# THE INFLUENCE OF MANUFACTURING STRATEGIES AND ENVIRONMENTAL MUNIFICENCE AS MODERATORS OF TECHNOLOGY-MANUFACTURING PERFORMANCE RELATIONSHIP: An Evidence From Indonesia

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**Abstrak:** Saat ini peran teknologi sebagai faktor keberhasilan dalam arena persaingan telah menjadi tumpuan perhatian baik bagi para praktisi maupun akademisi. Semakin banyak organisasi bisnis yang menginvestasikan berbagai teknologi baru untuk bisa tetap bersaing. Studi-studi terdahulu mengenai pengambilgunaan teknologi menemukan bahwa peningkatan penggunanaan teknologi manufaktur yang canggih dan praktik-praktik manajemen baru tidak dapat secara langsung dikaitkan dengan kinerja. Keuntungan atau manfaat yang signifikan baru dapat dicapai oleh perusahaan-perusahaan yang mengintegrasikan teknologi dengan pengembangan strategik perusahaan. Para ahli mengemukakan bahwa strategi dan kondisi lingkungan bisnis harus dipandang sebagai variabel moderator utama dan keberhasilan organisasi bisnis tergantung kepada kemampuan teknologi secara tepat untuk mendukung strategi kompetitif serta bagaimana bereaksi terhadap tajamnya arena persaingan. Penelitian ini memfokuskan kepada adopsi *hard technology* dan *soft technology* dengan strategi manufaktur dan tajamnya persaingan bisnis (environmental hostility) sebagai moderator. Data dikumpulkan melalui survey surat. Responden adalah pimpinan perusahaan skala menengah dan besar di seluruh Indonesia. Kuesioner dikirimkan kepada 1000 pimpinan perusahaan manufaktur, diperoleh tingkat respon sebesar 18.41%. Uji *non-response bias* menunjukkan bahwa sample yang digunakan dalam studi ini adalah representatif. Studi ini menemukan bahwa: (1) *Hard* and *soft technology* berpengaruh positif terhadap kinerja manufaktur. (2) Perusahaan-perusahaan manufaktur di Indonesia mengadopsi *soft technology* pada tahap yang lebih tinggi dibandingkan *hard technology*. (3). Keselarasan teknologi-strategi manufaktur sangat penting untuk menciptakan keunggulan kompetitif, dan (4). Pengaruh teknologi terhadap kinerja lebih baik jika kondisi persangingan relatif stabil, dan kurang hostile.

**Kata kunci**: Teknologi, strategi manufaktur, tajamnya persaingan (environmental hostility), kinerja manufaktur.

## Introduction

During the past twenty years, we have witnessed a wide array of advanced manufacturing technology, computer based technology, and new management practices implemented in varying degree of success. A growing body of research in manufacturing and technology management literatures suggest that firms are investing considerable sums into advanced manufacturing systems (hard technology) and new management practices (soft technology) to deal with fast changing product and fragmentation of traditional market, and to learn new process technologies that are important for shaping future industry evolution AMT systems, when properly understood and implemented, can help firms compete along dimensions of cost, quality, flexibility, delivery speed, productivity and even profitability of the firms. There is an abundant of literatures that have analyzed the relationship between technology adoption and performance (Porter, 1985; Morone, 1989; Higgins, 1995; Hottenstein & Dean, 1995). Maidique and Patch (1988) argued that technology is a critical force for a business organization in a competitive environment. Morone (1989) viewed technology as a source of competitive advantage. While Stacey and Aston (1990) argued that technology advancement plays a vital role in long-term profitability, and Higgins, (1995) identified technology as a contributing factor to successful operations.

Prior studies on technology adoption found that the increased use of advanced manufacturing technologies (AMT) and new management practices cannot be directly related to higher performance (Sweene, 1991; Kotha & Orne, 1989; Schroeder, et al., 1995). Significant benefits can be reaped by the firms that integrate technology and innovations considerations with strategic corporate development (Shariff, 1997). Scholars have argued that strategy must be viewed as a major moderating variable and the success of business organizations depend on the ability of new technologies to support the competitive strategy. Another issue raised on the relationship between technology and competitive advantage is whether the relationship is the same in all environmental context. Relating to this issue inconclusive results have been found on the impact of environmental munificence on the technology-performance relationship. Meyer and Goes (1988) and Shcroeder and Sohal (1999) found that the relationship between technological innovations and performance will be stronger for bigger organizations that have abundant resources, whereas, Irwin et al. (1998) found that the impact of technology on performance is greater for those organizations operating in less munificent environment, where the resources are scare. This study is conducted to investigate the moderating role of strategy and environmental munificence on the technology-manufacturing performance relationship, other than to investigate the impact of the level of technological adoption on manufacturing performance of the Indonesian medium and large manufacturing firms.

## Literature Review

### Technology and The Role to Create Competitive Advantage

A Review of literature reveals a lack of consensus concerning the notion of technology. The basic approach to define technology is derived from the classical Greek word, ‘techne’ and ‘logos’. The word ‘techne’ can be interpreted as skill of hand or technique. The word logos can be interpreted as knowledge or science.

Accordingly, technology can be viewed as a knowledge of skills or techniques or a science of skill or techniques (Autio & Laamanen, 1995).

Zeleny (1986) highlighted that technology consists of three interdependent, codetermining, and equally important components: (1) Hardware, which is the physical structure and logical layout of the equipment or machinery, used to carry out the required task. (2) Software, which is the knowledge of how to use the hardware in order to carry out the required tasks, and (3) Brainware, which is the reason for using the technology in a particular way (this may be referred to as *know-why*). In addition to these three, a fourth component must be considered interdependently for it encompasses all levels of technological achievement namely *know-how* (Khalil, 2000), p. 2). Know-how is the learned knowledge or acquired knowledge of technical skill regarding how to do a thing well. This is may be the result of experience, transfer of knowledge or hands-on practices.

The fact that technology is a potential source of competitive advantage is widely accepted in management and economic literature. Technological adoption and technological innovation are powerful forces for industrialization, increasing productivity, supporting growth and improving the standard of living (Abernathy & Clark, 1985). Technological strength has affected manufacturing cost and other competitive drivers (Harrison & Samson, 1997). Schroeder (1990) found that technology adoption creates competitive opportunities and threats for those who adopt them and for those who did not. To develop a competitive advantage, organization need to choose, design, and implement manufacturing technologies that are consistent with the needs of competitive advantage (Hottenstein & Dean, 1995).

**Technology and Manufacturing Performance**

Technological strengths have positive impacts on manufacturing performance and other competitive drivers (Harisson & Samson, 1997). When studying best practices about technology, they found that technological strength was directly related to the following competitive drivers: average change-over process, finished product defect rate, new product introduction lead time, on-time delivery, productivity and increased customer morale. Lower cost is achieved (i.e. total cost, material cost, labor cost, and overhead cost) when the firms use appropriate technology to its maximum potential. It can be concluded that technological strength was found to be generally a significant factor in explaining performance in manufacturing companies. Specific hardware is not be able to work as stand alone technology, but coupled with the other aspects of technological strength, appropriateness of technology and effectiveness of use and alignment with competitive strategy, significant explanatory power on business and operational performance variables can be achieved.

This study focuses on hard technology and soft technology. Hard technology comprises the process equipment used to physically transform and transport raw material into saleable components or products (Harrison & Samson, 1997). On the other hand, soft technology refers to the system which controls the technical processes and the human resources process within the organization such as TQM, JIT, TPM, MRP2 and benchmarking (Harrison & Samson, 1997).

Many past studies (e.g. Youseff, 1993; Zammuto & O' Connors, 1992; Beaumont & Schroeder, 1999) have looked at the role of hard technology for improving performance, especially manufacturing performance. Empirical research by Youseff (1993) found that firms that adopted and implemented computer based technology have a higher degree of flexibility than firms that did not. It also suggests that the proper implementation and utilization of AMT leads to increased manufacturing productivity (reflected by efficiency and effectiveness), which in turn will increase the firm's flexibility in responding to customer's needs and demands. AMT has given new dimensions to compete (beyond cost and quality) in terms of agility, quick response to customer's needs and timelines in all manufacturing activities.

Zammuto and O'Connor (1992) found that advanced manufacturing technology (AMT) gives a number of benefits such as 40% reduction in lead time, 30% improvements in machine utilization, 12% reduction unit cost, 30% reduction in labor costs as well as improved quality of product and work in the process. The integration of AMT will create economies of scale (the ability to produce a large volume of one or a few products efficiently) and economies of scope (the capacity to efficiently and quickly produce any range of products).

A study by Burges et al. (1998) of Turkish manufacturing firms revealed that no statistically significant relationship between AMT adoption and performance (measured by sales and market share). This contrary result may be related to the low level of technology adoption and if an effect is presented, it may be too small to be detectable. Another possible reason is that the link between innovation and technology adoption is moderated by some countervailing factors such as organization structure, competitive priorities and environment. Similarly Dean and Snell (1996) found that there is no relationship between AMT adoption and firms' performance. Perhaps the performance-enhancing effect of AMT is concentrated in the period of time just after the AMT is up and running effectively. Alternatively, it is due to the differing strategic posture of firms in implementing AMT, thus resulting in a mixture of positive and negative relationship between AMT and performance that simply cancelled each other out in the whole sample.

On the other hand, there are also numerous articles and empirical studies that investigated the impact of soft technology (e.g. TQM, JIT, TPM, MRP and benchmarking) on a firm's performance. Sohal and Terziovky (2000) argued that the effective implementation of quality improvement practices (TQM, benchmarking, process reengineering) lead to improvements in organizational performance in terms of both productivity and profitability, along with improved customer satisfaction. Research has also shown that JIT practices provide several potential benefits (e.g. eliminate waste in production process, reduce lead-time, decrease throughput time, improve product quality, increase productivity and enhance customer responsiveness)

Further, adoption and implementation of TPM help increase the productivity of plant and equipment in order to achieve maximum productivity (Al-Hassan et al., 2001). Adoption of TPM is a contributing factor to reduce work in process (WIP), improving response to customer through reduced cycle time and improved product quality (Tsang & Chan, 2000). Humpreys (2001) showed that the adoption of MRP2 can enhance firms competitive positions through improved customer service level, increased plan efficiency and more efficient production scheduling. When MRP was implemented with JIT, it reduced cost, increased productivity and integrated all functions to manufacturing (Lowe & Sim, 1993). Benchmarking has also proven to be a common tool for enhancing organization performance (Hinton, et al. 2000). It can be used to transfer the best practices and continuous learning to the other functions or organizations (Zairi & Whymark, 2000).

**Technology-Manufacturing Strategy Relationship**

Manufacturing strategy is viewed as the effective use of manufacturing strengths as a competitive weapon for the achievement of business and corporate goals (Swamidass and Newell, 1987). In addition, manufacturing strategy reflects the goal and strategy of business and enables the manufacturing function to contribute to the long-term competitiveness and performance of the business (Wheelwright and Hayes, 1985). Of late, manufacturing strategies adopted by manufacturing enterprises includes low cost strategy, quality strategy, flexibility strategy and dependability strategy. A manufacturing strategy is refered to by many researchers as a competitive priority (Burgess et al., 1998). Stonebaker and Leong (1994) defined a cost strategy as the production and distribution of a product with minimum expenses and wasted resources. Quality strategy focuses on the need to manufacture products and services that conform to the specifications and customer needs (Braglia, et al., 2000). Flexibility strategy is the ability to respond to the rapid changes of the products, services and processes. This strategy is often identified as a mix or volume flexibility. Leong, et al. (1989) delivery strategy as dependability of delivery (by meeting delivery schedule or promises) and speed of delivery (react quickly to customer order).

The literature on the link between technology and manufacturing strategy has been in existence for a long time (Skinner, 1974; Buffa, 1984; Burgess, et al., 1998; Cagliano & Spigna, 2000). Skinner (1974) advocated a wide variety of strategic priorities, including low costs, product quality, delivery reliability, short delivery cycle, flexibility to produce new product quickly, and flexibility to respond to volume change. These can be achieved by using manufacturing technologies. Buffa (1984) argued that Japanese firms have gained the lead in many industries through closer attention to integrated manufacturing strategies with appropriate technologies. Burgess et al. (1998) suggested that firms need to take action to improve process performance through the adoption of process innovation. Cagliano and Spina (2000) explored the empirical basis of the strategic alignment of manufacturing strategy choices in accordance with the strategic priority and past experience in determining the selections of manufacturing improvement program. A complete strategic alignment is expected when the choice of the improvement programs is highly coherent with competitive priorities and the past experiences, thus the maximum pay-off could be achieved.

Although a number of studies have tried to investigate the technology-manufacturing strategy relationship, no clear pattern of the relationship between technology and its strategy has been found. Prior studies on the link between technology and manufacturing strategy tends to use the process approach which describes what technology should be adopted by companies having certain manufacturing strategies or competitive priorities. However, the way technology should align with manufacturing strategy remains unresolved. The above review of the literatures shows the need to explore in greater depth the fit between manufacturing strategy and technology.

**Technology-Environmental Munificence-Performance Relationship**

Prior researches have also indicated that environmental munificence is positively associated with the range of strategy and organizational options available to firms. In this context, environmental munificence can be defined as the scarcity or abundance of resources needed by firms operating within the environment (Dess & Beard, 1984). Meyer and Goes (1988) study of hospital assimilation of innovations included environmental wealth (munificence) as a positive influence on the adoption of innovations. Hospitals in a wealthy environment benefit more from technological innovation since there would be greater demand for, and more resources available to support the use of technological innovation in a wealthy environment. In addition, Schroeder and Sohal (2000) found the same phenomenon where a greater slack of resources in the organization increases benefit of technology adoption in manufacturing firms.

Irwin et al. (1998) study of technology adoption in the hospital sector included environmental wealth (munificence) as a moderator on the relationship between technology and performance. They found that for hospitals operating in a munificent environment the effect of technology on performance is negative. In contrast, hospitals operating in a poor environment, the impact of technology on performance were positive. The negative effect of technology on performance for hospitals operating in munificent environment is caused by over-adoption of technology. They explained that over-adoption could lead to decreased performance in two ways. First, if a particular technology is over-adopted, any competitive advantage gained through increasing differentiation will be lost. Second, over-adoption may cause an under-use of technology. They suggested that hospitals need to be more selective in deciding which technology should be adopted and to make sure that the technology can be supported by adequate usage. Based on the above findings, the present study considers environmental munificence will negatively affect the impact of technology.

**Manufacturing Performance**

Numerous variables influence manufacturing performance. However, this study is focused on the impact of technology, competitive priorities, and the interaction among them on manufacturing performance. Swamidass and Newell (1987) described the difficulty in selecting performance measures. The adoption of any particular set of indicators embroil the researchers in the problems of quantification and dimensionality, not to mention the issue of validity in choosing the set of indicators which need universal acceptance. The appropriateness of the performance measurement used may depend on the circumstances and the uniqueness of the study (Badri, et al., 2000).

In most studies, the impact of technology, financial performance and operational performance are more often used. Financial performance refers to performance as measured by ROI, ROA, ROS, and profitability (Beaumont & Schroeder, 1997). Whereas, manufacturing or operational performance covers performance in terms of cost of production, product-process quality, delivery, product-volume flexibility, and productivity (Bond, 1999; Stonebaker & Leong, 1994; Leong et al., 1990). Cost is used in the sense that low cost would permit competitive pricing. Quality has an implicit bound of perfection. Any reduction in waste measured as scrap, will increase effectiveness by saving on material, labor, energy etc. Flexibility performance is measured by looking at the ability to respond to the rapid changes of the products, services and processes . Finally, delivery refers to the ability to meet delivery schedule or promises and the speed of reaction to customer order).Measuring performance by comparing firm performance with average performance in industry is frequently used as a perspective to measure firm performance (Dess & Byard, 1984).

Within this framework two major hypotheses are proposed:

H1: There is a positive impact of hard technology on manufacturing performance.

H2: There is a positive impact of soft technology on manufacturing performance.

H3: The impact of hard technology on manufacturing performance is moderated by manufacturing strategy.

H4: The impact of soft technology on manufacturing performance is moderated by manufacturing strategy.

H5: The impact of hard technology on manufacturing performance is greater in less munificence environment.

H6: The impact of soft technology on manufacturing performance is greater in less munificence environment.

**Research Framework and Hypothesis**

Based on the above discussion, the theoretical framework for this research is diagrammed below.

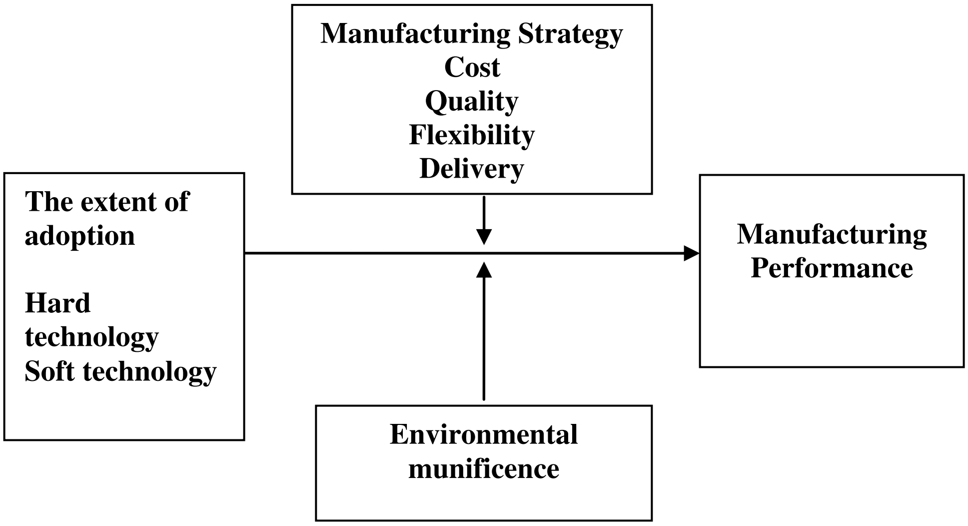



**Figure 1: Research Framework**

## Research Method

### Sample and Response Rate

For this study, a list of medium and large companies was obtained from the Directory of Manufacturing Industry, published by the Indonesian Statistic Center Bureau (Biro Pusat Statistic Indonesia, 2000). Data was collected through mailed questionnaires, which were addressed to the CEOs of medium and large manufacturing companies in Indonesia. The unit of analysis is organization and the samples were selected randomly from the directory. The sample selected were the manufacturing firms with more than 250 full time employees.

A total of 1000 questionnaires were sent to CEOs of large Indonesian manufacturing companies. Six companies were dropped from the target sample because four companies have moved to unknown addresses and the other two companies refused to participate. In addition, 47 incomplete responses cannot be used for this study. Finally, a total of 183 responses collected were used for the purpose of this study, an 18.41% response rate (See appendix 1).

### Respondents' Profile

The profile of the sample revealed an interesting spread of Indonesian large companies. Majority (60%) of the responding firms have less than 1000 full time employees with only 11.5% are very large, having in excess of 2500 full time employees. It is not surprising that about 90% of them have assets in excess of 25 million Rupiahs (1 USD equal to 9.850 Rupiahs). Most of them (80%) have been in existence for more than 10 years with only 8 companies (4.4%) being relatively new. Twenty-eight point four percent (28.4%) of the companies are in fabricated metal, machinery and automotive, and electronic industry, while 19.1% in food, beverage, and tobacco industry. The smallest (14.8%) group came from rattan, bamboo, furniture, and handicraft industries. In term of ownership, approximately 87% are Indonesian owned, while the remainders are either joint venture companies or totally foreign owned. However, locally owned companies do have some degree of alliances; only 47% indicated that they do not have any cooperative arrangement with foreign entities.

**Variables and Measures**

The variables of this study were measured using instruments derived from various sources.

**Level of technological adoption.** The two dimensions include hard technology and soft technology. Hard technology refers to a family of advanced manufacturing technologies and computer based technologies, which include 13 types of hard technology. Five point Likert type scales (1 = not adopted to 5 = very high) are used and in order to measure the level of adoption of hard technology, an instrument developed by Youseff (1993).

Soft technology refers to the system, which controls the technical processes within the organization such as TQM, JIT, TPM, MRP2, and Benchmarking. TQM measure are obtained and modified from Sohal and Terziovsky (2000). For the level of JIT adoption the components from Yasin, et al. (1997) as well as Sakakibara, et al. (1997) were adopted and modified based on the objective of this study. The level of MRP2 and TPM adoption is measured with the instrument developed by Warnock (1996) and Tsang and Chan (2000), respectively. While the level of benchmarking adoption is measured based on the general benchmarking practices (Hinton, Francis, Holloway, 2000). A five-point Likert scale anchored by 1 (not practiced) to 5 (very high) is used to measure the level of soft technology adoption.

**Manufacturing Strategy**. Manufacturing strategy is defined as key decisions about the specific role to be played by manufacturing function in achieving competitive advantage (Dangayah and Deskmush, 2000), which includes cost, quality, flexibility, and delivery strategy. The instrument to measure manufacturing strategy is adopted from Badri, et al. (2000). Here, the respondents are asked to indicate their assessment to statements on five point Likert's scale (1 = very unimportant to 5 = very important).

**Environmental munificence** means environment wealth, abundance of resources or capacity to support growth (Irwin et al., 1998). Six items is derived from Badri et al., (2000) to measure the availability of resources using a five-point Likert-like rating scale from 1 (very scarce) to 5 (abundant). As measured by Meyer and Goes (1988) as well as Badri et al. (2000), this study measures environmental munificence as the extent of availability of human and material resources.

**Performance.** This study looks at performance from the perspective of manufacturing performance by comparing each firm manufacturing performance to the average in the industry. Manufacturing performance covers performance on five dimensions of manufacturing, namely productivity, cost, quality, flexibility and delivery (Stonebaker & Leong, 1994).

These measures were subject to factor analyses to identify the structure of interrelationship (correlation) among a large number of variables (questionnaire responses in our case) by defining common underlying dimensions, known as factors. Factor analyses were conducted on the 13 questions of hard technology, 32 questions of soft technology, and 17 questions of manufacturing strategy. The factor analysis was conducted separately for extent of advanced manufacturing technologies and 32 organizational practices, two factors come up and named as hard technology (factor 1, Cronbach's alpha .9496) and soft technology (factor 2, Cronbach' alpha .9026). The results of factor analysis for manufacturing strategies emerged with four factors, the four factors are named accordingly, delivery strategy (factor 1, Cronbach's alpha .8813), quality strategy (factor 2, Cronbach's alpha .8344), flexibility strategy., and cost strategy (See Appendices 2 and 3). High Cronbach's alpha values of each of the derived factors indicated acceptable reliability level for further analyses (Nunnaly, 1978)

## Finding and Discussion

### The Impact of Technology on Performance

Table 1 presents the results of multiple regression analyses, which analyzed the impact of technology on firms' performance. Regarding the impact of technology on manufacturing performance we find that hard and soft technology have positive significant effects on manufacturing performance. Thus, the hypotheses 1 and 2 in this study are accepted. This finding indicates that companies can improve manufacturing performance by adopting hard and soft technology. Adoption of hard technology is a vehicle to increase process and product quality, process and volume flexibility, as well as delivery reliability, thus improvement of manufacturing performance and its growth can be attained. This finding is in line with a large number of previous studies done by Youseff (1993), Baumounth & Schroeder (1997), Buthcher et. al (1999), Gordon and Sohal (2001).

This finding also shows that the effective implementation of soft technology leads to improvement in manufacturing performance. Implementation of this technology can reduce rework, scrap, and product defect. Soft technology also plays an important role in shortening process/product development time, and enhancing delivery capability. This study appears in line with many previous studies about adoption of soft technology (Sohal & Terziovsky, 2000; Sakakibara, et al. 1997; Tsang and Chan, 2000; Hinton, et al. 2000) It shows that adoption of all types of soft technology will result in better performance than adoption of the specific technology. This is due complementary effect of all types of soft technology (Ellitan 2002a, Ellitan 2003).

We also find that the impact of soft technology is greater than hard technology. Adoption of soft technology will give more benefits than hard technology. This is largely due to some factors that inhibit adoption and implementation of hard technology such as disruption during implementation, lack of integration of AMT with operation systems, skill deficiency, technical difficulties etc (Ellitan, 2002b, Ellitan 2002c). These difficulties cause the impact of hard technology on manufacturing performance to be lower than that of soft technology (Ellitan, 2001, Ellitan 2004).

**Table 1.The Impact of Technology on Manufacturing Performance**

| Independent Variables | Manufacturing Performance |
|---|---|
| $R^2$ | .336 |
| Adjusted $R^2$ | .329 |
| Sig. F | .000 |
| **Standardized Coefficients (β)** | |
| Hard Technology (HT) | .158* |
| Soft technology (ST) | .475** |
| ** significant at .01 * significant at .05 | |

**The Moderating Impact Of Manufacturing Strategy**

Hierarchical regression analysis is used to analyze the moderating impact of manufacturing strategy on the relationship between technology and performance.

**Cost strategy As The Moderator**

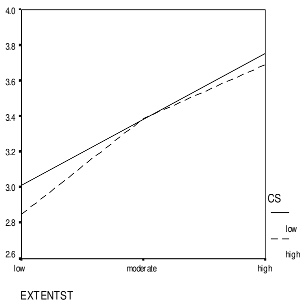
Table 2 shows the moderating role of cost strategy on the relationship between technology and manufacturing performance. The $R^2$ change and the F-change are significant at 10% level with the introduction the interaction terms, indicating that cost strategy significantly influence the impact of technology on manufacturing performance. The significant beta coefficient for interaction between soft technology and cost strategy (β = -1.306) explained that the impact of soft technology on manufacturing performance differ by the degree of emphasis on cost strategy. Hard technology requires large investment in equipment and facilities which goes against the philosophy of cost strategy. This could be the reason for no evidence of the moderating effect of cost strategy.

In general, the impact of soft technology on manufacturing performance is greater for those companies that focus less on cost strategy (Graph 1). This is because amongst companies that practice cost strategy, investment in hard or soft technology is not a priority, as this will only increase cost of operations. Therefore, amongst firms that are willing to spend on technology, the impact of technology on performance will be the same irrespective of emphasis cost strategy. The finding is in line with that Tan et al. (2000), who found that a strategy based on low cost correlates negatively with the use of product and process technology as a vehicle for performance improvement.

**Table 2. The Moderating Effect of Cost Strategy on The Relationship Between Technology and Manufacturing Performance**

| Variables | Step 1 | Step 2 | Step 3 |
|---|---|---|---|
| | Standardized Beta | | |
| HT | .158* | .159** | -.412 |
| ST | .475** | .486*** | 1.346*** |
| CS | | -.040 | .482 |
| HT x CS | | | .675 |
| ST x CS | | | -1.306** |
| $R^2$ | .336 | .338 | .360 |
| $R^2$ change | .336 | .001 | .022 |
| F change | 45.357 | .395 | 2.963 |
| Sig. F change | .000 | .531 | .054 |
| *** : significant at 0.01 ** : significant at 0.05 * : significant at 0.1 | | | |

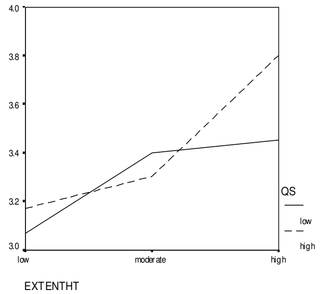
(Note: Step 1 refers to regression with the independent of hard technology (HT) and soft technology (ST); Step 2 refers to regression with the independent variables and the moderator (CS), whilst step 3 refers to the regression with the independent variables, the moderator and the interaction terms)




**Graph 1. The Impact of Cost Strategy on the Relationship between *Soft Technology* and Manufacturing Performance**

## Quality Strategy as The Moderator

Table 3 displays the moderating role of quality strategy (QS) on the relationship between technology and manufacturing performance (MP). The results of moderated regression shows that $R^2$ change and the F change from step 2 to 3 are significant at 5% level. The significance of standardized beta of the interaction between hard technology and quality strategy at 5% level indicates that quality strategy moderates the relationship between hard technology and manufacturing performance. The relationship between ST and MP is illustrated through Graph 2.




**Graph 2. The Impact of Quality Strategy on the Relationship between *Hard Technology* and Manufacturing Performance**

Graph 2 shows that when the level of hard technology is low to moderate, the impact of hard technology on manufacturing performance is greater for those companies that put less priority on quality strategy, whereas when the level of hard technology shifts from moderate to high the impact of hard technology is greater for those companies that put more emphasis on quality strategy. It can be argued from perspective that technology allows for greater efficiency and productivity in the operation function, thus improving both manufacturing and financial performance. When coupled with greater focus on quality issues, product produce will be even more competitive and wastages though defects, reworks, and scrap will also be reduced, thus reducing cost of production. This finding corroborates that Butcher et al. (1999), who found that the adoption of AMT (in term of CNC, CAD, LAN, and CIM) and greater emphasis on quality, flexibility and delivery reliability enhances companies' competitiveness through a range of improvement in production processes, quality control, increased capacity, flexibility, improved quality, reduced lead time, and increased internal rate of return.

**Table 3. The Moderating effect of Quality Strategy on The Relationship Between Technology and Manufacturing Performance**

| Variables | Step 1 | Step 2 | Step 3 |
|---|---|---|---|
| | **Standardized Beta** | | |
| HT | .158* | .158** | -.683* |
| ST | .475** | .473*** | .671* |
| QS | | .006 | -.185 |
| HT x QS | | | 1.016** |
| ST x QS | | | -.335 |
| $R^2$ | .336 | .336 | .359 |
| $R^2$ change | .336 | .000 | .023 |
| F change | 45.357 | .009 | 3.210 |
| Sig. F change | .000 | .924 | .047 |
| *** : significant at 0.01 | ** : significant at 0.05 | * : significant at 0.1 | |

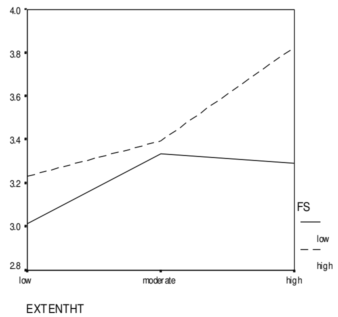
**Flexibility Strategy as The Moderator**

The moderating effect of flexibility strategy on the relationship between technology and manufacturing performance is displayed in Table 4. The F-change from step 1 to 2 is significant at 5% level, but the F-change is not significant from step 2 to 3. However, upon inspection of the beta coefficient for interaction terms, we find that the interaction between hard technology and flexibility strategy is significant at 5% level. This suggests that flexibility strategy moderates the relationship between hard technology and manufacturing performance.

**Table 4 The Moderating Effect of Flexibility Strategy on The Relationship Between Technology and Manufacturing Performance**

| Variables | Step 1 | Step 2 | Step 3 |
|---|---|---|---|
| | Standardized Beta | | |
| HT | .158** | .138* | -.168* |
| ST | .475*** | .424*** | .812** |
| FS | | .137** | .164 |
| HT x FS | | | 1.056** |
| ST x FS | | | -.701 |
| $R^2$ | .336 | .351 | .368 |
| $R^2$ change | .336 | .015 | .017 |
| F change | 45.357 | 4.047 | 2.308 |
| Sig. F change | .000 | .046 | .102 |

*** : significant at 0.01 ** : significant at 0.05 * : significant at 0.1




**Graph 3 The Impact of Flexibility Strategy on the Relationship *Hard Technology* and Manufacturing Performance**

**Delivery Strategy as The Moderator**

Table 5 summarizes the results of the regression analysis for testing the moderating role of delivery strategy on the impact of technology on manufacturing performance. Although we do not find a significant F-change from step 1 to step 2 and from step 2 to 3, but the inspection of beta coefficients of the interaction terms reveals that the interaction term between hard technology and delivery strategy is significant at the 10% level.

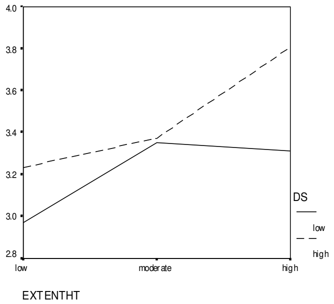
**Table 5 The Moderating Effect of Delivery Strategy on The Relationship Between Technology and Manufacturing Performance**

| Variables | Step 1 | Step 2 | Step 3 |
|---|---|---|---|
| | Standardized Beta | | |
| HT | .158* | .158** | -539 |
| ST | .475** | .475*** | .779** |
| DS | | .107 | .151 |
| HT x DS | | | .841* |
| ST x DS | | | -.585 |
| $R^2$ | .336 | .346 | .358 |
| $R^2$ change | .336 | .010 | .012 |
| F change | 45.357 | 2.602 | 1.613 |
| Sig. F change | .000 | .108 | .202 |
| *** : significant at 0.01 | ** : significant at 0.05 | * : significant at 0.1 | |

As mentioned above, delivery strategy moderates the relationship between hard technology and manufacturing performance (Graph 4). When the level of hard technology is low to moderate the impact of hard technology is greater for those companies that put less priority on delivery strategy. However, when the level of hard technology varies from moderate to high the impact of hard technology is greater for those companies that greater place emphasis on delivery as main competitive priority. Delivery strategy emphasizes on responding to the customer's order by meeting delivery schedule as well as responding quickly to customer order. Delivery strategy can be operationalized by having advanced manufacturing technologies such as automated material handling system, shop floor monitoring and control by computer and robotic. Based on the above discussions, one can conclude that there need to some degree of 'fit' between strategy and technology result in maximum performance. It is aligning with Schroeder et al (2000) and Cagliano & Spina (2000) who asserted that through alignment between technology and strategy high pay-off will be achieved. Based on the result of hierarchical regression analyses, hypotheses 3 and 4 of this study are partially accepted.

**Moderating Impact of Environmental Munificence**

Table 6 displays the results of the role of environment munificence (EM) in moderating the relationship between technology and manufacturing performance (MP). We can see that F-ratio and $R^2$ change significantly with the introduction of interactions terms in step 3. The significance of the standardized beta of the interaction term (HTxEM), indicates that EM moderates the impact of hard technology on manufacturing performance.



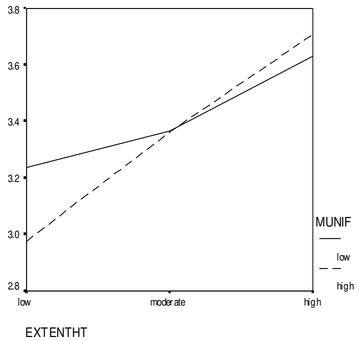

**Graph 4.The Impact of Delivery Strategy on the Relationship between *Hard Technology* and Manufacturing Performance**

The moderating effect of environmental munificence (EM) on the relationship between hard technology (HT) and manufacturing performance (MP) is illustrated in Graph 5. It shows that the impact of HT on MP is always positive in high munificence environment. From this graph we can see that when the level of HT is low to moderate, the impact of HT on MP is greater for those companies operating in highly munificent environment, but the reverse is true when level of HT is moderate to high. The finding indicates that hard technology supported by skilled workers; technical worker and the availability of material will result in high performance. This finding is consistent with that of Schroeder and Sohal, (2000) who found that the availability of resources increases the benefits of AMT adoption. In addition, Beede et al. (1998) also found that technology complements human capital. However, the result is contrary to the expectation with the finding of Irwin et al. (1998). This is largely due to the fact that in the context of Irwin's study, environmental munificence is seen from the context of generating demand for high-tech services, whereas our study looks at environmental munificence to support the use of technology in the production function. On the other hand, this study does not find the moderating impact of soft technology on performance. The impact of soft technology on performance does not depend on the munificence of environment. It may be due to the intangible nature of soft technology as organizational management practices, and therefore subsumes the dimensions of munificence (availability of skills). This finding is in line with Dean and Snell (1996), who found that munificent environment does not moderate the impact of TQM on performance.

**Table 6. The Moderating Effect of Environmental Munificence on The Relationship Between Technology and Manufacturing Performance**

| Variables | Step 1 | Step 2 | Step 3 |
|---|---|---|---|
| | Standardized beta | | |
| HT | .158** | .135* | -.767* |
| ST | .475*** | .476*** | .785** |
| EM | | -.085 | -.233 |
| HT x EM | | | .814** |
| ST x EM | | | -.416 |
| $R^2$ | .336 | .338 | .344 |
| $R^2$ change | .336 | .006 | .019 |
| F change | 45.357 | 1.760 | 2.686 |
| Sig. F change | .000 | .186 | .071 |
| *** : significant at 0.01 ** : significant at 0.05 * : significant at 0.1 | | | |

(Note: Step 1 refers to regression with the independent of hard technology (HT) and soft technology (ST); Step 2 refers to regression with the independent variables and the moderator (EM), whilst step 3 refers to the regression with the independent variables, the moderator and the interaction terms).




**Graph 5 .he Impact of Environmental Munificence (EM) on the Relationship between Hard Technology (HT) and Manufacturing Performance (MP)**

## Conclusion

In the real world, the evidence shows that the effective adoption and mastery of technology requires not just the establishment of new production facilities, but also the knowledge and expertise for implementing technical change. This study finds that technology positively influence performance. Thus, Indonesian manufacturing firms should consider adopting more of both types of technology. The findings of this study also imply that the impact of technology on performance is depended on the manufacturing strategy pursued. Aligning the resources required to support manufacturing strategies in achieving better performance. Further, this study contributes significantly to the understanding of the technology–manufacturing performance relationship in an environment of developing nations.

Although this study has presented a systematic approach to investigate the extent of technology adoption, however, it could not cover all the important issues in this field. Through this study, we still know little about the relationship between technology and performance. By doing this study it could be possible to observe and document variations of the extent of technological adoption, manufacturing strategy, environment variables and manufacturing performance interrelationship. Although this study used a sample of manufacturing companies in Indonesia, it would be interesting replicate the study on manufacturing companies in other developing countries, which are known to have similar culture in adopting technology. Such a study will address the generalizability of the finding of this study. Furthermore, this study only considering environmental munificence as moderator, and also not consider other environment perspectives such as dynamism, hostility and complexity that may moderate the technology-performance relationship. Thus, we suggest that taking consideration to these environmental perspectives will open up a new avenue for technology –environmental variable-performance relationship.

From methodological perspectives this study has several limitations. Firstly, data were collected based on perceived, self-judgment, and multiple choices questionnaire. Although this approach is adequate to gather a large amount of data within limited time, however, it should be desirable to develop a longitudinal study. Unfortunately, it was entirely beyond the scope and the possibilities of the study. Secondly, the questionnaires address to CEO (Chief Executive Officer), thus only CEOs responded as their perception of the extent of technological adoption, the emphasis on manufacturing strategy, the environment to be faced and the performance achieved. In this case the potential mono response bias emerges. The limitation is ‘ would manufacturing executives response the same way, even on priorities that clearly within the manufacturing domain?. Thirdly, the nature of requested data in some cases was considered confidential. It could limit their participation in this study. Finally, this study was conducted in Indonesia only, so the finding of this study might not be generalized to other cultures or other countries.

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## Appendices

### Appendix 1: The Questionnaires Distribution

| | |
|---|---|
| Questionnaires were distributed. | 1000 |
| Not delivered. | 4 |
| Refuse to participate | 2 |
| Potential sample | 994 |
| Returned and usable. | 183 |
| Returned but unusable. | 47 |
| Not returned. | 764 |
| Response rate. | 23.13% |
| Rate of usable response. | 18.41% |

**Appendix 2: Factor and Reliability Analyses on Manufacturing Strategies**

| No. | Dimensions of Manufacturing strategy | Factor 1 | Factor 2 | Factor 3 | Factor 4 | Reliability Cronbach's Alpha |
|---|---|---|---|---|---|---|
| | **Factor 1: Delivery strategy** | | | | | |
| 1. | Increase delivery capability | **.606** | .248 | .436 | .082 | |
| 2. | Increase delivery speed. | **.661** | .225 | .407 | .051 | |
| 3. | Improve pre-sale services and technical support. | **.811** | .157 | .236 | .123 | |
| 4. | Improve technical assistance of service to customer. | **.824** | .242 | .082 | .068 | |
| 5. | Improve after sales service. | **.830** | .161 | .105 | .059 | .8813 |
| | **Factor 2: Quality Strategy** | | | | | |
| 6. | Reduce defective rate | .205 | **.592** | .047 | .382 | |
| 7. | Improve vendor and supplier's quality | .292 | **.654** | .077 | .195 | |
| 8. | Implement quality control program | .312 | **.767** | .042 | .177 | |
| 9. | Obtain international quality certification | .096 | **.805** | .297 | -.028 | |
| 10. | Obtain local certification of quality. | .117 | **.815** | .292 | -. 099 | .8344 |
| | **Factor 3: Flexibility strategy** | | | | | |
| 11. | Reduce time to manufacture. | .138 | .205 | **.773** | .276 | |
| 12. | Reduce procurement lead time. | .134 | .258 | **.719** | .144 | |
| 13. | Reduce time to develop new product. | .184 | .063 | **.748** | .024 | |
| 14. | Reduce set up/changeover. | .269 | .099 | **.704** | .213 | .8206 |

**Continued**

| | | | | | | |
|---|---|---|---|---|---|---|
| | **Factor 4. Cost Strategy** | | | | | |
| 15. | Reduce unit cost | .053 | -.019 | .317 | **.776** | |
| 16. | Reduce material cost | .051 | .089 | .154 | **.849** | |
| 17. | Reduce inventory cost | .122 | .197 | .050 | **.829** | .8209 |
| | Eigen-values | 6.629 | 2.015 | 1.617 | 1.396 | |
| | Percentage variance explained | 38.995 | 11.851 | 9.511 | 1.396 | |
| Total variance explained | | | | | | 68.569% |
| Measure of Sampling Adequacy (MSA) | | | | | | .837 |
| Bartlett' test of sphericity | | | | | | 1772.030 |
| Significant | | | | | | .000 |

**Appendix 3: Reliability and Validity**

| Variables | Number of Items in Questionnaire | Coefficient Alpha | Item Homogeneity |
|---|---|---|---|
| Hard technology | 13 | .9496 | .684 - .866 |
| TQM | 7 | .8755 | .635 - .856 |
| JIT | 7 | .8729 | .677 - .813 |
| TPM | 6 | .9105 | .785 - .776 |
| MRP2 | 8 | .9027 | .639 - 824 |
| Benchmarking | 4 | .8604 | .760 - .886 |
| Cost strategy | 3 | .8209 | .702 - .948 |
| Quality strategy | 5 | .8344 | .665 - .856 |
| Flexibility strategy | 4 | .8206 | .551 - .794 |
| Delivery strategy | 5 | .8813 | .814 - .851 |
| Manufacturing performance | 7 | .8762 | .674 - .817 |