephone conversation at the data identification stage, in some cases, the questionnaire was addressed directly to the responsible key manager. Although the survey methodology is limited to some extent by the use of a single respondent, using one, well-informed source approach is common in recent empirical research in advanced manufacturing technology (Small and Yasin, 1997; Stock and McDermott, 2001), and also very common and accepted in studying buyer-supplier relationships (Theodorakioglou et al., 2006).

The cover letter used university stationery in order to increase the project's credibility, and thus the response rate. The cover letter also emphasised the fact that the respondents' answers could make a substantial difference to the success or failure of the study and the researcher's doctoral thesis. Although a brief introduction to the study was given in the initial telephone call to identify companies for eligibility, the cover letter still highlighted the issues and provided more detail of the research in order to ensure the respondents' full understanding of the project. This cover letter appears as Appendix 1.

### 4.3.3 Response rate and non-response bias

Several steps were taken to maximise the response rate of the survey, most of being employed during the questionnaire development stage, sample selection stage, and main survey stage. Two weeks after the mailing, the non-respondents were contacted by telephone with a request to complete and return their survey. An overview of the recommended methods to increase the response rate is given in Table 4.2. The list includes suggestions from Churchill (1999) and Sekaran (2003).

**Table 4.2: Factors influencing the response rate**

- Telephone pre-notification*
- Follow-ups*
- Monetary incentives
- Non-monetary incentives*
- Stamped addressed return envelope*
- Second mailing of the questionnaire and letter
- Assurance of anonymity and confidentiality*
- Appeals (e.g., egoistic, social utility, altruism)*
- Personalisation (e.g., hand-signed, or personal cover letter)*
- Interesting topic and not sensitive or controversial in nature*
- Simple questions and layout*
- Specification of return dateline*
- Questionnaire shorter than or equal to four pages

* Methods used in some form in the present study

Follow-up calls continued to be made; to the non-participating respondents, until the end of data collection period which took about 15 weeks. The questionnaire survey was mailed again to those firms that claimed not to have received the first mailing. During the follow-up exercise, various reasons were cited by the firms for their non-response, and Table 4.3 presents some of the frequently-widely cited reasons.

**Table 4.3: Reasons for Non-response**

- No time to fill in questionnaire/questionnaire too long
- Passed on to someone else and lost in system
- Claimed no questionnaire received
- Company policy not to fill in questionnaires
- The person in charge has left the company
- The person in charge away for out-stationed
- The project involves several suppliers, thus, not relevant to the study
- Cannot recall the event
- Not interested
- Ineligible to participate

At the end of the data collection period, a total of 149 questionnaires were returned, including 111 usable and 38 non-usable replies. Of the latter, seven were returned due to wrong addresses or because the respondent could not be reached, three were returned uncompleted, one with a message on the first page of the questionnaire explaining that the questionnaire was too long, and another two carrying notes from the secretary of the company that the manager in charge was currently not available due to out-stationed. Another 28 responses were unusable due to minor or excessive missing data. Of these 28, seven firms which had provided their email and company address at the end of the questionnaire were contacted again requesting them to complete the missing responses. After several discussions and explanations on issues in the questionnaire that were considered unclear to the firm, only four of the seven minor incomplete replies were completed. Therefore, including the 32 responses from the pilot test (detail of pre-test is in section 4.3.5.2), a total of 147 responses were usable for further analysis. The response rate achieved in this study was 27.8% (147/528*100).

Non-response bias is always a concern in the survey type of data collection, and various strategies have been used to test for such bias. For instance, Kotha and Swamidass (2000) have used the t-test on criteria like the number of employees, income growth, and sales growth between the respondents and the non-respondents. Krause (1999) and Siriram and Snaddon (2005) have used late respondents to test for the non-response bias, consistent with the suggestion by Armstrong and Overton (1977) and Lambert and Harrington (1990). In the present study, information such as the number of employees, and income growth of the non-respondents could not be obtained due to the anonymity of the respondents and the non-respondents. Therefore, the method of testing for significant differences between the response of early and late waves of the returned questionnaire (Armstrong and Overton, 1977; Lambert and Harrington, 1990) was used.

The respondents were categorised into early responses and late responses. Two groups of 30 respondents each were chosen from the first and the last batch of the survey received, and t-tests were performed on the responses of the two groups. The t-test yielded no statistically significant differences among the randomly selected survey items (Years in operation, level of complexity, buyer-supplier relationships and technology performance). The result suggests that non-responses may not be a problem to the extent that late responders represent the opinion of non-respondents (Armstrong and Overton, 1977; Krause, 1999; Lambert and Harrington, 1990; Siriram and Snaddon, 2005).

### 4.3.4 Response form

The majority of the responses required in the questionnaire were to closed questions, which had been employed in order to provide standardised data for statistical analysis. The questions were comprehensive and included all possible alternatives. Closed questions are especially appropriate when the response must be compared across multiple respondents and when the questionnaire is administered by mail (Churchill, 1999). Babbie (1998) endorses this approach, especially as respondents may be unwilling to write answers and, therefore, lose interest. A five-point Likert scale was used where appropriate, enabling the application of a number of tests to measure difference and correlation and to produce item analysis, factor analysis and reliability analysis. To break the monotony, for some questions, respondents were asked to place the number in a box corresponding to the question, while other questions required respondents to circle the number which best reflected their opinion.

### 4.3.5 Questionnaire design and scale development

#### 4.3.5.1 Initial design

The starting point for the questionnaire design was based on the conceptualisation and hypotheses developed and described in Chapters Two and Three. This process involved an extensive review of the literature supported by information gained during the preliminary field work conducted in the early stage of the research. During this process, the insights gained from managers experienced in implementing new and advanced technology in their firm helped the researcher to better understand the practical environment related to advanced manufacturing technology implementation and buyer-supplier relationships, which is particularly helpful in the process of developing items for each construct in the questionnaire

Then, the preliminary version of the questionnaire was subjected to review by two different practising managers in two different Malaysian companies that had started to make significant investments in advanced manufacturing technology beginning in the year 2002. The aim of this phase was to gain more information concerning the extent of involvement of AMT suppliers with local users with respect to implementation, as well as to make sure the measurement sufficiently related to the issues to be investigated. The first interviews were conducted on-site with the Production Manager and the Project Engineer of a small-sized company (approximately 60 employees) that had adopted a palletising system consisting of a robot and an automated conveyor system. The second company had adopted a computerised wire-cutting machine and employed around 40 people. In this company the interview was conducted with the CEO. Based on the recommendations and suggestions from the three individuals mentioned above, substantial expansion and revisions were made to the items in the questionnaire.

#### 4.3.5.2 Pre-testing

Since this study developed newly measured items, stringent evaluation was required. A thorough pre-testing of the research instrument was conducted before administering the questionnaire to the final sample. Following Churchill (1999), the questionnaire was first pre-tested through personal interview. Then, the instrument was further tested using the actual method to be adopted in the main study. The first stage of the pre-test in this study involved a review of the questionnaire by four colleagues who were lecturing in various fields at the University Putra Malaysia. Their comments were mostly related to the general layout, typographical errors, and problems in understanding the general instructions. After taking into account their suggestions, the questionnaire was reviewed again by five key managers from different manufacturing firms in Malaysia (including the previous two firms that had reviewed the preliminary version of the questionnaire). The questionnaire was self-administered in order to speed up the process and ensure maximum feedback. The managers identified several inadequate items, poorly worded questions, and also made several suggestions regarding the clarity and ambiguity of questions and the overall questionnaire design.

The questionnaire was revised on completion of the first stage of pre-test, and the revised questionnaire, as shown in Appendix 2 was then used in the next pre-test phase, the pilot test. The mailed pilot pre-test was conducted to identify any administration problems, to provide an indication of the response rate for the main survey, and to be able to further refine the instrument through the use of statistical techniques. In order to gain optimal results, the pre-testing sample used the same sample frame as the main survey so as to be representative of the actual target population. Therefore, of the 528 previously identified companies, 100 were selected for the pilot test. In order to accelerate the process, the companies selected for the pilot study were those that demonstrated interest during the telephone interviews and those situated around the Klang Valley. One week after the mailing, follow-up calls were made to request the progress of the questionnaire survey.

Of the 100 pilot questionnaires distributed, only 32 usable responses were received, after which further revisions were made to the instrument. It was found that the majority of the respondents failed to properly complete question number 5 in Section C. Many simply answered "yes" or "no" and failed to indicate the percentage value of each element within the total investment value (Refer to Appendix 2). Two companies that were contacted regarding that issue indicated that they were unsure about the percentage value and hence, preferred to leave it blank. The follow-up calls to the non-respondents also revealed that majority of them found difficulty in answering that particular question. This gives some idea of the *minimum* response rate if that particular question were to be asked in the main survey. Since the question was originally intended only to provide supplementary information, the decision was made to drop it from the main survey to avoid confusion and to simplify the questionnaire.

#### 4.3.5.3 Further scale purification

Since most of the items in the scale were newly developed for the purpose of the study, the initial purification procedures by Churchill (1999), Spector (1992), and DeVellis (1991) were utilised. The responses from the pilot test were used to refine the instrument and verify its reliability. As described by Churchill (1979), the instrument was purified by examining the corrected-item total correlations (CITC). Items with CICT of less than 0.5 were excluded. The item inter-correlation matrices provided by SPSS analysis were also used to exclude items if they did not strongly contribute to Cronbach's alpha for the dimension under consideration (Flynn et al., 1995). Some items which did not contribute strongly to alpha, but whose content was considered important to the study, were retained and modified. After making some minor modifications to the survey instrument, the final version of the questionnaire was mailed to the remaining 428 companies in the sample.

After receipt of the full usable 147 responses, before the data were subjected to hypothesis testing, the instrument was again further subjected to reliability and validity assessment. It was refined through exploratory factor analysis (EFA) to assess its dimensionality and through confirmatory factor analysis (CFA) to assess its convergent and discriminant validity (Anderson and Gerbing, 1988). According to Hurley et al. (1997), when using empirical data, it is necessary to choose the best items from a set of items that have equal face validity because it is not possible to write items that behave perfectly well in a psychometric sense. Therefore, after validity assessment through EFA and CFA, the final measures in this study were in some cases, quite different from those initially proposed. This will be demonstrated in further detail in Chapter Five.

### 4.3.6 Measurement/operationalisation

Objects that can be physically measured by some calibrated instruments pose less measurement problems. However, variables that involve people's subjective feelings, attitudes, and perceptions can become very complicated (Sekaran, 2003). The present research used multivariate measurements, also known as summated scales, for which several variables (items) were joined in a composite measure to represent a concept. The objective was to avoid the use of only a single variable to represent a concept, and instead to use several variables as an indicator, all representing different facets of the concept to obtain a more 'well-rounded" perspective (Hair et al., 2006) . The use of multiple indicators allows the researcher to more precisely specify the desired responses. It does not place total reliance on a single response, but rather on the "average". The responses from each item were gauged using five-point Likert-type scales. This section describes in detail, how the three main concepts used in this study (transaction attributes, buyer-supplier relationships, and performance) were operationally defined and measured. The rationale for using these dimensions and their expected association with each other, have been discussed earlier in the thesis. This section begins with a brief description of the main information solicited from the questionnaire survey, and follows by providing the details of the main variables used in this study.

#### 4.3.6.1 Information Sought

The instrument used to collect the survey data was a 7-page questionnaire, the final version of which was structured into six major parts, each one addressing separate issues. Section A served to profile the firm and respondent, asking for information such as number of employees, year of establishment, ownership status, the respondent's position(s) and years of working experience in the company. Section B sought information on the firm's production technology. Section C asked for information regarding the recently implemented AMT project, such as the specific type of AMT implemented, the year the technology was acquired, the origin of the technology (whether local or foreign), the value of investment, the term of payment for the acquired technology, and the arrangement involved in acquiring the technology.

Sections D and E requested that the respondent consider a recent AMT implementation project as identified from the previous section in answering the questionnaire items. In Section D, the respondent was asked to assess the attributes of the technology acquired regarding the three aspects namely, the complexity of the technology to the firm, the specificity of the technology to the firm, and finally, the uncertainty associated with the acquisition and implementation of the technology. In Section E, the respondent was asked to assess the extent of relationship with the technology supplier involving the seven aspects namely; trust, business understanding, involvement, commitment, communication, and information sharing. Finally, Section F consisted of two parts covering technology performance and implementation performance. Subjective measures were mostly employed, except when objectives measures were available. Appendix 3 shows the final version of the questionnaire. What follows in the next sections are the measurement and details of the operationalisation of the three major variables used in this study, namely transaction attributes, buyer-supplier relationships, and performance.

#### 4.3.6.2 Transaction attributes

In Chapter Two, it was observed that transaction attributes were perceived in terms of three aspects, these being the level of asset specificity, the level of uncertainty, and the level of complexity. A number of studies have used and operationalised this conceptualisation of transaction attributes, but to date, no research has been conducted to explicitly measure transaction attributes surrounding the acquisition and implementation of AMT. To remedy this, the researcher has developed a 4-item measure to capture the level of asset specificity, a 7-item measure to capture the level of uncertainty, and a 4-item measure to capture the level of complexity. The items are developed according to the extensive search of the literature and field information sought during the initial and pre-testing stage of the questionnaire design.

The level of asset specificity was operationalised using a five-point Likert-type scale, varying from "strongly disagree" (1) to "strongly agree" (5). Respondents were asked to indicate the degree of specificity of the asset (in this case the acquired technology) to the company, measured by the four items concerning the value of the investment on the acquired technology, the extent to which the technology represents a core competence for the company, the extent to which the company has put a high degree of learning and training in the technology, and the extent to which the company has dedicated special expertise for the implementation of the technology. The four main items used to measure asset specificity were influenced by the previous work of Wang (2002), Robertson and Gatignon (1998), and Skarmeas and Katsikeas (2001) which had highlighted the four aspects noted above when measuring the level of specificity. Minor changes were made to the wording of the items to suit and reflect the AMT acquisition and implementation environment.

Uncertainty in this study focuses on the uncertainty surrounding the acquisition and implementation of the specified AMT. In the context of AMT acquisition and implementation, newly-acquired technology is uncertain with regard to its performance. Whether the new technology will work as intended, often cannot be determined until implementation is complete and the technology is being used for a normal/regular production hour. The extensive capital spent on new advanced manufacturing technology may not provide the desired performance, and a firm's substantial investment in time and money may ultimately be rendered of little value. And even when the performance of a given technology is excellent for one firm, there is no guarantee that it will perform equally well in a different organisational setting.

Therefore, uncertainty in this study was measured by seven items relating to the uncertainty of the technology and uncertainty of the firm's capability. Uncertainty of the technology was assessed in terms of five items concerning its technical specification and performance. This measure was influenced by the work of Steensma and Fairbank (1999), with minor changes made to reflect the AMT acquisition and implementation context. On the other hand, uncertainty of the firm's capability was assessed in terms of the firm's past experience in handling similar technological capabilities and the availability of expertise in handling the technology. These two additional items were grounded from the practical information sought during the initial and the pre-testing stage of the questionnaire design, and were judged to be sufficiently important to be included in this measure. In the context of this study, the more that buyers are uncertain about these measured aspects, the more likely they are to be dependent on the technology supplier. Respondents were asked to indicate the degree of uncertainty concerning the acquired technology and the firm's capability, through the use of a five-point Likert-type scale that rated each item from "strongly disagree"(1) to "strongly agree" (5).

The level of complexity differs, not only between different AMT classes, but within the same AMT classification. In fact, considering the uniqueness of each firm and its environment, it is logical to believe that not only does the degree of complexity vary from one firm to another, but also the concept of complexity is also diversely defined from one firm to another. Although many research studies on AMT have emphasised complexity (Cook and Cook, 1994; Park, 2000; Zairi, 1998), none has really explained in detail what aspect of complexity is actually quantified. Diaz et al. (2003) mentioned that technical problems associated with the implementation of AMT are due to the complexity of the technology per se, and the technical and analytical decisions that have to be taken when AMT systems are introduced.

Kogut and Zander (1993) defined complexity as the number of critical and interacting elements embraced by an entity or activity. Tsang (1997) maintained that simple technology is easy to learn and use, and the embodied knowledge is usually explicit. Complex technology on the other hand cannot be codified in full, even if it is mature, since it contains a much higher tacit knowledge element than simple technology. Therefore, complexity in this study was operationalised by asking the respondent's view about the complexity of the technology per se, the degree of tacit knowledge embedded in the technology, and the changes the acquired technology would bring to the current manufacturing layout/process/practices. Each item was rated on the scale, varying from "strongly disagree"(1) to "strongly agree" (5).

#### 4.3.6.3 Buyer-supplier relationships (BSR)

The operationalisation of buyer-supplier relationships in this study was measured in terms of the strength of relationships between the technology buyer and the technology supplier. Multiple indicators were used to measure relationship strength. Seven dimensions which have been commonly used in the literature to denote BSR (details in Chapter Two), were used, these being: trust, business understanding, involvement, commitment, communication, information sharing, and knowledge acquired. These dimensions are treated at a construct level and it is proposed in the present research that they are strong indicators of a higher order construct, which is referred to as relationship strength. The items on each construct were specially developed to reflect buyer-supplier relationships in AMT acquisition and implementation. Each item was rated on a five-point Likert-type scale, varying from "Not at all" (1) to "To a very great extent" (5). The items in each construct were mostly based on the field information sought during the preliminary and the pre-testing stage of the questionnaire design. Except when objectives measures were available, the present study employed perceptual measures in gauging the concept.

#### 4.3.6.4 Performance

This study measures performance in terms of technology performance and implementation performance. Technology performance was operationalised using the achievement in manufacturing performance since the adoption of the technology. Small and Yasin (1997a) highlighted that the only pure measure of the effectiveness of technology may be in its ability to improve manufacturing performance. In fact, many studies that measure the benefits associated with AMT implementation focus on the achievement of manufacturing performance. For instance, Gupta et al. (1997) used the internal benefits of AMT, namely changes in quality, production costs, availability, dependability, and production schedule, as a measure of manufacturing performance. On the other hand, Cagliano and Spina (2000) used unit manufacturing costs, conformance to specification, inventory turnover, delivery lead time, on-time deliveries, manufacturing lead time, time-to-market, and product variety as a measure of manufacturing performance improvement as a result of AMT adoption.

Small (1998) however warned that in some cases, each performance achievement should not be construed as being mutually exclusive. The author exemplifies that a reduction in set-up times should lead to reduced manufacturing lead-times, and ultimately shortened delivery lead-times. A list of previous research together with the performance achievement appears in Table 2.5 (Chapter Two). Although various aspects of manufacturing performance have been explored, the literature indicated that the aspects of lead time, cost, quality, and efficiency have been frequently marked as a hallmark of AMT. In this study, respondents were asked to subjectively rate the achievement in manufacturing performance in terms of reduction in lead time, reduction in cost, increase in quality, and increase in efficiency and flexibility since the adoption of the technology. Each item was rated on the scale, varying from "Not at all"(1) to "To a very great extent" (5).

Conversely, aspects of implementation performance mainly focus on the issues related to implementation. Items in the construct were largely grounded in practical information sought from practising managers during the researcher's field work. The measurement includes: time taken to fully implement the technology and to gain benefits from it, the amount of downtime caused by the technology, time taken to tackle any technical problem, and also the capability of the technology in fulfilling the implementation objective and improving manufacturing process and performance. Each item was rated on the scale, varying from "Not at all"(1) to "To a very great extent" (5).

### 4.3.7 Data analysis techniques

In testing the proposed hypotheses and research framework, two statistical analysis techniques are applicable: structural equation modeling (SEM) and analysis of variance (ANOVA). The researcher was able to use both techniques for the data. The researcher started with multiple regression analysis by using SPSS software to test the hypothesised relationships proposed in the model. However, after considering the advantage of using SEM for the present research, the researcher has decided to reanalyse the data using SEM technique. As SEM will be largely used to test the overall hypotheses model, an overview of the technique is provided in the next part of this section, the main objectives being to familiarise readers with the analyses and findings part following this chapter, to assess the advantages of SEM and to justify the use of the technique in this study.

#### 4.3.7.1 Structural Equation Modeling (SEM)

Structural equation modeling (SEM) is a comprehensive statistical technique used to test the hypothesised relationships among observed and latent variables. Latent variables are unobserved variables that are implied by the covariance among two or more variables, while observed variables represent variables that are directly measured (Hoyle, 1995). SEM combines the measurement model (confirmatory factor analysis) and the structural model (regression or path analysis) in to a simultaneous statistical test (Garver and Mentzer, 1999).

The measurement model defines the relationships between the latent variables and their indicator variables (Byrne, 2001). It is used to specify the indicators for each construct by assessing the extent to which the observed variables are measuring something other than the latent construct, and determining the best indicators for a particular construct (Schumacker and Lomax, 1996). The relationships between observed and unobserved variables are expressed by factor loadings that inform researchers about the extent to which a given indicator is able to measure the variable or functions as validity coefficients. The measurement model also includes error that is associated with the observed variable. It represents indicator variance unexplained by the latent variable (Kline, 1998), and derives from two sources: random measurement error, and error uniqueness (error variance) arising from some characteristic specific to a particular indicator variable (Byrne, 2001).

The structural model specifies the relationships between latent variables and observed variables that are not indicators of latent variables (Hoyle, 1995). Structure coefficients that relate one latent variable to another indicate the strength and direction of the relationship among the variables. Error associated with latent variables is known as residual. It represents the error in prediction of dependent variables from independent variables (Byrne, 2001). Combining the measurement and the structural model results in a comprehensive statistical model that can be used to assess relationships among variables that are free from measurement error (Hoyle, 1995).

The acceptable fit between the hypothesised model and the sample covariance matrix suggests the plausibility of the hypothesised relationships. On the other hand, the unacceptable fit leaves the validity of the hypothesised relationship under query. There are various available ways to assess the fit between the hypothesised model and data. One of the common fit assessment indicators is a $\chi^2$ significant test in which a non-significant $\chi^2$ indicates that the model fits the data. However, this test receives much criticism due to its sensitivity to large sample size. To overcome the problem associated with the test, various alternative fit indices such as CFI, GFI, NFI, etc have been developed (Byrne, 2001).

Due to the above sought-after features, SEM has gained in popularity in organisational research and behavioural research, especially in non-experimental research, where most of the methods for testing theories are not well developed, and where ethical considerations put a limitation on experimental designs (Bentler, 1980). Stone-Romero et al.(1995) in their review, demonstrates the popularity of SEM in organisational research, especially testing models that involve measurement issues or testing theories with non-experimental data. This statistical technique has also become popular amongst operations management researchers (Shah and Goldstein, 2006). The following section will discuss the benefits of SEM over the conventional techniques followed by the justification of its use for the present research.

#### 4.3.7.2 The advantage of SEM and the justification of its use in the present research

SEM has become one of the commonly-used statistical tools to test the relationships proposed in a parsimonious model and has been used across different disciplines, especially for studies that involve quantitative analysis. SEM is similar to traditional methods like correlation, regression and ANOVA in many ways. For instance, both traditional and SEM are based on linear statistical models and statistical tests associated with both methods are valid if certain assumptions are met. However, SEM approach offers a lot more advantages and benefits over traditional multivariate techniques especially when addressing certain types of research questions.

Firstly, SEM can statistically test a theoretical model. Compared to most other multivariate technique approaches, SEM is confirmatory rather than exploratory in nature. The descriptive nature of most other multivariate techniques makes hypothesis testing difficult, if not impossible (Byrne, 2001). The advantages of SEM technique include its applicability for testing a model, testing a specific hypothesis in a model, modifying an existing model, and comparing competing theoretical models (Ullman, 1996). Secondly it offers a more comprehensive approach to research design and data analysis with the potential of testing more complex and specific hypotheses (Hoyle, 1995). SEM is also a statistical technique that allows the simultaneous analysis of a series of structural equations. It is particularly useful when a dependent variable in one equation becomes an independent variable in another equation (Hair et al., 2006). Third, SEM is a multivariate techniques incorporating observed (measure) and unobserved variables (latent variables) while traditional technique analyse only measured variables.

The next main benefit of SEM over traditional analysis techniques is its ability to account for measurement error in latent variables. Measurement error is often an issue with scale multiple indicators. It raises the problem of reliability and construct validity as the indicators of the scales have large measurement errors (random and systematic errors). In addition, parameter estimates between latent variables, which separate error from meaningful effects, are more likely to replicate across studies since they do not rely on the replication of error across studies, which is the case with measure variables (Bentler, 1980). In other words, taking these measurement errors into consideration would increase the ability to detect the relationship between variables and obtain parameter estimates close to their population value (Hoyle, 1995).

Finally, unlike regression analysis, SEM has no single statistical test that can be used to assess the "strength" of a model's predictions (Hair et al., 2006). Rather, several fit indices must be used together to assess goodness-of-fit, and these will be chosen by the researchers depending on which perspective of fit is best suited for the analysis. These measures assess fit from three perspectives: overall fit (absolute fit), comparative fit compared to a baseline model (incremental fit), and model parsimony (adjusts the fit for the number of variables in the model) (Hair et al., 2006; Hu and Bentler, 1995; Marsh et al., 1988; Tanaka, 1993).

For the present research, generally, the advantages offered by SEM over traditional multivariate techniques made the researcher decide to use this method. Specially, however, SEM was chosen over multiple regression technique in the present study due to three main reasons. Firstly, the advantage of SEM in its ability to test a comprehensive and complex model makes the technique applicable in relation to the model proposed in the study. In this study, it is conceptualised that the transaction attributes (LOC, LAS, and LOU) surrounding the acquisition and implementation of AMT is expected to affect the relationships with technology supplier. Then, the different pattern of relationships with the technology supplier is expected to affect performance (Refer to Figure 3.1). Given the multiple dependence relationships in the research model, where a dependent variable in one hypothesis will become an independent variable in another hypothesis, SEM is the most suitable statistical tool available to assess the models. When a dependent variable in one equation becomes an independent variable in another equation, SEM is the right technique to be used due to its interdependence nature (Hair et al., 2006).

As mentioned earlier, the researcher started to use regression analysis to analyse the data. However, regression analysis can only deal with one explained variable at a time. For example, to analyse the entire causal model proposed in the present study (Refer to Figure 3.1), requires one to conduct several stages of analysis, each stage focusing on one of the explained variables. The drawback of testing the model in a piecemeal way is that, although various part of the model might fit appropriately, we may fail to see how the overall model interacts. SEM technique on the other hand allows the researcher to examine a series of dependent relationships simultaneously. SEM has been in favour due to its explanatory ability and statistical efficiency for model testing with a single comprehensive method (Hair et al., 2006). Therefore, the advantage of using SEM in the present study is its ability to test the hypothesised path at once, especially with the interdependence nature of the relationships hypothesised in the present research.

Second, as SEM has the ability to account for measurement error in latent variables, the use of this technique allows the researcher to recognise the imperfect nature of measurement used in the study, especially when the scale has not been tested in other settings. SEM explicitly specifies error while traditional methods assume measurement occur without error. Finally, SEM has an additional features to handle multicollinearity problems. In SEM, multiple measures are required for a latent construct. Therefore, multicollinearity is less likely to occur because unobserved variables represent distinct latent constructs. Furthermore, the interdependence nature of SEM allows each exogenous variable to covariate with each other, and therefore allowing interpretation even in the face of multicollinearity.

#### 4.3.7.3 Assessment of Model Fits

The objective of this section is to familiarise the reader with the overall fit indices which will be used later in the data analysis chapter. It will also assist the reader with the interpretation part of the data analysis section in Chapter Five. In most SEM research, the main objective is to test the theory. However, assessment of the overall model fit is difficult to address. Even though there are various types of indices of overall fit for evaluating SEM, there is little consensus regarding the best index to be used or which index performs better under different conditions. Byrne (2001) notes that performance of each fit index is influenced by a number of issues including model misspecification, sample size, estimation method, model complexity and violation of normality assumption.

As suggested by Fan et al. (1999):

1) to the extent that a fit index should be sensitive to model misspecification, the RMSEA, GFI and AGFI are some of the indices with better performance than others;
2) to the extent that a fit index should be sensitive to sample size, the RMSEA and CFI perform better than others;
3) to the extent that a fit index should be sensitive to estimation method, the RMSEA, GFI and AGFI perform better than others.

West et al.(1995) suggest that:

1) to the extent that a fit index should be sensitive to data non-normality and small sample size, CFI is recommended;
2) to the extent that a fit index should be sensitive to model complexity, CFI performs better than others

Another suggestion by Marsh et al.(1988) is that ideal fit indices should possess these criteria:

1) relative independence of sample size
2) accuracy and consistency to assess different models; and
3) ease of interpretation aided by well defined pre-set range.

Based on these criteria, they proposed the use of Tucker Lewis index (TLI), the comparative fit index (CFI), and the root mean squared approximation of error (RMSEA)

Based on all the important criteria discussed above, as well as their frequency of use in organisational research, the present study will use the Chi-square statistics, GFI, CFI, TLI and RMSEA as fit indices to evaluate the overall fit of the model.

**Chi-square ($\chi^2$)** is the most commonly used for evaluating overall model fit (Hoyle, 1995). It tests the discrepancy between the hypothesised model and sample data. Technically, it is the statistical test of the lack of fit resulting from over-identifying restrictions on a model (Santorra and Bentler, 1994). What we are looking in this test are a 'non-significance' statistics. On other words, a small chi-square means a model has a good fit, while a large chi-square means a model has a bad fit. Chi-square is calculated as N-1 times the minimum value of fit function, with N being the sample size. It is recommended that the cut off points such as $p>0.05$ or $p>0.10$ are used, with the former more widely accepted in practice (Byrne, 2001).

Although the Chi-square is the most common method of evaluating overall model fit, it is frequently criticized due to its high sensitivity to sample size, and the significance level can be misleading (Hair et al., 2006). In addition, Cheng (2001) argues that the difficulty in attaining non-significance statistics may be attributed to the method that accounts for all possible relationships between construct and construct, between constructs and indicators, and between indicators and indicators. Thus, the more constructs and indicators in the model, the lower the p-value (the less non-significant) of the chi-square statistics, resulting in a poor fitting model (Cheng, 2001)

**Goodness-of-Fit Index (GFI)** is another analogous to squared multiple correlation in that it measures the amount of variance in the sample covariance matrix (Kline, 1998). It represents the overall degree of fit (the squared residuals from prediction compared with the actual data) but it is not adjusted for degree of freedom (Hair et al., 2006). The value range from 0 (poor fit) to 1.0 (perfect fit). According to a rule of thumb, a GFI higher than .95 indicates good fit, while the value between .90 and .95 indicates adequate model fit (Hulland et al., 1996).

**Comparative fit index (CFI)** represents comparison between the estimated model and a null model. It is used as a non-centrality parameter-based index to overcome the limitation of sample size effect. Previous research has shown that CFI is one of the best indices that satisfy the criterion for suitable fit index (Gerbing and Anderson, 1993). According to Bentler (1995), the CFI reflects fit relatively well at all sample sizes and is the recommended index to use. In addition, West et al.(1995) suggest that in cases where there is a considerable departure from normality, researcher should examine the CFI index. This index ranges from 0 to 1 with .90 or greater, representing an acceptable fit (Byrne, 2001). A rule of thumb suggest that a CFI index higher than .95 indicates good fit, while the value between .90 and .95 indicates adequate model fit (Hulland et al., 1996).

**Tucker Lewis Index (TLI)** compares a proposed model's fit to a nested baseline or null model. In addition to that, it also measures parsimony by assessing the degree of freedom from the proposed model to that of the null model (Garver and Mentzer, 1999). The index is highly recommended due to its resilience against variation in sample size (Marsh et al., 1988). A rule of thumb suggests that an acceptable threshold for the index of .90 or greater, indicates adequate model fit (Hulland et al., 1996). Specifically, Hu and Bentler (1995) recommend TLI value of .95 or higher.

**Root Mean Square of Approximation (RMSEA)** measures the discrepancy between the observed and estimated covariance matrices per degree of freedom (Hair et al., 2006). The values which range between 0 to 1 represent the goodness of fit that could be expected if the model were estimated in population, not just the sample drawn for the estimation. According to Muthen and Muthen (1998), the RMSEA is a more accurate measure of fit than other common fit indices such as the goodness-of-fit index (GFI). Byrne (2001) and Kelloway (1998) indicate that RMSEA values of less than .10 represent a good fit, while values below 0.05 represent a very good fit to the data.

### 4.3.8 Section summaries

The first two sections of this chapter have discussed in detail, the measurement /operationalisation, scale development process, and survey data collection process used in the present research. Then, the tools for analysing the data were also described and brief discussions on the SEM technique appeared to aid the reader's understanding of the interpretation of the research findings in Chapter Five. The next section will describe the method used for the qualitative part of the data collection.

## 4.4 PART II: CASE STUDY

### 4.4.1 Objectives

Referring to the investigative framework, the qualitative methods of data collection in this research were undertaken at two different points in time, these being before and after the pilot testing. The data from the earlier process aimed to develop and enhance the survey tools. As variables that involve people's subjective feelings, attitudes, and perceptions can become very complicated. Therefore, a preliminary qualitative exploration on the phenomenon was important so that the measurement instruments could be further enhanced for the later quantitative data collection.

The data from the case studies undertaken after the pilot test was initiated were intended to achieve the following objectives:

1) *To help the researcher interpret or explain quantitative data.* Even though data in this research are primarily quantitative, qualitative data are also obtained as they can support and explicate the meaning of quantitative research (Jayaratne, 1993). For instance, the quantification of the strength of the buyer and supplier relationships may leave unanswered questions about how both parties actually behave in the relationship. Thus, qualitative techniques will tell the story behind the comparative quantification.
2) *To increase the construct validity of the research.* The use of both qualitative and quantitative data increases the construct validity of the research through the concept of triangulation. Triangulation has been broadly defined as the combination of methodologies in the study of the same phenomenon (Denzin, 1974). Between-method triangulation can address issues related to external validity and provide evidence of cross-validation (Jick, 1979). In this research, both interview and

survey were used to provide convergent validity information, which contributes to construct validity. Jick (1979) recommends the use of qualitative data as an integral part of triangulation, for it "function(s) as the glue that cements the interpretation of multi-method results" (p.609).

3) *To complement the findings of quantitative methods and thus enhance the reliability of the overall finding.*

### 4.4.2 Case study design

This study used a multiple-case design. As recommended by Yin (2003), the use of a multiple-case design is appropriate, particularly when the case serves to predict similar results (a literal replication) or predicts contrasting results but for predictable reasons (a theoretical replication). Furthermore, the use of multiple-case design can provide more compelling support for the initial set of propositions or hypotheses.

Data was collected through semi-structured interviews, in which questions were structured around the research themes in the study, and were consistent with the items in the survey questionnaire. There are three reasons for adopting the semi-structured interview, the first being that compared to the structured interview method, it allows for more knowledge generation. Most studies of advanced manufacturing technology implementation in Malaysia are still largely exploratory. Thus, the use of a semi-structured approach allows for unexpected developments that may arise. Secondly, the dynamic nature of BSR is different from one acquisition to another and from one firm to another. Thus, the use of a semi-structured interview allows further questions to be asked based on the unique situation surrounding a particular implementation process. Finally, Compared to the unstructured interview style, the semi-structured approach is more likely to facilitate cross-case comparisons.

The case study comprises the evidence from the interview(s) held in one particular company and the available documentation from that firm. The interviews required a single visit to each company except for case A (two visits). Data were taken from a single respondent except for cases A and F (involve two respondents). It was clarified and ensured before the interviewing process that the individual to be interviewed was the person mostly responsible for, and most knowledgeable about, the whole acquisition and implementation process for the specific technology under investigation. The interview sessions were tape recorded except for case B and E, where notes were taken and immediately "written up" on return from the interviews. The interviews took between one and a half, to three hours (Refer to Table 4.4 for details).

**Table 4.4: The selected case companies: Interview details**

| Case | Number of visits to company | Individual interviewed | Duration of interview session (Approximately) | Method |
|---|---|---|---|---|
| A | Two visits | • Production manager<br>• Project engineer | 3 hrs | Tape recorded |
| B | Single visit | • CEO | 2 hrs 40 minutes | Notes taken |
| C | Single visit | • Executive Director | 1.5 hours | Tape recorded |
| D | Single visit | • CEO | 2 hrs 20 minutes | Tape recorded |
| E | Single visit | • Production Director | 3 hrs | Notes taken |
| F | Single visit | • Operation manager<br>• Senior plant engineer | 2.5 hrs | Tape recorded |
| G | Single visit | • Production and material Manager | 2 hrs 10 minutes | Tape recorded |

### 4.4.3 Sample selection method

A non-probabilistic sampling method was favoured as generalisation in a statistical sense was not one of the objectives. Merriam (1998) argues that probabilistic sampling is not necessary or even justifiable in qualitative research. Recommended however, is purposeful sampling, that is, selecting a sample from which the maximum can be learned, knowing that time is limited (Stake, 1995). Hence, the cases that are selected should be easy and willing subjects. In this research, cases were not selected all at once. Starting from the time of receipt of the pilot responses, firms that had their address and telephone number written at the back of the returned questionnaire were approached with a request for an interview. Initial contact was made over the telephone with the manager responsible for the entire implementation process. If this person agreed to participate, a meeting was arranged. Finally, by the end of data collection period, 18 on-site interviews (including the five pilot interviews) had been conducted.

According to Yin (2003), sample selection should be dictated by a replication logic rather than a statistical one. More precisely, each case should be considered as an experiment in itself, with subsequent cases being used either to confirm or refute previous findings. Cases should, therefore, be selected if they are expected to yield similar results (literal replication) or on the contrary, completely opposite results (theoretical replication). Cases may be chosen to replicate previous cases or extend emergent theory, or they may be chosen to fill theoretical categories and provide examples of polar types (Eisenhardt, 1989).

In light of the above, it was decided to select cases that represented different aspects of transaction attributes and the buyer and supplier relationship, since this would allow the impact on performance to be assessed. The selection of extreme cases aims to amplify differences that may exist between types of cases, thereby making these differences easier to observe. When comparing findings across homogeneous cases (e.g., pairs of firms that possess higher levels of transaction attributes and indicate strong buyer and supplier relationships), similar results are expected (literal replication). On the other hand, when comparing findings across different types of cases (e.g., between firms that possess higher levels of transaction attributes and indicate strong buyer and supplier relationships, and firms that possess higher levels of transaction attributes but indicate lower levels of buyer and supplier relationships), opposite results can be expected (theoretical replication).

Also, for obvious reasons, the sample size in a multiple-site study can not be large. Any sample exceeding ten cases would indeed make it virtually impossible for the researcher to analyse adequately the staggering amount of data to be collected. This is even more so in this particular project where the context dictated the use of only one investigator. Eisenhardt (1989) recommends a sample size of four to ten organisations (or sites). Therefore, it was decided to choose samples in the following categories:

**Figure 4.3: Desired sample structure**

| | | Buyer and supplier relationships: Strong | Buyer and supplier relationships: Weak |
|---|---|---|---|
| Transaction attributes | High | A<br>2 cases | B<br>2 cases |
| | Low | C<br>2 cases | D<br>2 cases |

After a preliminary case analysis, it was found difficult to find suitable cases to fill the set criteria described in the above grid, because of the 18 sample cases, half belonged to the A quadrant, and only two belonged to the D quadrant. Selecting extreme cases proved to be a difficult task. After a through consideration, only seven cases were finally selected. Priority was given to those cases that could fulfil the criteria set above, and could provide rich data from the interview session. Thus, the finally-chosen cases were: three from Quadrant A, one from Quadrant D, and another three belonging to none of the quadrants. The three last cases (marked * in Figure 4.4) may not be extreme cases in terms of transaction attributes and buyer and supplier relationships, but still had noticeable differences among them.

**Figure 4.4: Final sample structure**

| Transaction attributes \ Buyer and supplier relationships | Strong | Moderate | Low |
|---|---|---|---|
| High | 3 cases | 1 case* | |
| Moderate | 1 case* | | |
| Low | | 1 case* | 1 case |

### 4.4.4 Interview protocol

Prior to the interview session, the researcher studied the company's background using the organisation's website and company profile. At the beginning of the interview sessions, the researcher reviewed the purpose of the study with the individual involved, then moved into the interview questions, which were sequenced as follows:

1. Further questions were asked relating to the production technology and the main product of the company.
2. For the researcher's understanding, respondents were roughly asked about the main production issue that served as the motivation to acquire the technology.
3. For the assessment of transaction attributes, the following questions were asked[2]:
    a. Before the implementation process, how did you view the complexity of the technology?
    b. Did the implementation of the technology cause changes to your current manufacturing layout, process and practices?

[2] During the interview, the wording of the questions was not necessarily the same. Elaborations on the questions were sometimes required depending on the respondent's request and understanding.

c. Was the investment considered major or not major to the company, can you tell why?

d. Does the technology represent a core competence for your business? In what way?

e. How much learning and training were involved in the implementation of the technology?

f. Did your firm hire or pay for special expertise for the implementation of the technology. If so, who was this?

g. If you have previous experience in handling similar technological innovation, what is this experience?

h. Describe your degree of confidence or doubt about the capability of the acquired technology in achieving your investment goals, and meeting your technical expectations and customer demand.

i. Before the implementation, did you have an expert in the company who could handle the acquired technology?

j. Does your firm have experience in handling a similar technological innovation?

4. For the assessment of the buyer and supplier relationship, respondents were asked to describe in what way the technology supplier was involved at the three stages of the technology implementation, which are before, during, and after installation.
5. Then, further questions were asked about how the seven aspects of the buyer and supplier relationship were involved during the entire process of technology implementation, depending on the way the interviewees described their relationship with the technology supplier.
6. For the assessment of technology performance, the respondent was asked how the acquired technology had helped the company specifically in improving lead time, reducing cost, and increasing quality, efficiency and flexibility.
7. For the assessment of implementation performance, questions were asked in accordance with items from Section F, Part B of the survey questionnaire.

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Sometimes, during the interview, a question was repeated or rephrased to encourage the respondent to elaborate in more detail.

8. Finally, comments from the respondent were sought on how the involvement of the supplier could have improved both technology and implementation performance of the acquired technology.

### 4.4.5 Approach for analysing the data

In the cases where recording was not agreed by the interviewee, notes were taken during the interview sessions, and the information gathered from the interview was reviewed as soon as possible. A brief case analysis was performed on the same day while the information was still fresh in the mind of the researcher. For the tape-recorded data, the tapes were carefully listened to repeatedly, transcriptions were hand-written and notes (researcher reflections with regard to issues under investigation) were also used. Although the language during the interview was a mix of both Malay and English language, it was predominantly Malay. Therefore, the transcriptions were translated by the researcher into English language. The researcher took careful steps to ensure the quality and originality of the meaning was maintained[3].

As recommended by Yin (2003), data analysis in this research started with an in-depth study of each individual site, which is called "within-case analysis". This entailed sifting through all the data and discarding whatever was irrelevant. The idea was to allow the most significant observations to emerge from all the data gathered during the interview sessions, while reducing its volume. The response from the respondent representing a company was analysed individually.

Generally, from the transcription, direct quotations and a particular experience or incident describing the interviewee's experience, especially related to the technology supplier, were coded under several tracks as below:

1. Track A: key material pertinent to research theme
2. Track B: material such as general chit-chat, interview interruption or extended commentary by the researcher

[3] The translation was shown to 4 colleagues (each with different case company) to get the consistent agreement on the meaning.

3. Track C: Background in which the interview discourse departed from the primary research theme, but still offered useful context

Transcription's compilation of Track A was further divided into three main sections as follows:

1. Transaction attributes with sub-sections - Level of complexity, level of asset specificity, and level of uncertainty
2. Buyer-supplier relationships
3. Performance

Under each section of Track A, responses were categorised into two types which are:

1. direct quotion that clearly portrays each issue addressed by the interview questions
2. particular experience/incident describing the research themes.

These quotations and particular experience/incidents provided by respondent assisted the researcher's interpretation and assessment of each case.

Data about the transaction attributes were analysed by constructing a matrix with the brief answers and reason for each question in the left column and the researcher's assessment and interpretation on the right column. Based on these two, a score was assigned as whether the case had a high, moderate, or low level of complexity, asset specificity, or uncertainty, in relation to the technology being acquired and implemented.

As for buyer-supplier relationships, firstly, a narrative of the involvement of the technology supplier in the acquisition and implementation process, as told by the respondent, was briefly written up. Secondly, the seven dimensions of the buyer and supplier relationship, as told by the respondent, were highlighted. Thirdly, aspects of the buyer and supplier relationship which were not expressed by the respondent during the interview sessions, but detected from the respondent's description of the relationship with the technology supplier were noted. Fourthly, all three elements were thoroughly evaluated and an assessment was made regarding whether the case had developed a strong, moderate or weak relationship with the technology supplier.

Finally the case was written up by combining the aspects mentioned above. As for both of the performance aspects, a process similar to the buyer and supplier relationship assessment was carried out.

At the final result of the within-case analysis, aspects such as the level of transaction attributes, strength of buyer and supplier relationships, and level of performance, were able to be identified. As a means of double-checking, the results of the researcher's assessment through within-case analysis were then compared to the scale scored by each case from the structured survey questionnaire. In all of the extreme cases, the score fell well within the within-case assessment score by the researcher. In two of the three moderate cases assessed by the researcher, the result was slightly different from the survey score on the transaction attributes. Thus, the information from the case was thoroughly reviewed again in looking for the interpretation of such result. The individuals interviewed were also contacted again about some issues on which the researcher felt it was important to make a judgement. Finally, with the respondent's agreement, the original results from the researcher's interpretation were maintained as final.

In general, the way cases are written is by retelling the narrative, but from the researcher's point of view and interpretation. The way each case is written was influenced by the researcher's earlier assessment of the case. To facilitate the cross-case analyses that were to follow, all seven cases were written following the same format:

1. A brief introduction describing the organisation, its business, and the starting point that led to the technology acquisition.
2. A brief description of the technology acquisition.
3. A detailed description of the transactions attributes (complexity, asset specificity, and uncertainty) in relation to technology acquisition.
4. A detailed description of the nature of relationships with the technology supplier (includes before, during, and after technology installation).
5. The researcher's overall assessment of the implications of transaction attributes for the relationships with the technology supplier and their link with performance.

The second step of the analysis consists of cross-case analysis in the search for patterns of relationships. To begin with, firms with a similar level of transaction attributes were grouped together. The cases were then compared to each other to see the pattern of buyer and supplier relationships in the technology acquisition and implementation process. The similarities and differences among them were noted for further analysis. Then, firms with a similar pattern of buyer and supplier relationships were grouped together. The cases were then compared to each other on the basis of the performance achieved. The similarities and differences among them were noted for further analysis. Cases that indicated different patterns from the other cases were subjected to further comparison with each other. The final write up of the within case analyses were sent back to the respective respondents, whereas, the cross case analyses were sent back to all respondents as a means of validation.

## 4.5 CHAPTER SUMMARY

This chapter has confirmed the present research as a broadly deductive research study utilising multiple and complimentary quantitative and qualitative research methods. Quantitative data were collected in the form of a questionnaire survey and qualitative data were collected via semi-structured interviews. In respect of the survey, 147 usable responses were collected. Data collection procedures, the scale development process, and the operationalisation of the research have all been described in detail. This chapter has also introduced the tools to be used for analysing the survey data, and provided a brief discussion on SEM, with the intention of preparing the reader for the results interpretation to follow.

The second aspect of data collection, through the use of interviews, has also been discussed. Interview data from seven companies were used to develop seven case studies relating to the issue under investigation. Case study design, sample selection method, interview protocol, and the approach for analysing the interview data, have all been discussed. The following chapters present the reader with a detailed account of the quantitative and qualitative findings of this research.

# CHAPTER FIVE
# SURVEY ANALYSIS AND RESULTS

## 5.1 INTRODUCTION

This chapter presents the analysis of, and the results from, the data collected through the questionnaire survey. The first section provides the profile and characteristics of the responding companies. The next section indicates the further test carried out on the final scales in order to ensure the data were fit for further analysis. The subsequent section explains how the measurement used in data collection (items in the questionnaire) is transformed into the final scale. Thereafter, the descriptive analysis of the final scale is presented, and finally, the data are subjected to the hypotheses testing.

## 5.2 RESPONDENT PROFILE

As shown in Table 5.1, the respondents represented small (42.2%), medium (34.0%) and large (23.8%) manufacturing companies, being representative of the population of firms contained in Federation of Malaysian Manufacturers (FMM) directory. With respect to the industry sector, vehicle assembly and parts accounted for just over one-quarter (28.6%) of the sample. Other major sectors represented include electrical and electronic products (19.0%), food and beverages (18.4%), and metal working products (15.6%). Paper and paper products (8.2%) and rubber and plastic products (7.5%) were also significant sectors represented in the sample. Table 5.1 also shows the number of years that the companies had been in operation in Malaysia, from which it can be seen that 60% had been operating for less than 10 years. Another 28% had been in operation between 10 and 15 years with the remaining (12.2%) having been established for over 15 years.

**Table 5.1: Demographic distribution of respondents**

| Firm Size | Frequency | Percent |
|---|---|---|
| <100 | 62 | 42.2 |
| 100-300 | 50 | 34.0 |
| >300 | 35 | 23.8 |
| Total | 147 | 100.0 |

| Industry Sector | Frequency | Percent |
|---|---|---|
| Food and beverages | 27 | 18.4 |
| Paper and paper products | 12 | 8.2 |
| Rubber and plastic products | 11 | 7.5 |
| Metal working products | 23 | 15.6 |
| Electrical and electronic products | 28 | 19 |
| Vehicle assembly and parts | 42 | 28.6 |
| Others | 4 | 2.7 |
| Total | 147 | 100 |

| Years in Operation | Frequency | Percent |
|---|---|---|
| < 5 years | 41 | 27.9 |
| 5 to 10 Years | 47 | 32.0 |
| 10 to 15 years | 41 | 27.9 |
| >15 years | 18 | 12.2 |
| Total | 147 | 100.0 |

Table 5.2 indicates the types of AMTs adopted by the companies in the sample, the distribution indicating that almost 40% had acquired special purpose automated equipment. One in five companies had invested in robotics and 17.7% of the firms had invested in CNC machines. The findings show that only 8.2% of the firms had adopted integrated manufacturing systems. However, it is expected that the large number of firms with special purpose automated technology would have significant integration.

**Table 5.2: Distribution of respondents by technology acquired**

| Technology Acquired | Frequency | Percent |
|---|---|---|
| CNC | 26 | 17.7 |
| Robotic | 30 | 20.4 |
| Injection moulding machine | 7 | 4.8 |
| Special purpose automation technology | 57 | 38.8 |
| Flexible manufacturing system | 15 | 10.2 |
| Integrated manufacturing system | 12 | 8.2 |
| Total | 147 | 100 |

## 5.3 MEASUREMENT ASSESSMENT AND PURIFICATION

This section focuses on the assessment and purification of the measure used in the study. Most of the scales are not well established since they were adapted from previous research and some are newly-developed for the purpose of this research. Therefore, there is a need to examine the extent to which a particular measurement represents a certain construct. This examination involves the investigation of validity and reliability of each measure used in the study. Scales were further subjected to these analyses to ensure the data were fit for further analysis. The elimination of some of the items is expected in order to improve the validity and internal consistency of the scales. However, each decision to drop an item from the scale was made after thorough consideration had been given to the importance of the items to the research objectives.

### 5.3.1 Scale reliability for multi-item measures

The new measures in this study consist of sets of items to reflect the underlying constructs and, therefore, the items for each construct should exhibit a high level of internal consistency and a high level of correlation amongst the individual items. The reliability of a measure indicates the stability and consistency with which the instrument measures the concept and helps to assess the "goodness" of a measure (Sekaran, 2003). In the present research, internal reliability, which is specially used in multi-item measures, was employed to measure reliability. This refers to whether the items that make up the scale are measuring a single concept and whether those items are internally consistent (Bryman and Cramer, 2005). The most commonly-used approach is through the assessment of the coefficient alpha, better known as Cronbach coefficient alpha. Nunally (1978) recommends a value of .70 as the threshold for the lowest acceptable level for alpha. Another method of assessment is through the examination of composite reliability measures for each construct, which is made possible through the use of SEM. Composite reliability is considered to be similar to Cronbach's coefficient alpha but has the advantage that SEM structure reliability values do not assume that the individual items have equal reliabilities (Dunn et al., 1994). In many cases, this value will be close to coefficient alpha, and similar to the rule of thumb in Cronbach's alpha, the commonly- used threshold value for acceptable reliability is .70.

In the present research, Cronbach's coefficient alpha was first used to assess the reliability of all usable 147 returned questionnaires. Items that correlated negatively or did not correlate strongly were eliminated at this stage (Spector, 1992). This process resulted in the deletion of two items from the questionnaire, these being one from the business understanding scale, and one from the knowledge acquired scale. Then, after validity analysis (which resulted in the further elimination of questionnaire items) reliability was reassessed using both composite reliability and variance extracted measures for each construct to assess internal reliability. Full results of the reliability analysis appear in Appendix 4.

### 5.3.2 Validity analysis

Following the reliability analysis, a validity assessment was made. As noted by Sekaran (2003), the validity analysis testifies as to how well the results obtained from the use of the measure, fit the theories around which the test is designed Three types of validity are examined in this study, namely face validity, content validity and construct validity. Face validity is determined by a cursory review of items representing the scale by untrained judges, and is considered as being the least scientific measure of validity (Litwin, 1995). In this study, the measures used in the survey were reviewed by the researcher's colleagues and supervisor, as well as by managers who had implemented AMT (during the scale development process). Thus, the measures apparently met the requirement of face validity.

Content validity refers to "the extent to which a specific set of items reflects a content domain" (DeVellis, 1991, p43). All scales used in this study are considered to have content validity because the items came from relevant literature. The domains were clearly defined in each introduction and sub-heading within the questionnaire in order to assist the respondents to relate easily to the specific constructs. Furthermore, a number of academics and practitioners had assessed all items used in this study and this further supported the content validity of the measures (Sekaran, 2003).

Construct validity analysis testifies as to how well the results obtained from the use of the measure fit the theories around which the test developed, and it can be assessed in terms of discriminant validity (Sekaran, 2003). Discriminant validity refers to the extent to which a certain construct is different from other constructs. Indicators from one scale should not load closely to other scales. Highly correlated scales (e.g from two scales similar in nature) may suggest that they are measuring the same construct instead of two different ones. Therefore, these constructs need to be tested for discriminant validity so that the scales developed to measure them can be verified (Garver and Mentzer, 1999).

Factor analysis is often used to assess discriminant validity. Exploratory factor analysis (EFA) is frequently employed in the early stage of data analysis to uncover the underlying structure of a relatively large set of variables. The researcher's prior assumption is that any indicator may be associated with any factor. On the other hand, confirmatory factor analysis (CFA) is a more complex and sophisticated set of techniques used later in the research process to test (confirm) specific theories concerning the structure underlying a set of variables (Pallant, 2004). Since the scales are not well established, both exploratory and confirmatory factor analyses were undertaken to evaluate the construct validity of the scales. The reason for EFA is the researcher's need to assess the dimensionality (factor structure) of the scale, whereas CFA is used to further confirm that factor structure.

Firstly, EFA was carried out on all constructs comprising each scale, namely, the transaction attributes, buyer-supplier relationships, and performance through the use of Principal Component Factor analysis (PCA). Each item (indicator) was factor analysed simultaneously to find out whether each construct would separately show plausible correlations (i.e. significance, direction, and magnitude) with each other when grouped under the main variables identified for the research. Prior to performing PCA, the suitability of data factor analysis was assessed. Inspection focused on the correlation matrix that revealed coefficients of .3 and above. The Kaiser–Meyer-Oklin value should also exceed the recommended value of .6 (Kaiser, 1974) and the Barlett's Test of Sphericity (Bartlett, 1954) should reach statistical significance ($p \leq .05$), indicating the factorability of the correlation matrix. Scales that load significantly high into a single construct indicate the uni-dimensionality of the construct that has been operationally defined by each item.

Discriminant validity was then further tested using CFA. With CFA, the categories are predetermined by the researcher and the analysis determines how well each question within a factor correlates with that particular factor. To test for discriminant validity using CFA, the chi-square differences test is conducted by comparing the freely-estimated measurement model with a theoretical model where the correlation parameter is constrained to 1 (Joreskog, 1971). Discriminant validity of two constructs is achieved if the chi-square value for the unconstrained model is significantly lower than that of the constrained model (Bagozzi and Philips, 1982). Following Anderson and Gerbing (1988), a two-step approach using confirmatory analysis and SEM was followed. In SEM, the measurement model was first tested to validate the measurement instruments used in the study.

There are two methods commonly used by previous researchers in evaluating the validity of a measurement model: testing each construct separately, or testing all constructs together at one time (Cheng, 2001). Testing all constructs at once is preferable to testing each construct separately because of the ability to take into account the relationships between the indicators of different constructs. In this sense, discriminant validity is not only assumed but also statistically tested. However, it should be noted that researchers attempting to model relationships among a large number of latent variables (e.g. in overall measurement model with CFA) have found it difficult to fit such a model to predictions even with strong theoretical support (Joreskog and Sorbom, 1986). Therefore, steps are needed to decrease the number of indicators used, yet maintain the estimation of measurement error given by using multiple-item indicators. Thus, based on the complexity of the model and sample size limitations of the present study, the researcher employed both methods to measure the model's validity, one after another. Firstly, the constructs were examined individually, and then convergent and discriminant validity were examined through CFA.

### 5.3.3 Testing the reliability and validity of the measures

#### 5.3.3.1 Transaction attributes

Transaction attributes in this research are *level of complexity* (consisting of four items), *level of asset specificity* (consisting of four items), and *level of uncertainty* (consisting of six items). EFA was first conducted using PCA. Table 5.3 indicates the result of the rotated solution for the transaction attributes scale. The four items of the level of complexity (LOC) scale, six items of the level of uncertainty (LOU) scale, and four items of level of asset specificity (LAS) scale, were factor analysed simultaneously. Coefficient matrix inspection, Kaiser–Meyer-Oklin value, and Barlett's Test of Sphericity all indicate the suitability of the data for the factors analysed.

PCA revealed the presence of three components with eigenvalues exceeding 1, explaining 46.38%, 15.11%, and 9.38% of the variance respectively. An inspection of the screeplot revealed a clear break after the third component. To aid in the interpretation of these three components, Varimax[1] rotation was performed. The rotated solution (Table 5.3) revealed the presence of a simple structure, with all components showing a number of strong loadings, and many variables loading substantially on only one component. The three-factor solution explained a total of 70.87% of the variance, with component 1 contributing 27.35%, component 2 contributing 24.06%, and component 3 contributing 19.45%. However, one item (LOU5) was dropped from the scale because it loaded into an unintended factor with low loading value. The result of this analysis supports the use of level of complexity, level of uncertainty, and level of asset specificity as separate scales. Details of the

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[1] Both rotational approaches (orthogonal and oblique factors solution) were conducted. However, the orthogonal approach, using the Varimax technique was used because it gives the clearest and easiest pattern to interpret. Thurstone, L.L., 1947. Multiple factor analysis. University of Chicago Press, Chicago.

results are shown in Appendix 5. Then,. CFA was conducted for each dimension of the transaction attributes.

**Table 5.3: Varimax rotation of the three-factor solution of the transaction attributes scale**

| | Component | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| **Items** | LOC | LOU | LAS |
| LOC4 | **.866** | | |
| LOC1 | **.861** | | |
| LOC3 | **.804** | | |
| LOC2 | **.785** | | .358 |
| LOU6 | | **.843** | .432 |
| LOU3 | | **.781** | |
| LOU4 | | **.779** | .352 |
| LOU2 | | **.731** | |
| LOU1 | | **.619** | .511 |
| LAS3 | | **.583** | **.870** |
| LAS2 | .306 | | **.778** |
| LAS1 | | | **.670** |
| LAS4 | | | **.528** |
| LOU5 | .308 | | .311 |

KMO = .822; Bartlett's Test (Sig) = .000
Total percentage of variance explained = 70.87

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalisation.
Note: Only loadings above.3 are displayed

### CFA on level of complexity (LOC)

CFA for the level of complexity (LOC) resulted in an adequate fitting model of $\chi^2$ (2) = 8.92, p = .01; GFI = .97; CFI = .98, TLI = .94 and RMSEA = .08. Even though the chi-square statistic was significant, other fit indices indicate a recommended level of indices, thus suggesting a well-fitting measurement model. Table 5.4 shows the finally-retained items with their corresponding standardised loadings, and the reliability of the construct.

**Table 5.4: Factor loadings and scale reliability for the level of complexity (LOC) scale**

| Indicators | Std. Load. | Std. error | C.R |
|---|---|---|---|
| LOC1: The technology is quite straightforward | .83 | .07 | 6.44 |
| LOC2: The engineering of the technology is technically difficult and complex | .83 | .07 | 6.53 |
| LOC3: The technology contains a higher degree of tacit knowledge | .87 | .07 | 5.72 |
| LOC4: The implementation of the technology reflects major changes to our manufacturing layout/process/practice | .83 | .06 | 6.53 |
| Cronbach's alpha : .90 | | | |
| Composite reliability : .98 | | | |
| Variance extracted : .91 | | | |

### CFA on level of asset specificity (LAS)

CFA on the level of asset specificity (LAS) also resulted in an adequate fitting model of $\chi^2$ (2) = 3.69, p = .158; GFI = .99; CFI = .99, TLI = .98 and RMSEA = .08. The chi-square statistics were insignificant and other fit indices indicate a recommended level of indices, thus suggesting a well-fitting measurement model. Table 5.5 shows the finally-retained items with their corresponding standardised loadings, and the reliability of the construct.

**Table 5.5: Factor loadings and scale reliability for the level of asset specificity (LAS) scale**

| Indicators | Std. Load | Std. error | C.R |
|---|---|---|---|
| LAS1: Our firm has a major financial investment in the technology | .70 | .15 | 7.33 |
| LAS2: The technology represents a core competence for us | .82 | .11 | 5.70 |
| LAS3: Our firm has a high degree of collective learning and training for the implementation of the technology | .87 | .09 | 4.34 |
| LAS4: Our firm has a special expertise dedicated to the implementation of the technology | .68 | .09 | 7.47 |
| Cronbach's alpha : .85 | | | |
| Composite reliability : .91 | | | |
| Variance extracted : .90 | | | |

**CFA on level of uncertainty (LOU)**

CFA for the level of uncertainty (LOU) resulted in an adequate fitting model of $\chi^2$ (5) = 9.47, p = .09; GFI = .97; CFI = .98, TLI = .97 and RMSEA = .08. The chi-square statistics were insignificant and other fit indices indicate a recommended level of indices, thus suggesting a well-fitting measurement model. Table 5.6 shows the finally-retained items with their corresponding standardised loadings, and the reliability of the constructs.

**Table 5.6: Factor loadings and scale reliability for the level of uncertainty (LOU) scale**

| Indicators | Std. Load | Std. error | C.R |
|---|---|---|---|
| LOU1: We were confident that the technology would achieve our investment goals | .71 | .07 | 7.28 |
| LOU2: We were certain the technology would meet our technical expectations | .80 | .06 | 6.26 |
| LOU3: We were certain the technology would help us meet customer demands | .86 | .04 | 4.75 |
| LOU4: We were confident that the technology would work as it was intended technologically | .66 | .06 | 7.55 |
| LOU6: We have experience in handling similar technological innovation | .60 | .07 | 7.84 |
| Cronbach's alpha : .85 | | | |
| Composite reliability : .92 | | | |
| Variance extracted : .88 | | | |

### 5.3.3.2 Buyer-supplier relationships (BSR)

BSR consists of seven constructs namely, trust (TRUST), business understanding (BU), involvement (INVO), commitment (COMMIT), communication (COMMU), information sharing (IS), and knowledge acquired (KA). There were six items on the trust (TRUST) scale, five items on the business understanding scale (BU) scale, four items on the involvement (INVO) scale, five items on the commitment (COMMIT) scale, five items on the communication (COMMU) scale, five items on the information sharing (IS) scale, and five items on the knowledge acquired (KA) scale. Scales were simultaneously subjected to Principal Component Factor analysis (PCA). Coefficient matrix inspection, Kaiser–Meyer-Oklin value, and Barlett's Test of

Sphericity all indicate the suitability of the data for the factor analysed. PCA revealed the presence of eight components with eigenvalues exceeding 1. Since the research context used seven constructs for the buyer-supplier relationship, a seven factor solution was chosen. To aid in the interpretation of these seven components, Varimax[2] rotation was performed. Table 5.7 indicates the result of the rotated solution for the buyer-supplier relationships scale. The result revealed the presence of a simple structure, with components showing strong loadings into only five different factors. The *trust* and *business understanding* scales appeared to merge together as one scale, similar to the *commitment* and *involvement* scales.

[2] Both rotational approaches (orthogonal and oblique factors solution) were conducted. However, the orthogonal approach, using the Varimax technique was used because it gives the clearest and easiest pattern to interpret Thurstone, L.L., 1947. Multiple factor analysis. University of Chicago Press, Chicago.

**Table 5.7: Varimax rotation of the seven-factor solution of the buyer-supplier relationships scale**

| Items | Component | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| TRUST2 | **.805** | | | | | | |
| TRUST1 | **.783** | | | | | | |
| TRUST3 | **.755** | | | | | | |
| TRUST4 | **.741** | | | | | | |
| BU3 | **.684** | | | | | | |
| BU5 | **.666** | | | | | | |
| BU4 | **.628** | | | | | | |
| TRUST6 | **.582** | | .338 | | | | .328 |
| BU2 | **.547** | | | | | .491 | .318 |
| BU1 | **.488** | .474 | | | | | |
| TRUST5 | **.405** | | .328 | .347 | | .302 | |
| COMMU4 | | **.809** | | | | | |
| COMMU2 | | **.734** | | .323 | | | |
| COMMU1 | | **.717** | | .332 | | | |
| COMMU5 | .338 | **.677** | | | | | |
| COMMU3 | | **.660** | | | | .367 | |
| IS2 | | | **.767** | | | | |
| IS1 | | | **.757** | | | | |
| IS4 | | | **.734** | | | | |
| IS3 | | | **.723** | | | | |
| IS5 | | .362 | **.703** | | | | |
| INVO3 | | | | **.839** | | | |
| INVO2 | | | | **.832** | | | |
| INVO1 | | | | **.826** | | | |
| INVO4 | | | | **.808** | | | |
| COMMIT3 | | | | **.806** | | .430 | |
| COMMIT4 | .313 | .383 | | **.730** | | | |
| COMMIT2 | | | | **.707** | .302 | | |
| COMMIT1 | | | | **.604** | | | |
| COMMIT5 | | | | **.578** | .326 | | |
| KA5 | | .344 | | | **.802** | | |
| KA4 | .310 | | | | **.778** | | |
| KA3 | | | | | **.626** | | |
| KA2 | | .353 | | | **.615** | | |
| KA1 | | | | | **.571** | | |

KMO = .835; Bartlett's Test (Sig) = .000
Total percentage of variance explained = 57.14

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalisation.

The five-factor solution explained a total of 57.14% of the variance (See Table 5.8). The result of this analysis supports the use of only five factors that made up the buyer-supplier relationships. It suggests merging the *trust* and *business understanding* scales and labelling this the *Trust and Business understanding* (TBU) dimension. It also suggests merging the *commitment* and *involvement* scales, and entitling this *Committed involvement* (CI) dimension. Based on statistical evidence and through consideration of the suitability of the items in describing the concepts, a decision was made to use only five constructs to describe BSR, these now being: *trust and business understanding*, *committed involvement*, *communication*, *information sharing*, and *knowledge acquired*. These constructs were then for the subsequent CFA. Details of EFA result are shown in Appendix 5

**Table 5.8: Total variance explained**

| Component | Rotation Sums of Squared Loadings | | |
|---|---|---|---|
| | Total | % of Variance | Cumulative % |
| 1 | 5.781 | 16.518 | 16.518 |
| 2 | 4.156 | 11.875 | 28.392 |
| 3 | 3.543 | 10.124 | 38.516 |
| 4 | 3.373 | 9.637 | 48.153 |
| **5** | **3.147** | **8.991** | **57.144** |
| 6 | 1.577 | 4.506 | 61.650 |
| 7 | 1.234 | 3.525 | 65.175 |

Extraction Method: Principal Component Analysis.

**CFA of the trust and business understanding (TBU) scale**

CFA for *trust and business understanding* (TBU) resulted in an ill-fitting model of scale. Examination of the standardised factor loading revealed that one item (Trust 5) has a standardised loading below .40. Since the low standardised loading indicates low convergence validity, the poorly-performing items were deleted from the model. An examination of MI suggests that items Trust3, BU1, BU3, and BU4 were highly inter-correlated with each other and with other items in the scale. Therefore, these items were deleted and the model was re-estimated with the remaining seven items. CFA resulted in an adequate fitting model of $\chi^2$ (9) = 9.33, p = .41; GFI = .98; CFI =

1.00, TLI = 1.00 and RMSEA = .02. The chi-square statistics were insignificant and other fit indices indicate a recommended level of indices, thus suggesting a well-fitting measurement model. Table 5.9 shows the finally-retained items with their corresponding standardised loading, and the reliability of the construct.

**Table 5.9: Factor loadings and scale reliability for trust and business understanding (TBU)**

| Indicators | Std. Load | Std. error | C.R |
|---|---|---|---|
| TRUST1: To what extent do you trust that the supplier has dealt with you in a fair manner? | .90 | .04 | 4.78 |
| TRUST2: To what extent do you believe the supplier has provided your firm with the latest and appropriate technology? | .87 | .02 | 5.53 |
| TRUST4: To what extent do you believe the supplier has provided your firm with the best cost for the acquired technology? | .65 | .04 | 7.93 |
| TRUST6: To what extent has the supplier developed a reputation for fairness and trustworthiness in your relationship? | .66 | .05 | 7.89 |
| BU2: To what extent do you think the technology supplier has a good grasp of your manufacturing process? | .60 | .07 | 8.07 |
| BU5: To what extent do you think the technology supplier has been able to relate the supplied technology to your firm's requirements (The technology chosen is appropriate for your firm's manufacturing requirement) | .66 | .05 | 7.89 |
| Cronbach's alpha : .86 | | | |
| Composite reliability : .89 | | | |
| Variance extracted : .82 | | | |

**CFA of the committed involvement (CI) scale**

CFA for *committed involvement* (CI) resulted in an ill-fitting model of scale. Examination of standardised factor loadings revealed that items commit1 and commit2 had a standardised loading below .40. Consequently, these were deleted from the model. An examination of MI suggests one item (commit5) was highly inter-correlated with the other items in the scale. Therefore, these items were deleted and the model was re-estimated with the remaining six items. CFA resulted in an adequate fitting model of $\chi^2$ (14) = 21.32, p = .09; GFI = .96; CFI = .97, TLI = .96 and RMSEA = .06. The chi-square statistics were insignificant and other fit indices indicate a recommended level of indices, thus suggesting a well-fitting measurement model.

Table 5.10 shows the finally-retained items with their corresponding standardised loadings, and the reliability of the construct.

**Table 5.10: Factor loadings and scale reliability for committed involvement (CI)**

| Indicators | Std. Load | Std. error | C.R |
|---|---|---|---|
| INVO1: To what extent was the technology supplier involved in the planning process so that the technology implemented is compatible with the current system? | .70 | .05 | 6.71 |
| INVO2: To what extent has the technology supplier been involved in improving your firm's understanding of the new technology's requirements before the implementation process? | .72 | .04 | 6.53 |
| INVO3: To what extent do you think the technology supplier has helped your firm to mentally prepare for the new technology implementation before the implementation process? | .67 | .04 | 7.00 |
| INVO4: To what extent do you think the technology supplier was involved during the implementation process? | .71 | .05 | 6.67 |
| COMMIT3: To what extent has the supplier provided after sales service and technical support which has allowed you to implement the technology more successfully? | .52 | .07 | 7.84 |
| COMMIT4: To what extent was the supplier involved in fixing the disruption emerging from the implemented technology? | .54 | .06 | 7.77 |
| Cronbach's alpha : .81 | | | |
| Composite reliability : .92 | | | |
| Variance extracted : .89 | | | |

### CFA of the communication (Commu) scale

CFA for *communication* (commu) resulted in an ill-fitting model of scale. Standardised factor loadings for each item were satisfactory, but the MI suggested that one item (commu5) was highly inter-correlated with the other items in the scale. Therefore, these items were deleted and the model was re-estimated with the remaining four items. CFA resulted in an adequate fitting model of $\chi^2$ (2) = 7.34, p = .02; GFI = .98; CFI = .98, TLI = .96 and RMSEA = .08. Although the chi-square statistics were significant, other fit indices indicate a recommended level of indices, thus suggesting a well-fitting measurement model. Table 5.11 shows the finally-retained items with their corresponding standardised loadings, and the reliability of the construct.

**Table 5.11: Factor loadings and scale reliability for communication (Commu)**

| Indicators | Std. Load | Std. Error | C.R |
|---|---|---|---|
| COMMU1: To what extent did you communicate with the supplier's technical people whenever a problem emerged with the implemented technology? | .81 | .07 | 6.21 |
| COMMU2: To what extent did you communicate with the technology supplier before the technology was implemented? | .88 | .06 | 4.30 |
| COMMU3: To what extent did you communicate with the technology supplier during technology implementation? | .77 | .08 | 6.72 |
| COMMU4: To what extent did you communicate with the technology supplier after the technology was implemented? | .65 | .08 | 7.69 |
| Cronbach's alpha : .86<br>Composite reliability : .91<br>Variance extracted : .89 | | | |

**CFA of the information sharing (IS) scale**

CFA for *information sharing* (IS) resulted in an ill-fitting model of scale. Standardised factor loadings for each item were satisfactory, but the MI suggested that one item (IS4) was highly inter-correlated with the other items in the scale. Therefore, these items were deleted and the model was re-estimated with the remaining four items. CFA resulted in an adequate fitting model of $\chi^2$ (2) = 1.9, p = .38; GFI = .99; CFI = 1.00, TLI = 1.00 and RMSEA = .00. The chi-square statistics were insignificant and other fit indices indicate a recommended level of indices, thus suggesting a well-fitting measurement model. Table 5.12 shows the finally-retained items with their corresponding standardised loading, and the reliability of the construct.

**Table 5.12: Factor loadings and scale reliability for information sharing (IS)**

| Indicators | Std. Load | Std. error | C.R |
|---|---|---|---|
| IS1: To what extent do you think the technology supplier has conveyed true information on the technology before your firm made the investment in the technology? | .73 | .04 | 6.17 |
| IS2: To what extent do you think the technology supplier has conveyed complete information on the technology before your firm made the investment in the technology? | .85 | .05 | 3.72 |
| IS3: To what extent do you think the technology supplier shared confidential information during your relationship? | .63 | .05 | 7.31 |
| IS5: To what extent do you think the technology supplier has shared important information which is directly or indirectly useful for your manufacturing operation? | .59 | .08 | 7.55 |
| Cronbach's alpha : .79<br>Composite reliability : .88<br>Variance extracted : .81 | | | |

## CFA of the knowledge acquired (KA) scale

CFA for *Knowledge Acquired* (KA) resulted in an ill-fitting model of scale. Standardised factor loadings for each item were satisfactory, but the MI suggested that one item (KA4) was highly inter-correlated with the other items in the scale. Therefore, these items were deleted and the model was re-estimated with the remaining five items. CFA resulted in an adequate fitting model of $\chi^2$ (2) = 4.41, p = .11; GFI = .98; CFI = .98, TLI = .94 and RMSEA = .09. The chi-square statistics were insignificant and other fit indices indicate a recommended level of indices, thus suggesting a well-fitting measurement model. Table 5.13 shows the finally-retained items with their corresponding standardised loadings, and the reliability of the construct.

**Table 5.13: Factor loadings and scale reliability for knowledge acquired (KA)**

| Indicators | Std. Load | Std. error | C.R |
|---|---|---|---|
| KA1: To what extent have you learned from the technology supplier new technical skills relating to the implemented technology? | .74 | .04 | 5.86 |
| KA2: To what extent has the technical support provided by the technology supplier helped you to solved technical problems? | .89 | .05 | 2.50 |
| KA3: To what extent do you think your relationship with the technology supplier encouraged knowledge development? | .42 | .03 | 8.21 |
| KA5: To what extent do you think your relationship with the technology supplier has improved your analytical and technical skill to implement complex technological projects in the future? | .61 | .05 | 7.45 |
| Cronbach's alpha : .76 | | | |
| Composite reliability : .87 | | | |
| Variance extracted : .81 | | | |

In the present study, for the purpose of hypothesis testing, BSR will be treated as a latent factor represented by the five different constructs identified above. Items from each construct were averaged, and were then used as three different indicators of the latent BSR construct. This treatment allows the researcher to treat BSR as an integral construct with five different indicators. Furthermore, empirically, studies on BSR have used single items of each construct in measuring BSR. Therefore, as items under each BSR construct have demonstrated validity through CFA, a common factor underlying these dimensions would be a good way to represent the extent of relationships with the technology supplier during the entire process of technology acquisition and implementation. This treatment of BSR is deemed appropriate since the proposed hypotheses regarding BSR were at the construct level; the study did not hypothesise differential effects of each BSR dimensions.

**Second order CFA of the final BSR scale**

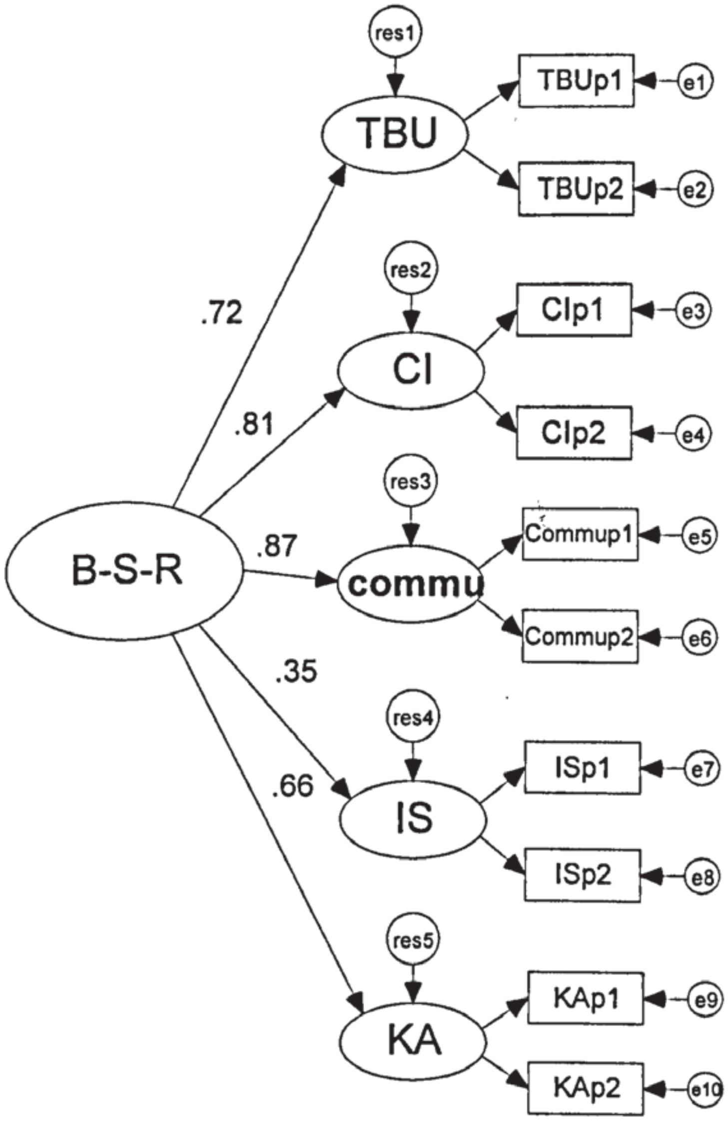
Figure 5.1 indicates the graphical representation of the BSR model under SEM. CFA resulted in an inadequately fitting model of $\chi^2$ (247) = 589.32, p = .00; GFI = .77; CFI = .80, TLI = .78 and RMSEA = .10. As previously mentioned, although testing all the constructs at once is preferable to testing each construct separately because of the ability to take into account the relationships between the indicators of different constructs, it should be noted that a large number of latent variables would find it difficult to fit such a model to predictions even with strong theoretical support (Joreskog and Sorbom, 1986). Therefore, parcelling procedures was used as a more parsimonious estimation strategy. The main justification for using this procedure was to improve the variable to sample size ratio. By employing this strategy, the number of variables would also be reduced and hence the model's degree of freedom is kept reasonable. Following the partial aggregation procedure recommended by Bagozzi and Heatherton (1994), items were combined by averaging them to create two indicators per factor. Indicators under each BSR construct were randomly aggregated to form a parcel. Prior to combining the items into composites, all the items were subjected to an assessment in terms of their reliability and validity. Details and justification for the used of parcelling procedure will be discussed in more detail in the next section. Table 5.14 indicates the indicators aggregated to form the parcel.

**Table 5.14: Aggregated items to form the BSR scale indicators**

| BSR construct | Indicators (Items) |
|---|---|
| Trust and Business Understanding (TBU) | TBUd1= Trust6, Trust2, BU2<br>TBUd2= Trust4, BU5, Trust1 |
| Committed involvement (CI) | CId1= invo1, invo3, commit4<br>CId2= invo2, invo4, commit3 |
| Communication (Commu) | CommuD1= commu1, commu2<br>CommuD2= commu5, commu3 |
| Information sharing (IS) | ISd1= IS1, IS2<br>ISd2= IS5, IS3 |
| Knowledge acquired (KA) | KAd1= KA1, KA5<br>KAd2= KA2, KA3 |

The model was re-estimated with the aggregated indicators. Figure 5.1 shows the graphical representation of the BSR constructs.

**Figure 5.1: The BSR construct and its standardised coefficient**




CFA resulted in an adequate fitting model of $\chi^2$ (30) = 70.40, p = .00; GFI = .92; CFI = .94, TLI = .91 and RMSEA = .09. The chi-square statistics were significant but other fit indices indicate a recommended level of indices, thus suggesting a well-fitting BSR measurement model.

#### 5.3.3.3 Performance

Table 5.15 indicates the results of the rotated solution for the performance scale. The four items of the *technology performance* (TP) scale and six items of the *implementation performance* scale (IP) scale were simultaneously subjected to Principal Component Factor analysis (PCA). Coefficient matrix inspection, Kaiser–

Meyer-Oklin value, and Barlett's Test of Sphericity all indicate the suitability of the data for factor analysis. PCA revealed the presence of three components with eigenvalues exceeding 1, explaining 30.61%, 19.75%, and 10.16% of the variance respectively. An inspection of the screeplot revealed a clear break after the second component. To aid in the interpretation of these three components, Varimax[3] rotation was performed. The rotated solution yielded a clear solution with two factors (respectively reflecting technology and implementation measure of performance). The two-factor solution accounted for 50.36% of the total variance, with component 1 contributing 27.78% and component 2 contributing 22.58. Details of the result are shown in Appendix 5. The result of this analysis supports the use of *technology performance* and *implementation performance* as separate scales.

**Table 5.15: Rotated component matrix for performance scale**

| Items | Component | |
|---|---|---|
| | 1 | 2 |
| IP3 | .742 | |
| IP2 | .738 | |
| IP4 | .730 | |
| IP5 | .671 | |
| IP1 | .621 | |
| IP6 | .523 | |
| TP2 | | .766 |
| TP3 | | .750 |
| TP1 | | .738 |
| TP4 | | .714 |

KMO = .685; Bartlett's Test (Sig) = .000
Total percentage of variance explained = 50.36

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalisation.
Note: Only loadings above.3 are displayed

**CFA of the technology performance (TP) scale**

CFA for *technology performance* (TP) resulted in an adequate fitting model of $\chi^2$ (2) = 10.70, p = .01; GFI = .97; CFI = .94, TLI = .81 and RMSEA = .10. The chi-square

[3] Both rotational approaches (orthogonal and oblique factors solution) were conducted. However,the orthogonal approach, using the Varimax technique was used because it gives the clearest and easiest

statistics were significant but other fit indices indicate a recommended level of indices, thus suggesting a well-fitting measurement model. Table 5.16 shows the finally-retained items with their corresponding standardised loading, and the reliability of the construct.

**Table 5.16: Factor loadings and scale reliability for the technology performance (TP) scale**

| Indicators | Std. Load | Std. error | C.R |
|---|---|---|---|
| TP1: Reduction in the lead time | .75 | .03 | 5.00 |
| TP2: Increase in quality | .65 | .03 | 6.57 |
| TP3: Reduction in cost | .68 | .03 | 6.19 |
| TP4: Increase in efficiency and productivity | .56 | .04 | 7.33 |
| Cronbach's alpha : .75 | | | |
| Composite reliability : .79 | | | |
| Variance extracted : .69 | | | |

**CFA on the implementation performance (IP) scale**

CFA for *implementation performance* (IP) resulted in an ill-fitting scale model. Standardised factor loadings for each item were satisfactory, but the MI suggested redundant items between IP1 and IP2, and therefore IP2 was deleted. Item IP6 was also correlated with another item and was, therefore, deleted. The model was re-estimated with the remaining five items. CFA resulted in a good fitting model of $\chi^2(2) = 0.24$, $p = .88$; GFI = 1.00; CFI = 1.00, TLI = 1.00 and RMSEA = .00. The chi-square statistics were insignificant and other fit indices indicate a recommended level of indices, thus suggesting a good-fitting measurement model. Table 5.17 shows the finally-retained items with their corresponding standardised loadings, and the reliability of the construct.

pattern to interpret Thurstone, L.L., 1947. Multiple factor analysis. University of Chicago Press, Chicago..

**Table 5.17: Factor loadings and scale reliability for the implementation performance (IP) scale**

| Indicators | Std. Load | Std. error | C.R |
|---|---|---|---|
| IP1: Time taken to fully implement the technology | .43 | .04 | 7.86 |
| IP3: The amount of downtime caused by the technology | .78 | .04 | 3.70 |
| IP4: The time taken to tackle any technical problem during the implementation process | .66 | .03 | 5.84 |
| IP5: The capability of the technology in fulfilling your implementation objective | .54 | .04 | 7.22 |

Cronbach's alpha : .70
Composite reliability : .72
Variance extracted : .64

The overall process of scale assessment and purification resulted in the following number of items being retained in comparison to the initially-proposed number of items developed to measure the construct;

**Table 5.18: Final items retained for hypothesis testing**

| Scale title | Original number of items in the scale | Number of items deleted during pre-testing | Items deleted during initial reliability assessment | Items deleted during validity assessment | Number of items retained for further analysis |
|---|---|---|---|---|---|
| Transaction attributes: | | | | | |
| Degree of complexity | 4 | | | | 4 |
| Level of asset specificity | 4 | | | | 4 |
| Degree of uncertainty | 7 | 1 | | 1 | 5 |
| BSR: | | | | | |
| Trust | 7 | 2 | | 2 | 3 |
| Business understanding | 7 | 1 | 1 | 2 | 3 |
| Involvement | 4 | | | | 4 |
| Commitment | 5 | | | 3 | 2 |
| Communication | 5 | | | 1 | 4 |
| Information sharing | 5 | | | 1 | 4 |
| Knowledge acquired | 7 | | 1 | 2 | 4 |
| Technology performance | 4 | | | | 4 |
| Implementation performance | 6 | | | 2 | 4 |

**Table 5.19: Final items for the BSR construct**

| BSR construct: | Number of items |
|---|---|
| Trust and Business Understanding (TBU) | 6 |
| Committed involvement (CI) | 6 |
| Communication (COMMU) | 4 |
| Information sharing (IS) | 4 |
| Knowledge acquired (KA) | 4 |

## 5.4 EXAMINATION OF ASSUMPTIONS UNDERLYING STRUCTURAL EQUATION MODELING

Having clarified the measure, the final step was to examine whether the data for the present study meets the assumptions of SEM. As discussed in Chapter Four, before conducting a full model SEM analysis, data should be examined in terms of the violation of the multicollinearity assumption, violation of the normality assumption, and the sample size requirement. The sections that follow describe each of these assumptions in relation to the present research.

### 5.4.1 Multicollinearity

Multicollinearity occurs when inter-correlations among some variables are so high that what appear to be separate variables actually measure the same things (Kline, 1998). It can be detected by inspecting the correlation matrix among the variables. No limit has been set that defines what is high, but values exceeding .90 should always be examined; in most cases, correlations exceeding .80 may indicate problems (Hair et al., 2006). Berry (1993), however, suggests that multicollinearity exists when the correlation is .90 or above, and the result will be an insignificant regression coefficient due to the large size standard error. Kline (1998), further argues that multicollinearity at the multivariate level is not as straightforward as at bivariate level. He suggested that one way to detect the presence is by calculating squared multiple correlations (R2) between each variable and all the rest; a value above .90 suggests multicollinearity. The present data have been checked for the possibility of multicollinearity. Collinearity diagnostics were performed using SPSS version 14.0. The tolerance values for LOC, LAS, and LOU are .57, .42, and .53 respectively. The tolerance values are all above the cut-off point of .20 and the VIF values are all below 4.0, indicating that the scales used in the present research appear to have no multicollinearity problems.

### 5.4.2 Normality

SPSS 14.0 software package provides for a normality test through the Kogomorov-Smirnoff (KS) test where a non-significant KS result signifies that the distribution was approximately normal (Hair et al., 2006). However, it has been argued that the KS test is extremely sensitive to any small deviation from normality. Another way to examine the normality of the distribution is by computing the Z-values of the skewness and kurtosis of the scale (Sharma, 1996). If the Z-values are less than the critical value of 1.96 for an alpha level of .05, it can be concluded that the distribution of the scale is normal. According to Tabachnick and Fidell (2001), by examining the scatterplots of residuals one can spot the violation of the three underlying assumptions of normality, linearity and homoscedasticity between predicted dependent variable scores and error prediction. The assumptions are met when the residuals have a straight-line relationship with predicted dependent variable scores and errors, and appear to be nearly rectangularly distributed with a concentration of scores along the centre.

In the present study, normality was first examined through the calculation of Z-values of the skewness and kurtosis, then normality was examined together with homoscedasticity and linearity through the inspection of the scatterplots of residuals in the SPSS 14.0 software package. Although inspection of the scatterplots of residuals reveals that the distributions do not deviate much from the straight line in most cases, the examination of Z-values of the skewness and kurtosis revealed that the distribution of the Level of complexity (LOC) and Level of asset specificity score (LAS) showed a slight departure from normality. As discussed in Chapter Four, support has been found that the Maximum Likelihood (ML) estimation used in the present study works well even when the assumption of normality has been violated (Hoyle, 1995). Therefore, the small deviation from normality does not pose a threat to the assumption of multivariate normality in the present study.

### 5.4.3 Sample size

The sample size in the present study is 147 respondents. In SEM, the sample size requirement is affected by the model complexity and the estimation methods used. For example, the more complex the model, the more parameters are being estimated, and thus the more cases that are required to achieve a stable solution. Using the recommended ratio of five observations per parameter as a guideline (Bentler and Chou, 1987; Hair et al., 2006), the present study does not meet the required sample size. The proposed structural model includes six latent variables with a total of 26 observed variables. In addition to these variables, SEM will also estimate the other parameters such as factor loading and error term, thus making it impossible to achieve the recommended ratio of five cases to one parameter. To handle the problem of sample size requirement, the present study employs the items parceling procedure.

#### 5.4.3.1 Items Parceling Procedure

As noted by Bandalos and Finney (2001), the parceling procedure has been used in many applied SEM studies published in journals such as the Applied Psychological Measurement, Journal of Educational Psychology, Journal of Marketing Research, Structural Equation Modeling, etc. Three reasons have been cited by researchers for using the procedure (see discussion by Aquino et al., 1999; Bagozzi and Heatherton, 1994; Bandolas and Finey, 2001; Garver and Mentzer, 1999):

1. responses to individual items are likely to violate the assumption of multivariate normality. Parcels have distributions that are more continuous and normally distributed than those of individual items, and thus conform more closely to the assumption of normality in SEM estimation.
2. obscure analysis employing individual items as measured indicators for the latent variables, often necessitates estimating a large number of parameters in fitting the model to the data. By using the parceling technique, fewer parameters will need to be estimated since factor loadings and measurement error variances are only estimated for each parcel rather than for each item. Thus, the technique is beneficial, especially in a study with a small sample size, since it will result in a more optimal ratio of variable to sample size, and

as a consequence more stable parameter estimation will be achieved (Bagozzi and Heatherton, 1994).

3. in addition to reducing random error, the technique will also simplify a complex model, and at the same time, maintain the concept of multiple indicator measurement (Garver and Mentzer, 1999).

In the present study, a parceling procedure was used as a more parsimonious estimation strategy. As mentioned earlier, the main justification for employing this procedure is to improve the variable to sample size ratio. Table 5.20 shows the indicators aggregated to form the parcel. By employing the procedure, the number of variables is reduced and hence, the model's degree of freedom is kept reasonable. Prior to combining the items into composites, the researcher tested the reliability and the validity of all the measures (see the section on measures development and purification). This step is important since previous research has warned that when using the parceling technique items that lack uni-dimensionality can obscure rather than clarify the factor structure of the data (West et al., 1995).

**Table 5.20: Aggregated items to form scale indicators**

| Scale | Indicators (Items) |
|---|---|
| Level of Complexity | LOCp1= loc4, loc1<br>LOCp2= loc2, loc3 |
| Level of asset specificity | LASp1= las2, las3<br>LASp2= las4, las1 |
| Level of uncertainty | LOUp1= lou2, lou1, lou3<br>LOUp2= lou6, lou4 |
| Buyer-supplier relationships | BSRp1= TBU, Commu, IS<br>BSRp2= CI, KA |
| Technology performance | TPp1= tp2, tp1<br>TPp2= tp4, tp3 |
| Implementation performance | IPp1= ip3, ip4<br>IPp2= ip5, ip1 |

## 5.5 PRELIMINARY EXAMINATIONS OF RESPONSES

This section aims to assess the responses of the sample as well as to examine whether the assumptions prior to hypotheses testing are met. The focuses of the examination are:

1. variations in the transaction attributes of firms acquiring the technology
2. variations in buyer-supplier relationships in the acquisition and implementation of the technology,
3. variations in performance level
4. the demographic information as potential control variables
5. correlations between all the variables in the study.

### 5.5.1 Variation in transaction attributes

Table 5.21 shows the responses on the transaction attributes scale of the present research, indicating that the responses for *level of complexity* (LOC) and *asset specificity* (LAS), vary from a minimum of 1.50 to a maximum of 5.00. The scale mean values of 3.52 and 3.41 respectively, were above the scale mid-point of 3.00. On the other hand, the response for *level of uncertainty* (LOU) ranged from a minimum of 1.60 to a maximum of 4.80 with the mean value of 3.31, slightly higher than the scale mid-point of 3.00.

**Table 5.21: Descriptive statistics of the transaction attributes scale**

| | N | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|
| Level of complexity | 147 | 1.50 | 5.00 | 3.5272 | 1.04362 |
| Level of asset specificity | 147 | 1.50 | 5.00 | 3.4082 | 1.08700 |
| Level of uncertainty | 147 | 1.60 | 4.80 | 3.3129 | .75455 |
| Valid N (listwise) | 147 | | | | |

To gain a closer understanding of the variation of responses regarding transaction attributes, the LOC, LAS, and LOU were examined on the basis of the technology being acquired (Table 5.22) and the value of investment (Table 5.23). For this purpose, LOC, LAS, and LOU were divided into three groups using the median as a cut off point. The groups are High (H), Moderate (M), and Low (L). Table 5.22 shows the cross tabulation results of transaction attributes by technological type. The results indicate, within a similar technological type, firms' varying levels of complexity, specificity, and uncertainty, with regard to the technology acquisition and implementation. For instance, out of 26 firms that invested in computer numerical control machines (CNCs), 13 considered them as highly complex, six as moderately complex, and seven as low or less complex.

**Table 5.22: Transaction attributes by the technology acquired**

| Technology acquired | LOC | | | LAS | | | LOU | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| | H | M | L | H | M | L | H | M | L | |
| CNC | 13 | 6 | 7 | 11 | 7 | 8 | 7 | 9 | 10 | 26 |
| Robotic | 9 | 13 | 8 | 9 | 7 | 14 | 4 | 10 | 16 | 30 |
| Injec. Moulding Machine | 0 | 2 | 5 | 1 | 0 | 6 | 0 | 4 | 3 | 7 |
| Special Purpose auto. tech. | 26 | 10 | 21 | 19 | 22 | 16 | 28 | 17 | 12 | 57 |
| Flexible mfg. System | 9 | 0 | 6 | 5 | 7 | 3 | 6 | 4 | 5 | 15 |
| Integrated mfg. System | 4 | 7 | 1 | 6 | 4 | 2 | 6 | 4 | 2 | 12 |
| Total | 61 | 38 | 48 | 51 | 47 | 49 | 51 | 48 | 48 | **147** |

Table 5.23 shows the cross tabulation results of transaction attributes by value of investment. The results indicate, within the same range of investment, firms' varying levels of complexity, specificity, and uncertainty with regard to the technology acquisition and implementation. A higher value of investment does not necessarily mean the technology is representing a major core competence or is regarded as a major investment to the firm. For instance, seven of the 16 firms that have an investment value below RM3000 indicate a higher level of specificity of the technology to the company, whereas 16 of the 31 firms that have an investment value between RM3000,000 and RM500,000 indicate a lower level of specificity of the technology to the company.

**Table 5.23: Transaction attributes by the value of investment**

| Value of investment (in RM) | LOC | | | LAS | | | LOU | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| | H | M | L | H | M | L | H | M | L | |
| Below 300K | 7 | 6 | 3 | 7 | 5 | 4 | 5 | 6 | 5 | 16 |
| Between 300K to 500K | 6 | 9 | 16 | 6 | 9 | 16 | 7 | 12 | 12 | 31 |
| Between 500K to 1Million | 16 | 8 | 20 | 8 | 14 | 22 | 15 | 10 | 19 | 44 |
| Between 1 to 2 Million | 20 | 6 | 4 | 14 | 11 | 5 | 13 | 8 | 9 | 30 |
| Above 2 Million | 12 | 9 | 5 | 16 | 8 | 2 | 11 | 12 | 3 | 26 |
| Total | 61 | 38 | 48 | 51 | 47 | 49 | 51 | 48 | 48 | **147** |

### 5.5.2 Variation in BSR

Table 5.24 shows the mean distribution of each element of buyer-supplier relationships measured in this study. Communication appears to be the most essential aspect (mean value = 3.33), whilst information sharing appears to be the lowest aspect, in comparison to the other elements of the buyer-supplier relationships measured in this study.

**Table 5.24: Descriptive statistics on each element of the buyer-supplier relationships scale**

| | N | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|
| Trust and Business understanding | 147 | 1.33 | 4.67 | 2.8946 | .65285 |
| Committed involvement | 147 | 2.00 | 4.58 | 2.9830 | .56586 |
| Communication | 147 | 1.25 | 5.00 | 3.3452 | .93144 |
| Information Sharing | 147 | 1.50 | 4.25 | 2.7398 | .64298 |
| Knowledge acquired | 147 | 1.75 | 4.50 | 3.0051 | .53433 |
| Buyer-supplier relationships | 147 | 1.83 | 4.28 | 2.9935 | .47947 |
| Valid N (listwise) | 147 | | | | |

Since it seemed strange to achieve the highest score for communication, yet the lowest score for information sharing, correlation analyses were performed to discover whether frequent communication was associated with information sharing. The result of the correlation analysis, shown in Table 5.25, indicates that communication is not significantly correlated with information sharing, which could suggest that frequent communication between buyer and supplier in the technology acquisition and implementation does not necessarily mean true and complete information is shared. However, trust and business understanding is highly correlated (p=.615) with the level of information shared. The other elements in buyer-supplier relationships, as measured in this study, are inter-related as expected.

**Table 5.25: Correlation between each of the elements of buyer-supplier relationships**

| | TBU | CI | Commu | IS | KA |
|---|---|---|---|---|---|
| Trust and Business understanding (TBU) | 1 | .395(**) | .563(**) | .358(**) | .404(**) |
| Committed involvement (CI) | .395(**) | 1 | .606(**) | .241(**) | .455(**) |
| Communication (Commu) | .563(**) | .606(**) | 1 | .094 | .415(**) |
| Information Sharing (IS) | .358(**) | .241(**) | .094 | 1 | .378(**) |
| Knowledge acquired (KA) | .404(**) | .455(**) | .415(**) | .378(**) | 1 |

** Correlation is significant at the 0.01 level (2-tailed).

Figure 5.2 shows the frequency distribution of the final buyer-supplier relationships scale used in this study. The response ranged from a minimum of 1.83 to a maximum of 4.28. The scale mean value was 3.00, similar to the scale mid-point of 3.00.

**Figure 5.2: Frequency distribution of the final buyer-supplier relationships scale**


### 5.5.3 Variation in performance level

Table 5.26 shows the responses on both the *technology performance* (TP) and *implementation performance* (IP) scales in the present research, indicating variation for TP from a minimum of 2.25 to a maximum of 4.75, with a scale mean value of 3.67 above the scale mid-point of 3.00. On the other hand, the response for IP ranged from a minimum of 2.5 to a maximum of 4.50 with the mean value of 3.43 slightly higher than the scale mid-point of 3.00.

**Table 5.26: Descriptive statistics of the performance scale**

| | N | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|
| Technology performance | 147 | 2.25 | 4.75 | 3.6701 | .42703 |
| Implementation performance | 147 | 2.50 | 4.50 | 3.4252 | .43736 |
| Valid N (listwise) | 147 | | | | |

Analysis of the frequency distributions indicates 87% of the respondents claiming an above average level of achievement in terms of *technology performance*, whereas, only 69% of respondents experienced an above average level of satisfaction in terms of *implementation performance* of the specified technology. The overall result shows that the majority of respondents indicate a higher level of achievement in terms of both aspects of the performance measure.

### 5.5.4 The demographic information as potential control variables

In the present research, demographic variables such as years in operation, the type of technology being acquired, and the type of company ownership, were tested to see whether any of them could potentially function as control variables. It is important to control for these variables so that the possibility of spurious relationships based on unmeasured variables can be reduced. To determine which of the co-variates should be included as control variables in the structural equation model, one-way analysis of variance (ANOVA) was conducted. ANOVA was used to test whether there is a significant difference in the mean of one dependent variable on an independent variable with two or more levels (Field, 2000; Kerr et al., 2002). The mean differences of LOC, LAS, LOU, BSR, TP, and IP according to these demographic variables were examined. As depicted in Table 5.27, the findings indicate that the only significant difference that exists is between the type of technology being acquired and the uncertainty surrounding its acquisition and implementation (F-Ratio= 1.80). Thus, based on the findings, AMT type will be used as a control variable later in the test of the hypothesised model with SEM.

**Table 5.27: ANOVA result for differences in all measured variables by selected demographic characteristics**

| Demographic Characteristics | LOC | LAS | LOU | BSR | TP | IP |
|---|---|---|---|---|---|---|
| Years in operation (F-Ratio) | 0.81 | 0.65 | 1.27 | 1.06 | 1.99 | 0.90 |
| Company Status (F-Ratio) | 0.90 | 0.87 | 0.73 | 0.77 | 1.51 | 0.61 |
| AMT type (F-ratio) | 0.76 | 1.05 | 1.80* | 1.36 | 0.93 | 1.35 |

*Significant at p<.05

### 5.5.5 Correlational analysis and mean scores of the responses

Pearson's bivariate correlational test was conducted to examine the correlations between the variables. The findings from this analysis were important as preliminary confirmation of the relationships and the direction of the hypotheses. Table 5.28 shows the descriptive statistics (mean and standard deviation) and zero order correlations between the variables under examination in the present study. Correlations are considered significant at the 5% level. In terms of demographic variables, *years in operation* was negatively related to *level of uncertainty* (at -.29) and *type of AMT* being acquired was positively related to *level of uncertainty* (at .17) and positively related to *buyer-supplier relationships* (at .19). In terms of predictor variables (only hypothesised links are elaborate at this point), *Level of complexity* (LOC), *level of asset specificity* (LAS), and *level of uncertainty* (LOU) are positively interrelated with each other. The three attributes (LOC, LAS, LOU) are positively related to *buyer-supplier relationships* (BSR) and BSR is positively related to both *technology performance* and *implementation performance.*

These initial findings indicate consistencies with the proposed direction of the model. They also suggest that all the hypothesised relationships between the three transaction attributes, BSR, and both aspects of performance were related and in the expected directions. These findings could also be used as a preliminary confirmation of the prescribed hypotheses before conducting SEM.

**Table 5.28: Means, Standard Deviations, and Zero-order Correlation (demographics, predictors and outcome variables)**

| | Mean | SD | 1 | 2 | 3 | LOC | LAS | LOU | BSR | TP | IP |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Company age (1) | 2.24 | 1.00 | 1 | | | | | | | | |
| Company status (2) | 1.90 | 1.40 | .11 | 1 | | | | | | | |
| AMT type (3) | 3.28 | 1.54 | -.29** | -.02 | 1 | | | | | | |
| Level of complexity (LOC) | 3.53 | 1.04 | .05 | -.11 | .02 | 1 | | | | | |
| Level of asset specificity (LAS) | 3.41 | 1.09 | .01 | -.06 | .14 | .66** | 1 | | | | |
| Level of uncertainty (LOU) | 3.31 | 0.5 | -.17* | -.07 | .28** | .39** | .61** | 1 | | | |
| Buyer-supplier relationships (BSR) | 3.00 | 0.48 | -.13 | .03 | .19* | .41** | .51** | .54** | 1 | | |
| Technology performance (TP) | 3.67 | 0.43 | .14 | .12 | .06 | .15 | .17* | .16* | .25** | 1 | |
| Implementation performance (IP) | 3.43 | 0.44 | -.08 | .04 | .03 | .12 | .19* | .37** | .47** | .17* | 1 |

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

## 5.6 HYPOTHESIS TESTING

It was shown that firms of all sizes and from all business backgrounds were represented in the sample. All measures were subjected to thorough analysis and demonstrated to be uni-dimensional, internally consistent, and to have construct validity. A series of assumptions of SEM data analysis were tested and the findings indicate that the data met all the requirements in terms of sample size, multicollinearity and normality. Preliminary examinations of the responses were also conducted prior to testing the hypotheses. The data are now qualified and ready to be used in further analysis to test the hypotheses developed at the conceptual stage of this study (Chapter Three).

### 5.6.1 Testing of five main hypotheses regarding research questions one and two

The full information hypothesised model (Figure 5.3) includes LOC, LAS, LOU, BSR, TP and IP. The inter-relationships between these variables will be tested simultaneously to test the five major hypotheses in this study regarding the two research questions:

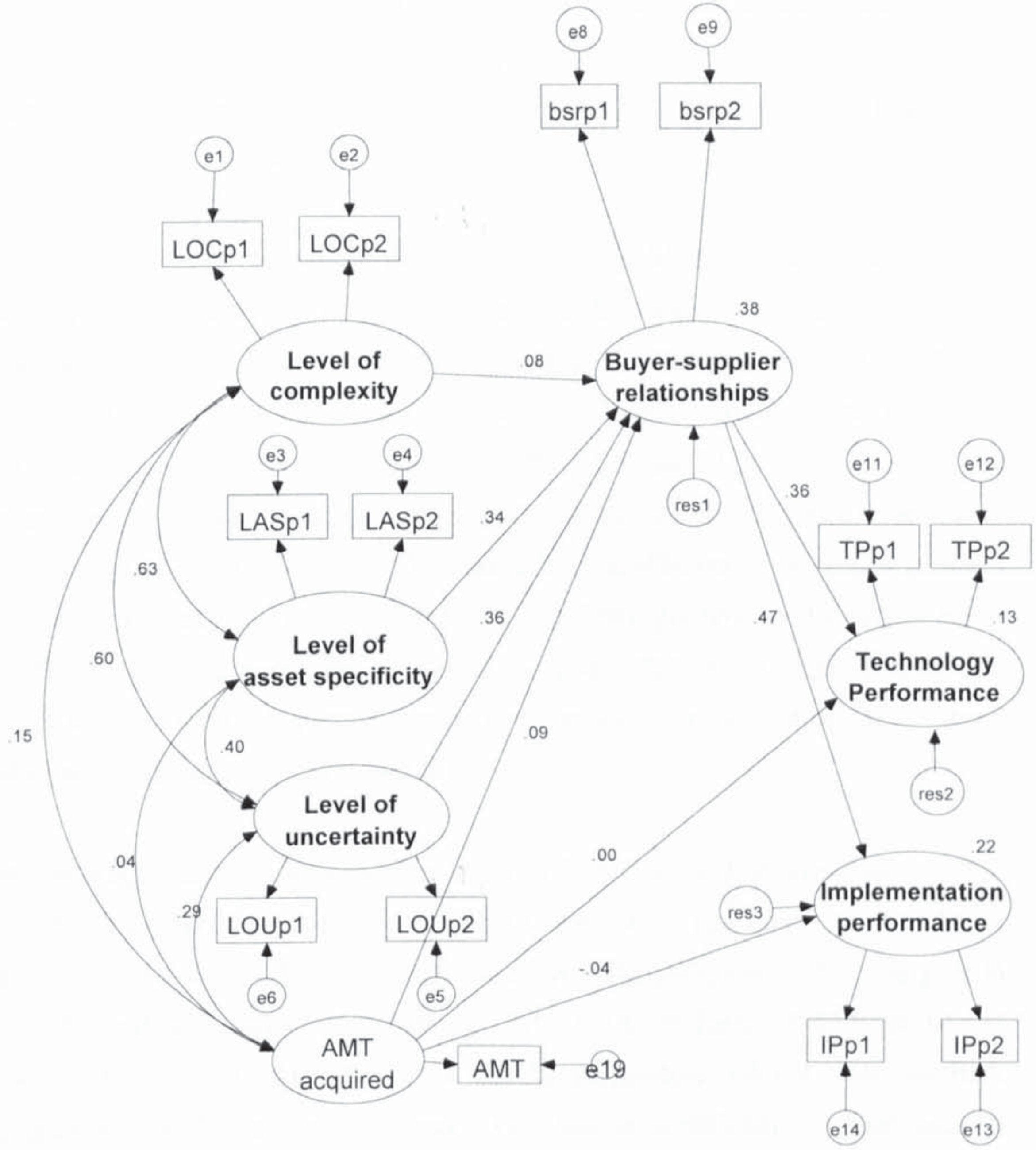
1. How do transaction attributes affect the development of buyer-supplier relationships in advanced manufacturing technology acquisition and implementation?
2. Are firms that develop closer relationships with the technology supplier more likely to achieve a higher level of performance?

The type of AMT being acquired was included in the model based on the findings from ANOVA indicating significant mean differences in the *level of uncertainty* associated with the type of technology being acquired. Other demographic characteristics such as *company years in operation* and *ownership status* were not included as control variables because of their non-significant findings from ANOVA. In SEM, the commonly-recommended approach to control for variables is to allow these variables to co-vary with each other and with other independent variables; and to cause all of the dependent variables. Thus in this study, the type of AMT being acquired was allowed to co-vary with LOC, LAS, and LOU and to cause BSR and both aspects of Performance.

Except for AMT being acquired, all other variables in the model are latent variables with more than one indicator. One issue with demographic variables in the SEM model is its single item variable. A common way to deal with a single item measure (i.e. composite scale) is by specifying or fixing the reliabilities of the variable. However, as noted earlier, it is impossible to estimate the reliabilities for demographic variables. One suggestion to handle the problem is to set the reliability to 1, indicating that there is no measurement error at all. However, this suggestion is not practical in a survey method because a measurement error should be expected since reliability is usually affected by data collection design (Hair et al., 2006) . Thus, allowing for the measurement error, (i.e. 10% chances of error in the response), the reliability for AMT type was set to .90 (error variance= 0.1).

Figure 5.3 indicates the path diagram of the hypothesised model and its standardised coefficient. SEM suggests that the hypothesised model was a satisfactory fit to the sample data with $\chi^2$ (52) = 97.50, p = .00; GFI = .91; CFI = .95, TLI = .92 and RMSEA = .08. The chi-square statistics were significant but other fit indices indicate a recommended level of indices, thus suggesting a well-fitting BSR measurement model. Since the interest at this point is the path between latent variables, there is no empirical and theoretical justification to modify or re-specify any of the existing relationships in the hypothesised model.

**Figure 5.3: The full hypothesised model and its standardised coefficient**




**MODEL-FIT INDICES**

| Chi-square ($\chi^2$) | GFI | CFI | TLI | RMSEA |
|---|---|---|---|---|
| 97.50, d.f. 52 | .91 | .95 | .92 | .08 |

In SEM, it is important to examine the decomposition of structural effects in the model. The estimation of direct and indirect effects can be looked at as "a way to decompose observed correlations into their constituent parts, spurious and non-spurious (causal). A path model is said to fit the data if these decompositions can reproduce the observed correlations" (Kline, 1998, p.53) . Total effects are the sum of all the direct and indirect effects of one variable on another. Direct effects represent the direct effect of one variable on another variable, while indirect effects involve "one or more intervening variables that transmit some of the causal effect or prior variables onto subsequent variables" (Kline, 1998, p.52). The magnitude of the direct effect is given by the product of the standardised coefficients of the paths linking the two variables (Bentler, 1995).

To summarise the findings from the hypothesised model in Figure 5.3, LOC has a non-significant positive (p=.37) direct effect on BSR (standardised coefficient = .08), LAS has a significant positive (p=.01) direct effect on BSR (standardised coefficient = .34), and LOU has a significant positive (p=.01) direct relationships with BSR (standardised coefficient = .36). Together, LOC, LAS, and LOU explain 38% of the variance in BSR. BSR is a significant predictor of TP and IP. BSR has a significant positive (p=.01) direct effect with TP (standardised coefficient = .36) and it explains 13% of the variance in TP. BSR also has a significant positive (p=.00) direct effect with IP (standardised coefficient = .47) and it explains 22% of the variance in IP. The control variable (AMT acquired) appears to have insignificant relationships with all endogenous variables (BSR, TP, and IP)

LOC has a significant positive indirect effect on BSR (standardised coefficient = .43). For LOC, the total of indirect effect to BSR (standardised coefficient =.50) is larger than the total of direct effect with BSR (standardised coefficient = .08). The path in which the indirect effect occurs is through LAS (LOC → LAS → BSR) and LOU (LOC → LOU → BSR). LAS has a significant positive indirect effect on BSR (standardised coefficient = .19), and LOU has a significant positive indirect relationship with BSR (standardised coefficient = .19). Together, LOC, LAS, and LOU explain 38% of the variance in BSR. For both LAS and LOU, the direct effect is larger than the indirect effect. Finally as for total effect, the total effect of LOC on BSR = .51, LAS on BSR = .53, LOU on BSR = .55, BSR on TP = .36, and finally the total effect of BSR on IP = .47. Table 5.29 summarises the result of the direct effect, indirect effect and total effect on the path model.

**Table 5.29: Standardised direct, indirect, and total effects of hypothesised path**

| Path | Direct effect (DE) | Indirect effect (ID) | Total effect (DE + ID) |
|---|---|---|---|
| LOC to BSR | 0.08 | Through LAS + Through LOU<br>0.21 + 0.22<br>= 0.43 | 0.51 |
| LAS to BSR | 0.34 | Through LOC + Through LOU<br>.05 + .14<br>= 0.19 | 0.53 |
| LOU to BSR | 0.36 | Through LOC + Through LAS<br>.05 + .14<br>= 0.19 | 0.55 |
| BSR to TP | 0.36 | - | 0.36 |
| BSR to IP | 0.47 | - | 0.47 |

### 5.6.2 Testing for mediation

In SEM, the indirect path represents a mediated path between variables. Investigation of the path in the hypothesised model indicates LOC has an indirect path towards BSR. It suggests that the correlation for LOC with BSR arises because LOC is correlated with LAS and LOC, not because LOC itself directly predicts BSR. Furthermore, a closer examination of the model indicated significant correlation between LOC and both LAS and LOU. The correlation value, however, is below the alarming value of .90 (Berry, 1993; Hair et al., 2006) for a multicollinearity problem (Test of multicollinearity was explained in section 5.4.1). Therefore, a test of mediation is conducted to see whether LAS and LOU mediate the relationships between LOC and BSR. A procedure recommended by Barron and Kenny (1986), who identified four required conditions for mediation, was adopted, as follows:

1. The independent variable must affect the dependent variable. In this model LOC must affect BSR;
2. The independent variable must affect the mediator. In this model, LOC must affect both LAS and LOU;
3. The mediator must affect the dependent variable, when the effect of the independent variable is controlled for. In this model, LAS and LOU must affect BSR when the effect of LOC is controlled for; and

4. The independent variable adds very little influence to the dependent variable beyond that added by the mediator. In this model the effect of LOC on BSR must be smaller in the presence of LAS or LOU compared to the absence of LAS or LOU.

At this stage, the main objective was to see the interaction effect of LOC on BSR alone, and therefore, the process was carried out using hierarchical multiple regression analysis. Firstly, regression analysis, with LOC as an independent variable and BSR as a dependent variable, was performed (Table 5.30). Then, in a separate hierarchical multiple regression analysis, the possible effect of LAS (Table 5.31) and LOU (Table 5.32) were removed, to discover whether the level of complexity was still able to explain the remaining variance in buyer-supplier relationships.

**Table 5.30: Regression analysis between LOC and BSR**

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
|---|---|---|---|---|
| 1 | .413(a) | .170 | .165 | .43825 |

a Predictors: (Constant), Level of complexity

**Table 5.31: Hierarchical regression analysis (LAS as mediator)**

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate | Change Statistics | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | R Square Change | F Change | Dfl | df2 | Sig. F Change |
| 1 | .506(a) | .256 | .251 | .41501 | .256 | 49.876 | 1 | 145 | .000 |
| 2 | .517(b) | .267 | .257 | .41330 | .011 | 2.203 | 1 | 144 | .140 |

a Predictors: (Constant), Level of asset specificity
b Predictors: (Constant), Level of asset specificity, Level of complexity

**Table 5.32: Hierarchical regression analysis (LOU as mediator)**

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate | Change Statistics | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | R Square Change | F Change | df1 | df2 | Sig. F Change |
| 1 | .543(a) | .294 | .290 | .40412 | .294 | 60.522 | 1 | 145 | .000 |
| 2 | .584(b) | .341 | .332 | .39179 | .047 | 10.274 | 1 | 144 | .002 |

a Predictors: (Constant), Level of uncertainty
b Predictors: (Constant), Level of uncertainty, Level of complexity

The results from Table 5.31 indicate that when the effect of LAS was controlled for, the level of complexity only explains 1.10% of variance in buyer-supplier relationships compared to 17.0% when the effect of LAS was not controlled for (Table 5.30). However, the change is not significant as the significant F change value exceeded the significant value of .05. Therefore, no consequence can be derived from this analysis. However, after controlling the effect of LOU, as seen from Table 5.32, LOC only explains 4.7% of the variance in buyer-supplier relationships, compared to 17.0% when the effect of uncertainty is not removed (Table 5.30). Since the F change value is significant and the effect of the independent variable (LOC) is smaller when the mediator (LOU) is in the equation (Barron and Kenny, 1986), the analysis suggests that most of the effect of LOC on BSR would be through LOU as a mediator. In other words, LOU partially mediates the relationships between LOC and BSR.

Another test used to measure the mediation effect is the single test, initially proposed by Sobel (1982). The Sobel test is much more common and is highly recommended (MacKinnon et al., 2002). It requires the following information:

1. Raw (unstandardised) regression coefficient (a) for the association between LOC and LOU
2. Standard error ($S_a$) of equation between LOC and LOU
3. Raw (unstandardised) regression coefficient for the association between LOU and BSR (when LOC is also a predictor of BSR)
4. Standard error ($S_b$) of the equation between LOU and BSR

To obtain the above information, two separate regression analyses were conducted. The first analysis was with LOC predicting LOU, and the second was with both LOC and LOU predicting BSR. The following results were obtained:

**Table 5.33: Sobel test for mediation effect**

| Input | | Test statistic | *p*-Value |
|---|---|---|---|
| a = 2.31 | Sobel test: | 5.18318234 | 2.2E-7 |
| b = .29 | Aronian test | 5.16773709 | 2.4E-7 |
| $S_a$ = .20<br>$S_b$ = .05 | Goodman test | 5.19876691 | 2E-7 |

The Sobel test resulted in p-Value of .0000022, indicating the significance of the test at $p<.05$. The test further confirms a significant, indirect effect of LOC on BSR, via LOC.

### 5.6.3 Examination of the competing model

The SEM results of the originally proposed model show a significant correlation value between LOC and both LAS and LOU, and the mediation test indicates that LOU mediates the relationships between LOC and BSR. Based on this statistical observation and guided by the theoretical justification, several competing models were developed to see whether they might offer an improvement in terms of model fit in comparison to the originally proposed model. Since control variables were found to have insignificant effect on all endogenous variables, it is excluded at this point of analysis. The first model is conceptualised by Figure 5.4. In this model both LOC and LAS correlate with each other and both affect LOU as well as BSR. Everything else remains the same as in the originally proposed model.

The second model is conceptualised by Figure 5.5. In this model, LOC affects both LAS and LOU, and then all the independent variables affect BSR. Everything else remains the same as in the originally proposed model. The third model is conceptualised by Figure 5.6 which shows the model being similar to model two, but instead of LOU and LAS correlating with each other, this time LAS affects LOU. The final model, conceptualised by Figure 5.7, is similar to model 3, but instead of LAS affecting LOU, this time LOU affects LAS. The results of the originally-proposed model and the alternative competing model are as follows:

**Table 5.34: Comparison of the competing (alternative) models**

| Model | Chi-square ($\chi^2$) | GFI | CFI | TLI | RMSEA |
|---|---|---|---|---|---|
| Proposed model (Figure 5.3) | 97.50, d.f. 52 | .91 | .95 | .92 | .08 |
| Model 1 (Figure 5.4) | 83.71, d.f. 47 | .91 | .95 | .95 | .08 |
| Model 2 (Figure 5.5) | 83.71, d.f. 46 | .91 | .95 | .95 | .08 |
| Model 3 (Figure 5.6) | 83.71, d.f. 46 | .91 | .95 | .95 | .08 |
| Model 4 (Figure 5.7) | 83.71, d.f. 46 | .91 | .95 | .95 | .08 |

* All direct paths in these model are significant at $p<.05$, except for the path from LOC to BSR

Four main observations from the analysis are derived:

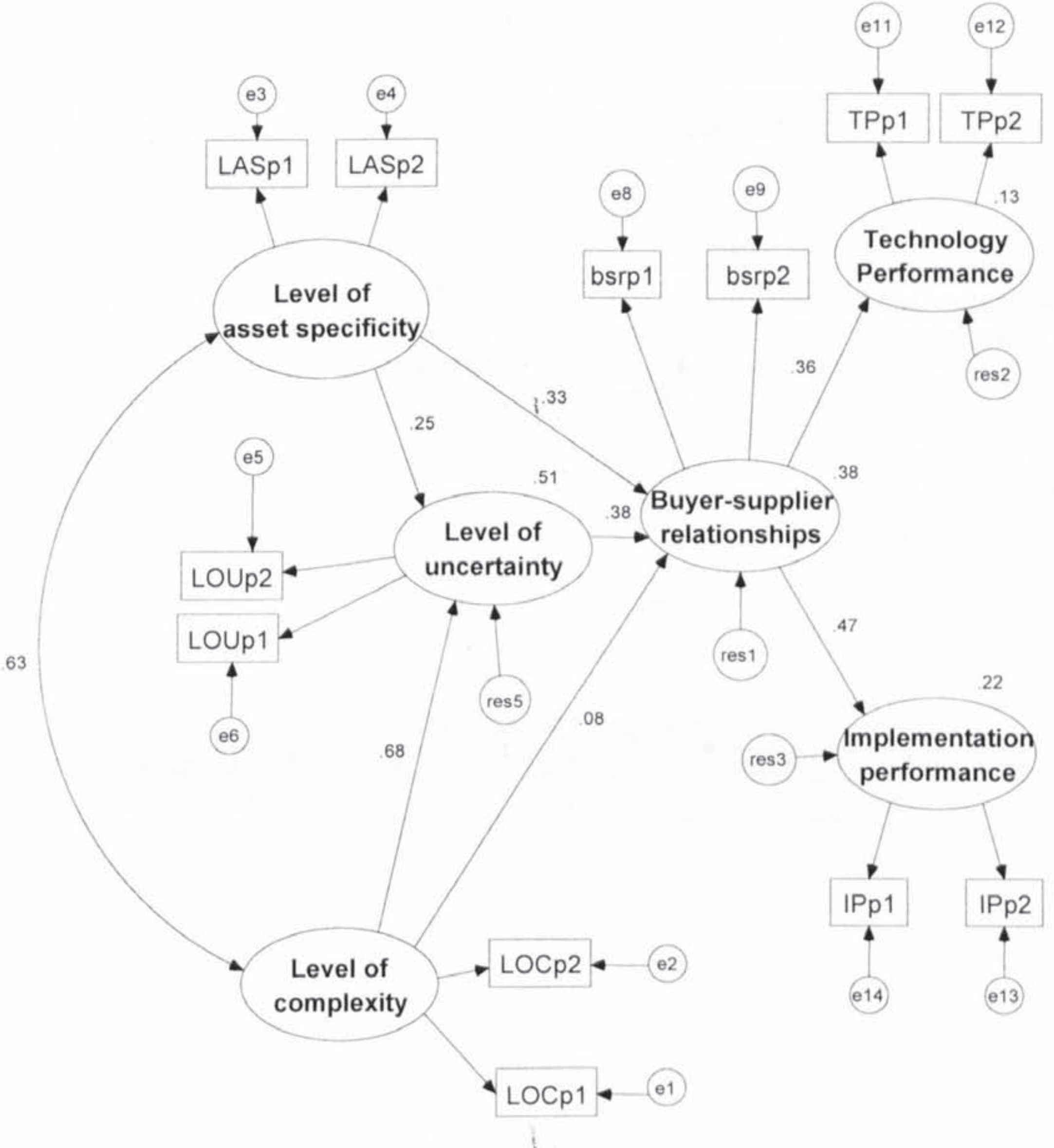
1. Compared to the original model, the alternative model results in a slightly lower value of chi-square.
2. Amongst the alternative models, chi-square value and other fit indices value are similar.
3. Regardless of the arrangement of LOC, LAS, and LOU in the model (original and alternatives), the result indicates these to explain 38% of the variance in BSR.
4. Regardless of the arrangement of LOC, LAS, and LOU in the model (original and alternatives), LOC indicates insignificant direct relationships with BSR.

Just like when using any other statistical technique, when using SEM, researchers have to make subjective choices on complex elements that are highly interdependent, in order to align research objectives with analytical requirements (Shah and Goldstein, 2006). Based on statistical evidence and theoretical judgement, a decision was made to take the alternative model 1 as an acceptable final model in understanding the impact of transaction attributes on buyer supplier relationships in the acquisition and implementation of advanced manufacturing technology. Model 1 was chosen over model 2 because model 1 did not pose any causal relationship between LOC and LAS, as it is proven in model 3 and 4 that both directions, from LOC to LAS and from LAS to LOC, result in the same value of correlation. Thus, choosing the bi-directional relationships between the two variables is the best available option. The final model suggests that:

1. Level of complexity and level of asset specificity are inter-correlated with each other and both are positively correlated with Level of uncertainty.

2. Level of asset specificity however, has more direct impact on buyer supplier relationships than indirect impact through level of uncertainty, whereas, level of complexity is related to buyer supplier relationships largely because it is related to uncertainty.
3. Level of uncertainty has direct impact upon buyer supplier relationships.
4. Buyer-supplier relationships have an impact on both aspects of performance. However, the impact is bigger on implementation performance than on technology performance.

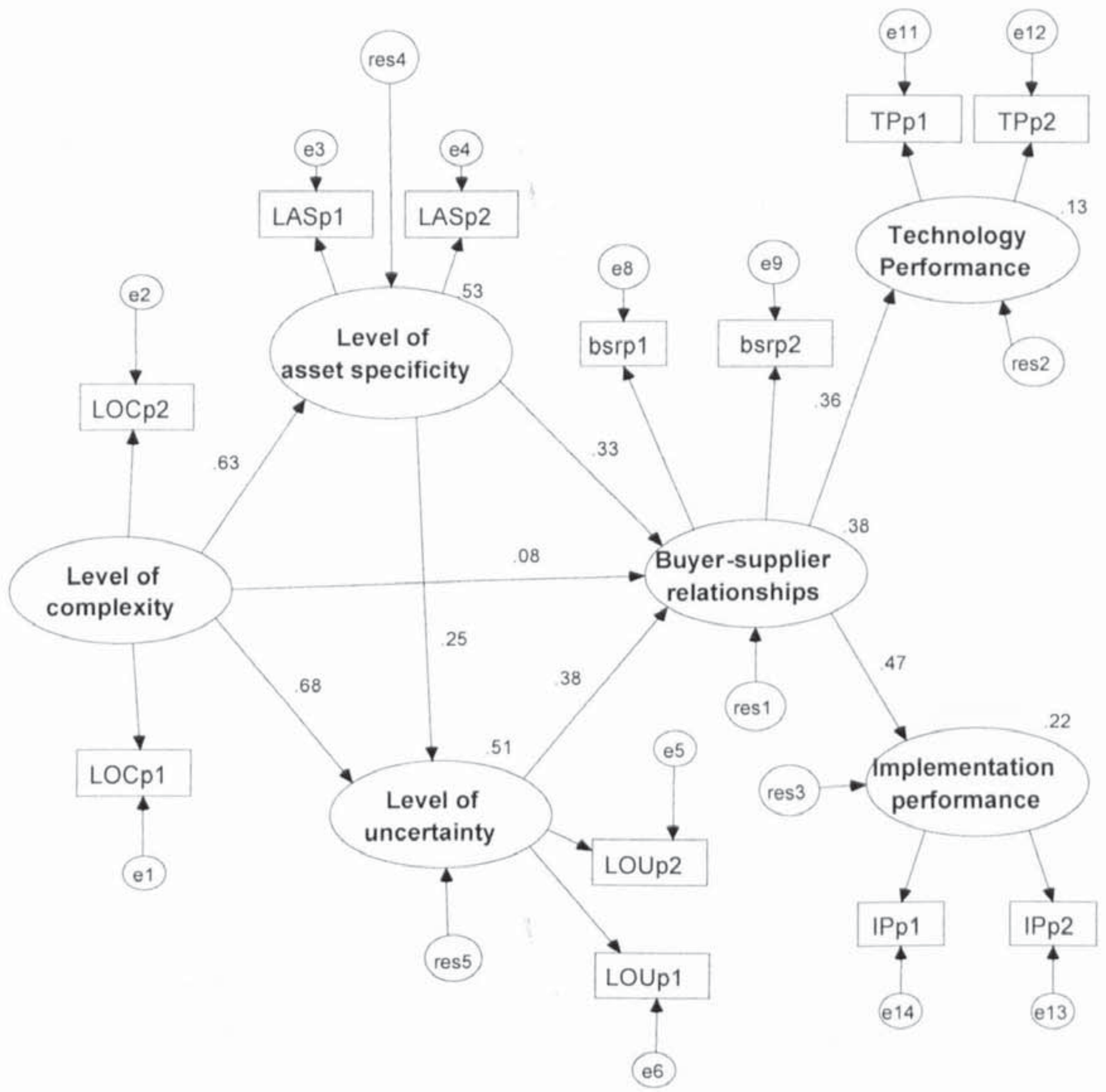
**Figure 5.4: Competing model (model 1) and its standardised coefficient**




**MODEL-FIT INDICES**

| Chi-square ($\chi^2$) | GFI | CFI | TLI | RMSEA |
|---|---|---|---|---|
| 83.71, d.f. 46 | .91 | .95 | .95 | .08 |

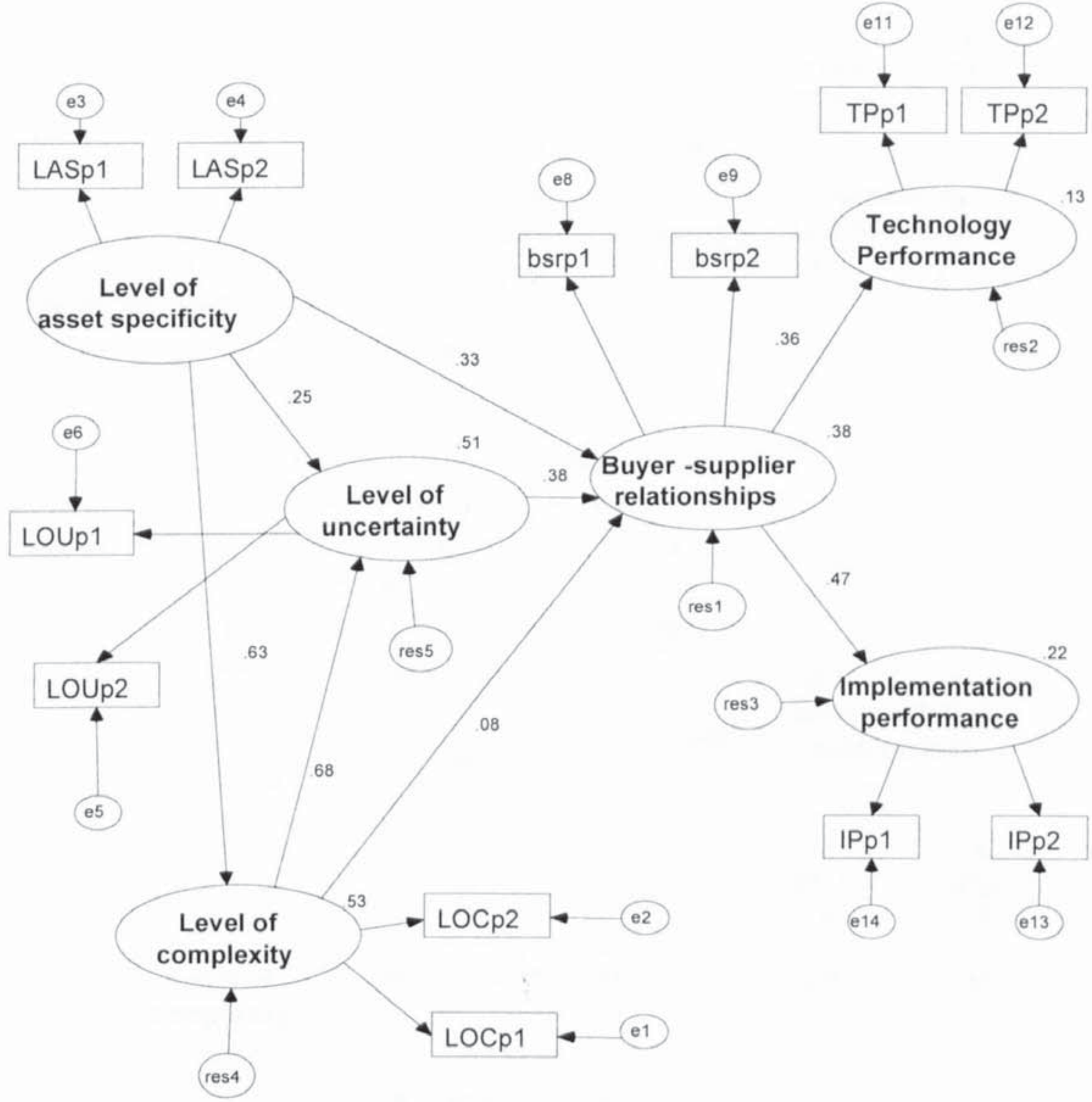
**Figure 5.5: Competing model (model 2) and its standardised coefficient**




## MODEL-FIT INDICES

| Chi-square ($\chi^2$) | GFI | CFI | TLI | RMSEA |
|---|---|---|---|---|
| 83.71, d.f. 47 | .91 | .95 | .95 | .08 |

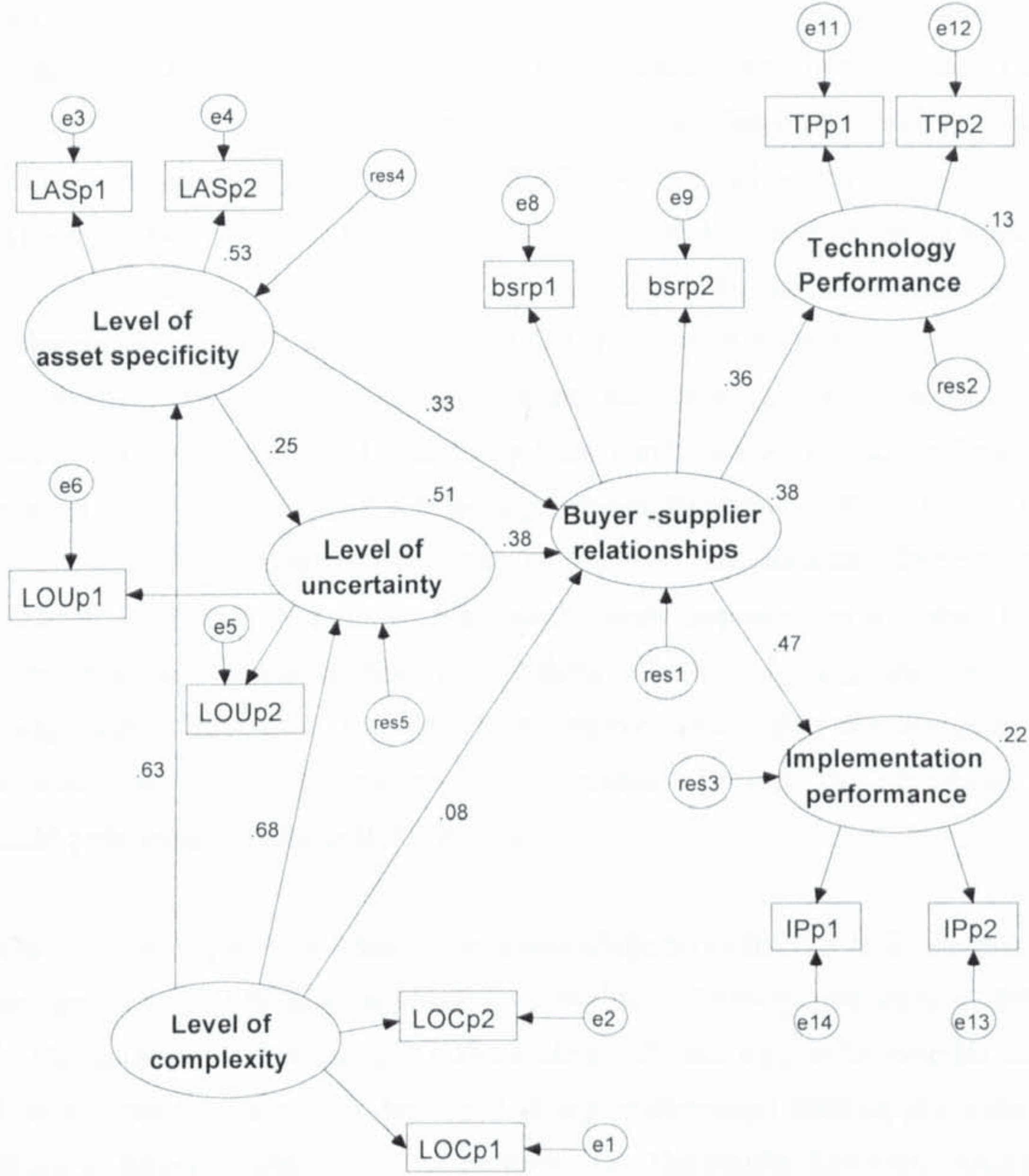
**Figure 5.6: Competing model (model 3) and its standardised coefficient**




**MODEL-FIT INDICES**

| Chi-square ($\chi^2$) | GFI | CFI | TLI | RMSEA |
|---|---|---|---|---|
| 83.71, d.f. 46 | .91 | .95 | .95 | .08 |

**Figure 5.7: Competing model (model 4) and its standardised coefficient**




MODEL-FIT INDICES

| Chi-square ($\chi^2$) | GFI | CFI | TLI | RMSEA |
|---|---|---|---|---|
| 83.71, d.f. 46 | .91 | .95 | .95 | .08 |

### 5.6.4 Summary of finding from SEM in relation to hypotheses testing

Five hypotheses were tested in the preceding analysis. The first three hypotheses relate to the effect of transaction attributes on buyer-supplier relationships. Level of asset specificity (H1), Level of uncertainty (H2) and Level of complexity (H3) were proposed to be significantly affecting the development of buyer-supplier relationships

(BSR). The finding provides support for H1 and H2. Level of asset specificity (LAS) and level of uncertainty (LOU) positively affected BSR. The higher the level of asset specificity and uncertainty surrounding the acquisition and implementation of the technology, the more likely firms will engage in closer relationships with the technology supplier. The findings from SEM, however, fail to provide support for H3. Although LOC and BSR were found to be correlated through bivariate correlation analysis, this was not significant in predicting BSR in comparison to other independent variables such as LAS and LOU. The overall interactions of the variables under simultaneous SEM analysis indicate that there was no significant direct relationship between level of complexity (LOC) and BSR. However, the findings did suggest a significant indirect relationship between LOC and BSR. A further test of mediation through regression analysis suggests that LOU mediates the relationships between LOC and BSR. In another words, firms experiencing a higher level of complexity will engage in closer relationships with the technology supplier because complexity affects their feelings of uncertainty surrounding the acquisition and implementation of the technology. The interrelations between LOC and LOU in the SEM path model also suggest this prediction.

The next two hypotheses relate to the relationships between BSR and performance. It was proposed that BSR is significantly related to technology performance (H4) and implementation performance (H5). The finding indicates support for both H4 and H5. It was found that firms that developed strong relationships with suppliers are more likely to achieve a higher level of performance. The results, however, indicate that BSR correlates more with implementation performance than with technology performance.

### 5.6.5 Testing of sub-hypotheses regarding research question three

The last research question aimed to establish whether transaction attributes influence the interaction effect between BSR and performance. For this purpose, the relationships between BSR and performance, on the basis of transaction attributes were investigated. With this procedure, the sample needs to be divided into three different groups using the median as a cut off point, thus reducing the sample from the original number of sample firms. Given the smaller sample size to parameter ratio in this analysis, a decision was made to test the sub-hypotheses using ANOVA instead of SEM.

A one-way ANOVA test was imposed using the SPSS 14.1 package. Apart from the ability of the test to observe how firms that possess different levels of transaction attributes achieved different levels of performance under different modes of buyer-supplier relationships, it also operates as a control mechanism to ensure that the differences in performance level are caused purely by the differences in buyer-supplier relationships, and are not contaminated by the level of transaction attributes possessed by the firm. BSR were divided into three groups using the median as a cut-off point. Scores below 2.8 were considered as representing low buyer-supplier relationships, scores between 2.8 and 3.2 were considered as moderate buyer-supplier relationships, and scores of 3.3 and above were considered as strong buyer-supplier relationships.

On the basis of transaction attributes, Tables 5.35 and 5.36 indicate the ANOVA results for the relationships between BSR and technology performance and implementation performance respectively. Levene's test for homogeneity of variances for all tests, gives the significant value of larger than .05, indicating that the assumption of homogeneity of variance across the three buyer-supplier relationships was not violated.

Hypothesis 6a stated that within the same level of complexity, performance will vary depending on the strength of BSR. The results indicate that there is a statistically significant difference ($p < .05$) in the mean score on implementation performance for each of the three BSR levels (Table 5.36). The post-hoc tests indicate that strong BSR differs significantly in terms of implementation performance level with both moderate and weak BSR. In other words, the results show that as BSR improves, so does implementation performance for all three levels of complexity. However, this is not the case for technology performance (see Table 5.35). The results indicate that, only in high levels of complexity, is there a significant difference in technology performance as the strength of BSR changes. Although in a moderate and low level of complexity, the results show a higher mean of technology performance achievement for those that develop strong buyer-supplier relationships, the ANOVA result indicates that the differences are not significant. Therefore, this gives support to hypothesis 6a with respect to implementation performance but does not fully support the argument for technology performance.

Hypothesis 6b stated that within the same level of asset specificity, performance will vary depending on the strength of BSR. The results again indicate that there is a statistically significant difference ($p < .05$) in the mean score on implementation performance for each of the three BSR levels (Table 5.36). The post-hoc tests showed similar relationships as found for level of complexity. As for the technology performance (Table 5.35), the result indicates that significant difference in this as the strength of BSR changes, is only found in a strong and moderate level of asset specificity. Again this gives support for hypothesis 6b with respect to implementation performance, but does not fully support the argument for technology performance. Finally hypothesis 6c stated that within the same level of uncertainty, performance will vary depending on the strength of BSR. The results show that except for low levels of uncertainty, both technology and implementation performance significantly increase as the strength of BSR improves. In this case hypothesis 6c is partially supported for both measures of performance.

Although the result indicates insignificant differences in technology performance in the moderate and lower levels of transaction attributes, several important observations were derived from the results in Tables 5.35 and 5.36. Firstly, within the same level of transaction attributes, strong buyer-supplier relationships perform higher than moderate or weak buyer-supplier relationships (refer to the mean value of both performance levels). Secondly, developing stronger relationships with the technology supplier also resulted in a significantly different performance achievement in comparison to developing moderate or weak relationships with the technology supplier.

Finally, observations from Table 5.36 indicate that in a higher level of complexity, asset specificity, and uncertainty, implementation performance is much lower for weak buyer-supplier relationships. On the other hand, implementation performance of firms that developed weak buyer-supplier relationships is much higher in a low level, compared to higher and moderate levels of complexity and asset specificity. This suggests that firms that experience a lower level of transaction attributes pose no immediate risk of not developing close relationships with the technology supplier compared to firms experiencing a higher level of transaction attributes. This further supports the second observation which identifies the fact that developing stronger buyer-supplier relationships is even more important when firms experience a higher level of transaction attributes in the technology acquisition and implementation process. However, again it should be noted that in any level of transaction attributes, strong buyer-supplier relationships still indicate a higher level of performance compared to moderate or low levels of buyer-supplier relationships.

**Table 5.35: ANOVA result for differences in technology performance and BSR score by level of transaction attributes**

| | BSR | N | Mean (Technology performance) | S.D | ANOVA[a] (sig. value) | Post Hoc Test (ρ-value < .05) |
|---|---|---|---|---|---|---|
| **Level of complexity** | | | | | | |
| High | Strong | 29 | 3.94 | 0.37 | 0.001 | Significant different between Strong BSR & Moderate BSR |
| | Moderate | 19 | 3.46 | 0.50 | | |
| | Weak | 13 | 3.73 | 0.31 | | |
| Moderate | Strong | 13 | 3.77 | 0.33 | **0.107** | - |
| | Moderate | 11 | 3.50 | 0.38 | | |
| | Weak | 14 | 3.73 | 0.29 | | |
| Low | Strong | 7 | 3.85 | 0.24 | **0.046** | - |
| | Moderate | 18 | 3.58 | 0.47 | | |
| | Weak | 23 | 3.43 | 0.37 | | |
| **Level of asset specificity** | | | | | | |
| High | Strong | 26 | 3.89 | 0.41 | 0.043 | Significant different between Strong BSR & Moderate BSR |
| | Moderate | 18 | 3.57 | 0.53 | | |
| | Weak | 7 | 3.29 | 0.35 | | |
| Moderate | Strong | 19 | 3.89 | 0.28 | 0.002 | Significant different between Strong BSR & Moderate BSR |
| | Moderate | 17 | 3.44 | 0.43 | | |
| | Weak | 11 | 3.50 | 0.42 | | |
| Low | Strong | 4 | 3.88 | 0.14 | **0.162** | - |
| | Moderate | 13 | 3.52 | 0.40 | | |
| | Weak | 32 | 3.54 | 0.32 | | |
| **Level of uncertainty** | | | | | | |
| High | Strong | 36 | 3.88 | 0.36 | 0.012 | Significant different between Strong BSR & Weak BSR |
| | Moderate | 11 | 3.50 | 0.66 | | |
| | Weak | 11 | 3.52 | 0.48 | | |
| Moderate | Strong | 10 | 3.85 | 0.36 | 0.043 | Significant different between Strong BSR & Weak BSR |
| | Moderate | 25 | 3.52 | 0.38 | | |
| | Weak | 9 | 3.72 | 0.26 | | |
| Low | Strong | 3 | 3.92 | 0.14 | **0.204** | - |
| | Moderate | 12 | 3.50 | 0.41 | | |
| | Weak | 30 | 3.56 | 0.34 | | |

Non significant values (ρ-value ≥ .05) are highlighted in bold

**Table 5.36: ANOVA result for differences in implementation performance and BSR score by level of transaction attributes**

| | BSR | N | Mean (Implementation performance) | S.D | ANOVA[a] (sig. value) | Post Hoc Test (ρ-value < .05) |
|---|---|---|---|---|---|---|
| **Level of complexity** | | | | | | |
| High | Strong | 29 | 3.76 | 0.33 | 0.000 | Significant different between: |
| | Moderate | 22 | 3.30 | 0.45 | | 1. Strong BSR & Moderate BSR |
| | Weak | 10 | 3.11 | 0.33 | | 2. Strong BSR & Weak BSR |
| Moderate | Strong | 13 | 3.81 | 0.33 | 0.000 | Significant different between: |
| | Moderate | 11 | 3.40 | 0.27 | | 1. Strong BSR & Moderate BSR |
| | Weak | 14 | 3.21 | 0.26 | | 2. Strong BSR & Weak BSR |
| Low | Strong | 7 | 3.83 | 0.19 | 0.004 | Significant different between: |
| | Moderate | 18 | 3.38 | 0.42 | | 1. Strong BSR & Moderate BSR |
| | Weak | 23 | 3.32 | 0.33 | | 2. Strong BSR & Weak BSR |
| **Level of asset specificity** | | | | | | |
| High | Strong | 26 | 3.76 | 0.34 | 0.000 | Significant different between: |
| | Moderate | 18 | 3.19 | 0.35 | | 1. Strong BSR & Moderate BSR |
| | Weak | 7 | 3.00 | 0.35 | | 2. Strong BSR & Weak BSR |
| Moderate | Strong | 19 | 3.81 | 0.26 | 0.001 | Significant different between: |
| | Moderate | 18 | 3.46 | 0.39 | | 1. Strong BSR & Moderate BSR |
| | Weak | 10 | 3.33 | 0.39 | | 2. Strong BSR & Weak BSR |
| Low | Strong | 4 | 3.88 | 0.39 | 0.002 | Significant different between: |
| | Moderate | 15 | 3.42 | 0.40 | | 1. Strong BSR & Moderate BSR |
| | Weak | 30 | 3.26 | 0.27 | | 2. Strong BSR & Weak BSR |
| **Level of uncertainty** | | | | | | |
| High | Strong | 36 | 3.82 | 0.29 | 0.000 | Significant different between: |
| | Moderate | 11 | 3.29 | 0.58 | | 1. Strong BSR & Moderate BSR |
| | Weak | 11 | 3.04 | 0.47 | | 2. Strong BSR & Weak BSR |
| Moderate | Strong | 10 | 3.73 | 0.33 | 0.002 | Significant different between: |
| | Moderate | 25 | 3.36 | 0.30 | | 1. Strong BSR & Moderate BSR |
| | Weak | 9 | 3.26 | 0.26 | | 2. Strong BSR & Weak BSR |
| Low | Strong | 3 | 3.56 | 0.54 | **0.139** | - |
| | Moderate | 12 | 3.39 | 0.38 | | |
| | Weak | 30 | 3.23 | 0.27 | | |

Non significant values (ρ-value ≥ .05) are highlighted in bold

The overall result from the sub-hypotheses confirms that within the same level of transaction attributes (for instance, similar level of complexity), performance improved when firms developed stronger relationships with their technology suppliers. This result was more supported for implementation performance than for technology performance.

## 5.7 CHAPTER SUMMARY

This chapter has presented the key findings of the statistical tests carried out in this study. Initial analysis highlighted the assessment on the measurement. Validity analysis (through both EFA and CFA) and reliability tests were carried out to ensure that the interpretation of statistical findings associated with this dataset could be made with confidence. Also, each main statistical analysis used to test the hypotheses was thoroughly checked to ensure all statistical assumptions are met. Hypotheses 1 to 5 were tested simultaneously using the SEM technique. The three sub- hypotheses (H6a, H6b, H6c were tested using one-way ANOVA. The results offer strong support for *level of asset specificity* and *level of uncertainty* in predicting BSR but fail to support *level of complexity* as the predictor of BSR. Instead, level of complexity is related to BSR largely because complexity affects the level of uncertainty, which has a direct impact on BSR. There is a linkage between strong BSR and the achievement of performance. However, the linkage is stronger for *implementation performance* than *technology performance*. Overall, H1, H2, H4, and H5 are supported but H3 fails. H6a is fully supported for *implementation performance* but partially supported for *technology performance.* H6b also is fully supported for *implementation performance* but partially supported for *technology performance*. Finally, H6c is partially supported for both *technology* and *implementation performance*. Chapter Seven explores in more detail, the implications of these results for both theory and practice. The following chapter builds upon, and extends these findings by presenting the case analysis as a result of the semi-structured interviews, which were also undertaken as part of the overall research methodology.

# CHAPTER SIX
# CASE STUDY ANALYSIS AND RESULTS

## 6.1 INTRODUCTION

This chapter introduces seven case studies from the research investigations, each with distinct features in terms of level of complexity, the level of asset specificity, the level of uncertainty, the nature of relationship with the technology supplier, and the level of performance achieved. Together, they provide an identification of how different transaction attributes lead to differences in the way a firm depends on or chooses to collaborate with the technology supplier during the entire process of technology implementation. The differences in the nature of the relationship with the technology supplier shown in these cases, demonstrate how they affect the level of performance achieved by the sample firm. The insights from the cases help to identify linkages between the transaction attributes, buyer and supplier relationships, and performance. They also help to further verify the results of the survey, and finally confirm the research framework.

This chapter consists of two main parts. Part one is an in-depth analysis of an individual case study and Part two provides the cross-case analysis where key issues arising from the individual case analyses were identified and discussed. The observations on the cross-case analysis were mainly related to the study's main hypotheses. In this case, the 'before installation phase' refers to the period when the buyer starts to deal with technology supplier, the 'installation phase' starts when the technology arrives at the buyer's site, and the 'after installation phase' starts after the technology is fully installed and/or the installation team leave the buyer's site.

In the assessment of the 'nature of relationships with the technology supplier' section, only problems with large supplier involvement are presented. Other problems associated with the technology implementation, especially without or with very minimal elements of supplier involvement, are beyond the scope of this case study. This section also presents how the technology buyer senses the aspects of trust, business understanding, involvement, commitment, communication, information sharing, and knowledge acquisitions, have taken place throughout the relationship with the technology supplier.

In the 'technology performance' section, companies were asked how the technology has improved manufacturing performance in terms of reducing lead-time, reducing cost, increasing quality, and increasing efficiency and flexibility. Thus, the 'performance' section only presents the above-mentioned aspects, and excludes other aspects such as strategic and financial. Alternatively, the 'implementation performance' section presents firms' satisfaction with the six aspects of implementation performance, as highlighted at the questionnaire, SECTION F, part b. It also presents the companies' acknowledgements of mistakes in their buyer-supplier relationships, which have subsequently led to a reduced level of satisfaction in the implementation stage of the acquired technology.

## 6.2 CASE A. HKK DOUBLE LION SDN BHD (HKK)

### 6.2.1 The background

HKK is a one of the oldest flavoured-juiced beverage manufacturing companies in Malaysia. The company was founded in 1972 and has been part of a family business for 33 years. It is located at Kuala Lumpur, Malaysia and employs 60 people. While retaining the family-owned feel and responsiveness, HKK has adapted in many ways, to the changing industries it serves. Due to increased demand, growing business, and as part of the ongoing process to fully automate its operations, the company has introduced a Robotics carton palletising system into its manufacturing operation. The reason for this latest acquisition was mainly to automate the previous manual packing, stacking, and storing system in order to keep up with the automated line speed. The system components consist of a high-speed, four-axis robot designed specifically for palletising applications, bottle handling end-of-arm-tooling, accumulation conveyor, and a push button interface panel.

### 6.2.2 Production process: Production of large batches

### 6.2.3 Brief description of the technology acquisition

- Technology acquired: Carton palletising robot system
- Technology manufacturer: Japan
- Technology supplier: Independent system provider
- Technology type: New
- Year of acquisition: 2002
- Nature of acquisition: Full system provided by one supplier

### 6.2.4 Case analysis

#### 6.2.4.1 Transaction attributes in relation to technology acquisition

Implementing the palletising systems is considered as a complex task for HKK especially because it gradually transformed itself from a small home-based business into a fully-automated business operation. Another challenge to HKK is the limited space in the company's manufacturing floor. HKK has no intention to invest in new production land since the plant and the land possessed by the company is already paid for and owned by the family. Thus, the only option is to rearrange the end design of its manufacturing space so that the newly-implemented technology will create a larger space for the robotic working envelope, and a smaller space for stacking and storing. This means that the implementation of the technology results in changes on the company's current manufacturing layout.

HKK recognises its lack of knowledge and expertise regarding the new technology, and hence, during the past ten years, it made sure that the company did not have a shortage of expertise in the robotic system. Before acquiring the system, HKK had hired an experienced facilities engineer to help transform it into a fully-automated operation. Apart from sending key workers for training, the CEO, who also acts as an operation manager, underwent ongoing training to increase his knowledge in the world of advanced manufacturing technology. The amount of money invested for training was considered small to the firm, when compared to the amount invested in the previous acquisition project.

Even though HKK invested a huge amount of money to acquire the technology, the investment was not, however, considered as major to the company, since although the robotic system is needed to complete the operation, it does not contribute to the main process of production, and therefore, does not represents a core competence to the firm's business. Essentially, the palletising robot functions to enhance the packing, stacking, and storing of the final product. Nonetheless, it delivers significant benefits in backing up the overall production performance.

Considering the achievement of its early automated bottling and labelling technology, HKK was certain that an investment in the new technology would bring added value to the company. However, despite the existing in-house expertise, HKK believed its lack of experience in handling similar types of technology, and the limitation of its production space, required it to depend on the technology supplier throughout the implementation process. Thus, a significant fee was paid to the supplier in providing consultancy and assistance to ensure the success of the technology implementation.

#### 6.2.4.2 Nature of relationships with the technology supplier

***Before installation***

The supplier was identified after a serious justification had been arrived at by HKK in respect of the technology features, capability and the priced offered, and from the early stage of implementation, the supplier was very involved, with frequent communication occurring between the two parties where information about HKK's manufacturing process and requirements was exchanged. Within just a short period of time, an agreement was achieved, HKK being convinced that the supplier would be capable of providing the company with the high quality technology at the best cost.

Business understanding was achieved through detailed discussion about HKK's product, manufacturing process, and performance objectives. For instance, HKK has 12 different types of juices with various types of bottles ranging from 220 ml to 5 litre sizes. Hence, the palletising system had to be capable of handling various sizes and styles of bottles and had to accommodate changes in each bottler's filled amount and volume. The bottle characteristics also vary depending on the types of ingredients used and the fill volumes required.

HKK recalls that the supplier understood that in these situations, the robot program should offer flexibility in order to easily adjust the palletising positions to adapt to the bottle variations. The system proposed by the supplier is the one capable of palletising the product on 12 different sizes of pallets and to different unit load heights. The pallet type and load heights were pre-specified based on HKK requirements. All these details were discussed with the supplier, and both parties made a joint effort to find the best solution for HKK's business need. HKK claims that the company was working very closely with the technology suppliers and was happy with the result.

After the initial proposal, the supplier visited HKK's manufacturing site, enabling a proper identification of the system requirements and the challenges faced by the firm in implementing the new system. Because the HKK facility had limited available space for palletising automation, the robotic system needed to fit into an area restricted by existing equipment and simultaneously had to allow complete access to adjacent aisle- ways. HKK operators also needed easy access to other process equipment around the robot system as part of the normal operation. Together with the technology suppliers, HKK worked to evaluate the process and identify performance characteristics, such as speed or rates of flow; system flexibility; packaging; palletising; and storage requirements. The technology supplier provided a demonstration of the system prior to finalising the system proposal.

***During the installation***

Once the technology was shipped to HKK manufacturing facilities, the supplier continued to work with HKK engineering on the system installation and trial production, a process that took about two weeks. During this period, the supplier's team members remained on the HKK manufacturing site to start up the system and familiarise HKK personnel with operation and maintenance procedures.

Although the process rate requirements of the palletising robot were within the 25 bottles per minute capability, consistent with HKK production line capability, the suppliers provided a full test and demonstration during the trial phase. They also validated the installed palletising system concept as well as the system throughput requirements. Once the functional challenges were met, the supplier worked with HKK to develop multiple iterations of system concepts to find an optimal configuration that met all of the process requirements with minimal disruption to the existing process.

Training on the technology was conducted at the HKK site during the implementation stage in order to save the costs of sending employees overseas for off-the-job training. During the first week of implementation, workers who operated the machine were trained by the suppliers on how to use the main interface point for the palletising system through the Robotics pendant. The workers were also trained to perform operations like selecting the appropriate pallet pattern, bottle size/type and number of layers to be palletised by using the system Pallet Tool software

*After the installation*

The systems package came with a full parts and labour warranty for the first 12 months. After the installation and trial production, the supplier was involved in the scheduled maintenance programme, and was also referred to regarding several technical problems on component trouble shooting or general programming through the on-line or telephone support service. At the time of interviewing, HKK was capable of conducting its own maintenance and troubleshooting in respect of any hardware or software problems.

HKK confirmed that supplier involvement with the implementation project extended well beyond the installation stage. The availability of the technical support was very helpful in ensuring the system performance. Moreover, the commitment of the supplier in responding to unexpected disruptions after the installation, and in making sure that the benefits from the technology were optimised was also very satisfying. HKK fully recognised the importance of involving the technology supplier throughout the entire implementation process, and believed that the process had been effective because true and complete information was shared between both parties and useful knowledge was acquired from the supplier, during the process.

#### 6.2.4.3 Technology performance

HKK has always had the reputation of being a company that emphasises customer satisfaction, attention to detail, and the flexibility to adapt to customer needs. It claims that the robotic system has helped to improve productivity, ensuring the company is well-positioned to be more flexible and responsive to customer's needs. The robot end-of-arm-tool is a mechanical clamp style tool, especially designed to accommodate a wide range of container size without having to stop, which according to HKK, saves changeover time. The powerful robotic systems, which can stack products much higher than manual pallets, also helped HKK to increased warehouse capacity and reduce pallet handling and forklift transfer. The overall efficiency of the fill line also improved. Since the implementation, daily production volumes have exceeded those achieved by the previous manual process, leading to reductions in lead-time and cost. Overall, HKK was fully satisfied with the performance of the technology implemented.

#### 6.2.4.4 Implementation performance

HKK claims that the system has worked excellently since its implementation, which as a process took less than two months, faster than the scheduled time. HKK acknowledged that the speed and efficiency provided by the supplier helped to minimise production down-time. The main objectives of the robotic palletising system were to relieve employees from heavy lifting, and to increase production throughput, and both were achieved. Indeed, HKK has now doubled its throughput and surpassed its required speed and weight parameters. The investment was part of the firm's mission to fully automate its production line. HKK agrees that the knowledge gained from the technology supplier throughout the implementation process has helped the company to effectively reap the benefits from the implemented technology and will definitely help the company to implement more advanced technology in the future.

### 6.2.5 Influence of transaction attributes on the relationships with the technology supplier and its link with performance

Case A demonstrates how a firm that possesses a moderate level of transaction attributes in the technology acquisition, was able to build a good relationship with the technology supplier and achieve better technology and implementation performance.

The firm considered the acquired technology to be highly complex due its lack of experience in handling a similar technological innovation, and because it required the company to make some changes to its current manufacturing layout due to its limited plant space. However, the specificity of the technology to the company is of a moderate level because even though the company hired expertise to handle the technology implementation, the technology was not considered as a core competence to the business and from the description, a small amount of money was invested in training. Uncertainty about the technology was also of a moderate level because even though the firm was confident about the technology's capability, its lack of previous experience suggested the need for it to invest in consultancy and assistance from the technology supplier. In this case, as the company viewed the implementation of the technology as highly complex and as having some degree of uncertainty, and consequently opted to work closely with, and depend fully upon, the technology supplier during the implementation process.

Trust and business understanding were fully developed during the early process of technology implementation, as were involvement and commitment from the supplier. Good communication was evident throughout the technology implementation process, and information was shared especially before and during the installation stage. The knowledge acquired built confidence within the company for it to independently do the maintenance on the technology, and to have confidence in any future technology implementation.

Strong business understanding, intense discussion and exchange of information, especially before the technology was chosen and installed at the customer's site apparently led to the adoption of the right type of technology that suited the firm's business operation, which indirectly led to the success of the technology in achieving manufacturing performance. Involving the supplier during the installation process in this case avoided unnecessary delay in the installation, even though the implementation process was considered complex.

## 6.3 CASE B. MEDIA DISPLAYS SDN BHD (MEDIA DISPLAYS)

### 6.3.1 The background

Media Displays was established in 1977. The company began as a home-based screen printing business, and eventually expanded into one of the leading companies specialising in wood and plastic wall design, glass etching, granite carving, signage, and computer graphics. The company serves the entertainment, advertising, corporate event, and graphic arts industries, supplying a wide range of products such as dimensional signs, vinyl graphics, vehicle graphics, 3M Scotch print Graphics and small to grand format sized banners. It is located in Kuala Lumpur, Malaysia, and currently employs around 45 people.

Media Displays previously focused most of its attention towards producing a small-scale wood and plastic wall design, custom advertising, retail and decorative products. The growing interest in dimensional signs in the advertising market, led clients to request multiple layers of substrate stacking three, four, or five layers thick to create a multi-dimensional look. Also, some clients required large signs, and the amount of hand-cutting needed to produce those kinds of signs on a large scale was cost-prohibitive. The company either had to find a way to do the work profitably or give it up. Thus, it decided to expand its capabilities in developing new styles and new design, by implementing computer technology that could automate its production process. Before using the new technology, Media Displays was using traditional and manual woodworking tools, but the complex design was too labour intensive to be profitable. Another problem was that it was difficult to achieve the level of accuracy required, for example, to develop a complicated inlay that fit just perfectly.

In early 2000, the company finally invested in advanced computer numerical control (CNC) router technology, with the main expectation being that it would be capable of giving the company the ability to produce complicated 3D- contoured and inlaid patterns to a high level of accuracy, as demanded by the current market.

### 6.3.2 **Production process:** Production of a few units to customer specification

### 6.3.3 Brief description of technology accquisition

- Technology acquired: CNC Router
- Technology manufacturer: Taiwan
- Technology supplier: manufacturer's local office
- Technology type: Used (Refurbished)
- Year of acquisition: 2000
- Nature of acquisition: Full system provided by one supplier

### 6.3.4 Case analysis

#### 6.3.4.1 Transaction attributes in relation to technology acquisition

With no previous experience in the application of the automation technology in business, the CEO, one of the joint partners of the company, started looking at the trade magazines and became curious about CNC technology. Initial information and knowledge about CNC technology was gained through the websites of the various manufacturers located overseas, trade shows, and trade magazines. To Media Displays, the entire process required many hours of research and negotiating with many CNC sales representatives, dealers, and manufacturers. The whole experience was invaluable to the company since it had no trained programmers or operators at the facility.

Complexity was undoubtedly the issue for the company, because the idea of automation was completely new and the implementation of the new technology was appreciated as entirely changing its current manufacturing process from manual to automated. Media Displays began accumulating knowledge on using new production technology for the business by learning from its competitors and the suppliers. Apart from having zero experience, another challenge faced by the company was that most of the manufacturers and marketers of the CNC router were based in overseas, and there were few opportunities to buy the imported CNC router, thereby leaving Media Displays with limited alternatives in terms of price and technology choice. Distance and cost makes it complicated to discuss requirements in great detail or to have a product demonstration without engaging into an initial proposal with the supplier.

Hence, the pre-implementation and the selection process are more complex. Being aware of its limited experience, Media Displays finally opted for Taiwan technology, which has a local office in Malaysia.

Media Displays' strength has been in its customer service and a high degree of collaboration with the customer in terms of the design idea. However, changes in customer demand and competition from competitors (new and old), who had introduced more advanced techniques and production technology, made the company's investment in the automated router machine a core competence for its business. The automated router technology also contributed to the main, and important part of the firm's manufacturing processes.

Before investing in the technology, Media Displays claims the company was very uncertain about the technology itself, and in its own capability to make the right choice of technology, to implement, and handle it. Media Displays selected a supplier that it trusted, and that it believed would help it throughout the implementation process and subsequently result in the company avoiding unnecessary costs resulting from implementation failure or failure in achieving the investment objective. Media Displays claimed that since it worked closely with the technology supplier, the knowledge accumulated slowly increased its confidence in the technology.

#### 6.3.4.2 Nature of Relationship with the Technology supplier

***Before installation***

Considering its small business scale, at the final stage of the supplier selection process, Media Displays looked at the one whose machine was specifically designed for producing wood and plastic parts to a high level of accuracy, consistent with the quality requested by its customers. Media Displays described the supplier's sales representative as very knowledgeable, paying attention to detail, and showing a higher level of integrity in answering all the questions. The firm recalls that the sales representative from the technology provider demonstrated a high level of information sharing, a superior level of technical knowledge, and a willingness to share its knowledge in the area.

The supplier sought detailed information about Media Displays' existing operation such as the size of the production floor in which it worked, volume of production work, the usual types of cutting job, and the pieces of equipment currently used. The supplier not only educated Media Displays in respect of various parts of the CNC machine relating to its particular business needs, but also shared all other related knowledge which was apparently useful for the future business needs.

A detailed technology demonstration was available from the supplier before the purchase was made, but since the supplier's location is in Taiwan, Media Displays was reluctant to invest in extra expenses. Both parties, however, had several long discussions on the machine specification and its suitability for Media Displays' business operation. The manager repeatedly mentioned that the supplier understood that Media Displays did not want to limit its business capabilities for the future. Media Displays also claimed that the supplier was very helpful in suggesting configurations for the machine and did not try to sell anything that was not needed.

At the time when Media Displays decided to sign the agreement and purchase the machine, the company believed that it had chosen the right supplier and technology for it business needs. A strong closeness and alliance with the supplier was born even before they entered into the agreement. Two weeks before the delivery, the CEO and the general manager of the company went to Taiwan for the training, which thoroughly explained all the machine functions and capabilities, the programming, cutter selection and speeds.

***During installation***

Once the technology was shipped to Media Displays production floor, the supplier provided a high level of assistance in the installation process. Even though it took only two days for the full installation, the highly-experienced sales engineer remained at Media Displays' site for the two weeks system trial to work through any problems and answer questions. Media Displays considered the supplier to be very committed in providing support and solutions. For instance, during the system trial, in the process of getting the design packages and the software to work properly with the router, there were several hiccups caused by the inappropriate set-up of a tool head, which is related to the template set-up in the CNC link. With the supplier help, the time taken to deal with the problem was very satisfying. In another instance, due to the design variety and uniqueness of each of Media Displays' products, the process of setting up the software to work with a router was quite time consuming especially for a first-time user. The supplier, however, provided guidelines and suggestions on how to minimise the time it took to set up a machine and the software.

*After installation*

The paid extended warranty programme allowed Media Displays to receive scheduled preventive maintenance twice a year for the first three years from the technology supplier. During the first six months of operation, Media Displays also frequently referred to the supplier on any problem, which was mostly on programming matters, since most of the technical problems had been solved by Media Displays' engineer. The company recognised that the knowledge gained through its relationship with the technology supplier had successfully allowed it to manage the technology on its own after the implementation.

Media Displays, however, commented that the CNC Router technology had advanced dramatically, and that the new machine on the market had placed the company at a competitive disadvantage. Consequently, after almost four years of using the technology, the company has recently updated its system software and hardware, incurring an unexpected cost, which was unplanned for in the company's investment strategy. Media Displays indicated that the company was unaware of this issue, until the technology had been purchased.

The company fully recognised the significance of the supplier role in making the technology acquisition a success. Early discussion and effective communication enabled the development of trust and thus, made the entire process less complicated. To Media Displays, appropriate technology selection and smooth installation are the ingredients for the acquisition success, and definitely cannot be achieved without the involvement of a good technology supplier.

#### 6.3.4.3 Technology Performance

Since the technology implementation, Media Displays has been able to create dimensional signs in the time-frames required by its customers, and to offer these at a competitive price and consistent quality. In the four years since the company acquired the technology, dimensional business volume has increased significantly, primarily because the machine makes it possible to produce large dimensional signs and produce the intricate three-dimensional design to a high level of accuracy that can not be achieved by hand. Unlike a flat image, a dimensional sign achieves a three-dimensional appearance by incorporating raised elements that have been cut out of plywood or other substrate. Large dimensional signs are difficult to produce profitably by hand, however, because it takes so long to cut the substrate. With the CNC approach, the image is simply loaded into a computer and run through a program that produces instructions for the machine. The substrate is then cut automatically, much faster and more accurately than is possible by hand. The technology also has the ability to provide turnaround times not widely available in the sign industry at the time of its implementation. Hence, the company has experienced an increase in quality and efficiency, improved lead times, and reduced costs.

#### 6.3.4.4 Implementation performance

The technology was installed in February 2000, with the goal of completing the installation, programming and routing of all material parts by October 2000. However, only five months after the CNC technology was delivered, Media Displays had successfully put the machine into full use for its daily production on customer orders. Although there was little interruption to the machine operation, Media Displays stresses the technical support as an important factor whether the technology buyer is a new or experienced user. During the first six months of its use, Media Displays occasionally referred to the technology supplier when there were interruptions to the system, and on each occasion, was satisfied with the response received from the supplier's technical staff. Down-time on a machine is non-productive and the technology supplier quickly attended when there was a need to remedy a problem. For instance, the company recalled having less than five occasions when the machine was down since its implementation. Furthermore, the down-time has not been too costly for the company because the supplier's technical representative has been able to remedy the problem in less than six hours on most occasions. Through learning and knowledge sharing with the technology suppliers, Media Displays' staff are now capable of tackling any technical interruptions of the machine, and currently the suppliers only provide preventive maintenance once a year, at Media Displays' cost. So far, the company has only needed to have a replacement part for the cutter and was satisfied with both the price and service provided by the supplier.

The technology acquired has positioned the company at the forefront of the trend. Media Displays claims that they are now also bidding on jobs that were previously not possible to do. The company fully agrees that the technology is successfully fulfilling the implementation objectives, which are to expand their market base by being able to develop new styles and design in line with customer demand.

### 6.3.5 Influence of transaction attributes on the relationships with the technology supplier and its link with performance

Case B demonstrates how firms that possess a higher level of transaction attributes, fully recognise the importance of the supplier role in the process of technology acquisition. The company worked closely with the technology supplier, especially at the early stage of technology acquisition, and thus achieved a desirable technology and implementation performance.

A lack of knowledge in the automation technique on the business, and zero experience in implementing CNC technology, led to a higher degree of complexity in implementing the technology. The technology also contained a high level of specificity to the firm because not only did it represent a core competence to the business, but its implementation also reflected major changes in its manufacturing layout as the process was transformed from being manual to automated. Moreover, mastering the CNC technology and its related software was a challenge that the firm needed in order to survive in the demanding business environment. Not only did the firm recognise its limited capability in implementing and handling the technology, but the restricted availability of local suppliers and the cost involved in gaining more information from the overseas supplier contributed to the higher level of uncertainty surrounding the new technology acquisition

Regarding higher level of transaction attributes, this case portrays how firms closely work with the technology supplier even before the agreement to buy the technology is achieved. This case demonstrates when the firm fully recognised its limited familiarity in the technology, it was determined to choose the supplier that had the knowledge, showed commitment, and exhibited a higher level of integrity during the early process of buyer and supplier interaction. Trust was a very important element, and the dimensions of business understanding, involvement, commitment, and knowledge acquisition from the technology supplier, were all present throughout the relationships.

The solid basis in the early stage of buyer and supplier collaboration led to the correct technology selection, which was then reflected by higher manufacturing performance. Strong support from the technology supplier also led to more successful implementation performance. The case, however, indicates how inadequate or incomplete information sharing has an unsatisfying impact on the buyer some time after acquiring the technology, which may not yet directly impact on the implementation or manufacturing performance on a short-term basis.

## 6.4 CASE C. TOOLMATCH MICRO TECHNOLOGY SDN BHD (TOOLMATCH)

### 6.4.1 The background

Toolmatch was incorporated in 1990 as a manufacturer of high precision tools, dies, moulds, jigs, fixtures and other precision-machined parts for the semi-conductor and electronic industry. The facility is located at the Oakland Industrial Park in Seremban, Malaysia. The company employs 63 employees. Since inception, Toolmatch has experienced tremendous growth and maintained its competitive edge in cost and quality control. The company policy and objectives are directed towards constantly meeting and exceeding the expectation of its customers through an excellent quality and customer service.

The electronic and electrical industry has been growing at a fast pace and is facing tough competition. Most of the industry competitors are enthusiastic about being first in the market with high-function or innovative products. In line with the advancement in the electrical and electronic technology, industry suppliers like Toolmatch have to make equally complex tools, dies, moulds, jigs, fixtures in response to the growing artistic and complex customers' product design. In early 2004, the company invested in CNC optical profile grinder technology, capable of grinding curved profiles of tools and small workpieces at higher accuracy. The system also has the monitor and built-in comparator quality control mechanism. The technology functions include cutting tool, die and mould, bearings, stamping, and support tools. The investment was consistent with Toolmatch's aspiration to consistently exceed its customers' expectations by continuously investing in a more advanced production technology.

### 6.4.2 Production process: Production of small batches of a similar unit

### 6.4.3 Brief description of technology accquisition

- Technology acquired: CNC Optical Grinder
- Technology manufacturer: Japan
- Technology supplier: Manufacturer's regional office
- Technology type: New
- Year of acquisition: 2004
- Nature of acquisition: Full system provided by one supplier

### 6.4.4 Case analysis

#### 6.4.4.1 Transaction attributes in relation to technology acquisition

The Toolmatch production floor is well-equipped with the latest engineering technology, consistent with its goal to achieve the finest quality and productivity by practising a more complete and error free manufacturing processes. At the time of the interview, the company manufacturing operation owned 20 grinding machine, 2 CNC grinding, 1 CNC optical profile grinder, 5 CNC machine center, 1 high speed center, 16 milling, 6 CNC wire cut, 3 EDM, 7 CNC EDM, 4 Lathe, and 1 CNC Lathe.

For Toolmatch, the complexity of the technology was not a major issue, despite its claim that the acquired CNC optical profile grinder technology is considered as the latest and most advanced in its class, and the company did not perceive its implementation and operation to be a complex task. Looking at its current production technology, and the amount of experience in acquiring similar type of technology, Toolmatch considers using a more advanced technology just like driving a different model of car.

Additionally, Toolmatch has well-trained and highly committed employees, distributed as shown in Table 6.1.

**Table 6.1: Distribution of expertise at Toolmatch Micro Technology Sdn Bhd**

| | |
|---|---|
| Wire Cut | 3 Persons |
| CNC Milling | 4 Persons |
| EDM | 4 Persons |
| Lapping/Polishing | 1 Person |
| Grinding | 13 Persons |
| CNC Grinding | 1 Person |
| CNC Profile Grinding | 1 Person |
| Milling | 10 Persons |
| Lathe | 2 Persons |
| CNC Lathe | 1 Person |
| Assy/Maint. | 2 Persons |
| Design Cad | 2 Persons |
| Cad-Cam | 2 Persons |
| Quality Assurance | 3 Persons |

Toolmatch already had in-house expertise to handle the new CNC machine, and whereas with its previous acquisition, it was necessary to send key employees for training, the company did not do this for the new machine. Employees simply received two days' demonstration from the technology supplier once the technology was shipped to the Toolmatch production floor. Nonetheless, the company claimed that every asset in which they invested was considered important to its business, and that the new CNC machine also added to its existing competency in delivering quality products to its customers. A consideration of the company's current available engineering technology and product lines, shows the new CNC not to be a core technology, but one that significantly contributes to its current business competency.

With enough experience in handling similar technological innovation, enough in-house expertise to operate the technology, and a trusted supplier, Toolmatch was very certain about the capability of the technology in meeting its customer demand and market goals. Toolmatch claims that that the learning culture embedded in the company, not only makes the company knowledgeable in its own business operation, but keeps it abreast of new and latest production technology available on the market.

### 6.4.4.2 Nature of Relationship with the Technology supplier

*Before installation*

The process of finding the right supplier for the new CNC optical profile grinder was not difficult for Toolmatch as the company had bought a CNC grinder two years previously, and hence chose the same source. According to Toolmatch, much of the supplier role was needed before the technology was implemented. A series of communications took place, and an understanding of the business operation was developed by the technology supplier. Such activity was mainly on the detailed specification of the technology and its ability to meet Toolmatch's production requirements.

Since Toolmatch had previous experience in implementing CNC machine, it was familiar with the issues concerned with purchasing the technology, such as price and terms of payment, training, support service, spare parts, preventive maintenance, and technology warranty. These were all discussed to the satisfaction of the both parties. From the Toolmatch viewpoint, the technology buyer is the one who should have a deep understanding of its business requirement and relate this to the technology to be acquired. During the communication with the supplier, most of the time, Toolmatch knows what the company wants and communicate it to the supplier to make sure the supplier is capable of giving the company what it required.

Even though the purchase proposal document offered many instructor-led training opportunities, including advanced operations, maintenance and programming, Toolmatch did not purchase any training with the machine, since it considered that its existing technical know-how, was adequate, especially since it chose the technology itself on the basis of its requirements.

***During Installation***

After the machine was shipped to the Toolmatch production facilities, the component inspection and the system installation was effected by in-house expertise. Toolmatch claimed that set-up and operation were extremely easy because the company had the required expertise to handle the controller and the programming. In fact, Toolmatch was very familiar with the CNC technology and aware of its expectations and requirements. Thus, it was not considered necessary to purchase assistance for the system installation.

Unless problems were apparently related to technology error, they were resolved by the company's own highly-competent and skilled machinist. The supplier provided a technologically superior phone system, which streamlined the technical support process offering quick and direct access to its most experienced experts, but Toolmatch recalled that the need to use that service was very minimal.

***After installation***

Since most of the company's staffs are experienced technical experts, the company was capable of meeting all the challenges after the implementation process without any involvement from the technology supplier. Less than a year after implementing the technology in the production facilities, Toolmatch claimed that the performance achieved was very satisfactory, and that the information provided by the technology supplier before the decision to invest in the technology was made, was accurate, especially regarding the technology capability and robustness. However, in terms of knowledge acquired from the technology provider, Toolmatch claims the company acquired more new knowledge from the provider of its earliest CNC technology.

Even though Toolmatch personnel did not undergo special training before the technology was implemented, about a year after the technology installation, the company provided ongoing software and equipment training through technology supplier, since this is believed to keep the company up to date with the newest methods and possible upgrades, and ahead of the competition. The company commented that from its previous experience, it had learned that if it paid no attention to how to get the benefit from what it purchased, it may end up using the equipment only at 50% of its capacity. Small newly-available items like tooling were known to increase output by as much as 60%.

#### 6.4.4.3 Technology performance

Since the implementation of the technology, Toolmatch has been able to produce difficult and tight tolerance grinding work and finer surface finish specifications compared to what it could deliver with its previous grinding technology. The technology is also capable of reaching higher levels of dimensional and positioning accuracy. As the tolerance and adherence to the specification are the vital aspect of quality assurance in Toolmatch's business operation, the company is fully satisfied with the technology performance in terms of quality achievement.

Apart from that, a swivelling wheelhead allows the grinding wheel to be repositioned to approach the workpiece from various angles. Also a fully programmable axis allows the shop to do face and angle grinding operations in a single set-up, significantly reducing the lead-time. Toolmatch was also satisfied with the ability of the technology to reduce cost through the reduction of scrap and rework. Furthermore, the technology allows Toolmatch to have volume and design flexibility to a great extent.

#### 6.4.4.4 Implementation Performance

Toolmatch has experienced no problems with the technology implementation. The process fell well within the scheduled time-frame and the company had the full use of the technology as soon as it was installed on the shop floor. The amount of downtime and time taken to tackle this has been acceptable to the company, which claimed that the technology was successfully meeting its intended objectives.

### 6.4.5 Influence of transaction attributes on the relationships with the technology supplier and its link with performance

Case C demonstrates how a firm that possesses a lower level of transaction attributes is less likely to depend on the technology supplier in the technology acquisition. It does however highlight that some important elements of collaboration are still needed, which should then lead to a more successful technology and implementation performance.

Prior knowledge, previous experience, and enough expertise in handling the technology were the main factors that contributed to the lower level of complexity of the technology and lower uncertainty surrounding its acquisition and implementation. Another factor that may have contributed to the low level of uncertainty was the circumstance that the firm had trust in the supplier as it had positive experiences connected with the previous technology acquisition from the same source.

Less dependence on the technology supplier in this case, arose because the buyer knew what it wanted rather than having to depend on the technology supplier for advice, and was independently capable of installing the technology without having to refer very much to the supplier, and was capable of tackling most of the technical problems after the installation without requiring supplier involvement.

However, despite the little dependence on the technology supplier, there was close collaboration at the early stage of technology implementation, for instance, discussions took place to avoid misunderstanding of the specification. Ongoing training from the supplier for knowledge updating in relation to the technology was also evident to ensure that maximum benefits are obtained from the implemented technology. These factors have led to the achievement of technology and implementation success in this case.

## 6.5 CASE D. G-PARTS ENGINEERING (M) SDN BHD (G-PARTS)

### 6.5.1 The background

G-Parts is a fabricator and assembler of customised sheet metal parts. The company produces hundreds of different parts annually for a variety of industrial applications, and was established in 1996, starting as a manufacturer of precision machine parts and components, and parts and components for machinery and automotive systems. Less than ten years since its operation, G-Parts is now also producing enclosures, cabinet, and lifting and handling equipment, and exporting these to France, Germany, Italy, Japan, Singapore, and Switzerland. The company is located at Selangor, Malaysia, and employs 28 people.

The sheet fabrication service in G-Parts includes a diverse range of processes to fashion sheet metal into usable products. The job shop specialises in short and medium runs, and the company most values its reputation for being the fastest supplier of custom parts. Product quality and reliable service are two other critical areas in which the company differentiates itself from competitors.

The production processes basically involve cutting, forming, and finishing services. In the cutting process, G-parts uses a shearing technique to cut metal into smaller pieces so that it can be moulded or formed into components. Shearing requires a specialised machine to cut sheet metal into smaller parts by applying shear stress. Then, depending on the part design, the CNC cutter or wire electrical discharge machining (EDM) equipment, which uses a thin electrode, is used. In the bending and forming processes, sheet metals are contoured to their final shape. This process consists of rolling, stamping, punching, and welding. G-Parts has primarily specialised in precision metal stampings for the machinery and automation industry. Everything the company welded was originally done manually.

Prior to 1999, G-Parts did not have many jobs that required welding, and if required, this was either done manually in the job shop or out-sourced. However, in 2000, the company found an increase in manufacturers' requirements for parts to be welded, especially from its OEM automaker customers. The assemblies became more complex, with more pieces and more welds. The operators had to set up parts and fixtures and then weld the parts manually. With so much moving around and repositioning, it was difficult to produce parts with the required consistency. Another problem was that the welder would have to weld the parts, get up to lift the finished assembly out of the fixture, then sit down and weld the next assembly. The weight of some parts also added to the fatigue factor.

Early in 2001, G-Parts purchased and installed a robotic welding automation system, its first robotic application in its production facility. The primary goal for G-Parts in moving from a manual to a robotic welding system, was for repeatable performance, high quality welds, and productivity.

### 6.5.2 **Production Process:** Production of multiple parts at varying volumes

### 6.5.3 Brief description of technology accquisition

- Technology acquired: Robotic welding system
- Technology manufacturer: Sweden
- Technology supplier: Manufacturer's local office
- Technology type: New
- Year of acquisition: 2001
- Nature of acquisition: Full system provided by one supplier

### 6.5.4 Case analysis

#### 6.5.4.1 Transaction attributes in relation to technology acquisition

With the sudden increase in welding jobs, G-Parts faced the dilemma of either to employ more welders or to switch to automation. Skilled and experienced welders are not easy to find and normally demand higher pay, as it takes years of experience, training and practice to become an experienced welder. Furthermore, to keep an experienced welder inside the company is difficult because the high market demand for experienced welders allows them to move from one company to another for better pay. Thus, the final decision was to adopt automation.

With no previous experience in robotic application, G-Parts viewed the technology as technically complex and one that required hours of employee training on understanding and using it. Moreover, the extra capability of the robot system also meant that work synchronisation had to be developed in order to avoid bottle- necks from the early cutting and bending process. Thus, the company not only had to learn about the technology, but also to be prepared for additional changes it would bring to the current manufacturing operation.

The welding robotic was G-Parts' first robotic application, representing a major investment and a core business competence at the time of its acquisition. Despite the time constraint imposed by the company's immediate need for the robotic technology in its manufacturing operation, the company took the time to learn more about the technology and its market. Key employees of the firm were sent for many hours of training and product knowledge, not only provided by the technology supplier but also by a local training institution. Since the technology was acquired from overseas and the training centre was also located overseas, G-Parts spent a huge amount of money on the training. The manager also attended overseas seminars and visited a few local production sites that had used robotic automation for the welding process.

G-Parts was confident that robotics was the only answer to its business and manufacturing demand. However, with no experience in implementing any similar technology, the company was quite concerned about the technology's ability to meet its technical and business expectation, and considered assistance and support from the technology supplier to be extremely important.

#### 6.5.4.2 Nature of the Relationship with the Technology supplier

***Before installation***

The technology was purchased under a lease purchase agreement, in which a fixed purchase price was agreed between G-Parts and the technology supplier at the beginning of the lease. At the end of the lease term, G-Parts will purchase the equipment for the pre-arranged price. However, the technology supplier retains a security interest in the equipment, while G-Parts has ownership and receives the depreciation benefits. The package also includes the training, full implementation, and two years of scheduled preventive maintenance.

Two months before the system was shipped to G-Parts' production facilities, a key employee was sent to Sweden for two weeks of hands-on mentoring on the actual robotic system and formal classroom training. The training involved basic operation training for workcell and robot operation and also advanced training for robot programming; maintenance training; and welding training, which G-Parts consider to be critical. The training took about one month, with one week spent on programming/operations training, one week on maintenance/operations training, and two weeks on advanced training.

Although at the time of implementation, G-Parts thought it had enough co-operation with the supplier, after going through a difficult implementation process, the company realised this not to be the case. The supplier's lack of understanding of G-Parts' business operation was one factor contributing to the difficulties, and the company recalled that even though during the pre-installation stage, it provided the supplier with information about the main goals it wished to accomplish with automation, the discussion on this issue was not in great detail, and did not include attention to quantities needed to be produced, number of shifts worked, inches of weld per part, and the quality and repeatability of parts entering the weld cell. To G-Parts, the results from this fact-gathering are very important since only from these, can the supplier fully understand the customer's goals, manufacturing process and priorities. Hence, this information was crucial to the success of the new technology acquisition, and in bringing a faster monetary return on the investment.

***During installation***

It took four days for the technology supplier to install the robotic welding systems at G-Parts plant. The installation was fully undertaken by the supplier's technical expert. Besides the equipment, the implementation package also included safety installations and the welding fume extraction system. Since the training had taken place beforehand, the supplier only gave a demonstration on the specifications for the cell's cycle time, and made sure that everything was working well. The supplier also gave a demonstration to the robotic welding cell operator on how to load and unload the part and to activate the equipment.

The package also included the development of the complete solution with verification of functional capability. The system was put into trial for two weeks. G-Parts recalls that during the trial period, the robot failed to weld at the exact point location on a certain part type. The supplier recognised that the problem lay in the positioner that determines how the part is presented to the robot for welding. Due to the complexity of the design of some parts, the positioner that comes with the system (the stationary table(s), turntables, and headstocks and tailstocks) was not sufficient. G-Parts then incurred an extra cost to purchase the automated fixture, especially designed for G-Parts' product types. An automated fixture was chosen as opposed to manual fixtures because, according to the supplier, this could hold the part to proper tolerances for welding, and avoid chances of human error. With the automated fixture, the problem was resolved, but there was the associated increase in expenditure.

***After installation***

G-Parts depended on the technology supplier very often after the installation, because although the training covered troubleshooting problems, robotic programming, welding data, and hardware problems (electrical and mechanical), it did not, however, include how to trouble-shoot for the rare or intermittent problems. The supplier was often contacted to solve such problems since it takes a considerable amount of time for the company to gain the proper knowledge and experience to remedy the problem itself.

In one instance, while producing high part volume, G-Parts had to rework most of the parts by manual welding. Productivity was not improved and the total cost increased. After many hours of trying to manage the problem by consulting the instruction manual and following the trouble-shooting plan, production was discontinued, and the company contacted the supplier's free on-line support service. The telephone support service was not able to resolve the problem, and ultimately, this was referred to the specialist. G-Parts recalls that it was hard and very time consuming to get the supplier's specialist to come to the plant to resolve the problem.

The supplier then evaluated the entire production process and found that the problems existed because G-Parts has a variety of production batches, some being high volume production welding projects, and some being small batch. Although the robot option has a detectable seam finding and tracking for part-to-part variation, it has limitations and this option consumes a great deal of the cycle time. The welding robot has a hard time dealing with gaps between component parts especially when the parts are not repeatable. Thus, G-Parts was advised to plan its production schedule so that the same parts could be welded consequently. Since the problem was not specific to the Robotic system, G-Parts was charged for the consultation cost.

The key workers were also retrained by the technology supplier at the G-Parts site. This training was more specific and related to G-Parts' production needs, including how to recover from errors, how to adjust the characteristics of the machine to operate in different situation, and training on optional equipment and devices such as seam tracking.

Apart from the quality problem, during the first six months of operation, the robot and the bend torch crashed a few times. On the first few such occasions, the G-Parts maintenance staffs were unable to correct the problem, even after working on the system for hours, and the supplier was contacted to solve it. However, after learning by working with the supplier, G-Parts is now capable of preparing a tip check and re-mastering the set-up without the supplier's help. G-Parts now keeps spare torches and other important spare parts. Unlike a human welder, a robotic welder cannot tolerate poor preparation. G-Parts has recently upgraded its cutting machinery and tooling for existing presses and punches, in order to optimise component part quality.

For the first two years, scheduled preventive maintenance on the equipment was performed fully by the technology supplier as it was included in the warranty period. G-Parts commented that the maintenance undertaken by the supplier was very helpful in increasing the up-time and productivity, and in helping the company to improve its product quality. For instance, through the scheduled preventive maintenance, the supplier was able to spot whether the system required new or serviced contact tips, nozzles, and wire feed rollers on a regular basis. Proper maintenance contributed to a more consistent welding arc, translating into better quality and process reliability.

After two years, the G-Parts maintenance and service personnel were capable of conducting their own maintenance service that included mechanical services such as lubricating and replacing motors, and electrical services such as troubleshooting circuit boards and tracking down failed components. The implementation of the robotic system provided continuous learning in the organisation, especially through the technology supplier, who responded very quickly to any problem emerging from the implemented technology. Despite the fact that the supplier gave a high level of commitment and never ignored any problem faced by G-Parts, the company believed that expensive mistakes could have been avoided if it had developed closer collaboration with the supplier during the earlier stage of technology implementation.

#### 6. 5.4.3 Technology performance

After two full years of the automated welding and gaining more knowledge from its application, G-Parts claims that the use of the robotics have significantly helped the company to reduce costs. Cost is reduced through reductions in direct labour costs, scrap and rework. The company maintains a small number of employees even after the addition to its product line, but most of the welding for its new products is now done by the robotic welding system, which requires two experienced operators at most. Robotic systems now weld cabinet, lifting and handling equipment into finished products

Quality is also achieved because the robotic welding can achieve a higher level of accuracy, especially when the setting is proper and accurate. Most of the problems arising from the robotic system during the operation were due to failure during the set-up stage. G-Parts, is however, quite disappointed to find that the expensive robot it acquired can reach only 90% of the welds on a particular part. For instance, the complex contours created when welds wrap around corners are sometimes difficult for robots to do. For a certain welding job, especially when the load/unload time is less than the robot cycle time, operators have long unproductive idle time. To shorten the robot cycle time, G-Parts has to give around 10% of the more difficult welds to manual welding, and although the overall effect is a better utilisation of the operator's time, and improved throughput due to decreased cycle times, the overall improvement in lead time is not fully achieved.

For G-Parts, manual welding is more flexible than robotic welding because humans can tolerate many defect in cutting, compared to a robot. Manual welding also can accomplish a variety of product designs whereas robots can not. However, the consistency in quality and the speed of welding achieved by a robot is something that cannot be achieved with manual welding.

#### 6.5.4.4 Implementation performance

Even though the technology was installed within four days, G-Parts experienced a number of problems during and after the technology installation, and is not satisfied with the time it takes to gain the benefits from the technology. Moreover, the length of time taken for the complete implementation was beyond expectation.

The amount of down-time during the first six months of its operation was unacceptable, creating a serious problem for G-Parts. At one time, while running the high volume order of its automotive customer, G-Parts experienced more than RM50,000 loss in just four hours due to lost time and required rework. Because of the company's little understanding of the robotic system, the time taken in tackling the technical problem was undesirable, and most of the time when such problems occur, G-Parts has to refer back to the technology supplier. Even though the technology is capable of improving the production process and performance of the company, and is now an important application to the company's new product line, the technology does not immediately fulfil its implementation objectives.

### 6.5.5 Influence of transaction attributes on the relationships with the technology supplier and its link with performance

Case D demonstrates how firms that possess a higher level of transaction attributes very much depend on the technology supplier, especially during and after the installation stage. However, inefficient collaboration during the earlier stage of technology acquisition led to a serious problem in technology implementation and the achievement of only moderate technology performance.

In this case, the firm viewed the technology as complex and important to the business at the time of its implementation, due to its lack of experience with such technology, and the sudden increase in welding jobs respectively. The company also invested a huge amount of time and money before its acquisition and was well aware of the importance of the technology supplier. However, inadequate collaboration with the technology supplier may be due to the newness of the firm to the technology, meaning the company does not have sufficient knowledge to critically review how the other processes at the plant could affect the new system. Also, compared to some companies that implement new systems as an update in their existing welding technology, firms with no previous experience, although aware the significant of supplier involvement, may not have a clear idea of the extent to which close collaboration is needed, until a problem arises.

The case describes how a lack of business understanding, information sharing, and involvement with the supplier in the early stage of technology implementation has resulted in delays in the implementation process. Although the supplier was very much involved after the technology was implemented, early involvement would have led to a better understanding of the customer business, and the production process would have been very helpful, thereby making the implementation more successful. A new adopter cannot anticipate the potential complications a system could bring to its operation, and hence, it is extremely important for the supplier to advise the buyer in this respect.

The case clearly describes how inefficient information sharing from the technology supplier resulted in a failure to convey a great deal of information which was directly or indirectly useful for the buyer's operation, and how this information was not shared until a particular problem arose. Problems and expensive mistakes could be avoided if the buyer firm can effectively involve the supplier in the early stage of implementation planning. The buyer firm could enjoy the benefit from the technology earlier, if all the important issues were discussed with the technology supplier, and the technology supplier in turn was efficient in giving its service to the buyer.

## 6.6 CASE E. AUTO INDUSTRIES SDN BHD (AISB)

### 6.6.1 The background

AISB was established in 1972 and is currently one of Malaysia's leading and biggest OEM exhaust system manufacturers. Apart from making exhaust systems, the company also manufactures "kangaroo 'bar", car seat frames, stamping parts, and pipes. It is located at Selangor, Malaysia and employs around 300 staff.

AISB is a subsidiary company of UMW Toyota Motor and UMW group of companies. It has had a technical assistance agreement on manufacturing/R&D with Sankei Industry Co. Ltd., Japan since 1985, when the company's operations centre proposed to establish a production line for car seat frames, as a means to strengthen the support chain of the other subsidiary company Takanichi SIM Sdn. Bhd, the manufacturer and marketer of an automotive seat. As the business has grown, and the industry has demanded more complex design, high quality, and uncertain product orders, the dual torch autoweld machine has been replaced with a fully automated welding line for the manufacturing of the car seat product. The welding robot, robot controller, computer-controlled pulsed arc machine technology, and laser technology, are integrated into the complex welding system.

### 6.6.2 Production process: Production of multiple parts at varying volumes

### 6.6.3 Brief description of technology acquisition

- Technology acquired: Robotic welding
- Technology manufacturer: Japan
- Technology supplier: Manufacturer's regional office
- Technology type: New
- Year of acquisition: 2001
- Nature of acquisition: Full system and integration provided by one supplier

### 6.6.4 Case analysis

#### 6.6.4.1 Transaction attributes in relation to the technology acquisition

Being in operation for more than 30 years, the company has witnessed and experienced how technology has changed during the last three decades. Business competition and changes in demand in terms of design and product durability for industrial customers as well as end users have led to improvements in manufacturing process and technology. Even though AISB have long been producing car seat frames, the company views the new integrated welding line as technologically complex compared to its previous welding machine, as it requires proper planned installation to avoid disruption to the customer order during the transition process from the old system to the new integrated line. The implementation of the new integrated line also ran under a very tight schedule because at the same time, the old welding machine system had to be removed before the implementation of the new technology due to space limitation.

In terms of financial investment, the technology is the company's first investment in the car seat production department since its establishment, about 20 years ago. Therefore, AISB view it as significant, not only in respect of the money invested in the technology, but also in terms of the positive impact it is expected to have on the remaining production facilities. At the time of implementation, AISB had already employed a project engineer with much experience in robotic applications, and had invested in many hours of training for the key engineer.

AISB received full assistance from its joint partner, Sankei Industry Co. Ltd, in identifying the appropriate technology and the right supplier. The company claims that during the pre-proposal stage, the assistance and the attentiveness of the technology supplier suggested that the technology would definitely be able to meet its customer and production demand. Consequently, AISB had much confidence in the ability of the technology to give a good return on the investment. It maintains that despite the company's lack of experience in integrated automated welding, it was less anxious about the implementation process because the technology was acquired together with a costly, full system integration package.

#### 6.6.4.2 Nature of Relationship with the Technology supplier

*Before installation*

According to AISB, apart from looking at the ease of programming and operation, one of the key interests in choosing the particular Japanese technology was because it has its own reputable customer service location in Kuala Lumpur, Malaysia that provides various levels of system integration depending on the customer specification. AISB had an opportunity to visit the demonstration centre to see test demonstrations of the robotic welding of its custom parts. This invitation was considered to be crucial because it provided proof that the system would work for AISB's parts production before a commitment to purchase was made. During the process, communication between AISB and the supplier took place, especially relating to AISB's own specific concerns about the application of an automated welding operation.

Then, an analysis that included time standard studies and a cost justification for four different welding applications, to be used in the investment justification was discussed. As part of the preliminary evaluation process, a run-off was held at the supplier demonstration facility to determine whether the largest and smallest parts could be welded successfully, and on being satisfied with the result, AISB placed an order for the system. The installation of a welding torch, wire feeder, welding fixtures and workpiece positioners, and full safety system was added to the scope of the task.

According to AISB, the technology supplier did all the planning on the fixturing, mechanical, electrical, and electronic systems. CAD drawings of the installation layout were created to permit AISB's engineering and welders to visualise the proposed handling and welding system. Detailed safety, maintenance, and operating instructions were also included.

AISB also recalls that the supplier handled all the engineering, integration, welding, fixturing, training, installation, programming, and the entire flow in the facility. Additionally, the supplier examined all involved parts to determine the potential variability in dimensions and location when in position for welding, the parameters required, the quality level demanded by AISB, and the entire flow of parts and materials to and from the welding station. According to AISB, the level of supplier understanding on its business operation was very good.

***During installation***

Once the technology was shipped to the AISB site, the supplier provided the installation and start-up assistance. During the process, training was also conducted in all aspects of the set-up, the welding process and how the robotic workcell's components interacted with one another. Throughout the process, the company's engineers and the supplier specialist spent significant amounts of time together, and the know-how was transferred effectively on a one-to-one basis.

AISB recalls having no problems during the installation stage. The concerns about the variability of the frame size and design, the complexity of the welds to be made, the productivity and quality requirement, and controlling the motion of both the part and the robot, had been earlier discussed with the supplier. For instance, as AISB parts are of various shapes and sizes, the path of the robot in the robotic systems must be programmed accurately by plotting point by point. This, however, leads to a substantial cost due to the time demand for a skilled operator. In addition, the heat generated by the welding process causes deformation that changes the location of the part relative to the arc. To resolve the issue, the supplier provided AISB with welding equipment that combines the use of synchronised motion control, which is seam tracking and touch-sensing. The option resulted in the achievement of synchronisation and simultaneous control with all axes, which included servo-driven positioners for complex welding.

The trial was conducted for two weeks on nine robots running, for one to three shifts each. During the trial run, the supplier also provided complete programming and tool tryout, ensuring that the master robot programming, process development and PLC programming, and all the hardware components, worked as one. During the trial, the system experienced bugs resulting from the integration of such a complicated system, and according to AISB, the supplier was very committed and experienced in providing a solution to this problem. The supplier's experienced applications personnel provided all of the programming and debugging needed with plenty of on-site support and training. Once the system was up and running in the plant, competent technical service engineers were very committed to helping AISB deal with any hardware and software problems as they arose

*After installation*

Six weeks after the trial run, when fully familiarised, AISB engaged in full production with the new system, and the organisation of part flow, to and from, it. Most problems, especially those related to factory manufacturing, were resolved by AISB's engineer. However, AISB continued to refer to the supplier in relation to malfunctioning of the system's parts, or for the purchase of spare parts. The supplier was, of course, involved in the two-year period of preventive maintenance, covered under the system warranty. According to AISB, the investment paid for itself in less than three years, because of the success of its implementation. Apart from the quality and the intensity of communication between both parties during all stages of the implementation, AISB was also completely satisfied regarding the completeness of information provided by the technology supplier, especially before the technology was implemented. In terms of the knowledge acquired directly and indirectly from the technology supplier through the implementation process, AISB claimed this to be substantial and on-going.

### 6.6.4.3 Technology performance

AISB confirmed that the technology had achieved impressive results, and that once the trial production was over, the efficiencies achieved in actual production far exceeded the job specification. For example, previous welding jobs on some frame parts required ten man-hours of effort, whereas the new robotic system reduced the labour consumed from the two man-hours forecast to only 1.8, a further 12% reduction from the prediction. The experience during an arc frame welding sequence exceeded approximately 90%. AISB commented that as efficiency increased, the lead-time improved and the cost was subsequently reduced. Moreover, the company expressed complete satisfaction with the quality of the welding job performed by the robotic system. For short runs, set-up and operation is faster with the new technology than with its previous welding machine.

#### 6.6.4.4 Implementation performance

AISB planned for full production eight to ten weeks down the road, but was, in fact, able to achieve this earlier than expected. However, the benefits gained from the implemented technology, were considered by the company not to have been achieved without the effective assistance by the technology supplier. The down-time was minimal and the time taken to tackle this, when it occurred, was considered acceptable, due to the well-equipped, trained staff. AISB claims that the technology has successfully fulfilled its implementation objectives and improved its manufacturing process and performance.

### 6.6.5 Influence of transaction attributes on the relationships with the technology supplier and its link with performance

Case E demonstrates how firms that possess a higher level of transaction attributes choose to have the supplier involved in every stage of the technology implementation, and thus achieve a higher level of technology performance and smooth implementation performance.

The firm in this case, considered the technology to be highly complex since it had no previous experience in handling similar technology. Furthermore, because of the need to avoid disruption to the current manufacturing operation, the technology had to be installed under a great time pressure because the old system could not be removed from the manufacturing floor until the new system was ready to be installed. The technology was also highly specific to the company and considered as a major investment, since a significant amount money and time were invested to hire and train employees.

Similar to case D, the firm in this case acquired robotic welding technology. However, case E demonstrates a higher level of trust with the technology supplier even before the commitment to purchase the technology was made. The case shows the supplier's understanding of the buyer's business and subsequent requirement, and the intense communication that occurred at the early stage of technology implementation. The supplier was also very involved in understanding the entire flow of the buyer's manufacturing parameters in order to ensure the provision of the right technology, which subsequently made the acquisition and implementation a success.

The case clearly shows that strong involvement of the supplier in the buyer's product and manufacturing process during the early stage of technology implementation gives the firm a great deal of advantage compared to case D. The ability of the supplier to provide the concept for the implementation solution and offer direction in choosing the equipment mix that best matches the production requirement and goal, also has a positive influence on the technology and implementation performance.

## 6.7 CASE F. MIDA MILL SDN BHD (MMSB)

### 6.7.1 The background

Mida Mill Sdn Bhd (MMSB) is part of Mida holding Berhad group of companies. The company was established in 1964 and employs 804 employees. The plant, which is in Selangor, Malaysia, runs into two division, which are the paper mill division and the packaging division. The mill division operates two paper mills, which have a combined capacity of 300,000 metric tons per year. The major product of the paper mill division includes testliners, corrugating medium, grey chipboard, laminated chipboard, core board and liner board. On the other hand, the packaging division manufactures a broad range of products such as small retail boxes, paper bags, and bulky special electrical and electronics packing containers.

In response to the changing business environment, MMSB has invested millions of dollars in high technology equipment such as the Mitsubishi 60G Single Facers Corrugator, Ward Flexo Rotary Die Cutters, automatic conveyor system and other model machines which provide accelerated running and set-up times, enhanced product quality and customer service. In 2003, MMSB acquired and implemented a robotic system to facilitate its labelling requirements by automating the previous manual operation. The system comprises an arm robot, robot controller, host computer, and thermal printer. The arm robot and the controller were provided by the robot manufacturer (the supplier), and the main host computer and the thermal printer were provided by the supplier's partner.

### 6.7.2 **Production process:** production of large batch

### 6.7.3 Brief description of technology accquisition

- Technology acquired: Pick and Place labelling robot system
- Technology manufacturer: Korea
- Technology supplier: Manufacture's local office
- Technology type: New
- Year of acquisition: 2003
- Nature of acquisition: Not a complete system

### 6.7.4 Case analysis

#### 6.7.4.1 Transaction attributes in relation to technology acquisition

The idea of using a robotic system was not new to MMSB, because in 1998, in response to an increase in production capacity, the company had installed the vision guide pick and place robots, at its paper packaging divisions. Compared to the manual insertion of the corrugated box into the final package, the robotic pick and place system had the capability of performing repetitive-motion for heavy and light corrugated boxes at a constant rate. Therefore, MMSB recognised that the installation of a second robotic system would not be as complex as the first. The second robot features and operation were quite straightforward. However, MSSB acknowledged that the integration required by the system, especially with its warehousing process, was quite demanding. The robot is not only programmed to pick up and attach the label at the right position of the reel, but before the label is printed using a thermal printer, the robot system must also capable of reading the barcode and then checking the information against the main computer details to ensure consistency between the information and the reel.

Beginning in 1990, MMSB has upgraded most of its 1970s manufacturing equipment into a more advanced and automated production technology. Since then, the company has employed a number of experts on automated systems, and it has repeatedly sent employees for training, consistent with the usage of automated equipment in all key stages of its manufacturing processes. For the second robotic system, MMSB believed that staff only needed the short training supplied with the technology, as part of the contract. The robotic system is used to enhance the labelling procedure of the production line, and thus, was not considered as contributing to the core process of MMSB production, and despite costing a quarter of a million Malaysian ringgits, it was not regarded as major investment by the company.

Before investing in the technology, given the achievement of its previous robotic acquisition, MMSB was very certain that the technology would be a success. With the available expertise and previous experience in handling similar technology, MMSB was confident that it had chosen the technology that would meet its technical and production requirements.

#### 6.7.4.2 Nature of Relationship with the Technology supplier

***Before installation***

An initial contact with the supplier began during the robotic exhibition in Kuala Lumpur. Most of the communication and information between the two parties related to the specific robot system and how it could be applied to enhance the labelling process of various business operations. After the initial contact, both MSSB and the supplier worked closely in reviewing how the MSSB manufacturing operation could be integrated with the robot system to enhance the labelling process. After thorough reviews of MSSB's cycle time, set-up, and throughput of the current manufacturing operations, the decision to purchase from the supplier was made within a month.

According to MSSB, the supplier's understanding of the company's detailed manufacturing operation was not necessary for the technology implementation because it is not related to the heart of process. Even though the robotic end effectors, the main computer system and the thermal printer are provided by the supplier and its system partner, whenever the cost is much lower, MSSB buys most of peripherals from a separate provider. MSSB also engineered its own workcell for the system to minimise cost. MSSB confirmed that the robot and its controller were quite standard and considered as high-end user technology, and that whilst the early involvement of the supplier was not intense, good communication and trust were developed during the early stage of the technology implementation.

***During installation***

The system installation took about two days and was jointly performed by the supplier and MSSB's engineer. At the same time, the robot operator for each shift was trained to gain detailed knowledge of the robots, the software, and the controller. The training was considered as only specific to the system since most MSSB operators are already well versed in the programmable logic control (PLC).

During the trial run, MSSB had a problem in synchronising the conveyor timing, the robot speed, and printing time, in order to yield maximum result. When MSSB tried to keep enough labels available for the robot arms to gain more efficiency, reels were overflowing at the beginning of the conveyor belt. Also, when the arm was set to pick up and attach the label at an accuracy of ± 2 mm, the system shut down. MSSB claims that during those problems, the company received very unsatisfactory feedback from the supplier, who claimed that the difficulty lay in the programming, and referred MSSB to the system partner. The partner then referred MSSB back to the robot supplier. Although the problem was finally resolved, pin-pointing the precise difficulties caused delays in the system's capacity to operate full production.

MSSB normally resolved minor breakdowns or other such problems internally, but in the case of a major breakdown the supplier was usually called, and in this respect, the level of commitment demonstrated by the supplier was not very satisfactory. The involvement of the supplier in remedying disruption during the implementation was minimal and inefficient, with most of the communication being by telephone communication. The geographical distance between the supplier's sales office and MSSB's plant also posed a problem because this required more resources in terms of money and time. MSSB also claimed that the supplier did not provide sufficient after-sales service engineer coverage to attend to its request for help.

***After installation***

When MSSB implemented the robotic system for full production, the supplier was no longer involved at all because most breakdowns were due to daily production issues, employee mistakes and maintenance set-backs. After a year, MSSB's maintenance department repaired and maintained all the equipment related to the system. Even though the computer software updates are available from the supplier, MSSB does not see the need to update its system yet. Since the integrated software simplifies the integration process and reduces programming time, the company does most of its own integration of the robotic workcells. MSSB acknowledged the importance of good support and after sales service. Not only could it have helped buyers to implement the technology more successfully, but it could have facilitated benefit maximisation from the technology.

#### 6.7.4.3 Technology Performance

With the robotic application, mistakes that occur during the labelling process have been reduced by 95%. Only one employee is required to program and monitor the system, and thus, the number of employees required to handle the task is also reduced by about 90% since the system can operate for all three shifts. The system has not only made the end position of the production more efficient, but eliminated the risk of employee injury by allowing maximum access to the other areas of operation, which was previously very narrow. MMSB however claims, that despite the ability of the technology to achieve the quality and efficiency level expected by the company, recurrent down-time due to simple mistakes on programming or handling, mean that the technology performance is not completely satisfactory.

#### 6.7.4.4 Implementation performance

MMSB claims the implementation performance was slightly delayed. The company recognised that the time allotted for production testing and for testing at the factory, were beyond expectation and should have been built into the schedule during the planning. When the company had trouble during the trial run, it found itself in a very tense situation, because the slow response and ineffective assistance from the supplier led to delays in gaining benefits from the technology. MMSB regards itself as not maintaining and experiencing good relationships with the technology supplier, and it does not consider the technology to be very robust, since even small programming mistakes can lead to unacceptable down-time. The company has spent a great amount of time working and finding software integration for the best synchronisation with the other system equipment, in order to reap the full potential from the technology.

### 6.7.5 Influence of transaction attributes on the relationships with the technology supplier and its link with performance.

Case F demonstrates how firms that possess a lower level of transaction attributes are less likely to get the supplier involved in the technology acquisition process, and by not positioning the supplier as an important aspect at this stage, a good relationship is not developed. The scenario is worsened when firms encounter problems during the implementation and receive poor support from the technology supplier. The company in this case failed to achieve implementation success and was not capable of optimising the technology benefits partly because of its lack of collaboration with, and support from, the technology supplier.

Previous experience in implementing a robotic system meant that the company had enough experts to handle the technology, and hence there was less complexity and uncertainty by the firm in acquiring and implementing the new system. The buyer and supplier relationship in this case indicated that the element of business understanding, communication and involvement by the supplier is insufficient. The element of trust, information sharing and knowledge acquired from the technology supplier in this case is very minimal as it cannot be highlighted anywhere in the entire implementation process. The case emphasises that, despite the capability of the technology buyer to handle the technology independently, having a supplier who is not familiar with the processes and not giving full commitment to the implementation process, can raise the failure risk immensely.

## 6.8 CASE G. FIBRETEX (M) SDN BHD (FIBRETEX)

### 6.8.1 The background

Fibretex was established in 1991. The company is located in Penang, Malaysia, and is a joint venture between Malaysia and Australia, with 70% Malaysian ownership. Fibretex is a manufacturer of fibreglass insulation products and Spigot Fabricated

Fittings for Butt Fusion. The company currently exports its products to Hong Kong, Netherlands, Philippines, Singapore, Taiwan, and Thailand, and has around 110 employees.

The company started in the early 1980s as part of Hexagon Holdings Bhd, and manufactured fibreglass water storage. Over the following nine years, it continuously experienced erosion in profit and subsequently separated from Hexagon Holdings, to operate under a new management and ownership. In 1991, the new owner disposed of the fibreglass water storage facilities and decided to focus on fibreglass insulation products. A joint venture was created with an Australian company and the enterprise was renamed as Fibretex (M) Sdn Bhd. Under the joint agreement, the Australian counterpart provides access to the market, and the expertise and advanced technology to manufacture a variety of fibreglass insulation product. As the business grew and prospered, the company expanded its product line into producing spigot fabricated fittings for butt fusion through a technology licensing agreement in 1998. Fibretex aspires to continue to add capacity, diversify its product line, increase its already-strong engineering capability, and improve its processes and products.

In early 2001, Fibretex continued its product line expansion through the licensing of fibreglass pultrusion (continuous automatic process) technology to produce custom-designed fibreglass studs and nuts. This advanced technique can produce a pultruded stud with threads cut in a glass mat reinforced outer layer where the centre of the stud is uni-directionally reinforced for high strength and a moulded nut. The technology is capable of producing high strength, lightweight, and corrosion-resistance studs and nuts. The product is a viable alternative in structures where fastener corrosion is a concern, or where metal fasteners are not permitted for a certain engineering reason.

The investment in the technology enabled Fibretex to be the first company in Malaysia to make these products and enhance its offering to the existing market. The latest product additions also will compliment Fibretex's already extensive offering to the various industries that use fibreglass material for their business solutions. The acquired pultrusion technology is a custom model designed and tailored to Fibretex's specific product needs. Under the agreement with the technology supplier, Fibretex is granted a process license and the equipment to carry out the process. Fibretex is the exclusive aftermarket distributor of the products. Further terms and conditions of the agreement such as the method and terms of payment, the royalty involved, and the length of time of the agreement, cannot be discussed further in this case because this is confidential information, which the company refused to disclose to the researcher.

### 6.8.2 **Production process:** Production of large batches

### 6.8.3 Brief description of technology accquisition

- Technology acquired: Process and equipment licensing of Pultrusion technology
- Technology manufacturer: United States
- Technology supplier: The technology manufacturer as a licensor
- Technology type: New
- Year of acquisition: 2001
- Nature of acquisition: Full system provided by one supplier

### 6.8.4 Case analysis

#### 6.8.4.1 Transaction attributes in relation to technology acquisition

The fibreglass industry is becoming competitive and to be successful, firms need to continuously learn and venture into new process and technology. Fibretex recognised that expanding through licensing was the best way for its business nature because it provides the process, together with the equipment to produce the innovative product. Athough Fibretex has been in a fibreglass industry for almost 14 years, the company claims the whole production process, production technology and equipment are very new to the company. The licensing package includes the process know-how and the production equipment. Thus, Fibretex views the acquired technology as complex and containing a higher degree of tacit knowledge. The company totally depended on the technology supplier to support the in-house expertise throughout the implementation project.

In terms of the value of the investment, Fibretex claims the licensing of the pultrusion technology was another major investment to the company and was made in the strong hope that the third product line would be a success. Even though the technology is not a core competence for its current business, the success of its implementation and application will significantly contribute to the overall success of the business. The firm also invested a huge amount of money and time in training and learning to prepare itself for the new licensed technology.

Even though Fibretex is confident about the new product market, the company is concerned about its ability to utilise the technology to quickly repay the investment cost within a specified time frame. Through the licensing agreement, Fibretex believes that the company can rely on the technology supplier for full assistance. The package of the licensing cost also precisely describes the point at which the technology supplier will assist Fibretex, and that provision consequently reduced the feeling of uncertainty surrounding the acquisition

### 6.8.4.2 Nature of Relationship with the Technology supplier

***Before installation***

During this phase, discussion and communication with the technology supplier was very intense on the essential and major parts of the contract, such as on the necessary legal, financial, and periodic terms, so it was clearly known what technology would be supplied and how. During this process, the technology supplier also assessed the necessary manpower resources and potential additional equipment requirements, in order to maximise the technology's benefit within the shortest possible period of time.

Fibretex paid an option fee, which gave it an exclusive opportunity to familiarise itself with the technology, and its market potential, as well as to work with the supplier to further develop the process application. Fibretex evaluated the technology at the supplier's site. The agreement and the documentation was finalised within six months. Fibretex entered into a mutual non-disclosure agreement permitting the exchange of all necessary and confidential information needed for both parties to determine their path forward toward a potential license agreement. Under the agreement, Fibretex is provided with assistance on equipment procurement, customised process/technology training, and the with the implementation process.

Before the technology was shipped to the Fibretex production site, engineers from both companies (Fibretex and the supplier) worked together to determine the proper process configuration and equipment required in accordance with Fibretex's product requirement. This process also included the assessment of Fibretex's production facilities in terms of space, working environment, and available expertise in process engineering. Fibretex stressed that the pre-implementation process required 90% of supplier involvement and support. The process also involved a high level of trust between each party, exchange of information, and understanding on each other's business requirement.

***During installation***

Once the equipment was shipped to the Fibretex production plant, the technology supplier performed the process steps including equipment cross-calibration. Process modules validation and the full process integration took about three months, during which, the supplier delivered a substantial amount of knowledge relating to the entire production processes. The process engineer underwent hands-on experience on the new techniques of the manufacturing process, and key employees and the maintenance engineer were trained on machine operation, trouble-shooting, and basic maintenance. Since the machine roller head moves according to computerised numerical control instruction, key employees were also trained on how to use the software and to change the instruction for a different configuration.

Fibretex recalls that the company did not have any problems during the technology installation stage, claiming that the supplier's experts demonstrated a high level of commitment. The supplier also worked well with Fibretex's staff, facilitating discussion, analysing problems, and jointly defining steps to solve any problems to ramp up the yield. Fibretex claims that the timing fell well within schedule and attributed this to the successful and effective supplier relationship. The implementation phase ends by the acceptance of the process based on mainly device specifications and approved functionality.

***After installation***

Fibretex ran the trial production batch for about four months, during which time the company's staff were working independently from the supplier, applying all the knowledge acquired throughout their relationship with the supplier. In addition to a scheduled twice-yearly preventive maintenance for the first two years of the technology acquisition, Fibretex still have on-site support from the technology supplier's technology expert to trace and solve problems.

After about three years of acquiring the technology, Fibretex is satisfied with the value brought to the business by it, because it has also enhanced the company's knowledge of the fibreglass business and of its production equipment technology. The relationship with the technology supplier is on-going, especially in the supply of spare parts and tools. From the Fibretex viewpoint, trust was the most important element in the early stage of the technology implementation. Commitment and knowledge transfer, on the other hand, are perceived as greatly required during the implementation stage. Although communication has been required throughout the entire process, to Fibretex, it was more intense during the negotiation process.

#### 6.8.4.3 Technology Performance

After almost three years of commercially running the production line, Fibretex is satisfied with the overall performance of the technology. Basing its judgement on the ability to find new markets, achieve customer satisfaction, and financial return on investment, the company agreed that there has been success in the overall manufacturing performance.

Firstly, compared to Injection die technology, the new pultrusion technology maintains both the performance and throughput characteristics. It provides a standard roving with reduced fibre density, which permits better resin penetration, that subsequently allows the company to produce to a wider range of parts, thus product design and production flexibility are achieved. Secondly, Fibretex is also satisfied with the mechanical performance of the finished part. Much of the improvement in parts performance is attributed to high-pressure moulding, which improves fibre impregnation, and provides Fibretex with the ability to manufacture the final product to a fine tolerance and higher durability. Consistency, higher dimensional accuracy, and higher durability mean higher product quality.

Thirdly, the technology has been able to improve lead time in terms of the ability to design and manufacture new products. This is because the technology is able to operate approximately 6 times more weight per square inch than the traditional processes. Fourthly, the use of standard reinforcing fibres and a streamlined manufacturing process not only lowers the material cost, but also reduces the total cost. Finally, the ability of the technology to reduce emission and contamination, provide increased production speeds, and better control of processing parameters, have also contributed to the overall success of the technology acquisition.

#### 6.8.4.4 Implementation performance

The whole implementation process took almost one and a half years, this being well within the timeframe as specified by the technology supplier. Fibretex expressed satisfaction with the overall implementation performance. So far the machine has not had any serious down-time, most problems being due to the technique and the process. For instance, Fibretex experienced undesirable fluctuations in the polymer chemistry, and consequently, in the composite properties, during the trial production run. The company also often deals with unexpected resin contamination and poor control of fibre orientation. However, good support from the technology provider and Fibretex's continuous trying and learning, have enabled the company to control resin viscosity, avoid resin contamination and achieve a better fibre orientation. The problem has caused slight delays in Fibretex gaining the financial benefits from the implemented technology.

The company acknowledged that with a good help from the technology supplier, the time taken to tackle any technical problem has been minimal. The proper planning and involvement of the supplier, especially during the initial process of technology implementation, will definitely lead the firm to implement a technology that is capable of fulfilling the implementation objectives. Fibretex considered its addition of product line as a success as it experienced profit from the new product line.

### 6.8.5 Influence of transaction attributes on the relationships with the supplier and its link with performance

Case G demonstrates how firms that possess a high level of transaction attributes on the technology acquisition, collaborate closely with the technology supplier, which results in the achievement of technology and implementation performance.

The technology was acquired through the licensing agreement because this contains a higher degree of intellectual property, which the firm views as complex as a high degree of tacit knowledge is embedded in the technology. Apart from the newness of the process and the technology to the firm, a huge amount of money was invested for the purpose of the acquisition. The nature of acquisition through licensing, may have reduced the feeling of uncertainty surrounding the transaction.

As the technology was viewed by the firm as complex, the investment was considered major, and a substantial amount of money and time were invested in its acquisition, the case clearly shows how the technology supplier was largely involved during the entire process of technology implementation. The nature of the licensing agreement itself actually led to the development of trust, business understanding, involvement, commitment, information sharing, and knowledge acquisition.

The case also demonstrated that even though the firm was confronted with the unexpected problems during its implementation, the implementation still can be completed within schedule with effective assistance from the technology supplier.

**Table 6.2: Summary of company profiles**

| Background information | Case studies | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Case A.** | **Case B.** | **Case C.** | **Case D.** | **Case E.** | **Case F.** | **Case G.** |
| Company name | HKK | Media Displays | Toolmatch | G-Parts | AISB | MMSB | Fibretex |
| Year of establishment | 1972 | 1977 | 1990 | 1996 | 1972 | 1964 | 1991 |
| Number of employees | 60 | 45 | 63 | 28 | 300 | 804 | 110 |
| Main product | Flavoured juice | Wood and plastic wall design | High precision tools, dies, moulds, jigs, and fixtures | Precision parts and component for machinery and automotive system | Automotive exhaust system, "kangaroo bar", and car seat frame | Paper mills. Testliner, and boards | Fibreglass insulation product, spigot fabricated fittings, and fiberbolt |
| Export | None | None | None | France, Germany, italy, Japan, Singapore, and Switzerland | None | None | Hong Kong, Netherlands, Philippines, Singapore, Taiwan, Thailand |
| Production process | Production of large batches | Production of few units to customer specification | Production of small batches of a similar unit | Production of multiple parts at varying volumes | Production of multiple parts at varying volumes | Production of large batches | Production of large batches |

**Table 6.3: Summary of technology acquired**

| Description of the technology Acquisition | Case studies | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Case A.** | **Case B.** | **Case C.** | **Case D.** | **Case E.** | **Case F.** | **Case G.** |
| Technology acquired | Carton palletising robot system | CNC Router | CNC optical profile grinder | Robotic welding system | Robotic welding system | Pick and Place labelling robot system | Process and equipment licensing of pultrusion technology |
| Technology manufacturer | Japan | Taiwan | Japan | Sweden | Japan | Korea | Unites States |
| Technology supplier | Independent system provider | Manufacture's local office | Manufacture's regional office | Manufacture's local office | Manufacture's regional office | Manufacture's local office | The technology manufacturer as a licensor |
| Technology type | New | Used | New | New | New | New | New |
| Year of acquisition | 2002 | 2000 | 2004 | 2001 | 2001 | 2003 | 2001 |
| Nature of acquisition | Complete system | Complete system | Complete system | Complete system | Complete system | Not a complete system | Complete system |

**Table 6.4: Summary of case features**

| Main issues under investigation | Case studies | | | | | | |
|---|---|---|---|---|---|---|---|
| | Firm A. | Firm B. | Firm C. | Firm D. | Firm E. | Firm F. | Firm G. |
| **Level of complexity** | • Limited experience (started from small home-based business<br>• challenging task due to limited space in manufacturing floor | • No previous experience (the idea of automation is completely new to the company)<br>• Changes of manufacturing operation from manual to automation.<br>• No trained programmer or operator in the company. | • Wide knowledge and experiences<br>• Production floor is well equipped with the latest engineering technology<br>• Manned by well trained and expert employees to handle the technology<br>• The technology acquired is considered as the latest and most advanced in its class, but claims " it's like driving a car with a different model" | • No previous experience in robotic application (Previously manual weld, due to sudden increase in part requiring welding job, the comp. opt for automation)<br>• Challenging task to synchronise work station timing (Process: Rolling, stamping, punching, and welding)<br>• Time constraint due to increased production demand | • Tight schedule since old system cannot be removed too early<br>• Interrupt prod. & customer order | • Had acquired and implemented a more complicated robotic system before<br>• Understand what is expected from the system once it is installed | • Complex and new process<br>• Tacit knowledge in the process engineering<br>• New to the production process, technology and its equipment |
| **Level of technology specificity** | • Hired an experienced engineer to help transformed the firm into a fully automate operation (always made sure the company did not have a shortage of | • Major investment<br>• Core to business operation | • An upgrade to the existing machining centre<br>• Not core technology | • Major investment<br>• Core technology<br>• Large expenses on training (overseas) and learning | • First investment since the last 20 years<br>• The success of this acquisition is important for the decision to upgrade the remaining production facilities.<br>• Invest in | • Not considered core technology – acquired to enhance the labelling procedure (end process)<br>• Emp. automation training comes with the technology package | • Another major investment<br>• Huge money invested in training and learning |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | expertise in robotic system)<br>• Invest in training (for the workers and CEO, that acts as an operation manager)<br>• Not represent the core competence to the business operation – not the main production process | | | | training and expertise | | |
| **Level of uncertainty** | • Moderate- due to success of previous implementation | • Uncertain on the technology and firm's capability | • Confident the new acquisition will be a success | • Concerned whether the tech. can meet all expectation | • Japanese Joint partner assist in selecting the right tech. & supplier | • In no doubt the technology would meet firm's technical and production requirement | • Concerned on the ability to utilise the technology to get ROI within specified time |
| **Buyer and supplier relationships** | • Technology supplier fully involved in all stage of tech. implementation<br>• Agreement was achieved after the comp. convinced the supplier will be capable of providing high quality technology at the best cost.<br>• 12 types of juice with different types of bottled – work together with the supplier to program a robot that can accommodate | • Work very closely especially at the early stage of technology acquisition<br>• Select supplier that can truly helps the company through the implementation process and subsequently avoid unnecessary extra cost result from imp. Failure.<br>• Knowledgeable supplier- provides all necessary info and educates the | • Not very dependent because the company knows what it want and what to expect<br>• Maintain good relationships in some aspects (early stage, e.g. technology specification)<br>• Installation was all done by the comp. in house expertise<br>• Through the technology supplier, the company keep up dated and ahead with the newest methods and possible | • Insufficient info. Sharing and misunderstanding (quantities to be produced, number of shift worked, inches of weld per part, qualities and repeatedly of parts entering the weld cell)<br>• As new adopter, the comp. cannot foresee the complication and expectation.<br>• Worse when the supplier may not realised buyers need it's full support<br>• Work with supplier only after problems in implementation (e.g. When the robot fail to weld at the exact point location on a certain part type) | • Very dependent and work closely with the supplier<br>• One criteria for the chosen supplier because it has its own reputable customer service in Kuala Lumpur, Malaysia.<br>• Supplier provides full concept (e.g. fixturing, machanical, electrical, and electronic systems) and implementation solution (e.g. | • Less likely to get the supplier involved<br>• Engineered own work cell & separately bought peripherals to save cost<br>• Some implementation problems (During trial run, problems to synchronise the conveyor timing, the robot speed, and printing time. The system shut down when the arm is set to pick up and attached the label at an accurate measure) – claims to received unfavorable supplier response<br>• The supplier claims the problems resides in the programming and refer buyer to the system | • Very dependent and work closely with the supplier<br>• Effective support from supplier helps everything on schedule amid many unexpected obstacles |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | the changes to the bottle size and weight.<br>• Installation and trial process takes 2 weeks. Supplier's team member remain on the site to familiarise the workers with the operation and maintenance procedures<br>• After installation, supplier were still being referred to for several technical problems. | company.<br>• 2 days for full installation and 2 weeks system trial – full commitment from supplier (e.g during the improper template setup in the CNC link<br>• "…appropriate technology selection and smooth installation are formula for success, and definitely cannot be achieved without the involvement of a good supplier". | upgrades available in the market. | • Unsatisfying support and commitment from supplier. (e.g. : Have to incur extra cost to buy the automated fixture because the positioner that comes with the system is not sufficient for the firm's complex, Slow after sales support service)<br>• The comp. claims that supplier did not fully understand buyer's production need (The robot has its limitation and consume so much cycle time when dealing with parts variation – Some high volume, some small batch)<br>• Lack of business understanding and inefficient information sharing result in lots of useful information was not conveys, until certain problems exist.<br>• Buyer firm could enjoy the benefits earlier if all the important issues were discussed with the technology supplier. | creates the CAD drawing of the installation layout)<br>• Supplier examined all involved parts to determine the potential variability in dimensions and location when in position for welding)<br>• The trial was conducted for 2 weeks on 9 robot running for 1 to 3 shift. | partner. The system partner then referred buyer back to the robot supplier – problem resolved but delayed in running for full production.<br>• Not enough after sales service engineer to attend to buyer's request. | |
| **Technology performance** | • Fully satisfied | • Fully satisfied | • Fully satisfied | • Some dissappointment in lead time achiement | • Fully satisfied | • Not fully satisfied due to recurrent down time | • Fully satisfied |
| **Implement. Performance** | • Fully satisfied | • Fully satisfied | • Fully satisfied | • Expensive mistakes<br>• Delayed installation<br>• Unacceptable down time | • Fully satisfied | • Delay than expected<br>• Not satisfied- ineffective supplier's assistance | • Fully satisfied |

**Table 6.5: Summary of case analysis**

| | Case studies | | | | | | |
|---|---|---|---|---|---|---|---|
| **Background information** | **Case A.** | **Case B.** | **Case C.** | **Case D.** | **Case E.** | **Case F.** | **Case G.** |
| Company name | HKK | Media Displays | Toolmatch | G-Parts | AISB | MMSB | Fibretex |
| Level of complexity | High | High | Low | High | High | Low | High |
| Level of asset specificity | Moderate | High | Low | High | High | Moderate | High |
| Level of uncertainty | Moderate | High | Low | High | Moderate | Low | High |
| Transaction Attributes* | Moderate | High | Low | High | High | Low | High |
| Buyer and supplier relationships | High | High | Moderate | Moderate | High | Low | High |
| Technology performance | High | High | High | Moderate | High | Moderate | High |
| Implementation performance | High | High | High | Low | High | Low | High |

* Note: assessment of transaction attributes is measured from a combined result of complexity, asset specificity, and uncertainty.

## 6.9 KEY ISSUES ARISING FROM THE CROSS-CASE ANALYSIS

### 6.9.1 Transaction attributes in the technology acquisition and implementation are related to the pattern of relationships with the technology supplier

From the above cases, it is shown that the transaction attributes, such as the level of complexity, the level of asset specificity, and the level of uncertainty surrounding the acquisition and implementation, play a major role in determining the strength of the relationship with the technology supplier. As seen from Table 6.6, majority of cases that possess a high level of transaction attributes engaged in a closer relationship with the technology supplier (Case B, E, and G), whereas, those firms with a low level of transaction attributes (Case C and F) do not see the need to develop strong relationships with the technology supplier. The pattern of relationship suggest that the higher the transaction attributes, the more firms are likely to engage in stronger relationships with their technology suppliers.

**Table 6.6: Grouping of firms by transaction attributes**

| Cases | Transaction attributes | | Buyer and supplier relationships |
|---|---|---|---|
| B | High | ⟶ | High |
| E | High | ⟶ | High |
| G | High | ⟶ | High |
| D | High | ⟶ | Moderate |
| A | Moderate | ⟶ | High |
| C | Low | ⟶ | Moderate |
| F | Low | ⟶ | Low |

From the transaction cost economic view (Williamson, 1975), in any transaction (exchange of goods and services across organisational boundaries, which this study considers as the acquisition and implementation of advanced manufacturing technology by the organisation), transaction cost (such as the cost of setting up, negotiating and safeguarding the relation and the costs of running, securing and correcting the relation while it is working) arise as transaction attributes (degree of complexity, asset specificity, and uncertainty) arise. Thus, the higher the transaction attributes, the more firms need to develop a good relationship with the technology supplier. A strong relationship acts as a mechanism to reduce the transaction cost and enhance transaction value in order to ensure that collapse in the transaction can be avoided.

#### 6.9.1.1 Level of complexity

As the buyer firms see the technology as complex, they are very much dependent on the technology supplier to give them complete and sincere information, even before the decision is made to purchase the technology. As demonstrated by case B, the view of the complexity of the technology surfaces from its unfamiliarity. Not only does the company have no previous experience in using the CNC machine, but the decision to choose the right technology is also complicated to the company. In that case, the choice of supplier was influenced by the level of integrity and reliability demonstrated by the supplier, which indirectly indicated greater dependence on the technology supplier. The trust in the supplier's capability to provide strong support throughout the implementation process was also extremely important to the company before the decision was made to purchase the technology. As pointed out by the CEO:

> "We don't have previous experience in using a CNC machine" (CEO, Media Displays).
>
> "This supplier seems very knowledgeable compared to the earlier one, this one shared a lot of information with us and was willing to share their knowledge.... although we have not yet signed any agreement" (CEO, Media Displays).
>
> "Judging from our early collaboration, we are confident we can depend on this supplier" (CEO, Media Displays).

Cases A, B, D, E, and G demonstrate that the view of complexity of the technology by the buying firms largely surfaces from two facets. Firstly, the technology itself is considered to be complex due to the firms' lack of knowledge about it or lack of experience in handling it. Secondly, the view comes from the complexity associated with implementing the technology, which is normally due to the anticipated problems or challenges arising during this period. In either facet, high complexity leads to a dependence on, or involvement of, the technology supplier throughout the implementation process. For instance, cases A and E show the supplier to be involved from the planning stage before installation to the full system installation and maintenance programme. Cases B and G show that intense communication and collaboration take place throughout the implementation, and that the aspect of trust, information sharing, commitment and involvement of the supplier, were apparently present in the relationship.

> "We don't have any problem on the installation.... the supplier expert was very committed" (Production and Material manager, Fibretex).

> "...but trust is the most important element during the earlier stage ... commitment and exchange of knowledge from both sides are greatly required during the installation stage" (Production and Material manager, Fibretex).

At another extreme, case C views the technology as uncomplicated and straightforward, consequently believing it to be unnecessary for the company to engage in a close relationship with the technology supplier.

> "No we don't see it as complex ... just like our other technology, it's like driving a car with a different model, the concept is similar, only the features and capability are different" (Executive Director, Toolmatch).

> "We know what we want, so we just make sure they can provide what we want" (Executive Director, Toolmatch).

> "The supplier was not involved at all for the installation ..." (Executive Director, Toolmatch).

#### 6.9.1.2 Level of asset specificity

If the investment is considered major, and the acquired technology represents a core competence to the business operation, the more likely is that firms feel the need to develop good relationships with the technology supplier. The probability of individuals engaging in the transaction to behave opportunistically increases as investments in specific assets increase (Hill, 1990), which means that the development of a good relationship with the technology supplier acts as a governance mechanism to protect the investment from various sources of failure. Furthermore, when the investment is classified as important to the business, and substantial resources in terms of money and time have been allocated, there is a need to guard the investment from any potential risk of failure.

Case G regarded the acquisition as a major investment, whereas in comparison, case F did not, and did not see it as contributing to the central part production processes. Given the differences in the level of asset specificity, case G collaborated more closely with the technology supplier, compared to case F.

> "It is not necessary for them to understand our manufacturing operation in detail because it is not related to the main manufacturing process ... early involvement of the supplier was not strong" (Operation manager, MMSB).

> "The pre-implementation process required 90% of the supplier involvement and support ... discussion and communication was very strong" (Production and Material manager, Fibretex).

#### 6.9.1.3 Level of uncertainty

Uncertainty surrounding the acquisition and implementation is another aspect that patterns the relationship with the technology supplier. For instance, case B was very uncertain about its capability in choosing, implementing and operating the technology, and selected a supplier it trusted and who truly helped the company throughout the implementation process. As it worked closely with the technology supplier, the knowledge accumulated and consequently, the confidence increased. Similarly, Case G opted for the full system integration package, involving full supplier responsiblility for the implementation process, in order to reduce the feelings of uncertainty surrounding the transaction.

> "We had a slight hesitation on whether or not we can choose the right technology as well as implementing and handling it ... To avoid unnecessary extra cost from failure of implementation and failure in achieving the company objectives, it's really important for us to go for a supplier who can help the company throughout the implementation process" (CEO, Media Displays).

In comparison, case C does not see the need to involve the supplier during and after the installation stage, and case E demonstrates least dependence on the technology supplier throughout the implementation process. Compared to cases B and G, cases C and E demonstrate a lower level of uncertainty about the technology capability and the firm's capability to implement and handle the technology.

> "...we were very confident the technology would enable us to fulfil customer demand" (Executive Director, Toolmatch).

### 6.9.2 The linkage between the buyer and supplier relationship and performance

The cases showed that the relationship with the technology supplier has a substantial impact on performance level. As indicated from Table 6.7, all cases that experienced strong buyer and supplier relationships achieved a higher level of performance. Table 6.8 indicated that the case that experienced weak relationships with the technology supplier achieved lower level of performance. An overall consideration of Tables 6.7 and 6.8 simultaneously imply that, no cases that experience strong buyer and supplier relationship experience a lower level of performance, thereby suggesting that developing a good relationship with the technology supplier facilitates performance improvement.

**Table 6.7: Grouping of firms that develop strong buyer and supplier relationships**

| Cases | Buyer and supplier relationships | | Performance level |
|---|---|---|---|
| A | High | ⟶ | High |
| B | High | ⟶ | High |
| E | High | ⟶ | High |
| G | High | ⟶ | High |

**Table 6.8: Grouping of firms that possess weak buyer and supplier relationships**

| Case | Buyer and supplier relationships | | Performance level |
|---|---|---|---|
| F | Low | ⟶ | Low |

Case B involved the technology supplier in all stages of the technology implementation, depending on the supplier for selecting the right technology for the company, being committed to providing support and problem solutions during the installation, and being involved on performing preventive maintenance after the implementation. For this company, the installation was completed earlier than scheduled and the technology successfully achieved the implementation objectives it set. Quality, efficiency and lead-time improved significantly and costs were reduced effectively.

> "... appropriate technology selection and smooth installation are the formula for success and definitely cannot be achieved without the involvement of a good supplier" (CEO, Media Displays).

In comparison, case D demonstrated that inefficient collaboration during the earlier stage of technology acquisition led to a serious problem in technology implementation and resulted in a moderate achievement of technology performance.

> "...expensive mistakes could surely have been avoided if we had collaborated more closely with the technology supplier" (CEO, G-Parts).

The supplier's lack of understanding of the buyer's manufacturing operation before the installation stage, for instance, not only caused delay in the installation stage, but also additional cost for the technology buyer.

> "During the trial period, on a certain part, the robot could not weld at the exact point location ... the positioner that comes with the system was not sufficient ... we then had to spend an extra cost to purchase the automated fixture, the one specially designed for our product type" (CEO, G-Parts).

Many of other instances described in case D, clearly indicated that inefficient information sharing and involvement by the technology supplier resulted in the loss of valuable information, which is directly and indirectly useful for the technology buyer, thereby having a significant impact on the achievement of the technology and implementation performance.

In case D, the company experienced unacceptable down-time and the length of time taken for complete installation was beyond expectation. The technology did not immediately meet its implementation objectives and the company was only moderately satisfied with the technology performance.

> "We were disappointed ... the expensive robots can reach only 90% of welds on a particular part" (CEO, G-Parts).

Based on the case result and literature review, it can be clearly distinguished that developing a close relationship with the technology supplier is crucial in order to make new technology implementation a success. Close links with suppliers are amongst the critical factors in respect of both technical and business success when implementing advanced manufacturing technology (Sohal and Singh, 1992). The price offered and the levels of support and back-up provided by the supplier to the buyers are two important criteria for success, together with other contributory factors such as the ability of people in the relationship to relate to each other, the flow of information, the ability to build teams for close co-operation in joint problem-solving, and the ability to encourage shared information (Zairi, 1992). Above all, the results suggest that the development of a strong relationship is important in new technology implementation since this is capable of enhancing the performance level.

### 6.9.3 Where there is a high level of transaction attributes, performance suffers more when firms develop weak relationships with the technology supplier

Cases C and D are the two unique cases where moderate relationships with the technology supplier resulted in contrasting high and low performance respectively (see Table 6.9). To fully understand the situation, Table 6.10 presents the entire pattern of linkages, from which it is noticeable that case C possesses a lower level of transaction attributes, develops moderate relationship with the technology supplier, but still achieves higher performance. In contrast, case D possesses a higher level of transaction attributes, develops a moderate relationship with the technology supplier, but achieves a lower level of performance. This observation suggests that where there is a high level of transaction attributes, performance suffers when firms do not develop strong relationships with the technology supplier, and indirectly hints that in the same circumstances, performance suffers more if firms develop weak relationship with the technology supplier.

**Table 6.9: Grouping of firms that possess moderate buyer and supplier relationships**

| Cases | Buyer and supplier relationships | | Performance level |
|---|---|---|---|
| C | Moderate | ⟶ | High |
| D | Moderate | ⟶ | Low |

**Table 6.10: The entire pattern of relationship**

| Cases | Transaction Attributes | Buyer and supplier relationships | | Performance level |
|---|---|---|---|---|
| A | Moderate | High | → | High |
| B | High | High | → | High |
| E | High | High | → | High |
| G | High | High | → | High |
| C | Low | Moderate | → | High |
| D | High | Moderate | → | Low |
| F | Low | Low | → | Low |

Case C possesses a lower level of transaction attributes. It views the technology and its implementation as simple, since it has the knowledge, previous experience and enough in-house expertise to implement and handle the technology. Before the acquisition and implementation, the company had no doubt that the technology would be capable of meeting the customer demand and achieving its market goal. Thus, the company did not see it as necessary to rely heavily on the technology supplier.

> "The supplier was not involved at all for the installation" (Executive Director, Toolmatch).

However, intense communication between both parties did occur at the early stage of technology implementation, when the elements of trust, business understanding, and information sharing were present. The company experienced a higher level of technology performance and had no problems in the technology implementation.

> "...we were fully satisfied with the performance of the machine" (Executive Director, Toolmatch).

Although the company in case D also demonstrated a moderate relationship with the technology supplier, it did nonetheless, experience poor implementation performance because compared to case C, case D possessed a higher level of transaction attributes. In that case, even minimal insufficient information-sharing and business understanding at the early stage of technology implementation, could lead to a various unexpected problems.

> ".. after several setbacks, we realised lots of things were not settled with the supplier ... their lack of knowledge of our business operation may have caused the bump in the process" (CEO, G-Parts).

A comparison between cases C and F, however, suggests that at least a slight relationship with the technology supplier needs to be developed regardless of the status of transaction attributes. Cases C and F, both possess a lower level of transaction attributes. Case C, which developed a moderate relationship with the technology supplier, however, experienced a higher level of performance in comparison to case F, which developed a weak relationship with the technology supplier. This finding implies that even in the event of lower transaction attributes, a relationship with the technology supplier still needs to be developed in order to make the acquisition and implementation a success. This indirectly suggests that the elements of trust, business understanding, involvement, commitment, communication, information sharing, and knowledge acquisition as measured in this study, need to exist at some point in the relationship.

## 6.10 INSIGHTS FROM THE CASE STUDIES

### 6.10.1 Insights about buyer and supplier relationships in AMT acquisition and implementation

The sample cases have demonstrated a deep and rich understanding of the buyer and supplier relationship in the technology acquisition and implementation process. Several key insights are noted from the cases. Firstly, it is evidence that the before installation stage is the most critical point for developing a good relationship with the technology supplier, since this is the time when the involvement of the technology supplier is compulsory. During this stage, information which is directly or indirectly useful for both parties to enhance the acquisition and implementation process, is shared.

Communication is a vehicle for the development of business understanding and information sharing, and is present in any good relationship, similar to the concept of trust. According to Tomkins (2001), trust is ubiquitous and a fundamental building block of social life. It is a belief by one party in a relationship that the other party will not act against his or her interest. If one desires an understanding of how any relationship works, one must, therefore, address the boundaries of trust within that relationship. As demonstrated by the case studies, the aspect of trust plays a significant role in the earlier stage of technology acquisition and implementation.

Although commitment is present at an initial stage of technology implementation, aspects of commitment, however, are much more obvious during and after the installation stages. Commitment at the initial stages of technology implementation appears in the form of a contractual commitment to continue collaborating with the intention to achieve a desirable result for each party. Commitment at the later stage of technology implementation, on the other hand, is in the form of a responsibility on the supplier to respond to any challenges faced by the buyer during and after the installation.

Secondly, buyer and supplier relationships take many forms, as demonstrated by the variety apparent in the cases. Case A, for instance, paid a considerable amount of money, and chose a system provider as a supplier, to ensure the full involvement and commitment of the supplier in the entire process of technology implementation. It regarded itself as having a strong relationship with the technology supplier. Case B demonstrated a close relationship with the technology supplier by depending heavily on it from the point of technology selection to the implementation and maintenance. From the beginning, it was determined to ensure the supplier it had chosen would give its full support and commitment to the entire implementation process. It also regards itself as having a strong relationship with the technology supplier.

In case E, the supplier plays an important role in all stages of technology implementation, from the evaluation process and the pre-installation planning, to the actual installation in which there was direct involvement and commitment. The company had no complaint and did not see any evidence of poor service, regarding itself as a having a good relationship with the supplier. Case G, on the other hand secured the relationship with the supplier, formally through the licensing agreement, which explicitly states how the technology and the know-how are to be delivered. Similar to case E, case G's supplier plays an important role in all stages of technology implementation and the company has no complaint, having seen no evidence of poor service, and again considering it to have a good relationship with the technology supplier.

Case C does not see the need for full supplier support and commitment. Indeed, there was no supplier involvement during installation stage and only minimal involvement after it, although the aspects of communication and business understanding were still present during the initial installation period. The company regards itself as having a moderate relationship with the technology supplier. In case D, the supplier was committed to the buyer company in every challenge faced by it and was very involved during the installation stages. However, the case is a good example of how inefficient communication, business understanding, and information sharing resulted in poor performance.

Case F does not consider the development of strong collaboration with the technology supplier to be part of the technology acquisition and implementation process. The act of choosing a separate supplier for the technology peripherals in order to reduce cost, indicated the feelings of least dependency on the technology supplier, which indirectly signals a low requirement for commitment from the supplier. From the initial installation stage, the firm was confident about its own capability and did not view the supplier as a key success factor in the technology implementation. In fact, the company experienced poor commitment from the technology supplier during the installation stages, and expressed disappointment with the level of communication. The company regards itself as having a weak relationship with the technology supplier.

The overall case analysis shows that the development of strong relationships is the result of either/both the buyer's preference or/and the excellent performance of the technology buyer. Similarly, the development of weak relationships is the result of either/both the buyer's preference or/and the poor performance of the technology buyer. The source of buyer preferences emerges from the buyer's view of the attributes surrounding the transaction (technology acquisition and implementation). It could also be argued that the technology supplier's performance is affected by the supplier's view of attributes surrounding the transaction (on a particular technology sold) but a different empirical study needs to be conducted to confirm this argument. Regardless of form of the relationship that develops, the aspects of trust, business understanding, information sharing, commitment, involvement, and communication and knowledge acquisition, are clearly evident, with differences only being apparent in the intensity of these dimensions. Figures 6.1a and 6.1b illustrate the pattern of relationships that exist between the technology buyer and technology supplier as identified from the case analysis.

In light of the above, the aspects of the buyer and supplier relationship as examined in this study, gauge the strength of the relationship by measuring the extent of trust, business understanding, involvement, commitment, communication, information sharing, and knowledge acquired that exist within it. It is not concerned with the form of relationship or who initiated it. As long as the buyer firm identifies that the seven dimensions of the relationship as measured in this study are strong, the study considers it as developing a strong relationship with the technology supplier. On the other hand, when the seven dimensions are weak in a relationship, the study considers it as developing a weak relationship with the technology supplier.

**Figure 6.1a: The different manner of buyer and supplier relationships in AMT acquisition and implementation**

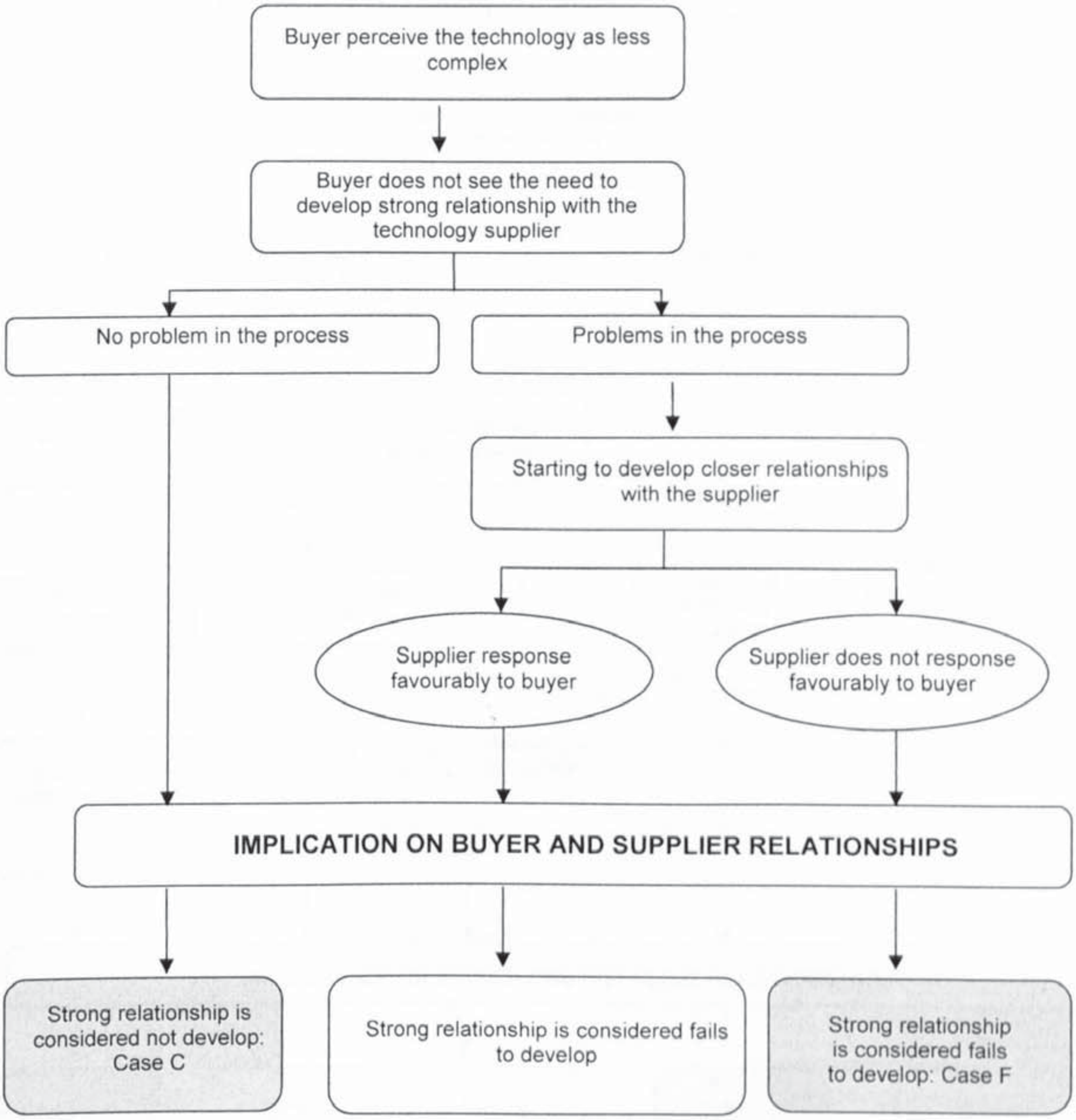
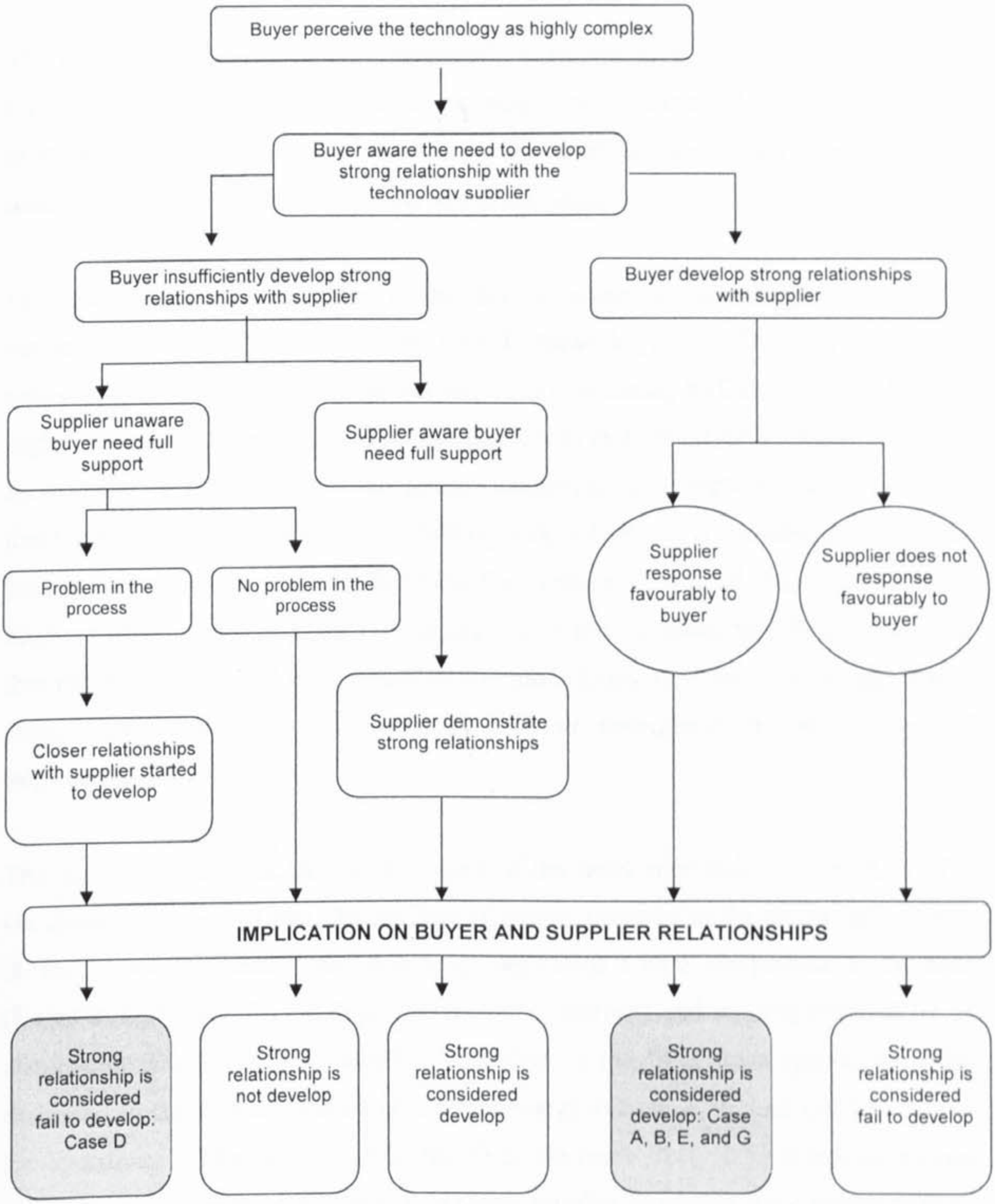


**Figure 6.1b: The different manner of buyer and supplier relationships in AMT acquisition and implementation**



### 6.10.2 Insights about transaction attributes in AMT acquisition and implementation

The case studies reveal that the transaction attributes such as level of complexity, level of asset specificity, and level of uncertainty were seen to play a significant role in determining the strength of the relationship with the technology supplier in the process of technology acquisition and implementation.

The case studies show that most of the feelings regarding technological complexity surface from the buyers' unfamiliarity with the technology (Case B, D, G) or from the noticeable challenges that exist as a result of implementing it (Case A, B, D, E). The higher the level of complexity, the more likely it is that the buyer attempts to involve the supplier in the process of technology acquisition and implementation (case B), that the buyer ensures the supplier's full support and service is included as part of the package price (case A and case G), or that the supplier is involved at some point in the implementation process (Case D). Regardless of the situation, this finding suggests that the higher the level of complexity, the more likely the firm is to engage into a close relationship with the technology supplier throughout the acquisition and implementation process.

The cases revealed that the buyers' view of the asset specificity is the result of a combination of factors like, the amount of money invested in the technology (Cases B, D, E, and G), whether the technology represents a core competence to the firm (Cases B, D, E, and G), the degree of collective learning and training required by its acquisition (Cases A, B, D, and G), and whether the firm has a special expertise dedicated to the implementation of the technology (Cases A, E, and G). The higher the specificity of the investment to the firm, the more likely it is to ensure a good relationship is developed with the technology supplier to protect the investment from various sources of failure.

The study measures uncertainty in terms of the buyers' confidence in the ability of the acquired technology to achieve their investment goals, meet their customer demand, and meet the technical expectations. It also considers firms' previous experience in handling a similar technological innovation and the availability of in-house expertise to handle the technology, as an additional aspect of uncertainty. The cases revealed that most buyers who expressed feelings of uncertainty about the technology, are aware of the need to work closely with the technology supplier. They also confirmed that developing a good relationship at the initial contact with supplier, and the demonstration by the supplier of a higher level of integrity, commitment and assistance at the early stage of technology implementation, can significantly reduce the feelings of uncertainty.

No previous experience in handling a similar technological innovation and the unavailability of in-house expertise to handle the technology, are also seen to increase the level of uncertainty as demonstrated by case A and case D. In contrast, Case C is a good example of how a firm with substantial experience in implementing a similar technological innovation and with enough in-house experts to implement and handle the technology, was very confident about all aspects of the technology and its implementation. The firm was very certain that the technology would work as it was intended, and that it would be able to achieve its investment goal and meet its customer demand. Cases A and F indicated that the success of previous technology implementation influenced their feelings of uncertainty. Regardless of the source of uncertainty, the cases obviously revealed that the more firms feel this way, the more likely they are to work closely with the technology supplier because this helps to reduce the uncertainty surrounding the acquisition and implementation.

## 6.11 CHAPTER SUMMARY

The overall case analysis indicates that the higher the level of complexity, asset specificity, and uncertainty, the more likely it is that the buyer firm will engage in a closer relationship with the technology supplier. In this case, firms tend to obtain strong supplier involvement for the entire stages of technology implementation, which are before, during, and after the installation. The cases also indicate that a close or strong relationship with the technology supplier appears to result in the achievement of technology performance and a smooth implementation process. Failure in a certain element of buyer and supplier relationships leads to undesirable performance achievement. It is suggested that complex technology, specific investment, and a higher level of uncertainty surrounding the transaction, requires strong supplier involvement in order to ensure the acquisition and implementation success.

# CHAPTER SEVEN
# DISCUSSIONS AND CONCLUSIONS

## 7.1 INTRODUCTION

This chapter will be divided into six main parts, namely the discussion, conclusions, contributions, implications, limitations and suggestions for future research. The discussion draws together various strands emerging from three important aspects namely, these being: the quantitative results, the qualitative results, and support from the literature. The conclusion is arrived at after considering the assessment conducted in all the previous chapters and on the basis of the evidence from the research findings and discussion.

The present study investigates how the transaction attributes affect the technology buyer and supplier relationships (BSR) in advanced manufacturing technology (AMT) implementation, and assesses its impacts on performance. Specifically, it addresses the issues of how the three transaction attributes, namely, level of complexity, level of asset specificity, and level of uncertainty, can affect the development of BSR in AMT acquisition and implementation, and then it explores the impact of different patterns of BSR on the two aspect of performance, these being technology and implementation performance.

In understanding the phenomena, the study mainly draws on, and integrates, the literature of transaction cost economic theory, buyer and supplier relationships, and advanced manufacturing technology. The data was collected through a questionnaire survey and semi-structured interviews. Data from the survey were analysed through the use of SPSS and AMOS software. Several rigorous tests were carried out to test the eight research hypotheses developed for the study. Data from the interview sessions were used to develop a case study with the intention of providing a richer and deeper understanding on the subject under investigation and to offer triangulation in the research process. The following discussions mainly refer to the research hypotheses with more implications explored.

## 7.2 DISCUSSIONS

### 7.2.1 Transaction attributes

The literature on transaction economic theory recognises that the three transaction attributes, namely level of asset specificity, level of uncertainty, and frequency of transaction are the three attributes that have a significant impact on the governance structure. However, having reviewed the literature, this study determined that level of complexity should also be taken into consideration when studying buyer-supplier relationships. Furthermore, the study excludes the "frequency of transaction" attribute, since this is less applicable to the study of capital equipment suppliers than to the study of industrial equipment suppliers. These issues were discussed in Chapters Two and Three of the thesis.

Within the broad five categories of technology types recognised in this study, it was found that different firms view the same type of technology differently in terms of its complexity, its specificity to the company, and the uncertainty surrounding its acquisition and implementation. For instance, 26 firms in the sample that have adopted computer numerical machines were found to attribute varying degrees of complexity to the technology being acquired and implemented. A technology which is viewed as complex by one firm may not be considered the same by another firm. Similarly, the same amount of resources devoted to the acquisition and implementation of the technology may be viewed as highly specific by one firm but as less specific by another. Firms may also experience varying levels of uncertainty about the same type of technology acquisition and implementation. All these variations spring from the uniqueness of each firm and its environment.

The case study exercise featured in Chapter Six further demonstrates these issues. For example, although the technology was not exactly the same, both Firms B and C had acquired computer numerical machines, but the value of the investment was significantly higher for firm C, yet the technology was not considered as a major investment or core to the business operation, and there was no uncertainty surrounding the acquisition and implementation process, whereas Firm B's perceptions were quite different. This signifies that the assessment of the transaction attributes relates to each firm's unique internal and external environment. In this regard, it is suggested that the variations in perception of the transaction attributes actually lie within the organisation itself.

### 7.2.2 The elements of buyer-supplier relationships

The measure of the buyer-supplier relationship in this study was taken from the buyer point of view. It gauges the extent of trust, business understanding, commitment, involvement, communication, information sharing and knowledge acquired from the buyer's relationships with the technology supplier. Chapter Two has reviewed the literature in depth, finding that these elements have been extensively used in previous research in measuring the buyer-supplier relationship. In this research, the initial seven dimensions of buyer-supplier relationships were reduced into five, based on the result of factor analysis. The elements of trust and business understanding, and the elements of commitment and involvement appeared to merge as one rather than two suggest the need for separate scales, hence trust and business understanding were combined, as were commitment and involvement, thus resulting in only five dimensional constructs that comprise buyer-supplier relationships.

When analysing the survey result, a strong relationship was considered to exist if firms indicated a higher score on these elements when referring to their relationships with the technology supplier. Furthermore, the interviews with the case companies provide evidence that elements were those at the forefront of discussion, when the interviewees were describing their relationships with their technology suppliers. Also, in cases where firms claimed that they did not have a good relationship with the technology supplier, the statements "they don't understand", "less communication", "not committed", "not fully involved", and "not telling information" frequently emerged during the conversation. Examples and illustrations provided during the interviews also provide significant indications of the existence of these elements. Table 7.1 presents a few examples of the circumstances and/or direct quotations from the case analysis that describe an element of BSR measured in this study.

**Table 7.1: Description of elements of BSR from interviews**

| Case | Quotation / illustration | Major elements |
|---|---|---|
| A | "We achieved agreement within a short period of time...we believed the supplier could provide us high quality technology at good cost" | • Trust<br>• Communication |
| G | "Communication heavily takes place during the negotiation process" | • Communication |
| A | Firm A has 12 different types of juices with various types of bottles from 220 ml to 5 litres sizes. The palletising system then had to be capable of handling various sizes and styles of bottles and had to accommodate changes in each bottler's filled amount and volume. The bottle characteristics also vary depending on the types of ingredients used and the fill volumes required. KHH recalls that the supplier understands that with those requirements, the robot program had to allow flexibility to easily adjust palletising positions to adapt to the bottle variations.<br><br>"...these details were discussed ... together we put a joint effort to find the best solution for the requirement." | • Business Understanding<br>• Communication |
| G | "We thought we had enough co-operation with the supplier, after several setbacks, we realised lots of things were not settled with the supplier ..." | • Lack of Involvement<br>• Lack of communication |
| G | G-metal recalls that during the trial period, the robot failed to weld at the exact point location on a certain part type. The supplier recognised that the problem lay in the positioner, the one that determines how the part is presented to the robot for welding. Due to the complexity of the design of some parts, the positioner that comes with the system, which are the stationary table(s), turntables, and headstocks and tailstocks are not sufficient. G-metal had to incur an extra cost to purchase the automated fixture, especially designed for G-metal product types.<br><br>"....the problem was resolved, but increased our cost". | • Lack of business understanding<br>• Insufficient information sharing |
| E | The trial was conducted for two weeks on nine robots running, one to three shifts each. During the trial run, the supplier also provided complete programming and tool tryout. The supplier made sure that the master robot programming, process development and PLC programming, and all the hardware components work as one. However, the system experienced bugs which resulted from the integration of a complicated system. | • Commitment<br>• Involvement |

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| | "They were very committed and experienced in providing the solution to the problem"<br><br>"...their experienced applications personnel provided all of the programming and debugging needed ... plenty of on-site support and training..." | |
| E | "...direct and indirect knowledge from the supplier was very useful and is still on-going" | • Knowledge acquired |
| B | "Whatever we learned from the supplier has to allow us to handle the technology on our own after the implementation process" | • Information sharing<br><br>• Knowledge acquired |
| F | "...they also guide us on how to utilise maximum benefits from the technology ... sales information was unbiased and honest..." | • Information sharing |

The survey results indicate that most of these dimensions are inter-related, and are consistent with findings of prior research (Goffin et al., 2006; Morgan and Hunt, 1994). They demonstrate that communication appears to be the most essential aspect in buyer-supplier relationships, and the case studies further illuminate this phenomenon. Almost all companies in the cases examined, recognised that communication was one of the most crucial elements of their relationships with the technology supplier. Communication with the technology supplier also exists even before the decision is made to purchase the technology. Furthermore, detailed collaboration between buyer and technology supplier in reaching the agreement for the technology specification, signifies a high degree of communication in the relationships. Moreover, communication is the basic underpinning for all relationships, and much of the previous research in BSR has pointed out that the evolution of IT in business (ie. internet technology) presents a powerful force on the communication pattern between buyer and supplier in many industries (Humphreys et al., 2006).

Although the survey respondents indicate a high degree of communication in their BSRs, they nonetheless recorded a low degree of information sharing, in comparison to the other elements of the BSR measured in this study. The insignificant value of correlation analysis between communication and information sharing suggests that frequent communication between buyer and supplier in the technology acquisition and implementation does not necessarily mean true and complete information is shared. Humphreys et al. (2006) stressed that timely and accurate information sharing is crucial in buyer-supplier relations and that this aspect can be made more achievable with the use of information technology. Yet, the authors recognised that both buyer and supplier found it difficult to adapt to the openness implicit in the notion of information sharing. Both parties engaging in the transaction were unwilling to disclose information that could be used by another party, due to constraints on their authority, or fear of opportunistic behaviour by the other party. This implies that although communication is enhanced through the use of information technology, that is no guarantee that complete and honest information is shared.

This situation could be even more critical in the process of acquisition and implementation of AMT. On the supplier side, there might be a reluctance to share honest information about the technology in the interests of selling the product to the customer. For example, the supplier may exaggerate information by portraying complex technology as easy to implement, or may withhold information about necessary upgrading costs. The supplier might also be unwilling to disclose information that could expose the weakness of the technology being supplied. However, trust and business understanding are highly correlated with information sharing, suggesting that when trust is established or when high business understanding is developed with regard to the technology being acquired and implemented, information is more likely to be shared. Humphreys et al. (2006) noted that information can be exchanged on a regular basis in an environment of trust. It could also mean that when information is shared, trust and business understanding are more likely to be developed in the relationships.

### 7.2.3 Patterns of buyer-supplier relationships

In trying to understand buyer-supplier relationships, the survey identifies the extent of their strength (weak, moderate, and strong). Referring to Chapter Six, section 6.10.1, it can be seen that the case study findings offer an interesting insight into patterns of buyer-supplier relationships in the acquisition of capital equipment, demonstrating that the strength of such relationships can emerge from many different bases, for instance, from the initiative and action of either that the technology buyer or the technology supplier. This initiative can be in terms of extra payment, establishing contact, or choosing the right and reputable supplier. In this case, its either the technology buyer realised the important role of the technology supplier, placed a heavy reliance on the technology supplier through the entire process and received satisfactory support, or simply because the technology supplier was aware the extent of support needed by the technology buyer in the entire process of adoption.

On the other hand, poor buyer-supplier relationships can result from either the technology buyer not wanting to rely on the supplier, or the buyer being aware of the importance of the technology supplier and over-depending on the supplier's support such that the perception of the service from the technology supplier is poor. Despite the different pattern of relationships, the case study indicates that trust and business understanding, committed involvement, communication, information sharing, and knowledge acquired are very apparent when firms are developing strong relationships with, or relying, on the technology supplier, compared to when they are developing weak relationships with the supplier, or less likely to rely on that company.

The case analysis also provides some evidence that the elements of trust and business understanding, committed involvement, communication, information sharing, and knowledge acquired, are found to be lacking in the situation where buyers did not receive full support from the technology supplier, or when buyers claimed that they did not have a good relationship with the technology supplier. The survey and case findings indicated that the buyer's preference for developing a close relationship with the technology supplier was affected by the specificity of the technology being acquired and the degree of uncertainty surrounding the acquisition and implementation of the technology. Therefore, it should be noted that the weak buyer-supplier relationships revealed in this study do not necessarily mean that the buyer received disappointing support from supplier, but that it was felt that strong supplier involvement was simply not required.

### 7.2.4 Transaction attributes and buyer-supplier relationships

Correlation analysis of the three attributes, indicates that level of uncertainty has the highest correlation with BSR, and asset specificity and level of complexity, follow. However, further SEM analysis indicates that in the same model, only level of asset specificity and level of uncertainty were found to have an impact on the strength of buyer-supplier relationships. The direct path from the level of complexity and BSR is not significant, but there is significance through the indirect path to BSR via level of asset specificity and level of uncertainty. The mediation test revealed that the impact of the level of complexity on the strength of buyer-supplier relationships largely exists only because it is correlated with the level of uncertainty that has a direct impact on buyer-supplier relationships, and not because the complexity itself directly predicts buyer-supplier relationships.

Hypothesis two, which states that the higher the level of asset specificity, the more likely firms will engage in closer relationships, is supported in this research. Within the operationalisation and the context of the research, the survey results suggest that, if the technology is highly specific to the firm, for instance, when a substantial amount of money and a high degree of training and learning have been invested in acquiring and implementing the technology, and when the technology represents a core competence to the business, firms are more likely to establish close relationships with the technology supplier. Cross-case analysis (Chapter Six) between cases B and C provides a good example of how firms that possess different levels of asset specificity exhibit different patterns of relationships with the technology supplier. In terms of cost, the technology acquired by firm C is significantly more highly-priced than that acquired by firm B, yet firm B considered the investment to be major as it was its first automated application, whereas firm C adopted the technology as part of its upgrading of the existing machining centre.

The case observes that firm B exhibited a higher degree of consultation with the technology supplier, who was extensively referred to, especially during the early stage of technology implementation. In this case, the specific asset signalled the need to safeguard the investment from any source of failure. The development of stronger relationships is partly in response to the presence of specific assets in the transaction

(Heide, 1995; Williamson, 1985). Firms continue working closely with their suppliers to ensure efficiency in the entire process. Developing close buyer-supplier relationships is not only done to minimise the transaction cost, but also to maximise the transaction value, as proposed by Zajac and Olsen (1993).

Hypothesis three, which states that the higher the level of uncertainty, the more likely firms will engage in closer relationships, is supported in this research. Within the operationalisation and the context of the research, the survey results suggest that, when firms experience a higher level of uncertainty regarding the capability of the technology to meet their investment goals, their technical expectations, their customer demands, or the ability of the technology to work as it is intended technologically, they are more likely to establish closer relationships with the technology supplier. Firms are also more likely to depend on the supplier when they lack experience in handling a similar technological innovation, or/and when they do not have enough expertise in the company to handle the technology. Under TCE reasoning, bounded rationality poses problems in a situation of uncertainty where the ability of people to make a fully rational decision is impeded (Hobbs, 1996); therefore, engaging in close relationships with the technology supplier could be seen as a mechanism to reduce the transactional hazards.

The result is consistent with findings from previous research (Anderson and Narus, 1990; John and Weitz, 1988; Jones, 1987; Klein et al., 1990; Noordewier et al., 1990; Robertson and Gatignon, 1998; Wang, 2002) where uncertainty has been seen to affect the choice of governance structure. Under high uncertainty, developing close relationships with the technology supplier allows great flexibility in monitoring problems (Jones, 1987), and is more cost effective (Robertson and Gatignon, 1998). High uncertainty also means greater difficulty for the firm to measure performance success (Robertson and Gatignon, 1998) and this results in firms engaging in stronger governance structures (Anderson and Narus, 1990) due to the possibility of readier access of information and a range of support from the supplier.

The case studies also illustrate the association between the level of uncertainty and the strength of BSR. For instance, firm B was very uncertain about whether the technology adopted would meet all its expectations due to its unfamiliarity, lack of expertise and experience with the technology. This firm worked closely with the technology supplier even before the agreement to buy the technology was finalised. Fully recognising its limited familiarity with the technology, firm B also ensured that the chosen supplier possessed the knowledge, commitment and a high level of integrity during the early process of buyer and supplier interaction. The plausible explanation could be, when the success of a particular technology acquisition and implementation are difficult to judge, due to various uncertainties resulting from the technology itself and/or it own organisational capability, strong relationships with the technology supplier enhance the monitoring of any possible problem that might exist as a result of the implementation. The ultimate goal from that is to be cost effective.

Although the case analysis observed that level of complexity impacts on the strength of the buyer-supplier relationship, the interaction of all variables under one model indicate that the level of complexity failed to show any significant influence on the strength of the BSR. Instead, it was found that the level of complexity only exerted an influence on the strength of the BSR because it was correlated with the level of uncertainty that does have a direct impact on buyer-supplier relationships, and not because the complexity itself directly is predictive in buyer-supplier interaction. Within the operationalisation and the context of the research, it was suggested that when firms view the technology as complex and major changes are expected to happen either to their current manufacturing layout, process or practice as a result of its implementation, it will affect the level of uncertainty surrounding the acquisition and the implementation, which in turn have an impact on the strength of the relationships established with the technology supplier.

Referring back to the insights gained from the case regarding the transaction attributes in AMT acquisition and implementation (Chapter Six, section 6.10.2), the case studies reveal that most of the feelings of technological complexity surfaced from firms' unfamiliarity with the technology. For instance, during the interview sessions, this issue was frequently mentioned, as the following extracts show:

> "We don't have previous experienced in using the CNC machine ... at that time, the technology was completely new to us" (CEO firm B).

"That was our first robotic application ... to us the technology is quite advanced and complex" (CEO, firm G).

"...we are familiar with the technology ... we have experience ... we have used a wide range of similar technology .... just like our other technology, it's like driving a car with a different model" (Executive Director, firm C).

The concept of unfamiliarity is also known to be related to confusion and uncertainty, and has been used in this study as one of the items to measure uncertainty. In this respect, it was also observed from the cases that firms referred to the lack of expertise as a source their impressions of the technology being complex (case B) and the availability of trained and expert employees as the reason why they consider the technology and its implementation as less complicated and more straightforward (case C). The presence of previous experience in handling a similar technological innovation and the availability of employees to handle the technology are amongst the measures used in this study to gauge uncertainty as this can breed familiarity or unfamiliarity. Therefore, this observation could further support the survey result that complexity is affecting the strength of buyer-supplier relationships, mostly because it affects the level of uncertainty.

### 7.2.5 Buyer-supplier relationships and performance

The results indicate a significant difference in terms of technology and implementation performance across the three different groups of buyer-supplier relationships. From the sample, it was found that firms that exhibit strong relationships with the technology supplier achieve a significantly higher level of technology and implementation performance than those that exhibit moderate and weak relationships with the technology supplier.

When investigating the links between buyer-supplier relationships and performance, it emerged that of 147 respondents, 87% claimed that they achieved considerable improvements in terms of lead-time, quality, cost, and efficiency and productivity, after the adoption of the technology. This is consistent with the findings of many previous research studies that indicate the adoption of advanced manufacturing technology to significantly improve many aspects of performance (Cook and Cook, 1994; Small, 1998; Swamidass and Kotha, 1999; Teng and Seetharaman, 2003). However, satisfaction in implementation performance is slightly lower, accounted for only 67% of respondents' perceptions. This outcome may be a sign that in technology adoption, many firms are still struggling with the implementation problems, consistent with previous research findings highlighting that implementation problems remain the important issues in any technology adoption (Chen and Small, 1996; Hottenstein et al., 1999; Sambasivarao and Deshmukh, 1995).

Hypothesis four that states there is a link between the technology user and supplier relationship and technology performance, is supported in this study. Within the operationalisation and conceptualisation of this research, the results indicate that firms that develop strong relationships with the technology supplier are more likely to achieve higher levels of manufacturing performance in terms of cost, quality, lead-time, and flexibility. Consistent with Small and Yasin (1997), it is assumed in this research that achievement in manufacturing performance as a result of a particular technology adoption is a true indicator, whether or not the technology is performing. The buyer-supplier relationships considered in this research includes the elements of trust, and takes into account the relationships even before the decision was made to purchase the technology. Therefore, it is expected that firms that develop strong links with the supplier will make the right selection of the technology, which is then be reflected in the manufacturing performance as measured by cost, quality, lead-time, and flexibility.

The case studies provide further insight and illumination regarding the significant role played by the technology supplier in the achievement of technology performance in AMT acquisition and implementation. For example, the interviewee from case A said:

> " ... lots of details were discussed with them ... we have 12 different types of juices with various types of bottles from 220 ml to 5 litres sizes, so you can imagine the palletising system must be able to handle various sizes and styles of bottles and to accommodate changes in each bottle filled amount and volume ... of course they understand ... the pallet type and load heights were pre-specified based on our requirements ... we are happy with the result" (Production manager, Firm A).

> "We save changeover time ... the robot end-of-arm-tool is a mechanical clamp style, especially designed to accommodate a wide range of container sizes without having to stop" (Production manager, Firm A).

The study also finds support for hypothesis five, which states that there is a link between BSR and implementation performance. Within the operationalisation and conceptualisation of this research, results indicate that firms that develop strong relationships with the technology supplier are more likely to perform better in terms of the time taken to fully implement the technology and begin to gain benefits from its implementation, and in tackling any technical problems that arise during the implementation process. Based on the implemented technology, the case study firms also claim to be satisfied with the capability of the technology in fulfilling their objectives, and improving manufacturing processes and performance.

Specifically relating to the implementation of AMT, the case studies provide a rich understanding of how the technology supplier can enhance or slow down implementation process. For instance, Case D complained of inadequate collaboration with its technology supplier. Due to the unfamiliarity of the firm with the implemented technology, it did not possess the knowledge to critically explore how the other processes at the plant could affect the running of the new system, and although the company was aware of the significance of supplier involvement, it did not fully appreciate the extent of what was necessary until the problem arise. Amongst the comments from case D, relating to BSR and implementation performance were:

> ".. after several setbacks, we realised lots of things were not settled with the supplier ... their lack of knowledge of our business operation may have caused the bump in the process" (CEO, Firm D).
>
> "Of course they assisted us whenever we contacted them, but we think expensive mistakes could surely have been avoided if we had collaborated more closely with the technology supplier ... especially at the early phase of implementation" (CEO, Firm D).
>
> "Down-time was unacceptable ... it did not immediately fulfil our objective in the first place, but it's okay now, we can use that system for our new product line ... almost a year ago"(CEO, Firm D).

In one of the positive experiences reported in the case studies, case E was assessed as having strong relationships with the technology supplier. For instance, the company recalled that the technology supplier planned all fixturing, mechanical, electrical, and electronic systems in addition to the robot. CAD drawings of the installation layout were created to permit its engineer and welders to visualise the proposed handling and welding system. The supplier also examined all involved parts to determine the potential variability in dimensions and location when in position for welding, the welding parameters required, the quality level demanded by firm E, and the entire flow of parts and materials to and from the welding station. Firm E claimed

> "... we were able to run for full production earlier than expected ... this cannot be achieved without effective assistance from supplier" (Production Director, Firm E).

Consistent with Youssef and Zairi (1996), the results from this study indicate that the development of close relationships enables buyers to depend on suppliers to effectively meet their needs. Amongst the various key examples of help and support are: the ability to help buyers to develop skills in relation to the technology being adopted; providing solutions for technical bottlenecks; facilitation of the implementation process; and post-implementation back-up and continued support. In this research, it was also found that close relationships with the supplier can avoid expensive mistakes as a result of problems in implementation.

Referring to TCE theory, a strong BSR leads to better performance because it acts as a powerful governance mechanism. Closer relationships can safeguard the transaction from bounded rationality and opportunism (Williamson, 1975). Control mechanisms have the objective of bringing about the perception of fairness or equity among transactors (Dyer, 1997). In the case studies, this can be seen in the situation where the suppliers sometimes manipulate the information about the technology to promote and sell it. In some cases, the supplier did not convey true and complete information, which resulted in buyers considering complex technology as being simple to implement, or them being locked into the supplier's technology and to have to incur expensive upgrading later. Referring to Williamson (1985), the purpose of safeguards is to provide, at minimum cost, the control, and 'trust' necessary for transactors to believe that engaging in the exchange will make them better off. A high level of trust and business understanding, communication, and information sharing between buyer and supplier could act as control mechanisms throughout the implementation process.

### 7.2.6 Buyer-supplier relationships and performance: on the basis of transaction attributes

Hypotheses 6a, 6b, and 6c further tested the link between BSR and performance when firms were grouped together under similar transaction attributes. When the relationships between buyer-supplier relationships with both performance scales were tested on the basis of the transaction attributes, more interesting findings were gained. For implementation performance, significant differences exist in all levels of the transaction attributes, except for lower level of uncertainty. Firms achieved significantly higher level implementation performance when they engaged in strong relationships with the technology supplier. On the other hand, in terms of technology performance, significant differences only exist in high and/or moderate, but not in the lower, level of transaction attributes.

The results suggest that developing good relationships will significantly affect a firm's technology performance when it possesses a higher level of transaction attributes in relation to the technology acquisition and implementation. However, less impact occurs when the firm possesses a lower level of complexity, asset specificity, and uncertainty with regard to the technology acquisition and implementation. This is, however, not the case for implementation performance, except where there is a lower level of uncertainty, developing strong relationships with the technology supplier will significantly affect the achievement of implementation performance despite the level of transaction attributes. The significant impact of strong relationships with the technology supplier in almost all levels of transaction attributes on implementation performance in comparison to technology performance, could suggest that strong links with the technology supplier are critical during the technology implementation process, as they could enhance the success.

Several important observations arise from this analysis: Firstly, within the same level of transaction attributes, strong buyer-supplier relationships perform higher than moderate or weak buyer-supplier relationships. Secondly, the development of stronger relationships with the technology supplier also resulted in a significantly different performance achievement in comparison to the development of moderate or weak relationships with the technology supplier. Finally, in the situation of a high level of complexity, asset specificity, and uncertainty, implementation performance suffers more when firms had weak relationships with the technology supplier. On the other hand, the implementation performance of firms that developed weak buyer-supplier relationships was much higher in a low level, compared to a higher and moderate level of complexity and asset specificity. This suggests that firms that experience a lower level of transaction attributes pose no immediate risk of not developing close relationships with the technology supplier compared to firms experiencing a higher level of transaction attributes. This further supports the earlier observation that the development of stronger buyer-supplier relationship is even more important when firms experience a higher level of transaction attributes in the technology acquisition and implementation process. Table 7.2 summarises the research results based on the hypotheses developed.

**Table 7.2: Hypotheses and findings summaries**

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| **H1:** The higher the level of asset specificity, the more likely it is that a firm will engage in a closer relationship with the technology supplier during the acquisition and implementation of AMT. | Survey | Zero order correlation test indicates BSR is strongly correlated with level of *asset specificity* at the value of .510. SEM results further support that *asset specificity* predicts BSR, and thus provide support for H1. The significance and direction of the relationship indicates that the higher the level of *asset specificity*, the more likely a firm will engage in a closer relationship with the technology supplier. |
| | Case studies | Cases B, E, and G illustrate that firms that possess a higher level of *asset specificity* are more likely to see the need to develop closer relationships with the technology supplier to make sure their specific investment is a success. On the other hand, Cases C and F demonstrate that firms which possess a lower level of *asset specificity* do not see the need to develop strong relationships with the technology supplier. |
| **H2:** The higher the level of uncertainty, the more likely it is that a firm will engage in a closer relationship with the technology | Survey | Zero order correlation test indicates BSR is strongly correlated with level of *uncertainty* at the value of .540. SEM results further support that *uncertainty* predicts BSR, and thus provide support for H2. The significance and direction of the relationship indicates that the higher the level of *uncertainty*, the more likely a firm will engage in a closer relationship with the technology supplier. Chi-square test further supports the finding. |

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| supplier during the acquisition and implementation of AMT. | Case studies | Cases B and G illustrate that firms that possess a higher level of *uncertainty* tend to develop closer relationships with the technology supplier in order to reduce the feelings of uncertainty as well as to make sure the acquisition and the implementation is a success. On the other hand, Cases C and F demonstrate that firms which possess a lower level of *uncertainty* do not see the need to develop strong relationships with the technology supplier. |
| **H3:** The higher the level of complexity, the more likely it is that a firm will engage in a closer relationship with the technology supplier during the acquisition and implementation of AMT. | Survey | Although the zero order correlation result indicates level of *complexity* is moderately correlated with BSR, simultaneous analysis under SEM indicates an insignificant path between *complexity* and BSR. Instead, *complexity* affects BSR through *uncertainty*. Therefore, within the sample data, the study fails to provide support for H3<br><br>Further mediation analysis indicates that *complexity* predicts BSR mostly because *complexity* affects the level of *uncertainty*, which has a direct effect on BSR. |
| | Case studies | Cases A, B, E, and G illustrate that firms that possess a higher level of *complexity* are more likely to obtain strong supplier involvement in the process of technology acquisition and implementation. On the other hand, Cases C and F demonstrate that firms which possess a lower level of *complexity* do not see the need to develop strong relationships with the technology supplier.<br><br>Case analysis still indicates that *complexity* leads firms to be more dependent on the supplier. However, from the case, it was found that most of the feeling of why firms feel uncertain is rooted in their unfamiliarity with the technology, which explained findings from the quantitative part of the research. |

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| **H4:** There is a link between the technology buyer and supplier relationship and technology performance | Survey | SEM results reveal a significant direct path between BSR and technology performance, suggesting firms that develop strong relationships with the technology supplier are more likely to achieve a higher level of technology performance compared to firms that do not. |
| | Case studies | Case analysis revealed that firms that develop a strong relationship with the technology supplier, experience a higher level of technology performance (as demonstrated by cases A, B, E, and G) compared to firms that do not (as demonstrated by cases D and F) |
| **H5:** There is a link between the technology buyer and supplier relationship and implementation performance. | Survey | SEM results reveal a significant direct path between BSR and technology performance, suggesting firms that develop strong relationships with the technology supplier are more likely to achieve a higher level of implementation performance compared to firms that do not. |
| | Case studies | Case analysis revealed that firms that develop a strong relationship with the technology supplier experience a higher level of implementation performance (as demonstrated by cases A, B, E, and G) compared to firms that do not (as demonstrated by case D and F) |

| | | |
|---|---|---|
| **H6a:** | | ANOVA results provide full support for H6 with respect to implementation performance but do not fully support the prediction for technology performance. |
| Within the same level of complexity, performance will vary depending on the pattern of relationships with the technology suppliers | Survey | ANOVA results indicate that there is a statistically significant difference ($p < .05$) in the mean score of implementation performance for each of the three BSR levels within each level of complexity. On the other hand, the mean score of technology performance for each of the three BSR levels only significantly different within high and moderate levels of complexity. |
| | Case studies | Due to the lack of representative case sample, no conclusion can be derived from the case analysis to support this hypothesis. |
| **H6b:** | | ANOVA results provide full support for H7 with respect to implementation performance but not for technology performance. |
| Within the same level of asset specificity, performance will vary depending on the pattern of relationships with the technology suppliers. | Survey | ANOVA results indicate that there is a statistically significant difference ($p < .05$) in the mean score of implementation performance for each of the three BSR levels within each level of asset specificity. On the other hand, the mean score of technology performance for each of the three BSR levels only significantly differs within a moderate level of asset specificity. |
| | Case studies | Due to the lack of representative case sample, no conclusion can be derived from the case analysis to support this hypothesis. |

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| **H6c:** | | ANOVA results partially support H6 on both implementation performance and technology performance. |
| Within the same level of uncertainty, performance will vary depending on the pattern of relationships with the technology suppliers | Survey | ANOVA results indicate that there is a statistically significant difference ($p < .05$) in the mean score of technology and implementation performance for each of the three BSR only within high and moderate levels of uncertainty. |
| | Case studies | Due to the lack of representative case sample, no conclusion can be derived from the case analysis to support this hypothesis. |

## 7.3 CONCLUSIONS

The aim of this research has been to examine how the transaction attributes of the implemented technology affect the pattern of relationships between the technology buyer and technology supplier and to see the impact of different patterns of relationships on the performance of AMT. The hypotheses were developed to examine the effect of transaction attributes on buyer-supplier relationships (BSR). Two were developed to examine the impact of BSR on performance, and another three sub- hypotheses were developed to examine the interaction of transaction attributes on the relationships between BSR and performance. The five primary objectives of the research were:

1. To understand how the level of complexity affects the strength of technology buyer and supplier relationships
2. To understand how the level of asset specificity affects the strength of technology buyer and supplier relationships
3. To understand how the level of uncertainty affects the strength of technology buyer and supplier relationships
4. To explore a link between technology buyer-supplier relationships and technology performance
5. To explore a link between technology buyer-supplier relationships and implementation performance

Each of the study objectives of the research was achieved. Within the sample population and operationalisation of the present research, the study concludes:

1. The specificity of the acquired AMT and the uncertainty surrounding the acquisition and implementation of the technology have an impact on the strength of the relationship with the technology suppliers. However, the complexity of the technology has a significant impact on the strength of relationship only when it affects the level of uncertainty surrounding the entire process of technology acquisition and implementation.

2. BSR is related to technology and implementation performance. However, the development of good relationships with the technology supplier has a stronger impact on implementation performance than on technology performance. The majority of firms in the sample indicated a higher level of technology performance. Yet, even within the higher achievement, the intensity of both aspects of performance measured in this study were still affected by the strength of relationship developed with the technology supplier.

3. Within the same, and between different, levels of transaction attributes, firms will be more likely to achieve higher technology and implementation performance when they develop a strong relationship with technology suppliers. However, between technology performance and implementation performance, strong BSR (in comparison to moderate and low BSR) does not distinctively lead to differences in technology performance in most levels of transaction attributes, when compared to the difference it makes to implementation performance. This means, for example, that the implementation performance of firms that establish closer BSRs appears to be significantly higher than those that establish moderate or weak BSRs. Instead, the technology performance of firms that establish closer BSRs appear to be more or less similar to those that establish moderate or weak BSRs. This observation further strengthens earlier findings in this research that good relationships impact more positively and stronger on implementation performance than on technology performance.

4. Compared to moderate and low levels of transaction attributes, in high levels of transaction attributes, implementation performance suffers more when a firm develops weak BSR. This means that when the technology is considered highly complex and specific to the firm and when the technology and its implementation is surrounded by a high level of uncertainty, firms should develop even stronger relationships with their technology suppliers, since failure to do so could severely affect the implementation process. The case investigations provide more interesting insights on this particular survey finding. There is some evidence within the qualitative data to suggest that under a certain condition (also in relation to transaction attributes), firms are still capable of achieving higher levels

of performance just by developing a moderate level of relationships with the technology supplier.

Beyond the objectives of the present research, but important for an overall understanding of the issues under investigation, the study also found: Firstly, evidence from the quantitative data indicates that the same technology type is viewed differently by different firms in term of its complexity, its specificity to the company, and the uncertainty surrounding its acquisition and implementation. A technology that is considered to be advanced to one firm may not be perceived in that way to another. In this regard, the need to assess a firm's intensity of transaction attributes (complexity, asset specificity, and uncertainty) when studying the strength of BSR in the acquisition and implementation of advanced manufacturing technology, should be recognised, since such assessment will give an indication of a firm's uniqueness in its own business environment.

Secondly, there is some evidence from the qualitative data to suggest that the perception of complexity was largely associated with the unfamiliarity of the technology and the anticipated challenge arising from its implementation. On the other hand, the source of uncertainty was associated with previous success or otherwise of past implementations, and the availability of expertise in the company. The case also identified that positive initial experiences with the technology supplier reduced uncertainty. The implication from this observation is that, the differences in firms' perceptions of asset specificity and uncertainty are rooted in many organisational aspects. Together, these differences are mirrored in this research by examining firms' transaction attributes of the acquired technology.

To conclude, the findings of the present research provide significant insight into the inter-relationships between the three main variables under investigation, namely transaction attributes, buyer and supplier relationships, and performance. They highlight the importance of the development of good relationships with technology suppliers, and recognise that under certain conditions, firms cannot afford to ignore the critical role of the technology supplier in enhancing performance levels. The findings from the case studies not only offer the opportunity for triangulation of data from the questionnaire survey, as presented in the discussion section, but also augment the theoretical understanding of the elements of transaction attributes and buyer-supplier relationships in the acquisition and implementation of advanced manufacturing technology.

## 7.4 CONTRIBUTION TO THEORY

### 7.4.1 The implication of using transaction economics theory as a framework for understanding buyer-supplier relationships

The broad scope and generality of the theoretical analysis offered by transaction economics theory has led to its usage across several research disciplines such as economics, marketing, and strategic management. For instance, the application of this theory has ranged from the analysis of outsourcing decisions (Coase, 1937; Ngwenyama and Bryson, 1999; Pisano, 1990; Poppo and Zenger, 1998; Rasheed and Geiger, 2001), the organisation of exchange relationships (Dyer, 1997; Dyer, 1996a; Noordewier et al., 1990), the choice of governance mode in technology development (Robertson and Gatignon, 1998), and technology transfer (Davies, 1992), to examining governance within a single governance mode such as an alliance (Nordberg et al., 1996). In short, the theory has been mainly concerned with the issues of crafting an efficient governance structure and the three transaction attributes have been widely used to predict the choice of such structure.

The use of transaction cost economic theory in predicting the governance arrangement in the acquisition and implementation of AMT was a starting point for this study. Within the sample population and scope of the present study, it was identified that in the acquisition of AMT, most transactions were carried out through market mode rather than hybrid or hierarchical mode. The recognition of this phenomenon leads to the development of an interest in investigating buyer-supplier relationships, which has been regarded in the literature of TCE, marketing, and strategic management, as part of the governance mechanism. Although buyer-supplier relationships, sometimes referred to as exchange relationships, have been regarded as one form of governance structure, the literature demonstrates a very limited understanding of how the transaction attributes affect the development of buyer-supplier relationships. The available limited studies (see Noordewier et. al, 1990; Dyer, 1996a; Dyer, 1997) have so far been on the relationships with industrial/parts suppliers.

This significant gap was narrowed in this research by an exploration of the relationships with capital equipment suppliers, in the specific context of AMT acquisition and implementation. The existing literature is still lacking in terms of evidence regarding whether the attributes of the transaction predict the development of the relationship with the technology supplier, particularly in the acquisition and implementation of AMT. A major contribution of this study was, therefore, the empirical testing of the relationships between the attributes surrounding the acquisition and implementation of the technology and the pattern of relationships with the technology supplier. Furthermore, by integrating the TCE framework with the investigation of buyer-supplier relationship, this study provides both BSR and AMT literature with a new lens through which the strength of buyer-supplier relationships in a particular technology acquisition and implementation could be understood.

Another contribution of this study is that, it expands and adds to the limited empirical research on buyer-supplier relationships as part of governance structure. The test findings relating to the hypothesis that the level of asset specificity and level of uncertainty have a significant impact on the development of buyer-supplier relationships, provide further empirical support to the argument that the supplier alliance is one form of inter-organisational relationship similar to other forms of inter-organisational relationship, such as joint ventures, mergers, acquisitions, and licence agreements (Stuart, 1997). These types of inter-organisational relationships have been widely recognised in the literature to be affected by the level of transaction attributes, which is directly related to transaction cost. The finding from this study also adds to the limited existing research considering buyer-supplier relationships as an alternative means of protection mechanism to safeguard the transaction (Dyer, 1997; Noordewier et al., 1990; Sako, 1992). This study found that when a firm possesses a higher level of asset specificity and uncertainty with regard to/ surrounding the acquisition and implementation of the technology, it is more likely to engage in closer relationships with the technology supplier. This result is consistent with the pattern of interaction found regarding many previous empirical studies testing the relationships between transaction attributes and the choice of governance mode. Applying transaction cost economics reasoning, close relationships as demonstrated by aspects like complete information sharing, trust and business understanding, and committed involvement, can be regarded as a highly efficient governance structure which minimises transaction cost (Sako, 1992). Close relationships also act as a safeguarding mechanism to protect the investment from various sources of failure.

### 7.4.2 Implications for structure and measurement of transaction attributes

Within the area of TCE, there has been no specific research looking at the attributes surrounding the acquisition and implementation of AMT. The largest proportion of empirically-measured transaction attributes has focused on the issue of technology development (Robertson and Gatignon, 1998) and the outsourcing decision (Rasheed and Geiger, 2001; Tyler and Steensma, 1995; Wang, 2002), but each of these studies has used a wide definition and operationalisation of transaction attributes as so far, there have been no consistent conceptualisation and measurement scales with regard to transaction attributes. Therefore, through a thorough literature review, from the viewpoints of experts in the field, and rigorous scale purification, this research could further contribute, in terms of scale development, to the understanding of attributes surrounding the acquisition and implementation of AMT.

As previously discussed, the survey results, further supported by case observation, provide important findings regarding the inclusion of complexity as another dimension of transaction attributes. The findings from this study support the argument by Globerman (1980) who argues that the complexity involved in different technological innovations must be acknowledged in the transaction cost reasoning because it is also predicted to increase directly with the complexity of the appropriate governance structure. Empirically, it was found in this study, that complexity should be acknowledged, because it is related to the level of uncertainty, the primary transaction attribute offered in the transaction cost economics model. Applying TCE to the area of buyer-supplier relationships, could explain the argument by Dodgson (1993) that another technological dimension or consideration for firms pursuing a collaborative relationship with the technology supplier is when the breadth and depth of expertise required exceeds the capability of an individual firm (referring to the complexity).

### 7.4.3 Implications for the area of BSR

This research also contributes to the literature in the area of BSR. Firstly, the application of TCE theory in predicting the development of the relationship with the technology supplier increases the understanding of the overall BSR and provides an explanation through the TCE lens of why strong relationships are/are not exhibited in a particular transaction. Furthermore, it provides support for close collaboration with the technology supplier, especially in the event of high transaction attributes, since such collaboration operates as a powerful protection mechanism. The gap in the literature on capital equipment suppliers is also narrowed by this study. Also, through a thorough literature review, the viewpoints of experts in the field, and rigorous scale purification, this research could further contribute, in terms of scale development, in understanding BSR in the acquisition and implementation of AMT.

### 7.4.4 Implications for the literature of AMT

Despite the previous claim that the technology supplier is one of the most important success factors in technology implementation, understanding in this area remains limited due to the sparse research specifically exploring this issue. The present research contributes to the literature of AMT as follows:

1. The findings of the present research improve our understanding of the limited existing knowledge on the role of the technology supplier on the acquisition and implementation of AMT
2. The present research provides an explanation of the antecedents of BSR in AMT acquisition and implementation and examines the interaction effect of transaction attributes from the basis of TCE theory.
3. Most of the empirical results on the effect of technology user and supplier relationship in AMT implementation, to date, have been supported by case studies (Sohal and Singh, 1992; Zairi, 1992; Zairi, 1992; Zairi, 1998) and survey support is rather limited. Therefore, the multi-methods approach of the present study offers an understanding of this area from a different methodological perspective.

## 7.5 IMPLICATIONS FOR PRACTISING MANAGERS

The findings highlight some important implications for practising managers. Firstly, the technology supplier can enhance the success of technology acquisition and implementation. Firms that develop stronger relationships with the technology supplier are more likely to experience higher achievements in terms of implementation performance. Secondly, the dependence on and/or collaboration with, the technology supplier are even more important when the complexity, specificity, and uncertainty of the technology and its implementation are higher to a firm. Managers need to be aware of the specificity, uncertainty and complexity of the technology being adopted. This also requires the key decision-maker, namely the technology champion, to be highly knowledgeable about the AMT being adopted.

The framework established in this research includes the determinants and effects of BSR in advanced manufacturing technology acquisition and implementation. Thus, it provides a conceptual approach and serves as a guideline on BSR issues, for the key managers responsible for new technology acquisition and implementation. To practically use the framework, the company firstly needs to recognise and understand the degree of specificity of the technology to the company and the degree of uncertainty surrounding the acquisition and its implementation. Firms also need to identify the degree of complexity surrounding the technology and its implementation because this could serve as an indicator of unfamiliarity, which leads to a certain degree of uncertainty about the entire acquisition and implementation process. This assessment indirectly provides an identification of the firm's strength and weaknesses in relation to the technology acquisition and implementation task.

From this point, firms must be self-aware. For example, firms could aim to alter the changeable aspect of transaction attributes of the specific technology acquired. As identified from the case analysis, the perception of complexity and uncertainty are derived from various sources. Therefore, firms can choose to employ more experienced workers, send key employees for training, and educate other employees in using the new technology in order to increase familiarity and reduce the feelings of uncertainty. The principal idea here is that firms must be knowledgeable about the technology being adopted and should engage in better planning even before the technology is implemented. Firms could also ensure that their supplier selection process takes into account the ability to develop a close relationship with the chosen supplier, and not just choose the cheapest option.

After a complete assessment and adjustment of the transaction attributes, the level of dependence on, or the involvement of, the technology supplier by the company should be identified. There are also costs involved in the development of close relationships, in terms of time, financial, and intellectual property. Therefore, the selection of the supplier and the way firms choose to collaborate should match the degree of the transaction attributes. At this stage, where there is a higher level of transaction attributes, key managers must make sure that close collaboration with the technology supplier is developed throughout the implementation process. Strong business trust and understanding should be built between both parties, the commitment and involvement of the supplier should be fully utilised, communication and information sharing should effectively take place, and finally, the key implementation team should ensure that the maximum level of knowledge is acquired from the technology supplier throughout the technology implementation process. Managers should constantly be aware that the ultimate objective from this is to avoid unnecessary and expensive mistakes, which detract from the achievement of technology and implementation performance of the acquired technology.

## 7.6 LIMITATIONS OF THE PRESENT STUDY

The findings of this research are not without limitations, but such drawbacks can stimulate future research. The limitations of the present research are as follows:

Firstly, the research only assesses the strength of BSR from the technology buyer perspective. From a methodological perspective, BSR can also be studied using different units of analysis such as a single party, both parties (the dyad), or multiple parties (the network). In assessing BSR in AMT implementation, as AMT is normally a major capital investment, it could be the only investment made by the buyer within a two-year period. However, the supplier may have supplied several technologies to several other different firms during that same period. Therefore, the measurement of relationship strength is further confounded by the fact that many suppliers frequently supply their customers with different types of technology, and therefore it will be less easy for them to recall their experience with one particular customer. Furthermore, as this study measures relationship strength, suppliers may be biased in their response by portraying themselves as giving the best service to buyers. The fact that the present study collects data anonymously through a survey questionnaire, makes the matching of responses from buyer and supplier impossible.

Secondly, although great care was taken to ensure that the respondent was the person best placed to answer the questions, the use of single key informant's response in collecting survey data always has limitations. For instance, single informants may give only their personal view, whereas multiple informants would allow for a richer picture to be drawn. This also raises the concern that common method variance alone may account for some significant findings. The observed relationships may have been artificially inflated due to respondents' tendency to respond in a consistent manner. Furthermore, the potential research bias of the researcher is also problematic, resulting from a degree of misinterpretation and misunderstanding of both primary and secondary material. However, the methodology has been designed to minimise such misinterpretation and limitations. For instance, interviews were employed as another means of data validation, and in some cases, they were carried out with more than one respondent as key informant.

These limitations implicitly suggest that a significantly different research design based on the relationships dyad with multiple respondents within the organisation could be considered, although not without difficulties in terms of sample size, dyad access, confidentiality and accuracy of responses.

Third, the use of cross-sectional data, in dealing with the interaction effect of complexity, uncertainty and BSR, may be problematic. The result shows that a higher level of transaction attributes is associated with close/strong buyer-supplier relationships. For instance, when the technology is considered as a major investment, a firm is more likely to develop strong relationships with the technology supplier to protect the investment from various source of failure. Also, when there is a high degree of uncertainty about either the technology or the activity surrounding the implementation, a firm is more likely to depend on the technology supplier for information, guidance, and assistance, in order to become familiar with the whole process. In terms of complexity and uncertainty, it could also be possible that the initial relationships with the supplier could affect the way a firm perceived the complexity of the technology and the whole implementation process, and hence, the uncertainty. Through richer information, this concern was distinguished from the qualitative data of the present research. Although it is noted in the questionnaire survey that respondents should describe their perception of complexity and uncertainty before the implementation process, it cannot be certain to what extent the supplier was involved during the initial process, because different firms employ different stages of acquisition and implementation, and thus, this issue cannot be discerned by the quantitative data of the present research. The present data cannot reveal how the perception of complexity and uncertainty changed over time. Therefore, to better capture this issue, further research should aim to use a longitudinal case study or survey approach in a number of firms to reveal the pattern of interaction between complexity, uncertainty, and BSR, over time.

Fourthly, although one of the criteria for the sample companies is that, the technology acquired must have been used for normal production, the research did not consider the performance effect of the technology over time. Again, longitudinal research that tracks the performance effect of the acquired technology over a much longer period could be undertaken because the time factor might have a large impact on how the company perceives the performance of the technology. Thus, further study is needed, possibly using longitudinal data.

Fifthly, the data used for the research are from Malaysian companies, and one could assume that findings would be different in other countries, where the technology being acquired is not imported. The differences in national culture which could lead to the differences in work culture would also be a potential source of differences in the way that buying firms develop relationships with their technology suppliers. Due to this limitation, the results of the present study should be carefully interpreted, since the sample was restricted to Malaysia. Therefore, future research could be conducted in other countries and the results could then be compared with the results of the present study.

Finally, as this study used a broad definition of AMT, the questionnaire survey does not provide the respondent with an option style format to indicate the type of technology being acquired and implemented. Instead, it used an open-ended type of question where respondents were asked to indicate the type of technology being acquired and implemented. As a result, the answer ranged from purely general types such as "automation" or "robotic", to the specific types of technological innovation such as "computerised backend solder plater (electro plating machine)". This made it difficult for the researcher to segregate the technology into several technological types. Therefore, most technology falls into "special purpose automation technology" as the name imply its use as specific to the firm's manufacturing operation. The effect of too diverse technological types, however, is reduced to some extent in this research by limiting the sample to firms that acquired and implemented what is termed as process technology (Kotha and Swamidass, 2000) / direct AMT (Beaumont et al., 2002) such as Robotics, CNC or automation line, rather than product design technologies (Kotha and Swamidass, 2000) / indirect AMT (Beaumont et al., 2002) such as CAD, logistic related technologies (Small and Yasin, 1997), MRP, or administrative AMT (Beaumont et al., 2002) such as job costing systems or electronic data interchange system (EDI). Although it is not the objective of this research to see the effect of different types of AMT on the BSR, further research concentrating on a narrow band of technological innovation could provide richer insight into this issue, especially when BSRs were found to be significantly different on AMT types, although not significant in predicting BSR under structured equation modelling in this research.

## 7.7 DIRECTIONS FOR FUTURE RESEARCH

In light of the findings of this research and the limitations highlighted above, the following directions for future research are proposed. Firstly, to the best knowledge of the researcher, this is the first piece of empirical research to have applied TCE theory to investigate buyer-supplier relationships in advanced manufacturing technology acquisition and implementation. In order to expand our knowledge and understanding regarding the investigated issues, many more empirical studies need to be carried out in a variety of different organisations, sectors, or even country settings. These new investigations should also extend the scope of the transaction attributes measured within this research, with more absolute measures of complexity and uncertainty potential being developed for new studies.

Secondly, within the AMT field, future studies may investigate in greater detail, the existence of differences between technology performance and implementation performance with regard to BSR. As the present research revealed that uncertainty is associated with complexity, and that complexity affects BSR through uncertainty, further investigation of why and how complexity affect BSR through uncertainty, or an improved operationalisation of both aspects, could be the avenue for future research in improving the overall understanding on this issue.

Building upon one of the key limitations in this study, a more complete insight into the antecedence and impact of BSR in AMT acquisition and implementation will only be provided by more longitudinal studies and dyad perspectives in investigating these issues. Further research that focuses on narrow types of technological innovation or governance arrangements could also provide richer insights in understanding the impact of transaction attributes on BSR. Future research can also investigate the impact of the early involvement of suppliers on the perception of complexity and uncertainty regarding the technology acquisition and implementation.

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**Appendix 1: Covering letter sent with the questionnaire survey**

ASTON
BUSINESS SCHOOL

ASTON ACADEMY FOR
RESEARCH IN MANAGEMENT

Aston University
Aston Triangle
Birmingham B4 7ET
United Kingdom
Tel +44 (0)121 204 3172
email: absresearch@aston.ac.uk

Date: 21 November 2004
**RE: SURVEY ON ADVANCED MANUFACTURING TECHNOLOGY IN MALAYSIA**

Dear Sir / Madam,

My name is Azmawani Abd Rahman. I am a lecturer at University Putra Malaysia (UPM) and am currently doing a PhD degree at Aston business school, England. My research interest focuses on the mechanism of governance in advanced manufacturing technology implementation in developing country, particularly in Malaysia. Specifically, my research will look at the attributes of technology being implemented, the relationship between the technology buyer and the technology supplier in the process of implementation, and finally to see its impacts on performance.

**Advanced manufacturing technology (AMT)** in this research refers to any kind of computer-based technologies which includes robotics or any automated identification techniques, which is advanced or new to your manufacturing operation or advanced when compared to your previous or current manufacturing technology. Further information about AMT and some useful terms are provided in the last part of the questionnaire. **If your company has invested/implemented any of these technologies within the past five years and has used it under a normal production hour for a period of more than a year,** I would be very grateful if your organisation is willing to participate in this study by filling up the attached questionnaire. I am aware that this represents a demand on your already busy schedule, but your participation really could make the difference between success and failure of both this study and my Phd degree!

The questionnaire will take less than 20 minutes to complete and can be answered by a production manager or any key managers who was in charge in the implementation process. All responses will be coded and used only in combined statistical form. Therefore, the information you provide will be held at the strictest confidence. Kindly return the completed questionnaire using the enclosed self-addressed envelope within the next 7 days. When you return your completed surveys, please return the reply postcard which is included in this corresponding separately to ensure anonymity. The postcard helps to notify me that your firm has returned the survey and therefore does not need further reminders or follow up phone calls.

**If you wish to know the outcome of the research,** please provide the e-mail or company address in the last page of the questionnaire. It will be provided to you once this study is completed. Your help and cooperation in this matter is really required and will be highly appreciated. Thank you.

Best Regards,

Azmawani Abd Rahman
Mobile: 013-3242685
Email: azar@putra.upm.edu.my or abdrahma@aston.ac.uk

**Appendix 2: Questionnaire used for pilot test**

UPM
UNIVERSITI PUTRA MALAYSIA

*SURVEY ON ADVANCED MANUFACTURING TECHNOLOGY IN MALAYSIA*

ASTON BUSINESS SCHOOL

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In this questionnaire, **"Advanced manufacturing technology (AMT)"** refers to any kind of **computer-based** technologies which are advanced and new to your manufacturing operation or advanced when compared to your previous or current manufacturing technology. "Advanced" in this context can be taken as referring to its capability or technological features.

## SECTION A: GENERAL INFORMATION

**Refers to the background of the company**

1. What are the major products of your company?

   ______________________________

2. Please indicate the total number of employees in your company.

   a) 100 or less — b) 101-300
   c) 301-500 — d) 501-700
   e) 701-1000 — f) More than 1000

2a. If your company is part of a larger company or group, how many employees does it have?

   a) 100 or less — b) 101-300
   c) 301-500 — d) 501-700
   e) 701-1000 — f) More than 1000

3. How long has your company been established?

   a) Less than 5 years — b) Between 5 and 10 years
   c) Between 10 and 15 years — d) More than 15 years

4. What is the ownership of your company?

   a) Sendirian Berhad — b) Berhad

5. What is the status of your company?

   a) Local-owned — b) Foreign-owned
   c) Joint venture with a foreign company (> 50% foreign majority) — d) Joint venture with a foreign company (< 50% foreign majority)
   e) Partnership (non-equity) — f) Others: ______________

**Respondent Profile**

6. Title of position held in the company? ____________________

7. Years of working experience in the company? _______ [years]

## SECTION B: PRODUCTION TECHNOLOGY

To what extent is each of the following major technologies used in your manufacturing processes? *(Please use the following scale and place the appropriate number in the box provided).*

| Not at all | A little | A moderate amount | A lot | To a very great extent |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

1. Custom technology: production or fabrication of a single unit or a few units to customer specification........................................................................................................ ☐
2. Small batch (job shop) technology: production of small batches of similar units e.g. tools and dies........................................................................................................ ☐
3. Large batch technology: production of large batches e.g. components for subsequent assembly as in a fabricating shop; of finished products such as bottles, cans, drugs, chemicals.................. ☐
4. Mass production technology: as on an assembly line e.g. automobiles, standard textiles........... ☐
5. Continuous-process technology: output is highly standardized and produced continuously rather than in batches or shifts e.g. liquids, gases............................................................... ☐

## SECTION C: INFORMATION ON THE RECENTLY IMPLEMENTED AMT

**Please refer your answer to a single recently-implemented AMT**

1. Please state the type of technological innovation recently acquired.

   ______________________________________

2. What year did your company acquire the technology? _________

3. Is it a local technology or a foreign technology? _______________

4. What is the value of the investment?

   a) Below RM 300 thousand
   b) Between RM 300 and 500 thousand
   c) Between RM 500 thousand and RM 1 million
   d) Between RM1 million and RM2 million
   e) Over RM 2 million

5. Please indicate if the element in the following list was included in your technology acquisition contract and estimate the percentage value of each within the total investment value

| | Element | Included (Yes / No) | % |
|---|---|---|---|
| a) | The machine | | |
| b) | The technology software | | |
| c) | The key know how | | |
| d) | Training | | |
| e) | Technical assistance / supervision | | |
| f) | Product warranty | | |
| g) | Others (please specify) :______________ | | |
| | | | Σ100% |

6. What are the terms of payment for the technology acquired?

    a) One-off payment
    b) Part payment at each phase of transfer
    c) Initial payment plus future royalty payments
    d) Payment for supply of key components
    e) Share of profits from sale (i.e. no initial payment)
    f) Other (Please specify): ______________________

7. Please state the form of arrangement involved in acquiring the technology.

    a) One-off purchase of machine
    b) Licensing
    c) Subcontracting
    d) Co-production
    e) Contractual joint venture
    f) Equity alliance
    g) Wholly-owned subsidiary
    h) Other (Please specify): ______________

8. Have you ever dealt with this technology supplier on any other technology implementation before?

Yes ☐ If yes, how many times? ☐ [time(s)]

No ☐

## SECTION D: TRANSACTION ATTRIBUTES

**Please refer your answer to a single recently-implemented AMT as specified in the previous section** *(Please use the following scale and place the appropriate number in the box provided).*

| Strongly disagree | Disagree | Not Sure | Agree | Strongly Agree |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

**a) The view of complexity before implementation process**

1) The technology is quite straightforward ........ ☐
2) The engineering of the technology is technically difficult and complex ........ ☐
3) The technology contains a higher degree of tacit knowledge ........ ☐
4) The implementation of the technology reflects major changes to our manufacturing layout/ process/practice........ ☐

**b. The specificity of the technology**

1) Our firm has a major financial investment in the technology ........ ☐
2) The technology represents a core competence for us ........ ☐
3) Our firm has a high degree of collective learning and training for the implementation of the technology........ ☐
4) Our firm has a special expertise dedicated to the implementation of the technology........ ☐

**c. Uncertainty surrounding the acquisition and implementation**

Before investing in this technology:

1) we were confident that the technology would achieve our investment goals ........ ☐
2) we were certain the technology would meet our technical expectations ........ ☐
3) we were certain the technology would help us meet customer demands ........ ☐
4) we were confident that the technology would work as it was intended technologically ........ ☐
5) we have enough expertise in handling this technology ........ ☐
6) we have experience in handling similar technological innovation ........ ☐

## SECTION E: TECHNOLOGY BUYER AND TECHNOLOGY SUPPLIER RELATIONSHIPS

**Please refer your answer to a single recently-implemented AMT as specified in the previous section** *(Please use the following scale and place the appropriate number in the box provided).*

| Not at all | A little | A moderate amount | A lot | To a very great extent |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

**a. Trust**

1) To what extent do you trust that the supplier has dealt with you in a fair manner? ........ ☐
2) To what extent do you believe the supplier has provided your firm with the latest and appropriate technology? ........ ☐
3) To what extent do you believe the supplier has provided your firm with a high-quality technology? .. ☐

4) To what extent do you believe the supplier has provided your firm with the best cost for the acquired technology? ..........

5) To what extent do you believe the supplier will keep its promise on the original agreement? ..........

6) To what extent do you believe that confidential/proprietary information shared with the supplier will be kept strictly confidential? ..........

7) To what extent has the supplier developed a reputation for fairness and trustworthiness in your relationship? ..........

**b. Business Understanding**

1) To what extent do you think the technology supplier has a good grasp of your product? ..........

2) To what extent do you think the technology supplier has a good grasp of your manufacturing process? ..........

3) To what extent do you think the technology supplier has a good grasp of your manufacturing performance? ..........

4) To what extent do you think the technology supplier understands your business objectives? ..........

5) To what extent do you think the technology supplier has been able to relate the supplied technology to your firm's requirements? (The technology chosen is appropriate for your firm's manufacturing requirement) ..........

6) To what extent was the supplier eager to respond to your initial enquiries before the implementation took place? ..........

7) To what extent do you think the technology supplier has an interest in your firm's future requirements? ..........

**c. Involvement**

1) To what extent was the technology supplier involved in the planning process so that the technology implemented is compatible with the current system? ..........

2) To what extent has the technology supplier been involved in improving your firm's understanding of the new technology's requirements before the implementation process? ..........

3) To what extent do you think the technology supplier has helped your firm to mentally prepare for the new technology implementation before the implementation process? ..........

4) To what extent do you think the technology supplier was involved during the implementation process? ..........

**d. Commitment**

1) To what extent has the assistance provided on the acquired technology helped your firm to increase the efficiency of your manufacturing operation? ..........

2) To what extent has the assistance provided on the acquired technology helped your firm to increase the reliability and the quality of your product? ..........

3) To what extent has the supplier provided after sales service and technical support which has allowed you to implement the technology more successfully? ..........

4) To what extent was the supplier involved in fixing the disruption emerging from the implemented technology? ..........

5) To what extent has the supplier made sure that the benefits of the technology are optimized? ..........

**e. Communication**

1) To what extent did you communicate with the supplier's technical people whenever a problem emerged with the implemented technology? ............................................................ ☐
2) To what extent did you communicate with the technology supplier <u>before</u> the technology was implemented? .................................................................................................... ☐
3) To what extent did you communicate with the technology supplier <u>during</u> technology implementation? ............................................................................................... ☐
4) To what extent did you communicate with the technology supplier <u>after</u> the technology was implemented? .................................................................................................... ☐
5) To what extent did you communicate with possible technology suppliers before a decision was made on the supplier choice? ......................................................................... ☐

**f. Information sharing**

1) To what extent do you think the technology supplier has conveyed <u>true</u> information on the technology before your firm made the investment in the technology? .................................. ☐
2) To what extent do you think the technology supplier has conveyed <u>complete</u> information on the technology before your firm made the investment in the technology? .................................. ☐
3) To what extent do you think the technology supplier shared confidential information during your relationship? ................................................................................................ ☐
4) To what extent do you think the technology supplier has shared important information which is directly or indirectly useful for your manufacturing operation? ........................................... ☐
5) To what extent do you think the technology supplier manipulated the information on the technology because of its vested interest in selling the technology? ................................................ ☐

**g. Knowledge acquired**

1) To what extent have you learned from the technology supplier new technical skills relating to the implemented technology? ........................................................................................ ☐
2) To what extent has the technical support provided by the technology supplier helped you to solve technical problems? .............................................................................................. ☐
3) To what extent do you think your relationship with the technology supplier encouraged knowledge development? ......................................................................................................... ☐
4) To what extent do you think your relationship with the technology supplier in the implementation of this new technology has improved your employees' overall skill at work? .............................. ☐
5) To what extent do you think your relationship with the technology supplier has improved your analytical and technical skill to implement complex technological projects in the future? ........... ☐
6) Overall, to what extent have you acquired knowledge from the technology supplier? .................. ☐

What are the significant areas of technology buyer and supplier relationships that are not covered in this questionnaire?

| |
|---|
| |

## SECTION F: PERFORMANCE

**Please refer your answer to a single recently-implemented AMT as specified in the previous section** *(Please use the following scale and circle the appropriate number in the box provided).*

| Not at all | A little | A moderate amount | A lot | To a great extent |
|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) |

a) To what extent have the following aspects been achieved since the adoption of the technology *?

| | | | | | |
|---|---|---|---|---|---|
| 1. Reduction in the lead time | 1 | 2 | 3 | 4 | 5 |
| 2. Increase in quality | 1 | 2 | 3 | 4 | 5 |
| 3. Reduction in cost | 1 | 2 | 3 | 4 | 5 |
| 4. Increase in efficiency and productivity | 1 | 2 | 3 | 4 | 5 |

* **Note**: Changes in the four performance measures above can be attributed to any of these facets (the box below) depending on the nature of the technology implemented.

**Reduction in lead time may due to:**
- Quotation to design lead times
- Design to manufacture lead times
- Ability to design and manufacture new products
- Production change over time
- Manufacturing lead times
- Delivery lead times

**Reduction in cost may due to:**
- Reduction in direct labour cost
- Material optimization
- Reduction in inventory cost
- Reduction in scrap and rework
- Reduction in lead time
- Increase in efficiency and flexibility

**Increase in quality may due to:**
- Improved design
- Consistency in quality
- Reduction of scrap rate and rework

**Increase in efficiency and flexibility may due to:**
- Product design flexibility
- Volume flexibility (ability to change production batch size or lot size)
- Efficiency in finished goods stocks
- Efficiency in raw material stocks

## Please Turn Over For The Final Question:

**Please refer your answer to a single recently-implemented AMT as identified from the previous section.** *(Please use the following scale and circle the appropriate number in the box provided).*

| Not at all (1) | A little (2) | A moderate amount (3) | A lot (4) | To a great extent (5) |
|---|---|---|---|---|

b) Based on the implemented technology, please indicate your **level of satisfaction** on the following aspects:

| | | | | | | |
|---|---|---|---|---|---|---|
| 1. | Time taken to fully implement the technology | 1 | 2 | 3 | 4 | 5 |
| 2. | Time taken before your company begins to gain the benefit from the implemented technology | 1 | 2 | 3 | 4 | 5 |
| 3. | The amount of downtime caused by the technology | 1 | 2 | 3 | 4 | 5 |
| 4. | Time taken to tackle any technical problem during the implementation process | 1 | 2 | 3 | 4 | 5 |
| 5. | The capability of the technology in fulfilling your implementation objective | 1 | 2 | 3 | 4 | 5 |
| 6. | The capability of the technology in improving your manufacturing processes and performance | 1 | 2 | 3 | 4 | 5 |

***END OF QUESTIONNAIRE***

**Thank you for your time and cooperation to complete this survey. Information provided will be held in strictest confidence.**

If you wish to receive the results of the survey please provide your name and address or your email address at the end of the questionnaire. We will send you the results soon after the analysis is completed.

| | |
|---|---|
| Name of respondent | |
| Company name & Address | |
| E-mail address | |

FOR ANY QUERIES, PLEASE CONTACT:

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Appendix 3: Questionnaire used for main survey (Final version)

UPM UNIVERSITI PUTRA MALAYSIA

*SURVEY ON ADVANCED MANUFACTURING TECHNOLOGY IN MALAYSIA*

ASTON BUSINESS SCHOOL

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In this questionnaire, **"Advanced manufacturing technology* (AMT)"** refers to any kind of **computer-based** technologies which are advanced and new to your manufacturing operation or advanced when compared to your previous or current manufacturing technology. "Advanced" in this context can be taken as referring to its capability or technological features.

* Useful terms are provided at the last page of the questionnaire

## SECTION A: GENERAL INFORMATION

**Refers to the background of the company**

1. What are the major products of your company?

   ______________________________

2. Please indicate the total number of employees in your company.

   a) 100 or less  b) 101-300
   c) 301-500  d) 501-700
   e) 701-1000  f) More than 1000

2a. If your company is part of a larger company or group, how many employees does it have?

   a) 100 or less  b) 101-300
   c) 301-500  d) 501-700
   e) 701-1000  f) More than 1000

3. How long has your company been established?

   a) Less than 5 years  b) Between 5 and 10 years
   c) Between 10 and 15 years  d) More than 15 years

4. What is the ownership of your company?

   a) Sendirian Berhad  b) Berhad

5. What is the status of your company?

   a) Local-owned  b) Foreign-owned
   c) Joint venture with a foreign company (> 50% foreign majority)  d) Joint venture with a foreign company (< 50% foreign majority)
   e) Partnership (non-equity)  f) Others: ______________

**Respondent Profile**

6. Title of position held in the company? ____________________

7. Years of working experience in the company? ________ [years]

## SECTION B: PRODUCTION TECHNOLOGY

To what extent is each of the following major technologies used in your manufacturing processes? *(Please use the following scale and place the appropriate number in the box provided).*

| Not at all | A little | A moderate amount | A lot | To a very great extent |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

1. Custom technology: production or fabrication of a single unit or a few units to customer specification........................................................................................... ☐
2. Small batch (job shop) technology: production of small batches of similar units e.g. tools and dies........................................................................................... ☐
3. Large batch technology: production of large batches e.g. components for subsequent assembly as in a fabricating shop; of finished products such as bottles, cans, drugs, chemicals................. ☐
4. Mass production technology: as on an assembly line e.g. automobiles, standard textiles........... ☐
5. Continuous-process technology: output is highly standardized and produced continuously rather than in batches or shifts e.g. liquids, gases.............................................................. ☐

## SECTION C: INFORMATION ON THE RECENTLY IMPLEMENTED AMT

**Please refer your answer to a single recently-implemented AMT**

1. Please state the type of technological innovation recently acquired.

   ______________________________________

2. What year did your company acquire the technology? __________

3. Is it a local technology or a foreign technology? ________________

4. What is the value of the investment?

   a) Below RM 300 thousand
   b) Between RM 300 and 500 thousand
   c) Between RM 500 thousand and RM 1 million
   d) Between RM1 million and RM2 million
   e) Over RM 2 million

5. What are the terms of payment for the technology acquired?

   a) One-off payment
   b) Part payment at each phase of transfer
   c) Initial payment plus future royalty payments
   d) Payment for supply of key components
   e) Share of profits from sale (i.e. no initial payment)
   f) Other (Please specify): ______________________

6. Please state the form of arrangement involved in acquiring the technology.

   a) One-off purchase of machine
   b) Licensing
   c) Subcontracting
   d) Co-production
   e) Contractual joint venture
   f) Equity alliance
   g) Wholly-owned subsidiary
   h) Other (Please specify): ______________

7. Have you ever dealt with this technology supplier on any other technology implementation before?

   Yes ☐ If yes, how many times? ☐ [time(s)]

   No ☐

## SECTION D: TRANSACTION ATTRIBUTES

**Please refer your answer to a single recently-implemented AMT as specified in the previous section** *(Please use the following scale and place the appropriate number in the box provided).*

| Strongly disagree | Disagree | Not Sure | Agree | Strongly Agree |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

**a) The view of complexity before implementation process**

1) The technology is quite straightforward ............................................................ ☐
2) The engineering of the technology is technically difficult and complex ................................ ☐
3) The technology contains a higher degree of tacit knowledge* ........................................ ☐
4) The implementation of the technology reflects major changes to our manufacturing layout/ process/practice.......................................................................................... ☐

**b. The specificity of the technology**

1) Our firm has a major financial investment in the technology ......................................... ☐
2) The technology represents a core competence* for us ................................................ ☐
3) Our firm has a high degree of collective learning and training for the implementation of the technology.......................................................................................... ☐
4) Our firm has a special expertise dedicated to the implementation of the technology................. ☐

**c. Uncertainty surrounding the acquisition and implementation**

Before investing in this technology:

1) we were confident that the technology would achieve our investment goals .......................... ☐
2) we were certain the technology would meet our technical expectations ................................ ☐
3) we were certain the technology would help us meet customer demands ................................ ☐
4) we were confident that the technology would work as it was intended technologically .............. ☐
5) we have enough expertise in handling this technology ................................................ ☐
6) we have experience in handling similar technological innovation ..................................... ☐

## SECTION E: TECHNOLOGY BUYER AND TECHNOLOGY SUPPLIER RELATIONSHIPS

**Please refer your answer to a single recently-implemented AMT as specified in the previous section** *(Please use the following scale and place the appropriate number in the box provided).*

| Not at all | A little | A moderate amount | A lot | To a very great extent |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

**a. Trust**

1) To what extent do you trust that the supplier has dealt with you in a fair manner? ....................
2) To what extent do you believe the supplier has provided your firm with the latest and appropriate technology? ....................
3) To what extent do you believe the supplier has provided your firm with a high-quality technology?...
4) To what extent do you believe the supplier has provided your firm with the best cost for the acquired technology? ....................
5) To what extent do you believe that confidential/proprietary information shared with the supplier will be kept strictly confidential? ....................
6) To what extent has the supplier developed a reputation for fairness and trustworthiness in your relationship? ....................

**b. Business Understanding**

1) To what extent do you think the technology supplier has a good grasp of your product? ....................
2) To what extent do you think the technology supplier has a good grasp of your manufacturing process? ....................
3) To what extent do you think the technology supplier has a good grasp of your manufacturing performance? ....................
4) To what extent do you think the technology supplier understands your business objectives? ..........
5) To what extent do you think the technology supplier has been able to relate the supplied technology to your firm's requirements? (The technology chosen is appropriate for your firm's manufacturing requirement) ....................
6) To what extent do you think the technology supplier has an interest in your firm's future requirements? ....................

**c. Involvement**

1) To what extent was the technology supplier involved in the planning process so that the technology implemented is compatible with the current system? ....................
2) To what extent has the technology supplier been involved in improving your firm's understanding of the new technology's requirements before the implementation process? ....................
3) To what extent do you think the technology supplier has helped your firm to mentally prepare for the new technology implementation before the implementation process? ....................
4) To what extent do you think the technology supplier was involved during the implementation process? ....................

**d. Commitment**

1) To what extent has the assistance provided on the acquired technology helped your firm to increase the efficiency of your manufacturing operation? ........................................................ ☐
2) To what extent has the assistance provided on the acquired technology helped your firm to increase the reliability and the quality of your product? ........................................................ ☐
3) To what extent has the supplier provided after sales service and technical support which has allowed you to implement the technology more successfully? ........................................................ ☐
4) To what extent was the supplier involved in fixing the disruption emerging from the implemented technology? ........................................................ ☐
5) To what extent has the supplier made sure that the benefits of the technology are optimized? ......... ☐

**e. Communication**

1) To what extent did you communicate with the supplier's technical people whenever a problem emerged with the implemented technology? ........................................................ ☐
2) To what extent did you communicate with the technology supplier <u>before</u> the technology was implemented? ........................................................ ☐
3) To what extent did you communicate with the technology supplier <u>during</u> technology implementation? ........................................................ ☐
4) To what extent did you communicate with the technology supplier <u>after</u> the technology was implemented? ........................................................ ☐
5) To what extent did you communicate with possible technology suppliers before a decision was made on the supplier choice? ........................................................ ☐

**f. Information sharing**

1) To what extent do you think the technology supplier has conveyed <u>true</u> information on the technology before your firm made the investment in the technology? .................................. ☐
2) To what extent do you think the technology supplier has conveyed <u>complete</u> information on the technology before your firm made the investment in the technology? .................................. ☐
3) To what extent do you think the technology supplier shared confidential information during your relationship? ........................................................ ☐
4) To what extent do you think the technology supplier has shared important information which is directly or indirectly useful for your manufacturing operation? .......................................... ☐
5) To what extent do you think the technology supplier manipulated the information on the technology because of its vested interest in selling the technology? .................................................. ☐

**g. Knowledge acquired**

1) To what extent have you learned from the technology supplier new technical skills relating to the implemented technology? ........................................................ ☐
2) To what extent has the technical support provided by the technology supplier helped you to solve technical problems? ........................................................ ☐
3) To what extent do you think your relationship with the technology supplier encouraged knowledge development? ........................................................ ☐
4) To what extent do you think your relationship with the technology supplier in the implementation of this new technology has improved your employees' overall skill at work? ............................. ☐
5) To what extent do you think your relationship with the technology supplier has improved your analytical and technical skill to implement complex technological projects in the future? ........... ☐

6) Overall, to what extent have you acquired knowledge from the technology supplier? .................. ☐

What are the significant areas of technology buyer and supplier relationships that are not covered in this questionnaire?

| |
|---|
| |

## SECTION F: PERFORMANCE

**Please refer your answer to a single recently-implemented AMT as specified in the previous section** *(Please use the following scale and circle the appropriate number in the box provided).*

| Not at all (1) | A little (2) | A moderate amount (3) | A lot (4) | To a great extent (5) |
|---|---|---|---|---|

a) To what extent have the following aspects been achieved since the adoption of the technology *?

| | | | | | |
|---|---|---|---|---|---|
| 1. Reduction in the lead time | 1 | 2 | 3 | 4 | 5 |
| 2. Increase in quality | 1 | 2 | 3 | 4 | 5 |
| 3. Reduction in cost | 1 | 2 | 3 | 4 | 5 |
| 4. Increase in efficiency and productivity | 1 | 2 | 3 | 4 | 5 |

* **Note**: Changes in the four performance measures above can be attributed to any of these facets (the box below) depending on the nature of the technology implemented.

| | |
|---|---|
| **Reduction in lead time may due to:**<br>• Quotation to design lead times<br>• Design to manufacture lead times<br>• Ability to design and manufacture new products<br>• Production change over time<br>• Manufacturing lead times<br>• Delivery lead times | **Reduction in cost may due to:**<br>• Reduction in direct labour cost<br>• Material optimization<br>• Reduction in inventory cost<br>• Reduction in scrap and rework<br>• Reduction in lead time<br>• Increase in efficiency and flexibility |
| **Increase in quality may due to:**<br>• Improved design<br>• Consistency in quality<br>• Reduction of scrap rate and rework | **Increase in efficiency and flexibility may due to:**<br>• Product design flexibility<br>• Volume flexibility (ability to change production batch size or lot size)<br>• Efficiency in finished goods stocks<br>• Efficiency in raw material stocks |

**Please refer your answer to a single recently-implemented AMT as identified from the previous section.** *(Please use the following scale and circle the appropriate number in the box provided).*

| Not at all (1) | A little (2) | A moderate amount (3) | A lot (4) | To a great extent (5) |
|---|---|---|---|---|

b) Based on the implemented technology, please indicate your **level of satisfaction** on the following aspects:

| | | | | | | |
|---|---|---|---|---|---|---|
| 1. | Time taken to fully implement the technology | 1 | 2 | 3 | 4 | 5 |
| 2. | Time taken before your company begins to gain the benefit from the implemented technology | 1 | 2 | 3 | 4 | 5 |
| 3. | The amount of downtime caused by the technology | 1 | 2 | 3 | 4 | 5 |
| 4. | Time taken to tackle any technical problem during the implementation process | 1 | 2 | 3 | 4 | 5 |
| 5. | The capability of the technology in fulfilling your implementation objective | 1 | 2 | 3 | 4 | 5 |
| 6. | The capability of the technology in improving your manufacturing processes and performance | 1 | 2 | 3 | 4 | 5 |

***END OF QUESTIONNAIRE***

**Thank you for your time and cooperation to complete this survey. Information provided will be held in strictest confidence.**

If you wish to receive the results of the survey please provide your name and address or your email address at the end of the questionnaire. We will send you the results soon after the analysis is completed.

| | |
|---|---|
| Name of respondent | |
| Company name & Address | |
| E-mail address | |

FOR ANY QUERIES, PLEASE CONTACT:

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**Useful terms:**

**AMT**

A group of computer-based technologies, which includes robotics, group technology, flexible manufacturing systems (FMS), automated materials handling systems, computer numerically controlled (CNC) machine tools, and bar-coding or other automated identification techniques, which is new or advanced to a company when compared to its previous or current manufacturing technology. "Advanced" in this context can be taken as referring to its capability or technological features. The study focuses on the hard form of AMT, and also soft technologies when they are embedded in hardware rather than being acquired independently. Some examples are as follows:

*Machining/fabricating and assembly:*
Numerical control machines (CNC/DNC)
Pick-and-place robots (PPR)
Other robots (ROB)
Materials working lasers

*Automated material handling technologies:*
Automated storage/retrieval systems (ASRS)
Automated material handling systems (AMHS)

*Automated inspection and testing technologies:*
Automated inspection and testing equipment (AITE)

*Flexible manufacturing systems:*
Flexible manufacturing cells/systems (FMC /FMS)

*Computer-integrated manufacturing:*
Computer-Integrated Manufacturing (CIM)

**Tacit knowledge**

knowledge that cannot be codified, but can only be transmitted via training or gained through personal experience. It involves learning and skill but not in a way that can be written down. (For instance, one does not know how to ride a bike or swim due to reading a textbook, but only through personal experimentation, by observing others, and/or being guided by an instructor)

**Core competence**

In the context of the present research, core competence means the asset that is important to the firm because it plays major part to the achievement of competitive advantage in the marketplace

Appendix 4: Reliability analysis of the final data set

## Reliability Result

## Scale: LEVEL OF COMPLEXITY

**Reliability Statistics**

| Cronbach's Alpha | N of Items |
|---|---|
| .902 | 4 |

**Item-Total Statistics**

| | Scale Mean if Item Deleted | Scale Variance if Item Deleted | Corrected Item-Total Correlation | Cronbach's Alpha if Item Deleted |
|---|---|---|---|---|
| loc1 | 10.5986 | 10.064 | .782 | .873 |
| loc2 | 10.5782 | 9.958 | .773 | .877 |
| loc3 | 10.5714 | 9.575 | .806 | .865 |
| loc4 | 10.5782 | 10.889 | .772 | .879 |

## Reliability

## Scale: LEVEL OF ASSET SPECIFICITY

**Reliability Statistics**

| Cronbach's Alpha | N of Items |
|---|---|
| .849 | 4 |

**Item-Total Statistics**

| | Scale Mean if Item Deleted | Scale Variance if Item Deleted | Corrected Item-Total Correlation | Cronbach's Alpha if Item Deleted |
|---|---|---|---|---|
| las1 | 10.2517 | 10.505 | .656 | .827 |
| las2 | 10.2789 | 10.572 | .726 | .792 |
| las3 | 10.1429 | 10.986 | .766 | .776 |
| las4 | 10.2245 | 12.614 | .627 | .835 |

# Reliability

## Scale: LEVEL OF UNCERTAINTY

**Reliability Statistics**

| Cronbach's Alpha | N of Items |
|---|---|
| .846 | 5 |

**Item-Total Statistics**

| | Scale Mean if Item Deleted | Scale Variance if Item Deleted | Corrected Item-Total Correlation | Cronbach's Alpha if Item Deleted |
|---|---|---|---|---|
| lou1 | 13.2789 | 9.216 | .642 | .818 |
| lou2 | 13.3401 | 8.842 | .698 | .802 |
| lou3 | 13.3129 | 9.134 | .773 | .783 |
| lou4 | 13.2449 | 10.063 | .621 | .823 |
| lou6 | 13.0816 | 10.048 | .549 | .841 |

# Reliability

## Scale: TRUST AND BUSINESS UNDERSTANDING (TBU)

**Reliability Statistics**

| Cronbach's Alpha | N of Items |
|---|---|
| .863 | 6 |

**Item-Total Statistics**

| | Scale Mean if Item Deleted | Scale Variance if Item Deleted | Corrected Item-Total Correlation | Cronbach's Alpha if Item Deleted |
|---|---|---|---|---|
| trust1 | 14.3878 | 9.623 | .804 | .810 |
| trust2 | 14.5850 | 10.847 | .791 | .819 |
| trust4 | 14.4898 | 11.676 | .618 | .847 |
| trust6 | 14.5238 | 11.251 | .599 | .850 |
| b.u.2 | 14.4966 | 11.074 | .543 | .863 |
| b.u.5 | 14.3537 | 11.216 | .621 | .846 |

# Reliability

## Scale: COMMITTED INVOLVEMENT (CI)

**Reliability Statistics**

| Cronbach's Alpha | N of Items |
|---|---|
| .806 | 6 |

**Item-Total Statistics**

| | Scale Mean if Item Deleted | Scale Variance if Item Deleted | Corrected Item-Total Correlation | Cronbach's Alpha if Item Deleted |
|---|---|---|---|---|
| invo.1 | 14.9592 | 8.152 | .613 | .764 |
| invo.2 | 14.8435 | 8.321 | .625 | .763 |
| invo.3 | 14.8231 | 8.492 | .586 | .771 |
| invo.4 | 14.9796 | 8.071 | .603 | .766 |
| commit3 | 14.9320 | 8.362 | .478 | .797 |
| commit4 | 14.9524 | 8.498 | .497 | .791 |

# Reliability

## Scale: COMMUNICATION (COMMU)

**Reliability Statistics**

| Cronbach's Alpha | N of Items |
|---|---|
| .863 | 4 |

**Item-Total Statistics**

| | Scale Mean if Item Deleted | Scale Variance if Item Deleted | Corrected Item-Total Correlation | Cronbach's Alpha if Item Deleted |
|---|---|---|---|---|
| commu.1 | 9.9524 | 8.087 | .710 | .825 |
| commu.2 | 9.9524 | 7.854 | .770 | .800 |
| commu.3 | 10.0476 | 7.826 | .731 | .817 |
| commu.5 | 10.1905 | 8.895 | .633 | .855 |

# Reliability

## Scale: INFORMATION SHARING (IS)

**Reliability Statistics**

| Cronbach's Alpha | N of Items |
|---|---|
| .788 | 4 |

**Item-Total Statistics**

| | Scale Mean if Item Deleted | Scale Variance if Item Deleted | Corrected Item-Total Correlation | Cronbach's Alpha if Item Deleted |
|---|---|---|---|---|
| IS1 | 8.1973 | 4.255 | .614 | .731 |
| IS2 | 8.2925 | 3.633 | .691 | .684 |
| IS3 | 8.2517 | 4.286 | .567 | .750 |
| IS5 | 8.1361 | 3.762 | .538 | .774 |

# Reliability

## Scale: KNOWLEDGE ACQUIRED (KA)

**Reliability Statistics**

| Cronbach's Alpha | N of Items |
|---|---|
| .763 | 4 |

**Item-Total Statistics**

| | Scale Mean if Item Deleted | Scale Variance if Item Deleted | Corrected Item-Total Correlation | Cronbach's Alpha if Item Deleted |
|---|---|---|---|---|
| KA1 | 9.0816 | 2.678 | .604 | .684 |
| KA2 | 9.1701 | 2.334 | .697 | .626 |
| KA3 | 8.7619 | 3.443 | .403 | .781 |
| KA5 | 9.0476 | 2.635 | .565 | .707 |

## Reliability

## Scale: TECHNOLOGY PERFORMANCE (TP)

**Reliability Statistics**

| Cronbach's Alpha | N of Items |
|---|---|
| .751 | 4 |

**Item-Total Statistics**

| | Scale Mean if Item Deleted | Scale Variance if Item Deleted | Corrected Item-Total Correlation | Cronbach's Alpha if Item Deleted |
|---|---|---|---|---|
| tp1 | 11.0000 | 1.726 | .595 | .667 |
| tp2 | 11.0136 | 1.822 | .529 | .703 |
| tp3 | 11.0204 | 1.760 | .577 | .677 |
| tp4 | 11.0068 | 1.801 | .490 | .726 |

## Reliability

## Scale: IMPLEMENTATION PERFORMANCE (IP)

**Reliability Statistics**

| Cronbach's Alpha | N of Items |
|---|---|
| .683 | 4 |

**Item-Total Statistics**

| | Scale Mean if Item Deleted | Scale Variance if Item Deleted | Corrected Item-Total Correlation | Cronbach's Alpha if Item Deleted |
|---|---|---|---|---|
| ip1 | 10.2449 | 2.049 | .351 | .690 |
| ip3 | 10.3333 | 1.731 | .579 | .539 |
| ip4 | 10.3197 | 1.959 | .514 | .591 |
| ip5 | 10.2041 | 1.876 | .435 | .639 |

# Appendix 5: Exploratory Factor Analysis (EFA)

## Scale: TRANSACTION ATTRIBUTES

**KMO and Bartlett's Test**

| | | |
|---|---|---|
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy. | | .822 |
| Bartlett's Test of Sphericity | Approx. Chi-Square | 1431.110 |
| | df | 91 |
| | Sig. | .000 |

**Communalities**

| | Initial | Extraction |
|---|---|---|
| loc1 | 1.000 | .768 |
| loc2 | 1.000 | .761 |
| loc3 | 1.000 | .719 |
| loc4 | 1.000 | .780 |
| las1 | 1.000 | .822 |
| las2 | 1.000 | .779 |
| las3 | 1.000 | .837 |
| las4 | 1.000 | .650 |
| lou1 | 1.000 | .618 |
| lou2 | 1.000 | .672 |
| lou3 | 1.000 | .737 |
| lou4 | 1.000 | .612 |
| lou5 | 1.000 | .842 |
| lou6 | 1.000 | .324 |

Extraction Method: Principal Component Analysis.

**Total Variance Explained**

| Component | Initial Eigenvalues | | | Extraction Sums of Squared Loadings | | | Rotation Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 6.492 | 46.375 | 46.375 | 6.492 | 46.375 | 46.375 | 3.829 | 27.351 | 27.351 |
| 2 | 2.116 | 15.112 | 61.486 | 2.116 | 15.112 | 61.486 | 3.369 | 24.064 | 51.415 |
| 3 | 1.313 | 9.381 | 70.867 | 1.313 | 9.381 | 70.867 | 2.723 | 19.452 | 70.867 |
| 4 | .863 | 6.164 | 77.031 | | | | | | |
| 5 | .659 | 4.708 | 81.740 | | | | | | |
| 6 | .567 | 4.052 | 85.792 | | | | | | |
| 7 | .396 | 2.827 | 88.619 | | | | | | |
| 8 | .366 | 2.612 | 91.230 | | | | | | |
| 9 | .307 | 2.194 | 93.424 | | | | | | |
| 10 | .295 | 2.111 | 95.535 | | | | | | |
| 11 | .224 | 1.603 | 97.138 | | | | | | |
| 12 | .173 | 1.238 | 98.375 | | | | | | |
| 13 | .130 | .926 | 99.301 | | | | | | |
| 14 | .098 | .699 | 100.000 | | | | | | |

Extraction Method: Principal Component Analysis.

**Rotated Component Matrix**[a]

| | Component | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| loc4 | .866 | | |
| loc1 | .861 | | |
| loc3 | .804 | | |
| loc2 | .785 | | .358 |
| lou6 | .781 | | .432 |
| lou3 | | .843 | |
| lou4 | | .781 | .352 |
| lou2 | | .779 | |
| lou1 | | .731 | .511 |
| las3 | | .619 | .870 |
| las2 | .306 | .583 | .778 |
| las1 | | .511 | .670 |
| las4 | | | .528 |
| lou5 | .308 | | .311 |

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 3 iterations.

# Factor Analysis

# Scale: BUYER-SUPPLIER RELATIONSHIPS

**KMO and Bartlett's Test**

| | | |
|---|---|---|
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy. | | .835 |
| Bartlett's Test of Sphericity | Approx. Chi-Square | 3204.759 |
| | df | 595 |
| | Sig. | .000 |

**Communalities**

| | Initial | Extraction |
|---|---|---|
| trust1 | 1.000 | .736 |
| trust2 | 1.000 | .752 |
| trust3 | 1.000 | .672 |
| trust4 | 1.000 | .621 |
| trust5 | 1.000 | .746 |
| trust6 | 1.000 | .618 |
| b.u.1 | 1.000 | .531 |
| b.u.2 | 1.000 | .738 |
| b.u.3 | 1.000 | .632 |
| b.u.4 | 1.000 | .608 |
| b.u.5 | 1.000 | .679 |
| invo.1 | 1.000 | .625 |
| invo.2 | 1.000 | .605 |
| invo.3 | 1.000 | .652 |
| invo.4 | 1.000 | .627 |
| commit.1 | 1.000 | .651 |
| commit.2 | 1.000 | .434 |
| commit.3 | 1.000 | .561 |
| commit.4 | 1.000 | .602 |
| commit.5 | 1.000 | .532 |
| commu.1 | 1.000 | .727 |
| commu.2 | 1.000 | .743 |
| commu.3 | 1.000 | .733 |
| commu.4 | 1.000 | .833 |
| commu.5 | 1.000 | .683 |
| info.s.1 | 1.000 | .667 |
| info.s.2 | 1.000 | .677 |
| info.s.3 | 1.000 | .619 |
| info.s.4 | 1.000 | .655 |
| info.s.5 | 1.000 | .725 |
| know.1 | 1.000 | .545 |
| know.2 | 1.000 | .646 |
| know.3 | 1.000 | .530 |
| know.4 | 1.000 | .686 |
| know.5 | 1.000 | .722 |

Extraction Method: Principal Component Analysis.

**Total Variance Explained**

| Component | Initial Eigenvalues | | | Extraction Sums of Squared Loadings | | | Rotation Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 11.228 | 32.079 | 32.079 | 11.228 | 32.079 | 32 079 | 5.781 | 16.518 | 16 518 |
| 2 | 3.302 | 9.433 | 41.512 | 3.302 | 9.433 | 41.512 | 4.156 | 11.875 | 28.392 |
| 3 | 2.797 | 7.992 | 49.504 | 2.797 | 7.992 | 49 504 | 3.543 | 10.124 | 38.516 |
| 4 | 1.814 | 5.184 | 54.688 | 1.814 | 5.184 | 54.688 | 3.373 | 9.637 | 48.153 |
| 5 | 1.405 | 4.015 | 58.703 | 1.405 | 4.015 | 58.703 | 3.147 | 8.991 | 57.144 |
| 6 | 1.155 | 3.301 | 62.005 | 1.155 | 3.301 | 62.005 | 1.577 | 4.506 | 61.650 |
| 7 | 1.109 | 3.170 | 65.175 | 1.109 | 3.170 | 65.175 | 1.234 | 3.525 | 65.175 |
| 8 | 1.062 | 3.034 | 68.208 | | | | | | |
| 9 | .906 | 2.588 | 70.796 | | | | | | |
| 10 | .839 | 2.398 | 73.195 | | | | | | |
| 11 | .793 | 2.265 | 75.460 | | | | | | |
| 12 | .748 | 2.138 | 77.598 | | | | | | |
| 13 | .705 | 2.016 | 79.614 | | | | | | |
| 14 | .673 | 1.923 | 81.537 | | | | | | |
| 15 | .646 | 1.845 | 83.382 | | | | | | |
| 16 | .572 | 1.633 | 85.015 | | | | | | |
| 17 | .536 | 1.531 | 86.546 | | | | | | |
| 18 | .514 | 1.469 | 88.015 | | | | | | |
| 19 | .461 | 1.318 | 89.333 | | | | | | |
| 20 | .454 | 1.297 | 90 630 | | | | | | |
| 21 | .403 | 1.151 | 91.781 | | | | | | |
| 22 | .371 | 1.061 | 92.842 | | | | | | |
| 23 | .326 | .932 | 93.774 | | | | | | |
| 24 | .303 | .865 | 94.639 | | | | | | |
| 25 | .273 | .781 | 95.420 | | | | | | |
| 26 | .241 | .689 | 96.109 | | | | | | |
| 27 | .238 | .680 | 96.789 | | | | | | |
| 28 | .219 | .626 | 97.415 | | | | | | |
| 29 | .195 | .556 | 97.971 | | | | | | |
| 30 | .162 | .463 | 98.434 | | | | | | |
| 31 | .149 | .425 | 98.859 | | | | | | |
| 32 | .120 | .342 | 99.201 | | | | | | |
| 33 | .104 | .298 | 99.498 | | | | | | |
| 34 | .089 | .256 | 99.754 | | | | | | |
| 35 | .086 | .246 | 100.000 | | | | | | |

Extraction Method: Principal Component Analysis.

**Rotated Component Matrix[a]**

| | Component | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| trust2 | .805 | | | | | | |
| trust1 | .783 | | | | | | |
| trust3 | .755 | | | | | | |
| trust4 | .741 | | | | | | |
| b.u.3 | .684 | | | | | | |
| b.u.5 | .666 | | | | | | |
| b.u.4 | .628 | | | | | | |
| trust6 | .582 | | .338 | | | | .328 |
| b.u.2 | .547 | | | | | .491 | -.318 |
| b.u.1 | .488 | .474 | | | | | |
| trust5 | .405 | | .328 | .347 | | .302 | |
| commu.4 | | .809 | | | | | |
| commu.2 | | .734 | | .323 | | | |
| commu.1 | | .717 | | .332 | | | |
| commu.5 | .338 | .677 | | | | | |
| commu.3 | | .660 | | | | .367 | |
| info.s.2 | | | .767 | | | | |
| info.s.1 | | | .757 | | | | |
| info.s.4 | | | .734 | | | | |
| info.s.3 | | | .723 | | | | |
| info.s.5 | | .362 | .703 | | | | |
| invo.3 | | | | .839 | | | |
| invo.2 | | | | .832 | | | |
| invo.1 | | | | .826 | | | |
| invo.4 | | | | .808 | | | |
| commit.3 | | | | .806 | | .430 | |
| commit.4 | .313 | .383 | | .730 | | | |
| commit.2 | | | | .707 | .202 | | |
| commit.1 | | | | .604 | | | |
| commit.5 | | | | .578 | .326 | | |
| know.5 | | .344 | | | .802 | | |
| know.4 | .310 | | | | .778 | | |
| know.3 | | | | | .626 | | |
| know.2 | | .353 | | | .615 | | |
| know.1 | | | | | .571 | | |

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 7 iterations.

**Component Transformation Matrix**

| Component | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| 1 | .627 | .491 | .297 | .360 | .320 | .200 | .071 |
| 2 | .059 | -.450 | .787 | -.332 | .236 | -.053 | .074 |
| 3 | -.609 | -.012 | .103 | .547 | .557 | -.070 | -.058 |
| 4 | -.158 | .008 | .451 | .463 | -.707 | .167 | -.171 |
| 5 | .347 | -.736 | -.275 | .427 | .041 | .242 | .141 |
| 6 | -.273 | .122 | .026 | -.097 | -.059 | .506 | .801 |
| 7 | .108 | .010 | .041 | .234 | -.161 | -.781 | .544 |

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

# Factor Analysis

# Scale: PERFORMANCE

**KMO and Bartlett's Test**

| | | |
|---|---|---|
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy. | | .685 |
| Bartlett's Test of Sphericity | Approx. Chi-Square | 375.854 |
| | df | 45 |
| | Sig. | .000 |

**Communalities**

| | Initial | Extraction |
|---|---|---|
| tech.p.1 | 1.000 | .553 |
| tech.p.2 | 1.000 | .591 |
| tech.p.3 | 1.000 | .590 |
| tech.p.4 | 1.000 | .509 |
| impl.p.1 | 1.000 | .398 |
| impl.p.2 | 1.000 | .547 |
| impl.p.3 | 1.000 | .555 |
| impl.p.4 | 1.000 | .534 |
| impl.p.5 | 1.000 | .469 |
| impl.p.6 | 1.000 | .288 |

Extraction Method: Principal Component Analysis.

**Total Variance Explained**

| | Initial Eigenvalues | | | Extraction Sums of Squared Loadings | | | Rotation Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|---|---|---|
| Component | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 3.061 | 30.613 | 30.613 | 3.061 | 30.613 | 30.613 | 2.778 | 27.779 | 27.779 |
| 2 | 1.975 | 19.746 | 50.359 | 1.975 | 19.746 | 50.359 | 2.258 | 22.580 | 50.359 |
| 3 | 1.016 | 10.159 | 60.517 | | | | | | |
| 4 | .843 | 8.432 | 68.949 | | | | | | |
| 5 | .814 | 8.144 | 77.093 | | | | | | |
| 6 | .642 | 6.423 | 83.516 | | | | | | |
| 7 | .552 | 5.518 | 89.034 | | | | | | |
| 8 | .435 | 4.353 | 93.387 | | | | | | |
| 9 | .358 | 3.575 | 96.962 | | | | | | |
| 10 | .304 | 3.038 | 100.000 | | | | | | |

Extraction Method: Principal Component Analysis.

**Rotated Component Matrix[a]**

| | Component | |
|---|---|---|
| | 1 | 2 |
| impl.p.3 | .742 | |
| impl.p.2 | .738 | |
| impl.p.4 | .730 | |
| impl.p.5 | .671 | |
| impl.p.1 | .621 | |
| impl.p.6 | .523 | |
| tech.p.2 | | .766 |
| tech.p.3 | | .750 |
| tech.p.1 | | .738 |
| tech.p.4 | | .714 |

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 3 iterations.