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Buyer-Supplier Relationships in Advanced Manufacturing Technology Acquisition and Implementation in Malaysia

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ABSTRACT

In an increasingly competitive environment, manufacturing firms in developing countries have continued to acquire and implement new and advanced technologies aimed at improving plant performance. In any new technology adoption, implementation remains the main issue, having been recognised by practitioners and widely reported by researchers as a major source of project failure. This is particularly true if the technology is considered to be advanced for the firm. While many factors have been blamed for causing project failure, efforts continue to be made to identify the critical success factors in technology implementation. In the implementation of advanced manufacturing technology (AMT), the relationship between technology buyers and suppliers has been widely cited as crucial to overall success. This paper explores technology buyer-supplier relationships and both implementation and performance of technology throughout the process of acquisition and implementation. Data obtained from 147 manufacturing firms in Malaysia was used to test several hypotheses, which were derived from an extensive review of literature relating to advanced manufacturing technology and buyer-supplier relationships (BSR). The data was analysed using the structured equation modelling (SEM) technique. The results indicate that although a majority of the firms reported improvements in performance since initiating the use of AMT, firms demonstrating a closer relationship with the technology

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suppliers are more likely to achieve higher levels of performance than those that do not. The result of this study also provides useful insights that are especially pertinent for improved understanding of buyer-supplier relationships in the procurement of capital equipment, about which research literature is currently quite sparse.

Keywords: Advanced manufacturing technology, Buyer-supplier relationships, technology implementation, performance.

INTRODUCTION

Research literature on manufacturing highlights that competitive capabilities are built upon both structural aspects (e.g. technologies or processes) and infrastructural aspects (e.g. management or people) (Monge et al., 2006, Small and Yasin, 1997a, Swamidass and Kotha, 1998, Wheelwright, 1984, Wheelwright and Hayes, 1985). Given today's increasingly competitive business environment, firms continue to invest in state-of-the art equipment and facilities in order to strengthen the structural aspects of their business. In fact, continuous investment in more advanced manufacturing technology (AMT) has been seen as one of the criteria of world-class manufacturing practices (Guimaraes et al., 2002, Yusuff, 2004). AMT is absolutely crucial for the survival of a manufacturing operation as it impacts both organizational and operational performance (Monge et al., 2006, Raymond, 2005).

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, Waldeck and Leffakis, 2007). 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. Several past empirical studies revealed that implementing AMT has often not been as successful or as straightforward as had been expected and many firms are still struggling with AMT implementation (Chen and Sun, 2000, Da-Costa et al., 2006, 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 for enhancement of success of technology acquisition and implementation, is 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). However, despite the wide claims about the 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, 1992b, Zhao and Co, 1997), very limited knowledge has been gained in this area as only few studies have specifically focussed on this issue. The claim that the technology supplier's role is imperative in AMT implementation was identified through wide scale investigation of the factors that facilitate or hinder the implementation process. The aim of the investigation reported in this paper was therefore to undertake an empirical and quantitative survey based investigations to establish the relationship between BSR and AMT acquisition and implementation performance. The empirical evidence required for this investigation was collected from buyers of AMT in the Malaysian manufacturing industry across a range of sectors.

AMT AND THE MALAYSIAN MANUFACTURING INDUSTRY

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 systems (Tracey and Tan, 2001). 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 improvement in the efficiency and effectiveness of the firm in manufacturing a product or providing a service. 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, literature generally agrees that it has been widely defined as a group of computer-based technologies, which include computer-aided design (CAD), computer-aided manufacturing (CAE), 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 (Guimaraes et al., 2002, Lewis and Boyer, 2002, Millen and Sohal, 1998, Sambasivarao and Deshmukh, 1995, Stock and Tatikonda, 2000, Zairi, 1992a, Zammuto and O'Connor, 1992). The present research applies the existing definition of AMT but extends this to include any technology, which is new or considered advanced by a company when compared to its previous or existing manufacturing technology. The study focuses on the hard form of AMT, and also soft technologies when they are embedded in hardware rather than transferred independently. Continuous investment in these types of technological innovations have been heralded as a new way for manufacturing companies to gain competitive advantage (Dangayach and Deshmukh, 2005, Pagell et al., 2000, Sohal et al., 2006). Their use in manufacturing operations is becoming crucial to remain competitive in today's business environment.

AMT has also been widely used in the Malaysian manufacturing sector, consistent with the government's vision for the country to achieve higher levels of technological competitiveness. The Malaysian government has also continued to play a key role in the promotion and execution of newer technologies among local manufacturing companies. The Second Industrial Master Plan (IMP2) 1996-2005 has been responsible for moving the whole value chain in the Malaysian manufacturing sector to a higher level through productivity-driven growth achieved through the use of advanced technologies such as automation and robotisation. In a survey of implementation and justification of the usage of AMT amongst local manufacturing companies in Malaysia, Teng and Seetharaman (2003) found that 94.5% of the responding firms have been using AMT in their manufacturing operations. Demand from the country's manufacturing sector 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 abroad 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).

AMT AND THE IMPLEMENTATION ISSUE

Despites the advantages, the implementation of AMT does not guarantee that a firm will reap all the potential benefits being offered (Chen and Sun, 2000, Meredith, 1987, Small and Yasin, 1997a). 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 benefits.

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) attributed the lack of absorptive capabilities to internalise AMT to managerial deficiencies and organisational obstacles. 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) credited the neglect of critical human resource factors for AMT implementation failure. 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 (Chen and Sun, 2000, Hottenstein et al., 1999, Sambasivarao and Deshmukh, 1995). Meredith (1987) observed that implementing AMT is one of the most lengthy, expensive and complex tasks that 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 in fact 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 claims that this has not been the case, primarily due to the tremendous change in complexity of technologies, and states that difficulties related to AMT implementation are as severe today as they were in the 1980s when many forms of automation first appeared.

As the success of AMT in achieving competitive advantage depends primarily on correctly selecting and properly managing AMT projects (Guimaraes et al., 2002), 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 course to enhance AMT success. Zammuto and O'Connor (1992), on the other hand, recognised the importance of firm design and culture on the potential outcomes of AMT investment. Zhao and Co (1997) highlighted that project team integrity, strategic planning and project championship, and technical knowledge, were found to be significant in the successful use of AMT. Small and Yasin (1997b), Millen and Sohal (1998), and Efstathiades et al. (2002) drew attention to the importance of planning for the success of AMT implementation. Small and Yasin (1997b) 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 compared to firms that were using neither business nor manufacturing planning.

In light of the above discussion based on relevant literature, it can be seen that much of previous research examining critical success factors has been identified and carried out with reference to factors internal to the firm (see Efstathiades et al., 2000, Frohlich, 1999, Millen and Sohal, 1998, Small and Yasin, 1997b). 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, 1992b). Studies by Udo and Ehie (1996) and Zhao and Co (1997) indicate that supplier support and/or relationships with the technology suppliers 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 for successful AMT implementation (Bessant, 1994, Burgess and Gules, 1998, Chen and Sun, 2000, Fynes and Voss, 2002, Kaighobadi and Venkatesh, 1994, Sohal, 1999, Sohal and Singh, 1992), yet very few studies have been conducted in relation to this issue.

Efstathiades et al. (2000) cautioned that the process of technology transfer is very complicated and requires skills and managerial know-how in 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 buyers remain 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. This explains the chronic gaps between forecasted and actual rates of production resulting from under-utilisation of the technology.

Hence, 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 to transfer of technology, lower wage rates, size of the firms and the paradigm of competition may be some of the compelling reasons which indicate 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, these circumstances, therefore, provide further motivation for the researcher to seek evidence regarding these issues from the Malaysian manufacturing industry perspective.

BSR AND THE AMT ACQUISITION AND IMPLEMENTATION PROCESS

Since the late 1980s, research in BSR has received increasing attention, especially as it has become widely known that various benefits can be enjoyed by developing closer relationships with suppliers. As noted by Tang et al. (2001), BSRs have evolved towards a new form in response to intensified competition in industry. The movement towards closer co-operation between buyers and suppliers also results from a global and competitive market place which 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 BSR, believing that firms engage in co-operative BSR because they expect to benefit from them. Only for as long as the firms perceive a benefit from the relationship do they continue in a co-operative fashion.

The review of the literature on BSR reveals three important observations. Firstly, there is increased evidence that suggests that BSRs 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 BSRs have been studied by various research sectors, efforts have been concentrated on the relationships with industrial suppliers rather than on those with capital equipment suppliers. In fact, within the limited BSR research in the OM field, investigations are still predominantly on relationships with industrial suppliers, and hence, knowledge on buyer-supplier relations in procurement of capital equipment, remains limited and inadequate.

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 (of which AMT acquisition is a sub-set) 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 utilise it immediately.

Hence, there may be a need for more communication, co-ordination and co-operation between the AMT recipient and the supplier than which is required in an 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 so is not in its completed form when it arrives at the recipient's facility, greater communication, co-ordination, and co-operation are required. AMT, by its very nature, is complex technology especially for firms that have no previous experience in automation, and even with previous experience, each new technology feature embodies specialised know-how that differentiates the product. Not all firms possess the ability and know-how on the technology, especially when it is not the type of product that the firm buys 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 leads to difficulties for users in specifying their own technical requirements, without the close involvement of suppliers.

Saleh et al. (2001) reported that even the process justifying AMT 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 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. In this respect, a well-established, close relationship may make inter-firm boundaries more permeable, allowing technology to be transferred more easily into the organisation (Heide and John, 1990).

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, 1992b, Zhao and Co, 1997), very limited knowledge has been gained in this area as only few studies have specifically focussed on this issue. The claim that the technology supplier's role is imperative in AMT implementation was identified through wide scale investigation of the factors that facilitate or hinder the implementation process. Studies by Youssef and Zairi (1996) and Zairi (1992b), are however, two that have specifically examined factors that inhibit or facilitate the implementation process and which pertain mainly to suppliers of AMT. Nonetheless, although these studies offer insightful understanding of BSR in the AMT acquisition and implementation process, they remain limited, leaving gaps in literature concerned with the following:

1. 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 examine factors affecting AMT adoption success often take a broader view of performance achievements when in fact; performance associated with the technology suppliers should be associated more closely to the monitoring of implementation performance, in addition to the assessment of manufacturing or business performance as a whole.

2. Todate, most of the empirical results on the effect of the technology buyer and supplier relationships (BSR) in AMT implementation have been supported by case studies (Sohal and Singh, 1992, Zairi, 1992a, Zairi, 1992b, Zairi, 1998), and evidence from survey research is rather limited. Consequently, there has not as 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. (This is particularly true in terms of evaluating the performance of AMT implementations. Previous research has not concentrated sufficiently on the evaluation of the implementation process per se.)

This investigation also asserts that it is useful to deconstruct the concept of 'performance' further. The performance of AMT has conventionally been viewed in terms of the improvement of manufacturing performance derived from AMT implementation. 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 specifications, 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. For the purpose of this study, manufacturing performance improvement resulting from the application of AMT is termed 'technology performance'. The adoption of a TCE perspective to view AMT acquisition and manufacturing highlights that acquisition and implementation alone will have an associated impact on performance. This aspect of performance was termed by this study as 'implementation performance.' This delineation led to the following hypotheses being proposed:

H1: There is a link between the strength of BSR and technology performance.
H2: There is a link between the strength of BSR and the implementation performance.

METHODOLOGY

Data Collection

The population for the study was the Malaysian manufacturing sectors that had acquired advanced manufacturing technology within the last five years, the length of time suggested by Burgess and Gules (1998) and Frohlich (1999). The population frame 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. The questionnaire was mailed to the target population, together with a cover letter, a postage-paid return 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 company. 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 process. This was to ensure that the questionnaire respondent possessed appropriate and adequate knowledge on the subject under investigation. The data collection efforts yielded 147 usable questionnaires. So the response rate achieved in this study was around 8%.

To test for non-response bias, the method of testing for significant differences between the response of early and late waves of the returned questionnaires (Armstrong and Overton, 1977, Lambert and Harrington, 1990) was used. The assumption is that companies who respond less readily are more likely to be non-respondents. In this regard, mean comparisons of early respondents yielded no significant differences. 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)

Measurement/Operationalization

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 indicators, all representing different facets of the concept to obtain a more ‘well-rounded” perspective (Hair et al., 2006).

The operationalisation of BSR 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 that have been commonly used in literature to denote BSR were used, these being: trust, business understanding, involvement, commitment, communication, information sharing, and knowledge acquired. Table 1 summarises prior research studies that have used each of these indicators to measure BSR. 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 for each construct were specially developed to reflect BSR in AMT acquisition and implementation.

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. Although various aspects of manufacturing performance have been explored, related literature indicated that the aspects of lead time, cost, quality, and efficiency have been frequently been marked as hallmarks 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.

Table 1 Indicators of BSR and supporting references

Indicators	References
Trust	(Benton and Maloni, 2005, Burgess and Gules, 1998, Dyer, 1997, Fynes and Voss, 2002, Guimaraes et al., 2002, Lee and Kim, 1999, McCutcheon and Stuart, 2000, Morgan and Hunt, 1994, Sako, 1992, 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, Dyer, 1997, Fynes and Voss, 2002, Guimaraes et al., 2002, Lee and Kim, 1999, Morgan and Hunt, 1994, Sako, 1992)
Communication	(Burgess and Gules, 1998, Carr and Pearson, 1999, Fynes and Voss, 2002, Guimaraes et al., 2002, Lee and Kim, 1999, Sako, 1992)
Information Sharing	(Burgess and Gules, 1998, Dyer, 1997, Fynes and Voss, 2002, Lee and Kim, 1999, Stump and Sriram, 1997)
Knowledge acquired	(Kotabe et al., 2003, Moller et al., 2003, Sako, 1992)

Aspects of implementation performance mainly focus on issues related to implementation. Items in the construct were largely grounded in practical information sought from practising managers during the researchers' 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 processes and performance.

Scale Development

The starting point for the questionnaire design was based on the conceptualisation and hypotheses developed in the present research. This process involved an extensive review of literature supported by information gained during the preliminary field work conducted at the early stage of this research. 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 that the measurement sufficiently related to the issues to be investigated. Next, four colleagues were requested to evaluate the items, after which 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). Based on the recommendations and suggestions from the individuals mentioned above, substantial expansion and revisions were made to the items in the questionnaire.

The scale was refined through exploratory factor analysis to assess its dimensionality and through confirmatory factor analysis to assess its convergent and discriminant validity (Anderson and Narus, 1990). 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. Consequently, 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 greater detail in the next section.

Testing The Hypotheses: Measurement And Structural Model

All hypotheses in the present study were tested simultaneously using the structured equation modelling (SEM) technique. SEM simultaneously measures multiple relationships among independent and dependent variables in one model (Bollen, 1989). Following Anderson and Gerbing (Anderson and Narus, 1990), 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. Next the structural model was developed. The structural model differs from the measurement model because it includes causal paths based on hypothesised relationships between specific factors in the model. A number of indices were used to determine whether the fit of the data to the model was adequate. One of the common fit assessment indicators is a Chi-square (χ^2) statistics significant test in which a non-significant χ^2 indicates that the model fits the data. However, this test receives much criticism due to its sensitivity to large sized samples. To overcome the problem associated with the test, various alternative fit indices such as Goodness fit index (GFI), Composite fit index (CFI), and Root mean squared approximation of error (RMSEA) have been developed (Byrne, 2001). In this study, these were used as fit indices as these are the frequently used indices in organizational research which measure the discrepancy between the observed and estimated covariance matrices per degree of freedom (Hair et al., 2006). Byrne (2001) and Kelloway (1998) indicate that RMSEA values of less than .10 represent a good fit, while values below 0.05 represent very good fit to the data. It was desired that both CFI and GFI be .90 or above (Byrne, 2001, Hulland et al., 1996).

Scale Purification

Before the data were used to test the hypotheses, all items in the scale (BSR and Performance) were subjected to validity and reliability analysis. As for validity analysis, exploratory factor analysis (EFA) using principle component analysis (PCA) was conducted. This was then followed by confirmatory factory analysis (CFA) which was conducted during analysis of the measurement model under the first step of the SEM technique. As this study involved scales development through exploratory and confirmatory analysis, it was expected that some variables would be dropped during these procedures. During EFA some items were dropped from the scale because they loaded into an unintended factor with low loading value. Several items were also dropped from the scale during the examination of fit of the measurement model through CFA. Each decision to drop an item from the scale was made based on statistical evidence and thorough consideration being given to the importance of the items to the research objectives. A measure of internal consistency approach is through the assessment of the Cronbach coefficient alpha. If internal consistency is high, then the scale items have a strong relationship to each other. Nunally (1978) recommends a value of .70 as the threshold for the lowest acceptable level for alpha. For this study, coefficient alpha levels range between .76 and .90. Details are discussed in the next section.

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 BSR, a seven factor solution was chosen. To aid in the interpretation of these seven components, Varimax[2] rotation was performed. Table 2 indicates the result of the rotated solution

Table 2 Varimax rotation of the seven-factor solution of the BSR 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	

[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. *Multiple factor analysis*. Chicago: University of Chicago Press, 1947.

Table 2 (continued)

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.

for the BSR 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.

The five-factor solution explained a total of 57.14% of the variance. The result of this analysis supports the use of only five factors that made up the BSR. 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 naming this the *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 being: *trust and business understanding*, *committed involvement*, *communication*, *information sharing*, and *knowledge acquired*. These constructs were then utilised for the subsequent CFA.

In the present study, for the purpose of hypothesis testing, BSR was treated as a latent factor represented by the five different constructs identified above. Items from each construct were averaged, and were then used as five 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 dimension.

Figure 1 indicates the graphical representation of the BSR model under SEM. CFA resulted in an inadequately fitting model of χ^2 (247) = 589.32, p = .00; GFI = .77; CFI = .80, TLI = .78 and RMSEA = .10. As previously mentioned, although testing all the constructs together 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 make it difficult to fit such a model to predictions even with strong theoretical support (Joreskog and Sorbom, 1986). Therefore, in the present research, parcelling procedures were 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. Table 3 indicates the indicators aggregated to form the parcel.

The model was re-estimated with the aggregated indicators, and CFA resulted in an adequate fitting model of χ^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.

Performance

Table 4 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) 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.

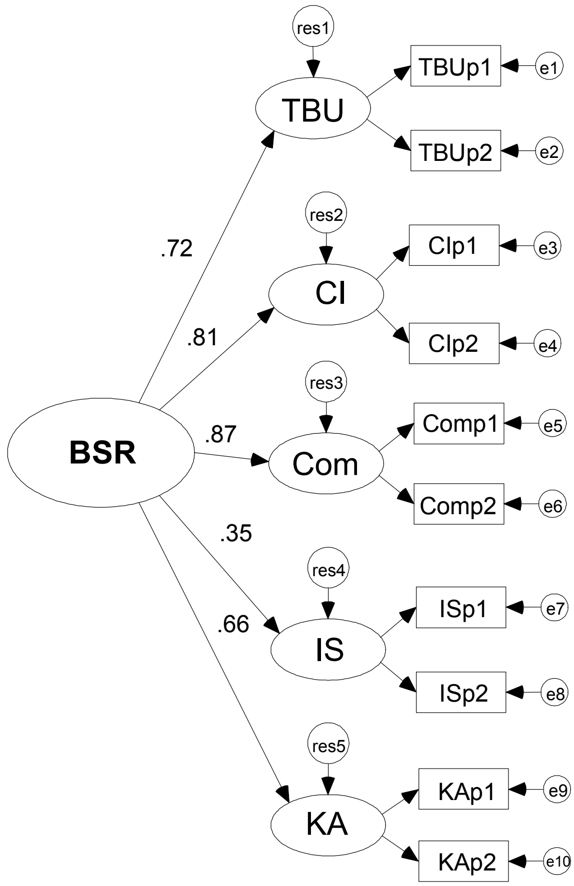

Figure 1 The BSR construct and its standardised coefficient

Table 3 Aggregated items to form the BSR scale indicators

BSR construct	**Indicators (Items)**
Trust and Business Understanding (TBU)	TBUd1= Trust6, Trust2, BU2TBUd2= Trust4, BU5, Trust1
Committed involvement (CI)	CId1= invo1, invo3, commit4 CId2= invo2, invo4, commit3
Communication (Commu)	CommuD1= commu1, commu2 CommuD2= commu5, commu3
Information sharing (IS)	ISd1= IS1, IS2ISd2= IS5, IS3
Knowledge acquired (KA)	KAd1= KA1, KA5 KAd2= KA2, KA3

Table 4 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

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 (reflecting technology and implementation measure of performance respectively). The two-factor solution accounted for 50.36% of the total variance, with component 1 contributing 27.78% and component 2 contributing 22.58. The result of this analysis supports the use of *technology performance* and *implementation performance* as separate scales.

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 statistics were significant but other fit indices indicate a recommended level of indices, thus suggesting a well-fitting measurement model. Table 5 shows the final-retained items with their corresponding standardised loading, and the reliability of the construct.

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 indicated a

Table 5 Factor loadings and scale reliability for the technology performance (TP) scale

Indicators	Std. Load	Std. error	C.R
TP1: Reduction in 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			

recommended level of indices, thus suggesting a good-fitting measurement model. Table 6 shows the finally-retained items with their corresponding standardised loadings, and the reliability of the construct.

Table 6 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	7.8
IP3: The amount of downtime caused by the technology	.78	.04	6
IP4: The time taken to tackle any technical problems during the implementation process	.66	.03	3.70
IP5: The capability of the technology in fulfilling your implementation objective	54	.04	5.84
Cronbach's alpha : .70			
Composite reliability : .72			
Variance extracted : .64			

RESULTS

Respondent Profile

As shown in Table 7, the respondents represented small (42.2%), medium (34.0%) and large (23.8%) manufacturing companies, being representative of the population

Table 7 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

of firms contained in the Federation of Malaysian Manufacturers (FMM) directory. With respect to 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 7 also shows the number of years that the companies had been in operation in Malaysia, where it is seen that 60% had been operating for less than 10 years, another 28% had been in operation between 10 and 15 years while the remaining (12.2%) had been established over 15 years ago.

Table 8 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 8 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

Variation In BSR

Table 9 shows the mean distribution of each element of BSR 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 BSR measured in this study.

Table 9 Descriptive statistics on each element of the BSR 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				

Variation In Performance Level

Table 10 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.

Analysis of the frequency distributions indicates that 87% of the respondents claim an above average level of achievement in terms of *technology performance*,

Table 10 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				

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 performance measure.

Testing Hypotheses: Structural Model

The full information hypothesised model includes BSR, TP and IP. The inter-relationships between these variables were tested simultaneously to test the two major hypotheses in this study. Figure 2 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 $\chi^2(63) = 111.27$, $p = .00$; GFI = .90; CFI = .90, TLI = .87 and RMSEA = .07. 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.

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 2, BSR has a significant positive (p=.00) direct effect on TP (standardised coefficient = .34) and it explains 12% of the variance in TP. BSR also has a significant positive (p=.00) direct effect on IP (standardised coefficient = .56) and it explains 31% of the variance in IP.

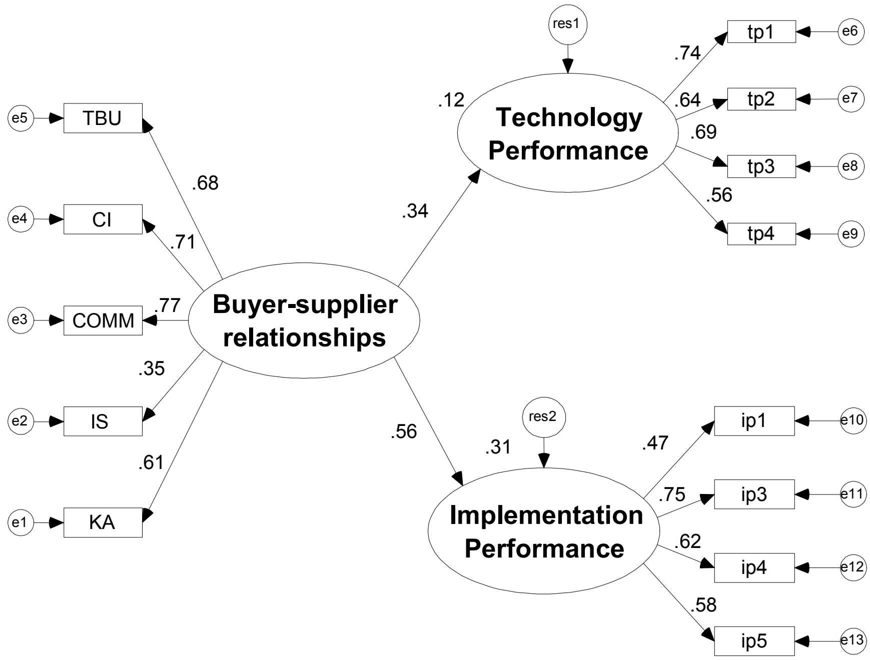

Figure 2 The full hypothesised model and its standardised coefficient

DISCUSSIONS AND CONCLUSIONS

Components of BSR

The survey results indicate that most of the BSR dimensions are inter-related, and are consistent with findings of prior research (Goffin et al., 2006, Morgan and Hunt, 1994). The results demonstrate that communication appears to be the most essential aspect in BSR. Although the survey respondents indicate a high degree of communication in their BSR, they nonetheless recorded a low degree of information sharing, in comparison to the other elements of 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 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 BSR and that this aspect can be made more achievable with the use of information technology. Yet, the authors recognise that both buyer and supplier found it difficult to adapt to the openness implicit in the notion of information sharing. Both parties engaged 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, there 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.

Links between BSR and performance

When investigating the links between BSR 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 (Guimaraes et al., 2002, Small, 1998, Swamidass and Kotha, 1999, Teng and Seetharaman, 2003). However, satisfaction in implementation performance is slightly lower, accounting for only 67% of respondents' perceptions. This outcome may be a sign that in technology adoption, many firms are still struggling with implementation problems, consistent with previous research findings highlighting that implementation problems remain an important issue in any technology adoption (Chen and Sun, 2000, Hottenstein et al., 1999, Sambasivarao and Deshmukh, 1995).

Although responding firms indicate higher achievement in terms of technology performance in comparison to implementation performance, results indicate that BSR relates more to implementation performance compared to technology performance. There are two possible explanations for such an outcome. First, in comparison to implementation performance, developing close BSR may not be as critical or closely linked to the achievement of technology performance since there could be other significant factors that affect technology performance. Second, the time factor might have an impact on how companies perceive the performance effect. For example, respondents referred to their relationships with the supplier at around the time the technology was being acquired and implemented. However, when it comes to the performance of the technology, they might be appraising this in the context of present time, which could be better or worse than previously.

Two hypotheses were tested in the preceding analysis. It was proposed that BSR is significantly related to technology performance (H1) and implementation performance (H2). The finding indicates support for both H1 and H2. It was found that firms developing strong relationships with suppliers are more likely to achieve a higher level of performance in acquiring and implementing AMT. Close BSR can be seen as capable of further integrating resources and activities throughout the AMT acquisition and implementation process. For instance, through trust and early collaboration with the technology supplier, firms will be able to make the right technology selection and avoid misspecification and expensive mistakes during the early stages of technology acquisition.

CONTRIBUTIONS AND LIMITATIONS

The findings of the present study that the technology supplier can enhance the success of technology acquisition and implementation, denotes that BSR represent some of the most important attributes of AMT acquisition. In practice, developing and maintaining strong BSR requires careful attention by managers. The findings suggest that firms developing stronger relationships with the technology supplier are more likely to experience higher achievement in terms of implementation performance which requires the key decision-maker, namely the technology champion, to be highly knowledgeable about the AMT being adopted. Therefore, key managers must make sure that close collaboration with the technology supplier is developed throughout the acquisition and implementation process. The principal proposition here is that firms should 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. 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 take place effectively, 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 is to avoid unnecessary and expensive mistakes, which detracts from the achievement of technology and implementation performance of the acquired technology.

Although this research has generated new understanding and appears to be useful for practising managers, three main limitations of the study must be considered. First, the research only assesses the strength of BSR from the AMT acquirer perspective. From a methodological perspective, BSR can also be studied using different units of analysis such as 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 the 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 experiences 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.

Second, although great care was taken to ensure that the respondent in each company was the person best placed to answer the questions, the use of a single key informant's response in collecting survey data always has limitations. For instance, single informants may give only their personal views, 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. 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.

Finally, as the data used for the research are from Malaysian companies, one could assume that findings may be different in other countries where the technology being acquired is not imported but sourced locally. Differences in national culture which could lead to differences in work culture would also be a potential source of difference in the way buying firms develop relationships with their technology suppliers. Due to these limitations, 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.

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