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# Advanced Manufacturing Technology Acquisition, Implementation and Buyer-Supplier Relationships: The Case of Malaysia

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## Abstract

This paper explores how transaction attributes of technology affect differences in the relationship between technology buyers and suppliers. It also examines the impact on performance of different patterns of relationship between technology buyers and suppliers. Data obtained from 147 manufacturing firms in Malaysia are used to test several hypotheses, which were derived from a review of the literature on technology, transaction cost theory and buyer-supplier relationships (BSR). The research results indicate that the higher the level of technological complexity, specificity and uncertainty, the more firms are likely to engage in a closer relationship with technology suppliers. Even though the majority of firms reported improvements in their performance, results indicate that firms demonstrating a closer relationship with technology suppliers are more likely to achieve higher levels of performance than those that do not. It is also shown that 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 attribute.

## Keywords:

Advanced Manufacturing Technology; buyer-supplier relationships; technology acquisition and implementation; transaction cost theory; Developing countries; Malaysia

## 1. Introduction

Technology is considered as one of the most important factors for remaining competitive in the global business environment and the ability to master technological competencies has underpinned the industrial achievements of Asian countries like Korea and Taiwan. These countries have evolved from being acquirers of foreign technology from industrialised countries into becoming developers of their own technological capability. Malaysia has a mission to transform its manufacturing industry into being resilient, broad-based and internationally competitive. Manufacturing is the main contributor to Malaysia's growth and gross domestic product (GDP) and in 2007 the economy expanded by 6.3 percent with manufacturing remaining the strongest industrial sector. The country's demand for the latest manufacturing technologies is currently valued at MYR 30 billion (Malaysian Ringgit) per year, or USD 8.2 billion, (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 keeping Malaysia a net importer of machinery and equipment. In 2004 these imports amounted to USD 7.8 billion.

The means of acquiring technology is unique to each firm, which means they also exhibit different ways in which they rely on suppliers during the process of technology implementation. For instance, a technology that is advanced for one firm may not be considered the same by others. The same technology may be viewed differently in term of its complexity and its specificity to the company, as well as the uncertainty resulting from its acquisition. These differences are rooted in many aspects such as organisational characteristics (e.g. size, ownership and industry sector) (Beaumont et al., 2002; Swamidass and Kotha, 1999), internal management practices, past experiences or even the organisational culture (McDermott and Stock, 1999). The differences are mirrored in this research by examining the transaction attributes of the firms' acquired technology. These attributes, namely complexity, asset specificity, and uncertainty were recognised as drivers for strong relationships between technology buyers and suppliers. Therefore, some of the important questions include: How does the complexity of the technology impact the pattern of relationships with the technology suppliers? If the specificity of the technology is higher to the firm, does it affect the way firms interact with technology suppliers? Does technological and organisational uncertainty affect the pattern of relationships with technology suppliers? And finally, within the same, and between different, transaction attributes of the acquired technology, who will benefit more from developing closer relationships with suppliers?

## 2. Justification for the study

Issues of technology implementation continue to be an important part of the research agenda, especially relating to AMT. Many studies have reported that the implementation of advanced manufacturing technology does not guarantee that a firm will reap all the potential benefits (Small and Yasin, 1997). Efstathiades et al. (2000) warned that the process of technology transfer is very complicated and requires skills and managerial know-how in the acquiring firm. In the context of newly industrialising countries in the developing world, where local technological capabilities are still relatively low and most technology is acquired from foreign countries, the problem of not fully realising the benefits of acquired technology is even more apparent. More often than not the technology buyer is in a weak position, especially when dealing with a stronger and more experienced supplier from an industrialised country (Efstathiades et al., 2000).

A good relationship with the technology supplier was found to be one of the most important factors that can facilitate implementation success (Kaighobadi and Venkatesh, 1994; Sohal and Singh, 1992; Zairi, 1992a; Zairi, 1992b). However, despite the recent research interest in buyer-supplier relationships (BSR) and the advances in manufacturing technology, knowledge about development and the role of technology suppliers in AMT implementation remain inadequate. There is a need to better understand the drivers of such relationships about which the literature is lacking (Claro et al., 2006; Hobbs, 1996). Furthermore, most of the empirical results relating to the effect of buyer-supplier relationships in AMT implementation have been derived from case studies (Sohal and Singh, 1992; Zairi, 1992a; Zairi, 1992b), while its support from survey research is limited. Moreover, there has been little quantitative research evidence within the area of AMT and BSR on how closer relationships result in better performance.

Most studies relating to BSR and AMT implementation have been undertaken from the perspective of industrialized economies. According to Zhao and Co (1997) barriers to the transfer

of technology, lower wage rates, size of firms and the paradigm of competition are some of the compelling reasons to believe that the factors affecting AMT adoption in newly developing countries are different from those in industrialized economies. Hipkin and Bennett (2003) highlighted that the technology acquirers in developing countries must take the initiative to use suppliers and networks to reap a full range of benefits from the new technologies. Therefore, a systematic empirical investigation was considered necessary to understand the impact of BSR on AMT acquisition and implementation, using evidence from a developing economy such as Malaysia. In the context of this present research Malaysia is representative of newly industrialising developing economies that are still unable to draw on their own technological capability, so much of their production technology comes from abroad and there are few indigenous sources (UNIDO, 2005).

In the literature on BSR, the issue of developing good relationships has been focused largely on the relationships with materials and parts suppliers. Less is known about its implication for industrial equipment suppliers, such as for the manufacturers and suppliers of AMT. Furthermore, despite the claim that developing good inter-organizational relationships is critical to firm performance through the reduction in transaction cost (Masten, 1993; Swink and Zsidisin, 2006) no existing studies or models from the literature have explained how transaction attributes affect the development of inter-organizational relationships and how they impact performance. The study described in this paper therefore examines the connection between transaction attributes and BSR in AMT implementation and performance.

**3. Literature review**

**3.1. Advanced manufacturing technology**

Advanced manufacturing technology (AMT) is defined as a group of computer-based technologies, including computer-aided design (CAD), robotics, group technology (GT), flexible manufacturing systems (FMS), automated materials handling systems (AMHS), computer numerically controlled (CNC) machine tools, and bar-coding or other automated identification techniques (Sohal et al., 2006; Zairi, 1992a). AMT is a powerful competitive weapon because this type of technology has the potential to improve product quality and manufacturing flexibility (Beaumont et al., 2002). AMT has also generated a great deal of interest and been widely researched from various aspects. Examples include research on addressing the adoption model and factors determining success or failure in acquisition and implementation (Sohal et al., 2006; Sohal and Singh, 1992; Voss, 1988), on benefits associated with AMT (Beaumont et al., 2002; Efstathiades et al., 2002; Kotha and Swamidass, 2000), and on planning associated with its implementation (Efstathiades et al., 2002; Millen and Sohal, 1998; Small and Yasin, 1997; Sohal and Singh, 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 also focuses on the hard form of AMT as well as soft technologies when they are embedded in hardware rather than being transferred independently. Technology implementation in this study refers to the three implementation processes proposed by Voss (1988) and Small and Yasin (1997). These processes are Pre-installation (planning & justification), Installation and commissioning (acquisition, installation and start-up) and the Post-commissioning (operating, monitoring & evaluating).

### 3.2. *Transaction attributes*

Transaction cost economics theory defines a transaction as the transfer or exchange of goods and services across an organisational boundary (Williamson, 1975; 1979). It focuses on the minimization of opportunism as a means of minimizing transaction costs, which are the customer's costs of being in the exchange relationship. They 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 dimension of a transaction that make an exchange problematic or prohibitively expensive, and then to specify the governance mechanism that can handle most efficiently the transaction so as to economize on these costs. This is also 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 many studies examine BSR using the transaction cost economics lens (Dyer, 1996; Hallikas et al., 2002; Noordewier et al., 1990; Swink and Zsidisin, 2006). In this study, transaction cost economics theory is used to identify the characteristics or dimension of a transaction in AMT acquisition, where close BSR acts as a safeguarding mechanism against bounded rationality and opportunistic behaviour between the technology buyer and supplier.

Transaction cost economics theory relies on three attributes in describing a transaction, i.e. the condition of asset specificity required to support the transaction, the degree and type of uncertainty surrounding the transaction, and the frequency of the transaction. Globerman (1980) argues that the complexity involved in different technological innovations must also be acknowledged in transaction cost reasoning. Thus, in the context of acquisition and implementation of new and advanced technology, transaction attributes are derived from the level of technological specificity, level of technological uncertainty, and the level of complexity.

### 3.3. *Buyer- supplier relationships in AMT implementation*

One of the critical success factors in AMT implementation is closer and effective BSR. Chen and Small (1996) asserted that adopting AMT requires a more complex relationship and greater integration with the organisation's key environmental constituencies (i.e. customers, parts suppliers and technology suppliers). In fact, one of the reason for companies to choose a particular level of integration with the technology supplier is to help them acquire the technology more efficiently (Baines et al., 1999). Close links with suppliers are among the important factors for both technical and business success in implementing AMT (Sohal and Singh, 1992). Teng and Seetharaman (2003) found that among the most critical problems encountered in the implementation of AMT amongst Malaysian manufacturing firms is the adequacy of installation and pre-installation support provided by AMT vendors or outside consultants. So far, there has not been any quantitative research instrument developed to assess the strength of BSR in AMT acquisition and implementation, and for this reason its association with performance remains difficult to explore. While efforts to measure BSR have concentrated on relationships with industrial parts suppliers rather than on those with companies that supply capital equipment.



3.4 . *The terms and dimensions of BSR*

Apart from assessing the degree of closeness, the assessment of buyer-supplier relationships in this study aims indirectly to investigate the user’s reliance on the supplier during the entire process of technology implementation. “Closeness” has been widely identified as an important characteristic of relationships. In fact, over the last decade it has dominated how the supplier base is viewed by both practitioners and academics (Goffin et al., 2006). However, in the literature a clear definition of relationship closeness and a way of measuring it are still lacking. Some empirical studies (Johnson et al., 2004; Kotabe et al., 2003) focus on individual relational dimensions. However, Fynes and Voss (2002) recognised that all relationships may be influenced by past, present, and future events, so there needs to be a comprehensive measure that includes such temporal dimensions in buyer-supplier relationships. Most existing research has used multi indicators of BSR because they can better capture the extent of closeness or strength of relationships.

Based on existing research it appears that aspects of trust, business understanding, commitment, communication, and information sharing, have always been taken as dimensions of BSR. Trust plays a key role in any organizational relationship (Morgan and Hunt, 1994) and its presence can reduce the specification and monitoring of contracts, provide material incentives for cooperation, and reduce uncertainty (Hill, 1990). Related to the development of trust, researchers have also stressed the need for both parties to clarify expectations carefully (Johnson et al., 2004). The present research referred to this expectation in terms of business understanding of the supplier firm towards the buyer’s business or manufacturing operation and requirement. Commitment refers to trading partners exerting effort on behalf of the relationship and attempting to sustain relationships in the face of unanticipated problems (Fynes and Voss, 2002). On the other hand, frequent and timely communications are important because they assist in resolving disputes and aligning perceptions and expectations (Morgan and Hunt, 1994). Information sharing refers to the extent to which the information exchange is effective in a partnership and includes the level and quality of information sharing (Monczka et al., 1998). 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 during an alliance refers to skills learned and knowledge acquired from a partner by the focal firm (Norman, 2004). Collaborative experience was found to affect knowledge acquisition (Simonin, 1997) and knowledge transfer is strongly affected by the relationship between source and recipient (Albino et al., 2004). Involvement has frequently been used as a single construct that denotes supplier relationships, which in turn have an impact on various aspects of performance (Liker et al., 1998; Tracey and Tan, 2001). Involvement can also be what existing research has called “participation” (Guimaraes et al., 2002) in terms of participation in joint planning (Sheu et al., 2006) or problem solving (Stuart, 1997). Therefore, for the purpose of this study seven dimensions were chosen that make up buyer-supplier relationships. These are: 1) The level of trust developed throughout the relationship; 2) Supplier understanding of the user’s product, manufacturing process, manufacturing performance, and manufacturing objectives; 3) Supplier involvement in the planning process before the implementation takes place; 4) Supplier commitment in terms of technical support and assistance, and response to the disruption during the implementation process; 5) The communication process before, during and after the implementation process; 6) The extent of true, important and complete information shared throughout the relationship; and 7) The amount of knowledge

acquired throughout the relationship. These dimensions of buyer-supplier relationship are distinct but interrelated (Mohr and Speakman, 1994).

## 4. Research hypotheses

### 4.1. *Transaction attributes and BSR*

According to transaction cost economics theory, transaction costs increase as the level of asset specificity increases. As investments in specific assets increase, so the probability of individuals engaging in the transaction behaving opportunistically also increases (Hill, 1990). The party making significant investments in transaction-specific assets is at risk of exploitation by the other party because of the latter's opportunistic behaviour. Hence, it is anticipated that different levels of asset specificity for the investment in AMT will have different patterns of relationship with the technology provider. This explanation also draws from the contention that, apart from operating as a mechanism to safeguard the transaction, specific assets create value in a relationship and they require greater effectiveness and efficiency from both parties. As higher asset specificity requires a more complex governance form it indirectly provides a powerful signal of commitment and participation to the technology supplier.

Different firms deal with different kinds of uncertainty, especially before the acquisition process. Among the uncertainties in the process of technology acquisition are whether the technology will meet the manufacturing objectives, or whether it will fit the current manufacturing outlay. The source of uncertainty also surfaces from the firm's own technological capability. Firms with experience in acquiring and implementing similar types of technological innovation and having expertise in handling the technology may possess a low level of technological uncertainty. Thus, it is reasonable to expect that the more complex the technology, and the less experience firms have in handling similar types of technological innovation, the higher the level of uncertainty surrounding the transaction.

The complexity of the appropriate governance structure is also predicted to directly increase with the complexity involved in different technological innovations (Globerman, 1980). According to Dodgson (1991), another technological dimension or consideration for firms pursuing a collaborative relationship with the technology supplier is 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. These disadvantages will create opportunistic behaviour by the technology provider and also cause firms to be more dependent on them. Three hypotheses relating to technology acquisition were therefore derived and tested in the Malaysian context:

- H1:** The higher the level of asset specificity, the more likely that a firm will engage in a closer relationship with the technology supplier in acquiring the technology.
- H2:** The higher the level of technological uncertainty, the more likely that a firm will engage in a closer relationship with the technology supplier in acquiring the technology.
- H3:** The higher the level of complexity, the more likely that a firm will engage in a closer relationship with the technology supplier in acquiring the technology.



4.2. *BSR and performance*

Developing closer relationships enables buyers to depend on suppliers for meeting their needs. The key stages of support include: helping users develop skills in relation to the particular innovation; solving technical bottlenecks; facilitating the implementation process; and post-implementation backup and continued support (Youssef et al., 1996). Previous studies also indicate that closer relationships with suppliers lead to successful AMT implementation (Cheng, 2001; Sohal and Singh, 1992; Zairi, 1992b). Furthermore, closer relationships can safeguard the transaction from bounded rationality and opportunism, thus reducing transaction costs (Noordewier et al., 1990; Swink and Zsidisin, 2006; Williamson, 1975) Therefore, it is reasonable to expect that a strong relationship with suppliers also increases the technology and implementation performance, so two further hypotheses were developed for testing in the Malaysian context:

- H4:** As the relationship between the buyer and the supplier strengthens, technology performance improves.
- H5:** As the relationship between the buyer and the supplier strengthens implementation performance improves.

If there is a link between BSR and performance, and the transaction attributes of the implemented technology play a vital role in shaping the pattern of relationship with the technology suppliers, then transaction attributes must also have an impact on the interaction between BSR and performance level. On the basis of transaction attributes, three further sub hypotheses related to performance were developed:

- H6:** Within the same level of complexity (High, Moderate or Low), technology performance and implementation performance will vary depending on the strength of the BSR (High, Moderate or Low).
- H7:** Within the same level of asset specificity (High, Moderate or Low), technology performance and implementation performance will vary depending on the strength of the BSR (High, Moderate or Low).
- H8:** Within the same level of uncertainty (High, Moderate or Low), technology performance and implementation performance will vary depending on the strength of the BSR (High, Moderate or Low).

Figure 1 illustrates the association between each variable included in the study. It 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 strength of relationship between the technology acquirer and the technology supplier. These differences then impact on technology performance and implementation performance. The relationship between BSR and performance is also expected to be significantly different on the basis of their transaction attributes.

\*\*\* INSERT FIGURE 1 ABOUT HERE \*\*\*

5. Research methodology

### 5.1 *Data collection and sample selection*

The methodology for this study involved two phases. Phase I obtained general information concerning the extent of involvement between AMT suppliers and two local users with regard to implementation. In the first, a medium-sized company that had adopted a palletising system consisting of a robot and an automated conveyor system, interviews were conducted on-site with the Production Manager and Project Engineer. In the second, a company that had adopted a computerised wire cutting machine, the interview was conducted with the CEO. Phase II involved a questionnaire survey that was mailed to a sample of Malaysian manufacturers. This was initially developed using the knowledge gained from Phase I interviews and relevant literature. It was refined further before pilot testing.

The sample was drawn from the Federation of Malaysian Manufacturers (FMM) directory for 2003. Each company listed in the directory was contacted by telephone or e-mail to ask whether it had made an investment in AMT in the past five years. This resulted in 528 manufacturing companies being identified. Of these, 100 were randomly selected for pilot testing the questionnaire, resulting in 32 responses. The questionnaire was addressed to the Production Manager of each company.

After making some minor modifications the final version of the questionnaire was mailed to the remaining 428 companies in the sample, with 115 responding (26.8%). In the final analysis, the 32 responses from the pilot study were included, giving a total of 147 responses from the original sample of 528 companies (i.e. an overall response rate of 27.8%).

### 5.2 *Questionnaire design and operationalisation*

The scales used to measure transaction attributes, BSR, and performance were specially developed for the research. The scales for asset specificity were developed based on the work of Wang (2002), Robertson and Gatignon (1998) and Skarmeas and Katsikeas (2001), while the scales on level of uncertainty were influenced by the work of Steensma and Fairbank (1999). For this research, the specificity of the assets was assessed in terms of the degree of collective learning, training and special expertise dedicated to the technology, the degree to which the technology represents a core competence for the business, and the value of investment in the technology.

Uncertainty in this study refers to any disturbance related to the transaction that is not definitely or precisely known. Among the uncertainties in the process of technology acquisition are whether the technology will meet the manufacturing objectives or whether it will fit the current manufacturing outlay. A source of uncertainty also results from the firm's own technological capability. Thus, the firm's prior experience in implementing similar types of technological innovation and the availability of expertise to handle the technology was also included in assessing its uncertainty level. As for level of complexity, consistent with Kogut and Zander (1993), this 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 completely codified, even if it is mature, so it contains a much higher tacit knowledge element than simple technology (Tsang, 1997). This study measures technological complexity in relation to its degree of tacitness and the extent to which the technology reflects major changes to the firm's manufacturing outlay, process, or practices.

As for operationalising BSR, the scale was developed mainly for the purpose of this research. The main attributes describing BSR closeness were identified from the literature, described earlier. In this research, BSR was measured using the multi- indicators that measure relationship strength or the extent of closeness between buyers and suppliers. Finally, the research measured performance in term of technology performance and implementation performance. In accordance with Small and Yasin (1997) achievement in manufacturing performance since the adoption of the technology was used to measure technology performance. Thus, the performance measure that has been used, which is targeted at the heart of the manufacturing operation, includes reduction in lead time, reduction in cost, increase in quality, and increase in efficiency and flexibility. Conversely, aspects of implementation performance were grounded largely from practical information. Measurements include: time taken to fully implement the technology and to begin gaining benefits from the technology; the amount of downtime caused by the technology; time taken to tackle any technical problem; the capability of the technology in fulfilling the implementation objective and improving manufacturing process and performance. The responses for each item were made using a five-point Likert scale.

Results from the pilot test were used to refine the instrument and verify its reliability and clarity as well as its construct and predictive validity. The instrument was refined 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. Analysis of the data was carried out using SPSS. Table 1 shows the overall internal consistency for the scales used for all the variables. For all items Cronbach’s alpha is above 0.70 as recommended by Nunally (1978).

\*\*\* INSERT TABLE 1 ABOUT HERE \*\*\*

6. Results

6.1 Profile of respondents

As shown in Table 2, the respondents represented small (42.2%), medium (34.0%) and large (23.8%) manufacturing companies. This make-up is representative of the population of firms in the Federation of Malaysian Manufacturers (FMM). With respect to industry sector, vehicle assembly and parts production account for just over one-quarter of the sample (28.6%). 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%) are also significant sectors represented in the sample. Table 2 also shows the number of years that the companies had been operating in Malaysia (60% for less than 10 years, 28% between 10 and 15 years and 12.2% for more than 15 years). Table 3 shows the types of AMT adopted by the companies in the sample. 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 specifically adopted integrated manufacturing systems. However, it is expected that the large number of firms with special purpose automated technology would have significant integration.

\*\*\* INSERT TABLES 2 AND 3 ABOUT HERE \*\*\*

## 6.2. Hypothesis Testing

Hypotheses 1 to 5 were tested using multiple regression analysis. The use of this technique was justified in preference to the alternative approach of structural equation modelling (SEM) because the indicators used to measure performance (Technology performance and Implementation performance) are formative in nature. An underlying assumption of SEM analysis is that the items or indicators used to measure latent variables are reflective in nature, which mean they do not need to be highly correlated or to have high internal consistency (Bollen, 1989; Shah and Goldstein, 2006). Also, SEM is not recommended when the measurement structure is not well developed, thus simpler data analysis techniques may be more appropriate (Hurley et. al., 1997).

The correlation/covariance matrix for the regression model is shown in Table 4 from which it appears that the independent variables (level of complexity, level of asset specificity, and level of uncertainty) are also correlated with each other. This suggests that the multicollinearity problem should be investigated. No limit has been set that defines what represents high correlation, but values exceeding .90 should always be examined, while in most cases values exceeding .80 could indicate collinearity problems (Hair et al., 2006). However, Berry (1993) suggests that multicollinearity exists when correlation is .90 or above, and the result will be insignificant regression coefficients due to the large standard error. The survey data has therefore been checked for the possibility of multicollinearity and the result shows that tolerance values for level of complexity, level of asset specificity and level of uncertainty are .83, .57, and .62 respectively. The tolerance values are all above the cut-off point of .20 and the values of the variance inflation factor (VIF) are all below 4.0, indicating that the scales have no multicollinearity problem.

\*\*\* INSERT TABLE 4 ABOUT HERE \*\*\*

The result of regression analysis for hypotheses 1 to 3 and 4 to 5 are shown in Tables 5 and 6 respectively. The significance of the hypotheses was tested using t-statistics, with beta estimates considered significantly different from zero when  $t > 1.96$  ( $p < .05$ ). Results indicate that all hypotheses are supported at the 5 percent level. The result (Table 5) revealed that 38.1% of variance in BSR is explained by each of the elements of transaction attributes. Level of complexity (H1), level of asset specificity (H2) and level of uncertainty (H3) are significant in making a unique contribution in explaining the outcome in BSR. Similarly, regression results (Table 6) indicate that technology performance explained 6.2% of variance in BSR and implementation performance explained 20.3% of variance in BSR. The significance of the result suggest that close BSR impacts both technology and implementation performance, which provides support for H4 and H5.

The regression results reported in Table 6 for H4 did not indicate the possibility that transaction attributes have a moderating effect on technology performance. Tests were carried out on the moderating effect of each element of the transaction attributes on the relationships between BSR and both types of performance and results indicate transaction attributes have no moderating effect on both aspects of performance.

\*\*\* INSERT TABLE 5 and 6 ABOUT HERE \*\*\*

For hypotheses 6 to 8, one-way analysis of variance (ANOVA) was used to determine if there are statistically significant differences between the strength of BSR and performance level on the basis of the transaction attributes of the technology acquired. The scores of BSR were therefore divided into 3 groups, i.e. weak, moderate, and strong, using the median as a cut-off point.

The one-way ANOVA served two purposes. First, it was used to test how firms possessing different levels of transaction attributes achieved varying performance levels under different buyer-supplier relationships. Second, it operated as a control to ensure that the differences in performance level were caused purely by the differences in buyer-supplier relationships, and were not contaminated by the firm's level of transaction attributes. The results indicate that the relationships between BSR and performance vary, although under the same level of transaction attribute (for example within a high level of transaction attribute alone). By performing ANOVA it was possible to control the interaction effect (if any) of transaction attributes on the relationships between BSR and performance. Consequently there was a need to segregate the respondents that possessed "high", "moderate", and "low" levels of transaction attribute. H6 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 7). 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 8). The results indicate that for moderate levels of complexity there is no significant difference in technology performance as the strength of BSR changes. This supports H6 with respect to implementation performance but it is not fully supported for technology performance.

H7 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 8). The post-hoc tests showed similar relationships as for level of complexity. Except for the moderate level of asset specificity there is no significant difference in technology performance as the strength of BSR changes. Again, this gives support for H7 with respect to implementation performance but not full support for technology performance. H8 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, implementation performance significantly increases as the strength of BSR improves. However, significant improvement in technology performance as a result of strong BSR is only observed in higher levels of uncertainty. In this case H8 is not fully supported for both measures of performance.

There are two possible explanations for why several relationships in Table 8 are not significant and suggest that the technology performance of firms that establish closer BSR will be more or less similar to those that establish moderate or weak BSR. 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, time might have an impact on how companies perceived the performance effect. For example, respondents referred to their relationships with the supplier around the time the technology was being acquired and implemented. However, when it comes to the performance of the technology, they might be referring to the present time, when it could be better or poorer.



Since the data used in the research are from Malaysian companies it might be assumed that the findings could be different in other countries, especially 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 influence on the way that buyers develop relationships with their technology suppliers.

\*\*\* INSERT TABLES 7 AND 8 ABOUT HERE \*\*\*

## 7. Discussion

The discussion of the results can be summarised into four important points. First, the transaction attributes of AMT acquired by Malaysian companies have an impact on the strength of relationship with suppliers. Among the three transaction attributes, level of uncertainty has the highest correlation with BSR, followed by level of asset specificity and level of complexity. This means the higher the technological and organisational uncertainty, the more firms are likely to engage in a closer relationship with suppliers. The greater the level of such uncertainty, the greater the amount of information an organisation has to process to complete transactions efficiently, and thus the higher are its costs (Jones, 1987). Hence, a closer relationship with the technology supplier acts as a safeguard to reduce any transaction cost involved during the entire process of implementation.

Second, BSR is related to technology and implementation performance, which suggests that firms having a relationship of trust with technology suppliers build good business understanding and communication, attain strong involvement and commitment from the supplier, experience greater information sharing and knowledge during the relationship, and will be more likely to achieve higher levels of performance.

Third, within the same and between different levels of transaction attribute, firms will be more likely to achieve higher technology and implementation performance when they develop a strong relationship with suppliers. However, strong BSR (compared with moderate and low BSR) does not lead to distinct differences in technology performance in most levels of transaction attribute when compared to the difference it makes to implementation performance. This means the implementation performance of firms that establish closer BSR will be significantly higher than those with moderate or weak BSR. Alternatively, the technology performance of firms that establish closer BSR will be more or less similar to those establishing moderate or weak BSR.

Fourthly, for the same levels of complexity, asset specificity and uncertainty (except in low levels of uncertainty) strong BSR results in distinctly higher implementation performance compared with moderate or low levels of BSR. This suggests that, compared to other attributes, where technology and organisational uncertainty is low, a stronger BSR does not lead distinctly to higher implementation performance. When firms are more confident about the technology they are implementing, or possess prior experience, or have enough expertise in handling a similar technological innovation, the strength of relationship they develop with the suppliers does not necessarily create a difference in the level of implementation performance. However the results show that in high levels of transaction attribute (compared to moderate and low levels) implementation performance suffers more when a firm develops weak BSR. This indirectly provides an explanation for H1, H2, and H3 which suggest that the higher the transaction attributes the more firms need to develop closer relationships, otherwise performance will more likely suffer.

Finally, the results of this research differ from previous studies conducted in industrialized economies. The existing AMT literature still lacks 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 is, 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.

By integrating the TCE framework with the investigation of buyer-supplier relationships this study provides both the BSR and AMT literature with new perspectives through which the strength of buyer-supplier relationships in a particular technology acquisition and implementation can be understood.

Within the research on BSR, much attention has been directed towards understanding the relationship between buyers and suppliers for the industrial/parts purchases (repetitively used items). The relationships between buyer and supplier for capital equipment purchases (for instance in the procurement of AMT) has scarcely been examined. Therefore, this research contributes in terms of the development and applicability of BSR literature, which is currently focused on industrial/parts buyer-supplier relationships, in understanding the relationships between buyers and suppliers in capital equipment purchases.

**8. Conclusions**

This research has focused primarily on the application of transaction cost economics in assessing the strength of BSR in technology implementation among Malaysian manufacturing companies. Thus, one of the contributions is to extend the use of transaction cost theory beyond paradigmatic research questions and to provide empirical evidence of such relationships. Practically, the results imply that relationships with technology suppliers also act as a governance mechanism to safeguard the transactions and reduce the transaction cost. It also signifies that the nature of transaction attributes governs the form of relationship with technology suppliers throughout the acquisition and implementation process. The current limited literature, particularly on the governance mechanism in AMT implementation, is supplemented from the findings of this research. Finally, apart from bridging a gap in this area, the study also contributes to the literature on AMT transfer, buyer-supplier relationships, and extends the existing research on organisational performance.

There are a number of implications for practicing managers of the reported findings, especially for those from a developing economy. Existing research on the transfer and implementation of technology in developing countries has identified that they have a number of features that makes the process more challenging. This would make the reliance on technology suppliers in the acquisition and implementation process even more important, especially when transfer is from a foreign country. This study in Malaysia finds empirical support for the assertion that firms developing good relationships with their technology suppliers are more likely to achieve higher levels of performance compared with firms that do not. Therefore managers should be aware of the importance of strong relationships with technology suppliers for enhancing implementation success. The results of the study also highlight the importance of identifying transaction attributes such as complexity, asset specificity and uncertainty in AMT acquisition and implementation. In this case, managers were at a disadvantage since most of the implemented technology was being acquired from outside Malaysia. Also, developing countries

do not have sufficient technological capability, which means the key decision maker, namely the technology champion, must be highly knowledgeable about the AMT being adopted, either through training or from collaborating more closely with the technology supplier throughout the acquisition and implementation process. Policy makers such as the government bodies should also try to develop initiatives through various incentives to increase the number of local sales and support offices for manufacturing technologies in order to ensure that local firms have a better opportunity for consultation and more detailed analysis of the technology being acquired. Possibly governments can also introduce special taxes or loan incentives for firms to gain more training or consultation from the supplier on the specific technology being acquired. Finally, it is recommended that similar studies be conducted in other developing countries as well as in developed countries. These would enable cultural differences to be assessed during the development of buyer-supplier relationships.

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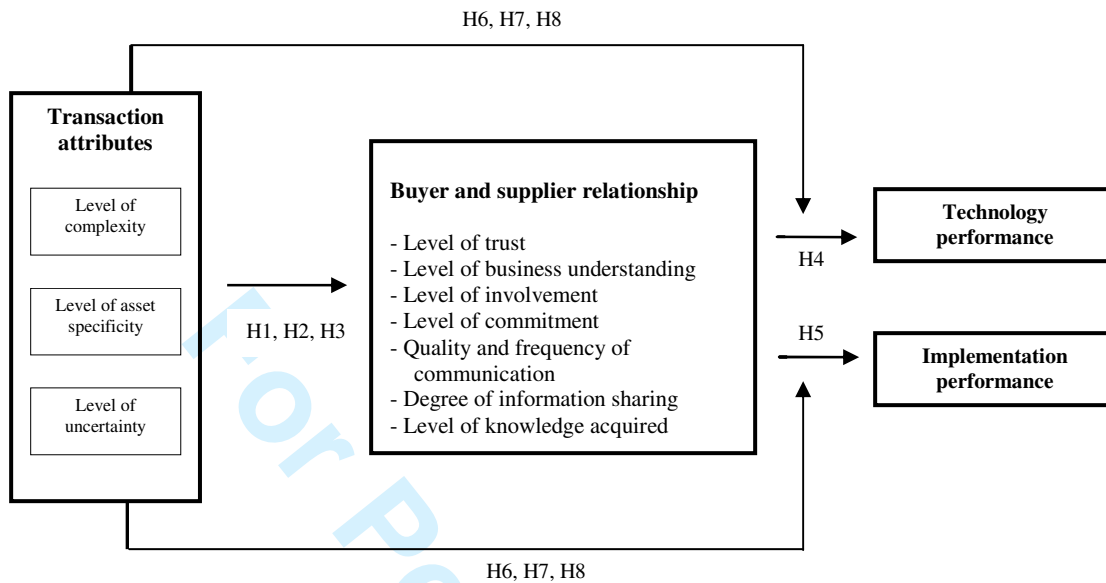


Figure 1. Framework to investigate relationships between variables

Table 1. Overall internal consistency of scales (the measurement items are described in full in the survey questionnaire, copies of which are available from the first author)

Scale title	Cronbach's alpha	Number of items in scale	Number of items deleted
Transaction attributes	0.91		
Degree of complexity	0.89	4	
Level of asset specificity	0.85	4	
Degree of uncertainty	0.83	7	1
Buyer and supplier relationships	0.93		
Trust	0.86	7	1
Business understanding	0.83	7	2
Involvement	0.79	4	
Commitment	0.70	5	
Communication	0.90	5	
Information sharing	0.83	5	
Acquired knowledge	0.81	7	2
Technology performance	0.74	4	
Implementation performance	0.76	6	

Table 2. Profile 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 product	12	8.2
Rubber and plastic product	11	7.5
Metal working product	23	15.6
Electrical and electronic product	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 3. 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

Table 4. Correlation results

	Level of complexity	Level of asset specificity	Level of uncertainty	Buyer and supplier relationship	Technology performance	Implementation performance
Level of complexity	1	.673(**)	.422(**)	<b>.411(**)</b>	.162(*)	.129
Level of asset specificity	.673(**)	1	.611(**)	<b>.513(**)</b>	.205(*)	.191(*)
Level of uncertainty	.422(**)	.611(**)	1	<b>.579(**)</b>	.168(*)	.361(**)
Buyer and supplier relationship	.411(**)	.513(**)	.579(**)	1	<b>.262(**)</b>	<b>.451(**)</b>
Technology performance	.162(*)	.205(*)	.168(*)	.262(**)	1	.196(*)
Implementation performance	.129	.191(*)	.361(**)	.451(**)	.196(*)	1

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

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

Table 5: Multiple Regression result<sup>a</sup> for H1, H2, and H3

	<b>Dependent variable</b>
	<b>Buyer-Supplier Relationships</b>
Intercept	1.568** (10.006)
Level of complexity	.071* (2.062)
Level of asset specificity	.086* (2.316)
Level of uncertainty	.268** (4.997)
Adjusted R <sup>2</sup>	.381
Overall F	30.932**

<sup>a</sup> t-value are shown in parentheses. \*p<0.05, \*\* p<0.01

Table 6: Regression result<sup>a</sup> for H4 and H5

	Dependent variable
	Technology performance
Intercept	2.886** (12.418)
Buyer-supplier relationship	.251** (3.267)
Adjusted R <sup>2</sup>	.062
Overall F	10.675**
Implementation performance	
Intercept	2.276** (11.556)
Buyer-supplier relationship	.396** (6.077)
Adjusted R <sup>2</sup>	.198
Overall F	36.932**

<sup>a</sup> t-value are shown in parentheses. \*\* p<0.01



Table 7. ANOVA result for differences in implementation performance and BSR score by level of transaction attributes

	BSR	N	Mean (Implementation performance)	S.D	ANOVA <sup>a</sup> (sig. value)	Post hoc test (p-value < .05)
Level of complexity						
High	Strong	29	3.76	0.33	0.000	Significant difference between: 1. Strong BSR & Moderate BSR 2. Strong BSR & Weak BSR
	Moderate	22	3.30	0.41		
	Weak	10	3.07	0.36		
Moderate	Strong	13	3.81	0.33	0.000	Significant difference between: 1. Strong BSR & Moderate BSR 2. Strong BSR & Weak BSR
	Moderate	11	3.45	0.22		
	Weak	14	3.19	0.26		
Low	Strong	7	3.83	0.19	0.005	Significant different between: 1. Strong BSR & Moderate BSR 2. Strong BSR & Weak BSR
	Moderate	18	3.32	0.36		
	Weak	23	3.36	0.37		
Level of asset specificity						
High	Strong	26	3.76	0.34	0.000	Significant difference between: 1. Strong BSR & Moderate BSR 2. Strong BSR & Weak BSR
	Moderate	18	3.21	0.34		
	Weak	7	2.95	0.34		
Moderate	Strong	19	3.81	0.26	0.001	Significant difference between: 1. Strong BSR & Moderate BSR 2. Strong BSR & Weak BSR
	Moderate	18	3.45	0.38		
	Weak	10	3.33	0.41		
Low	Strong	4	3.88	0.39	0.005	Significant difference between: 1. Strong BSR & Moderate BSR 2. Strong BSR & Weak BSR
	Moderate	15	3.36	0.33		
	Weak	30	3.28	0.31		
Level of uncertainty						
High	Strong	36	3.82	0.29	0.000	Significant difference between: 1. Strong BSR & Moderate BSR 2. Strong BSR & Weak BSR
	Moderate	11	3.32	0.56		
	Weak	11	3.21	0.49		
Moderate	Strong	10	3.73	0.33	0.002	Significant difference between: 1. Strong BSR & Moderate BSR 2. Strong BSR & Weak BSR
	Moderate	25	3.36	0.30		
	Weak	9	3.26	0.26		
Low	Strong	3	3.56	0.54	0.301	-
	Moderate	15	3.32	0.29		
	Weak	27	3.25	0.32		

<sup>a</sup> Non significant value ( $p\text{-value} \geq .05$ ) are highlighted in bold

Table 8. ANOVA result for differences in technology performance and BSR score by level of transaction attributes

		N	Mean (Technology performance)	S.D	ANOVA <sup>a</sup> (sig. value)	Post hoc test (p-value < .05)
BSR						
Level of complexity						
High	Strong	29	3.93	0.38	0.001	Significant difference between Strong BSR & Moderate BSR
	Moderate	22	3.42	0.57		
	Weak	10	3.78	0.34		
Moderate	Strong	13	3.73	0.30	0.229	-
	Moderate	11	3.50	0.35		
	Weak	14	3.64	0.32		
Low	Strong	7	3.82	0.24	0.024	Significant difference between Strong BSR & Weak BSR
	Moderate	18	3.64	0.47		
	Weak	23	3.36	0.44		
Level of asset specificity						
High	Strong	26	3.87	0.41	0.227	-
	Moderate	18	3.60	0.61		
	Weak	7	3.79	0.49		
Moderate	Strong	19	3.86	0.28	0.008	Significant difference between Strong BSR & Moderate BSR
	Moderate	18	3.42	0.49		
	Weak	10	3.45	0.57		
Low	Strong	4	3.88	0.14	0.097	-
	Moderate	15	3.53	0.33		
	Weak	30	3.50	0.33		
Level of uncertainty						
High	Strong	36	3.88	0.38	0.011	Significant difference between Strong BSR & Weak BSR
	Moderate	11	3.50	0.76		
	Weak	11	3.41	0.60		
Moderate	Strong	10	3.78	0.28	0.108	-
	Moderate	25	3.50	0.44		
	Weak	9	3.72	0.26		
Low	Strong	3	3.92	0.14	0.181	-
	Moderate	15	3.55	0.34		
	Weak	27	3.52	0.36		

<sup>a</sup> Non significant values (p-value ≥ .05) are highlighted in bold