# The Impact of Successful Implementation of New Manufacturing Practices and Company's Structural and Environmental Characteristics on Performance

*Moon Jong Chung and Kyung Tae Lee*


## Abstract

The increasing adoption of new manufacturing practices such as TQM, JIT, FMS raises questions as to how successfully companies implement them and whether these practices do lead to performance improvement. A study of a moderate size sample of Korean manufacturing companies shows that the executional levels of the new practices positively affect the performance. Our analysis also finds that the structural characteristics (the complexity of production and the level of automation) adversely affect performance while the competitive environment does not have a significant impact.

The success of these practices, however, is not determined solely by the way these practices are implemented. A more interesting question is whether competition and structural characteristics influence the impact of the new practices on performance. We find that the positive impact of the new practices is greater for companies with higher levels of production complexity and/or automation. In other words, the need for successful implementation of the new practices is greater for those companies. The competition, however, does not show a positive interaction effect with the executional levels of the new practices.

We also investigated whether teamwork and employee empowerment positively affect the new practices' impact on performance. Unlike the findings of previous research, we do not observe any positive effect of teamwork and employee empowerment on performance.



**Moon Jong Chung**
Ewha Women's University
mchung@ewha.ac.kr

**Kyung Tae Lee**
Yonsei University
kyungtae@yonsei.ac.kr


## 1. Introduction

During the 70's and 80's, we witnessed a wider recognition that manufacturing function can greatly contribute to the competitiveness of a company (e.g., Skinner, 1985). Since then many studies have shown the importance of production function by focusing on its contribution to a company's overall performance (Marucheck *et al.*, 1990). Manufacturing efficiency has become more important as competition in many industries has become worldwide and the pace of innovation has accelerated.

Intensified competition entails companies to lower prices, improve qualities and offer more choices to customers. In fact, companies have to produce more diverse line of products than ever in various quantities specified by the customers to be delivered on time. At the same time the increase in customers' expectation level of quality requires companies to strive for improving product quality while lowering the prices. In order to adapt to these manufacturing environmental changes, many companies have gone through waves of improvement programs such as total quality management (TQM), just-in-time (JIT), flexible manufacturing system (FMS), etc. to enhance quality, reduce cost, increase output and eliminate delays in responding to customers.

Despite the increasing adoption of new manufacturing practices (NMP), however, there is not enough evidence as to how successfully companies implement them, whether these practices do lead to performance improvement and what factors affect the impact of NMP on performance. Production and strategy literatures (e.g., Parthasarthy and Sethi, 1992) advocate the importance of strategic focus in implementing production technologies. Among the few studies dealing with the impact of NMP on performances, for example, Dean and Snell (1996) examined matches between strategic directions (core competences) and NMP, and their impact on the companies' performance in terms of core competences. In other words, the focus of the literatures was to examine whether companies align NMP with strategic directions and whether the alignment leads to core competence improvements. Their results, however, were not as clear as they expected. We find a similar result that matches between strategic directions and NMP are not significant among companies.

The current study differs, however, in several ways from prior studies. Rather than concentrating on the matches, we are interested primarily in investigating the moderating effect of company characteristics on NMP-performance relationship. Among the moderating effect of company characteristics, prior studies examined that of competition only. We examine the moderating effects of production complexity and automation also. In fact, complexity is one of the key structural aspects of today's companies emphasized by many researchers in management accounting. Complexity can greatly influence companies' performance. However, it is not clear as to how it affects companies' performance and, particularly, how companies deal with complexity via NMP to improve performance.

Secondly, unlike the prior studies examining the performance impact in terms of core competences only, we investigate whether NMP lead to improvement not only in core competences but also in financial performance which measures the ultimate performance dimension companies try to achieve.

Lastly, few studies have dealt with the impact of NMP in the emerging economies. Most studies involve the U.S. companies only. We investigate whether the positive impact of NMP can be found in the case of Korean companies also.

A study of a moderate size sample of Korean manufacturing companies is made. We first identify companies' strategic directions in manufacturing in terms of core competences: quality, dependability, flexibility and cost. Then we investigate whether the executional levels of NMP are related to strategic directions of the companies. Also investigated is how the executional levels of NMP positively affect companies' achieved levels of core competences and financial performances.

The result shows that, compared to the high levels of importance attached to competences in quality and dependability, companies attach less importance to flexibility and cost. This is similar to what Dean and Snell (1996) observed for the U.S. companies. In terms of the achieved levels of the core competences, flexibility and cost levels are also lower while those of quality and dependability are relatively higher. As in the case of the U.S. companies (e.g., Dean and Snell (1996)), the matches between strategic directions and the executional levels of NMP are not observable for our sample of Korean companies either. The association between the achieved levels of core competences and the executional levels of NMP is also not evident except for quality. This result is not consistent with claims made in strategy and production literatures that companies should be able to align NMP to their strategic directions in such a way of improving core competences which are suitable to their manufacturing environment. Despite the lack of strategic alignment, in terms of financial performances, however, successful implementation of TQM, JIT and FMS has positive influence on performance in Korean companies, too.

The success of these practices, however, is not determined solely by the way these practices are implemented. A more interesting question is whether the competitive environment and the structural characteristics of a company influence the impact of the new practices on performance. As competition among companies grows, production technologies will change more rapidly and a higher level of customer demand diversity will prevail in the market. In fact, companies face varying degrees of technology changes and customer preference changes. In response to the behavior of competitors and the expectations of customers, a company will configure its structural shape of production. Among others, complexity and automation are some major dimensions of such production structures. Particularly, complexity is a structural characteristic which has attracted much attention of accountants. In almost all companies, complexity of production in terms of production technologies, number of product types, product mix and quantities, production scheduling, etc. has been increased to a great extent. Activity-based costing is an example of showing how researchers in management accounting are concerned with the complexity of operation. The impact of complexity on performance, however, has rarely been explored by researchers, particularly in relation to the implementation of NMP.

We will investigate how competition, complexity and automation affect the effectiveness and efficiency of company's operation. What will be more interesting, however, is to investigate how the environmental and structural variables moderate the impact of the executional levels of NMP on performance. For example, the need for successfully implemented NMP to enhance the competitive advantage may be greater for companies in higher competition. Similarly, performance of a company with higher levels of complexity and/or automation may be affected by the executional levels of NMP to a greater extent.

Our analysis finds that the complexity of production and the level of automation adversely affect performance while the competitive environment does not have a significant impact. The result that both a higher level of complexity and that of automation lead to lower performance implies that either production complexity or automation itself is not what enhances the competitiveness and growth of a company. As for the interaction effect between the structural/environmental variables and NMP on performance, however, we find that the positive impact of the new practices is greater when a company shows a higher level of the complexity and/or that of automation. In other words, the need for successful implementation of the new practices is greater for those companies. The competition, however, does not show an interaction effect with the executional levels of the new practices.

Many researchers advocated the importance of teamwork and employee empowerment in today's manufacturing environment (e.g., Banker, et al., 1993). In an environment where technologies keep changing and complexity of operation is high, employees need team approach to solve difficult problems. It is also asserted that employee empowerment is important to let the employees find and solve problems in operation for themselves. We investigated whether teamwork and employee empowerment positively affect NMP's impact on performance. Unlike the findings of previous research, however, we do not observe any positive effect of teamwork and employee empowerment on performance.

## 2. Research Issues

### 2.1. Strategy and Manufacturing Practices

A company's production technologies can affect its choice of a strategy (Hayes, 1985). At the same time, production technologies are basically determined by its strategy (Skinner, 1969). In order to attain competitive advantage in manufacturing, a strategy to increase the core competence that is different from other companies is essential (Swamidass and Newell, 1987). Basically, core competences consist of four components which are quality, dependability, flexibility and cost (Skinner, 1969; Wheelwright, 1981). Traditionally, it is understood that the performance of a company is determined based on trade-offs between cost and quality of which only one of them can be stressed at a time. These days, however, cumulative theory states that a company builds up dependability on the basis of quality, then builds up flexibility, and then ultimately achieves cost competitive advantage (e.g., Ferdows and De Meyer, 1990). That is, a company builds high level competence onto the lower level one, and concurrently enhances the lower level competences. Others argue that companies can increase its competence in quality, dependability, flexibility and cost simultaneously through the execution of strategy that recognizes the interrelationship of all the activities within the companies (Suarez *et al*., 1995, p26).

In other words, strategy and production literatures emphasize that a company needs competitive advantages in all the dimensions of core competences, and that relevant and sufficient levels of competences can be obtained by the alignment of manufacturing practices with strategy in such a way of improving those core competences which are suitable to its manufacturing environment. All the activities needed for production are not independent of but closely interconnected to each other. On the basis of this interconnection, manufacturing paradigm has been changing to integrated manufacturing system that aims to increase the efficiency of production through TQM, JIT, FMS, etc. (Schonberger, 1987).

Basically, integrated manufacturing is to eliminate the inefficiency of non-value added activities such as transportation, storage and rework through this integration and to establish efficient automated manufacturing lines (Snell and Dean, 1992). TQM is a philosophy or culture of a whole organization that continuously attempts to improve all the activities in a systematic manner and problem-solving methodology which supports such pursuit. The core components of TQM consist of customer view, participation of and development of employees, appropriate planning and management of processes, design quality, etc. (U. S. Department of Commerce, 1994).

JIT attempts to reduce or eliminate lead-time, inventories and other waste elements. It is a system that eliminates waste through reducing the variety of parts and the number of suppliers as well as employing demand-pull manufacturing. Moreover, JIT encourages worker skill improvements, process improvements and effective communication between workers that are needed to reach higher quality and eliminate or reduce buffer stocks.

FMS consists of material transportation system that is operated and controlled by a series of robots and computers. It is a system that enables a company to quickly meet the changes in manufacturing requirements. FMS refers not only to a computer-integrated manufacturing system but also to any system that has the ability to switch-over from one kind of production to another quickly or one that develops products fast. In other words, FMS is a manufacturing system that attempts to provide various kinds of goods according to client's needs quickly but at cheaper prices.

TQM is generally understood as a manufacturing practice that corresponds to a strategy that puts emphasis on quality. Quality in terms of TQM, however, is a very broad concept relating to all the components of core competences mentioned above. In fact, there is a viewpoint that TQM's basic goal is to improve cost and quality at the same time (e.g., Belohlav, 1993). Some connects TQM with the promotion of flexibility in manufacturing (Ciampa, 1991). Therefore, it can be said that TQM is a manufacturing practice that corresponds with various strategic directions.

Zipkin (1991) argued that JIT is appropriate for a strategy that emphasizes cost and quality but is not suitable for a strategy that promotes variety or availability of products. Swamidass and Newell (1987) and Zygmont (1989), however, claimed that JIT contributes to the strategic directions that stress not only cost and quality but also flexibility. Flexibility is widely viewed as the main purpose of FMS (Sanches, 1995). Owing to the general opinion on the close connection between FMS and flexibility, there are many researches that regard FMS and flexibility as the same thing (e.g., Gupta and Somers, 1996). However, just as FMS is not the only method that can promote flexibility, flexibility is not the only thing that FMS is linked to. FMS can be helpful in promoting quality and dependability as well as flexibility (Small and Yasin, 1997).

Production and strategy literatures (e.g., Parthasarthy and Sethi, 1992) advocate the importance of strategic focus in implementing production technologies. Among the few studies dealing with the impact of NMP on performances, for example, Dean and Snell (1996) examined matches between strategic directions in terms of core competences and NMP, and their impact on the companies' performance in core competences. In other words, the focus of the literatures was to examine whether companies align NMP with strategic directions and whether the alignment leads to core competence improvements. Their results, however, were not as clear as they expected. We will examine this issue again, particularly for Korean companies. It will provide a chance to reevaluate the claim that matches between strategic directions and NMP are important, particularly for non-U.S. companies in an Asian emerging economy.

## 2.2. The Level of Successful Execution of New Manufacturing Practices

The executional level of a manufacturing practice (practice scale) refers to how well all the activities involved in implementation of the practice have been executed. For example, the executional level of TQM depends on how adequately the activities or the methods comprising the TQM program to promote and improve core competences have been applied. The success of each manufacturing practice, however, may not be the same for all companies even though the companies executed all the activities in the same way. In other words, the success of NMP is not determined solely by the way these practices are implemented. Many factors can influence the level of successful execution of each practice. The competitive environment, the structural characteristics, and the infrastructure of a company may influence the impact of NMP on performance.

### *Infrastructures*

Some of important aspects of a manufacturing organization for successful implementation of NMP include employee empowerment and teamwork or team practice. Many researchers advocated the importance of teamwork and employee empowerment in today's manufacturing environment (e.g., Banker, et al., 1993). In a new manufacturing environment where technologies keep changing and complexity of operation is high, employees should be able to deal with more diverse and complicated situations and are required to come up with solutions for themselves for problems they might encounter while performing activities. Thus, it is necessary to endow the employees with considerable amount of authority or responsibility so that they can attempt to identify and solve problems on their own.

In addition, employees are encouraged to work together as a team in order to be able to better identify problems and find effective solutions for difficult problems in today's more complex manufacturing environment. From this point of view, employee empowerment and teamwork systems are called manufacturing infrastructures, and they may affect the effectiveness of NMP (Boyer *et al*., 1997; Small and Yasin, 1997, (Ward *et al*., 1994), etc). [1]

Sakakibara *et al*. (1997) showed interaction effect between employee empowerment and teamwork and successful execution of JIT on company's core competences and several non-financial performances. We will examine the direct impact of the infrastructures on performance as well as the indirect impact they might have on performance in conjunction with NMP.

### *Environmental and structural characteristics: competition, complexity and automation*

Competition is one of the major environmental characteristics of a company which can greatly affect the company's performance. As competition among companies

1 Human resource management system is another example of the infrastructures (Snell and Dean, 1996).

grows, production technologies will change more rapidly and a higher level of customer demand diversity will prevail in the market. In fact, companies face varying degrees of technology changes and customer preference changes. NMP may help companies to better develop and implement new production technologies and to better accommodate customer preference changes. In other words, the need for successfully implemented new manufacturing practices to enhance the competitive advantage may be greater for companies in higher competition. Therefore, it seems likely that the relationship between the new practices and performance is moderated by the level of competition, and we examine whether there is interaction effect between them.

Dean and Snell (1996) measured competition by the rate of sales increase within an industry (munificence) and industry concentration ratio. Ward *et al.* (1995) examined the influence of labor force availability, competitive hostility and market dynamics as environmental characteristics. In this study, we define competition in terms of speeds of changes in customer preferences and of rival companies' product development and innovation.

In response to the behavior of competitors and the expectations of customers, a company will configure its structural shape of production. Among others, complexity and automation are some major dimensions of such production structures. Depending on how a company builds its structure in relation to complexity and automation, its effectiveness and efficiency of operation will be greatly affected. Particularly, complexity is a structural characteristic which has attracted much attention of accountants. Due to increased competition, complexity of production in terms of production technologies, number of product types, product mix and quantities, production scheduling, etc. has been increased to a great extent. Complexity of production increases complex manufacturing transactions Miller and Vollman (1985) talked about. Activity-based costing is an example of showing how researchers in management accounting are concerned with the complexity of operation. The impact of complexity on performance, however, has not been explored sufficiently by researchers, particularly in relation to the implementation of NMP.

In general, the complexity can adversely affect the effectiveness and efficiency of production. Particularly, delivery and quality performance as well as cost performance can be greatly affected by the complexity. NMP may mitigate the adverse effect of production complexity. In fact, the purpose of NMP is to reduce quality problems, manufacturing cycle and waste. Therefore, positive effect of NMP should be greater for companies with higher levels of complexity.

Automation is another structural aspect of a company. In general, the purpose of automation is to obtain economy of scale in operation and to enhance the homogeneity in production quality. The purpose of automation, however, is not just increasing the quantity of the product and cost savings. It is to produce goods of higher quality in a consistent, quick and efficient manner.

In many cases, however, ill-implemented automation leads to low flexibility and cost increases. In the perspective of traditional automation, flexibility tended to decrease as the automation level rose. Successfully implemented automation, for example, should be able to promote production of even non-standardized products with promptness and flexibility. Through successful FMS, the economy of integration must be made possible. At the same time, by combining automation with successful JIT or TQM, a company can minimize the inventory, lead-time, and other inefficiencies, and must be able to manufacture high quality goods meeting customers' needs.

The above discussion can be summarized as follows. The company's choice of automation level may be influenced by the characteristics of its industry and market, and its manufacturing technology. The performance of the automation, then, can be influenced by the executional levels of NMP. The automation level itself may have a negative influence on the company's performance. The automation, however, may produce positive effect when it is combined with appropriately implemented NMP. Examining whether automation brings out synergy effect in company's core competences and performance could be an interesting topic.

In sum, competition, complexity and automation are company's characteristics which will affect the effectiveness and efficiency of its operation. The need for successfully implemented NMP to enhance the competitive advantage may be greater for companies in higher competition and with higher complexity and automation. Therefore, it seems likely that the relationship between NMP and performance is moderated by the level of competition, complexity and automation, and we examine the moderating effect of competition, complexity and automation in relation to the impact of NMP on performance.

## 3. Research Methods

### 3.1 Data and Sample Collections

The basic objective of this study is to examine the relationship between company's various operational aspects and its performance. Due to the nature of the research questions addressed, there are many variables which cannot be measured by actual data. Hence, the use of survey questionnaires was inevitable. Surveys were sent to a total of 900 companies: 600 drawn from listed companies in all industries except for the finance and the wholesale and retail industries, and 300 drawn from non-listed companies in three selected industries. The three selected industries mentioned above are mechanics, electronics, and metal.

Manufacturing practices and other operational aspects may vary significantly among factories even when they belong to the same company. Many companies in the sample have more than one factory. If one tries to measure the manufacturing aspects at a whole company level not at an individual factory level, he will face at least two problems: (1) He will find many companies in the sample consist of a group of factories varying from each other so much that they cannot be clearly identified as one homogeneous business unit in terms of the manufacturing practices and other operational aspects; (2) If he wants to measure regarding a whole company, he has to include all factories belonging to that company in his survey. It is, however, very difficult to administer so extensive a survey as the one we used here to all the factories belonging to each company in the sample. Therefore, we took a factory as the unit of subject for our analysis. A manufacturing manager or a person in charge of quality management of a factory was asked to fill out the survey.

A final total of 97 factories one from each company participated in the study. Among them we excluded 8 factories due to their incomplete answers, and were able to retain 89 factories in the sample. The numbers of factories from the mechanics, electronics, and metal industries were 26, 19, and 12, respectively. The remaining 32 factories in the sample were classified as 'other' industry.

The number of employees, total investment, and manufacturing costs of factories in the sample are presented in Table 1. In terms of the manufacturing costs and total assets per employee, the three industries are similar to each other while the other industry shows higher values. Due to the idiosyncrasy of the other industry, we decided to exclude the other industry from the analysis, and the final sample consists of 57 factories from the three industries only.[2] From now on, all the results presented are for the three industries.

**Table 1**
***Number of employees, total assets and manufacturing cost of sample factories***

| Industry | Mechanics (n=26) | | Electronics (n=19) | | Metal (n=12) | | Other (n=32) | | All (n=89) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Mean** | **SD** | **Mean** | **SD** | **Mean** | **SD** | **Mean** | **SD** | **Mean** | **SD** |
| **Number of employees** | 1,746 | 2,670 | 568 | 534 | 1,538 | 3,316 | 1,072 | 1,438 | 1,268 | 2,107 |
| **Manufacturing cost** (1,000$) | 240,371 | 316,638 | 77,148 | 75,218 | 221,363 | 317,003 | 315,903 | 745,669 | 251,698 | 544,623 |
| **Total Assets** (1,000$) | 403,898 | 607,757 | 187,939 | 209,274 | 448,793 | 800,906 | 515,435 | 970,104 | 434,542 | 785,261 |

'n' represents the number of factories in each subsample.

## 3.2 Definition and Measurement of Variables

Most of the variables used in the study are measured by a set of questionnaire items. The values of the variables are determined by simple averages of responses. The constructs of many variables used in this study are very complex and not well established in the literature, yet. In answering the items, the definitions and meanings might have been differently understood by different responsees. In addition, not much is known about the validity of these survey instruments when they are used in Korea. Therefore, through statistical analyses, we tried to assure the validity of the survey responses. The reliability of each variable was measured and evaluated by Cronbach's alpha coefficients. To evaluate the construct validity of variables, factor analysis was made.

Based on the reliability and the construct validity analysis, we eliminated inappropriate questionnaire items. Particularly, for the construct validity we tried to

2 The other industry seems different from the three industries in other dimensions too. Though we do not show the details in the paper, the three industries are perceived as more competitive and complex than the other industry. In terms of the degree of emphasis for each component of core competence and manufacturing practice variables, the three industries also exhibit values different from those of the other industry.

The idiosyncrasy of the other industry may lead to a different NMP and performance relationship compared to that of the three industries. In fact, the results of analysis are more clear and significant when the other industry is excluded from the analysis presented in Section 4. It is consistent with the fact that NMP are widely adopted and implemented in these three industries while they are not in other industries. Therefore, we exclude the other industry from our analysis.

make sure that each variable reflects only one construct except for two cases.[3] Moreover, in order to assure content validity of each variable, almost all of the researches till today were used in preparing the survey questionnaires. In what follows, we discuss only those questionnaire items retained in the analysis. Detailed list of questionnaire items retained for each variable are contained in the appendix.

### *Environmental and structural characteristics*

Concentration ratio and munificence are popular variables used to measure competition (e.g., Dess and Beard, 1984). Munificence measures the growth or decline in sales over time in an industry. Instead of using these variables, we employ measures indicating the direct impact of competition on manufacturing practices by asking managers how manufacturing requirements are being affected and changed by competitors and customers. When competition becomes higher, companies will have greater needs to develop higher competitive advantage to retain or attract customers relative to competitors. The degree of such needs is measured by speed of changes in customer preferences and that of rival companies' product development and innovation.

Using complexity variable we would like to measure the structural characteristic of a company which increases complex manufacturing transactions Miller and Vollman (1985) talked about. Such a characteristic is determined by various factors of a company: production technologies, number of product types, product mix and quantities, production scheduling, etc. We measure complexity of manufacturing by asking questionnaire items regarding number of product types, product differences in designs and functions, degree of planned production, and predictability of product demand. The construct encompasses a wide array of manufacturing complexity from planning to implementation.

There exist no universal classification criteria for the level of automation, and those of Japan are not appropriate for Korean companies (Kang, 1997). In this study, automation level is measured in a five-point scale ranging from primitive automation using some automated machines to plant-wide integrated automation based on prior researches about automation levels of Korean companies (e.g. Kang, 1997).

### *Core competences: Degree of emphasis and Achieved level*

Core competences are divided into four factors: quality, dependability, flexibility, and cost. Questionnaire items to measure core competences are developed based on prior researches (Ward *et al*., 1995; Dean and Snell, 1996; Small and Yasin, 1997; Gupta and Somers, 1996; Ferdows and De Meyer, 1990; Sakakibara *et al*., 1997). For each item measuring a certain facet of each core competence, both the degree of emphasis the company places on it and the achieved level on it are asked. The degree of emphasis indicates company's strategic directions reflecting how important the aspect is in the company's manufacturing planning and processing. The achieved level indicates company's performance on that facet.

The questionnaire items to measure core competence in cost consist of various cost

3 More on this will be discussed in Section 3.3.

categories: material costs, labor costs, distribution costs, post-sale service costs, indirect manufacturing personnel efficiency, and facility usage efficiency. Core competence in quality encompasses various dimensions from work quality to customer-perceived quality. Items for quality include reliability, durability, exceptional product performance, conformance to specifications and free from defects. Manufacturing flexibility permits a company to cope with environmental uncertainty. Some researchers viewed flexibility primarily in terms of programmable machines, and others viewed it in terms of versatility of people and skills. We include various items to measure flexibility: adapting to changes in product mix, adapting to changes in production quantities, flexibility in developing new products, speed and ease in product changeover, flexibility in redesigning and modifying products, and flexibility in facilities and human resources. Dependability refers to delivery reliability and delivery speed. Questionnaire items include delivering exact items ordered, on-time delivery, improving pre-sale services, and improving post-sale services

### *Practice scales of new manufacturing practices and infrastructures*

The executional level of a manufacturing practice (practice scale) refers to how well all the activities involved in implementation of the practice have been executed. For example, the executional level of TQM depends on how adequately the activities or the methods comprising the TQM program to promote and improve core competences have been applied. Questionnaire items for TQM, JIT, FMS, and infrastructures were selected and developed to effectively measure such executional level of each practice by integrating many researches on the new production method (Ittner and Larcker, 1995; Sakakibara *et al*., 1997; Gupta and Somers, 1996; Lawrence and Hottenstein, 1995; Dean and Snell, 1996; Xenophon *et al*., 1998; Boyer *et al*., 1997; Maffei and Meredith, 1995). The list of specific items used is presented in the appendix. Each item pertains to one of the key aspects of the practices. It was asked whether the manufacturing aspect described by the item is consistent with manufacturing practices at the factory.

### *Financial performance measures*

Besides the achieved levels in core competences, we use various financial performance measures and market share improvement measure. The measures are divided into two categories and presented in the appendix. Relative performances in comparison to those of rival companies for the year of '97 are measured in terms of cost and income. The relative performance measures are presented in Panel A. Improvement performance measures in terms of market share, sales, cost and income are shown in Panel B. They were measured by asking how the performances were improved in a two-year period of '96 and '97.

## 3.3 Construct Validity and Reliability of Variable

Factor analysis and Cronbach’s alpha coefficient computation are made for each variable to examine the construct validity and the response reliability of the variable, and the results are summarized in Table 2. Each variable is measured by a set of questionnaire items. To ensure the construct validity of a variable, it is desirable to make sure that the variable reflects only one construct. To evaluate the construct validity of variables, factor analyses were made. We tried to make sure that the questionnaire items for a variable do not load on more than one factor with eigenvalue greater than 1. If items for a variable load on more than one factor, we deleted some items so that there remains only one factor with eigenvalue greater than 1 for that variable. As a result, except for the variables dependability and FMS, each variable is measured by only one construct, and the proportion of variance loading on the largest factor ranges from a low of 0.485 for JIT to a high of 0.698 for direct cost.

**Table 2**
***Construct Validity and Reliability of Variables***

| Variables | Competition | Complexity | Quality | Dependability | Flexibility | Direct cost |
|---|---|---|---|---|---|---|
| **Cronbach's Alpha** | 0.719 | 0.646 | 0.841 | 0.683 | 0.833 | 0.567 |
| **Proportion of variance loading on largest factor** | 0.560 | 0.488 | 0.614 | 0.538 | 0.551 | 0.698 |
| **No. of factors with Eigenvalue > 1** | 1 | 1 | 1 | 2 | 1 | 1 |
| **Variables** | **Overhead cost** | **TQM** | **JIT** | **FMS** | **Team work** | **Empowerment of employees** |
| **Cronbach's Alpha** | 0.785 | 0.869 | 0.687 | 0.667 | 0.854 | 0.794 |
| **Proportion of variance loading on largest factor** | 0.617 | 0.528 | 0.485 | 0.278 | 0.636 | 0.620 |
| **No. of factors with Eigenvalue > 1** | 1 | 1 | 1 | 3 | 1 | 1 |

Such development of questionnaire items was to increase the construct validity of variables measured. In the case of dependability and FMS, we did not attempt to omit some questionnaire items though we were not able to achieve the unidimensionality of the construct. If we attempt to achieve the unidimensionality of the constructs, we would have lost too many questionnaire items. For example, to sufficiently reflect the aspects of FMS, among 12 questions asked only 3 questions with very high correlation coefficient were eliminated from the computation of the practice scale, and there were 3 factors with eigenvalues greater than 1. As for the Cronbach's Alpha values, the importance of direct cost shows the minimum value which is 0.567, and all the others show considerably higher values.

## 4. The Results and Discussion

Means, standard deviations and correlation coefficients are shown in Table 3. Responsees perceive that the industries are competitive and the production requirements are fairly complex.

**Table 3**
***Correlation coefficients between key variables***

| | Mean | SD | CPT | CMPX | ATM | CST | QLT | FLX | DEP | TQM | JIT | FMS | RCGS | ARP | IMS | IROI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CPT** | 3.325 | 0.672 | | | | | | | | | | | | | | |
| **CMPX** | 3.611 | 0.752 | 0.193 | | | | | | | | | | | | | |
| **ATM** | 2.625 | 0.983 | 0.046 | -0.146 | | | | | | | | | | | | |
| **CST** | 3.939 | 0.608 | 0.153 | 0.104 | 0.068 | | | | | | | | | | | |
| **QLT** | 4.468 | 0.549 | 0.134 | 0.157 | 0.099 | ** 0.336 | | | | | | | | | | |
| **FLX** | 4.000 | 0.620 | ** 0.337 | 0.180 | -0.133 | ** 0.494 | ** 0.431 | | | | | | | | | |
| **DEP** | 4.464 | 0.473 | -0.034 | 0.185 | -0.077 | + 0.230 | * 0.286 | * 0.403 | | | | | | | | |
| **TQM** | 3.267 | 0.717 | 0.074 | 0.051 | * 0.303 | 0.108 | 0.175 | 0.048 | 0.202 | | | | | | | |
| **JIT** | 3.680 | 0.602 | -0.004 | -0.068 | 0.196 | -0.128 | ** 0.431 | 0.102 | 0.034 | ** 0.456 | | | | | | |
| **FMS** | 3.381 | 0.479 | 0.012 | -0.021 | 0.166 | 0.145 | + 0.230 | 0.145 | 0.042 | ** 0.653 | ** 0.507 | | | | | |
| **RCGS** | 3.074 | 0.887 | ** 0.360 | 0.008 | -0.057 | 0.215 | 0.181 | * 0.296 | 0.133 | * 0.330 | 0.094 | ** 0.381 | | | | |
| **ARP** | 3.198 | 0.659 | 0.120 | -0.080 | -0.204 | -0.010 | 0.114 | 0.128 | -0.237 | 0.202 | * 0.328 | ** 0.363 | ** 0.652 | | | |
| **IMS** | 3.339 | 0.898 | + 0.229 | + -0.257 | -0.062 | 0.021 | + 0.250 | 0.159 | -0.285 | 0.047 | * 0.291 | + 0.240 | * 0.326 | ** 0.560 | | |
| **IROI** | 3.132 | 1.038 | 0.037 | -0.163 | 0.007 | -0.020 | 0.111 | 0.037 | -0.164 | 0.068 | ** 0.389 | 0.208 | 0.113 | ** 0.471 | ** 0.652 | |
| **AIP** | 3.311 | 0.796 | 0.153 | -0.204 | -0.076 | 0.018 | + 0.262 | 0.088 | -0.151 | 0.067 | ** 0.390 | + 0.258 | + 0.256 | ** 0.554 | ** 0.838 | ** 0.902 |

****Significance level below 1%, * Significance level below 5%, +Significance level below 10%**

**CPT: Competition**
**CMPX : Complexity**
**ATM: Automation**
**CST: Degree of emphasis on cost**
**QLT: Degree of emphasis on quality**
**FLX: Degree of emphasis on flexibility**
**DEP: Degree of emphasis on dependability**
**TQM: Executional level of TQM**
**JIT: Executional level of JIT**
**FMS: Executional level of FMS**
**RCGS: Relative performance in cost of goods sold ratio**
**ARP: Average relative performance**
**IMS: Improvement performance in market share**
**IROI: Improvement performance in ROI**
**AIP : Average improvement performance**

Core competence shown in Table 3 are the degrees of emphasis. They represent competitive priorities or strategic directions in manufacturing. They are quite high for all the components. Comparing the degrees among the components, they are higher for quality and dependability and lower for flexibility and cost[4]. According to the cumulative theory (Fedoras and De Meyer, 1990), a company needs to build up dependability based on quality competitiveness. Then it can achieve flexibility, and finally cost competitiveness. That is, the upper dimension competitiveness can be built based on lower ones. [5] Viewing from this perspective, Korean companies sufficiently recognize the importance of quality and dependability, but put relatively less emphasis on flexibility and cost, yet. In other words, companies have not reached sufficiently high stage in terms of the cumulative theory.

Though we used different questionnaire items and response scales, the responses by Korean companies can be compared to those of the U.S. companies in Dean and Snell (1996) presented in Table 4. It is interesting to observe that Korean companies show a response pattern similar to that of the U.S. companies in that the competitive priorities are higher for quality and dependability and lower for flexibility and cost. In Dean and Snell (1996) response level 4 represents moderate level of importance out of 7-point scale. Corresponding response level would be between 3 and 4 for the current study out of 5-point scale. Hence, the responses are very comparable between the two studies in terms of the response levels, too.

A similar observation can be made for the NMP executional level comparisons between the two studies. The levels are higher for JIT than TQM, and the executional levels can be regarded as fairly high in both countries.

**Table 4**

4 In terms of the achieved levels, the levels for quality, dependability, flexibility and cost are 3.93, 3.95, 3.61 and 3.32, respectively. The achieved level for each component is lower than the degree of emphasis for that component. The differences among the achieved levels, however, are quite similar as the case of the degrees of emphasis: higher levels for quality and dependability but lower levels for flexibility and cost.

5 Others argue that companies can increase its competence in quality, dependability, flexi bility and cost simultaneously through the execution of strategy that recognizes the interrelationship of all the activities within the companies (Suarez *et al*., 1995, p26).

***Degrees of emphasis in core competence and NMP levels in the U.S. companies***

| Variables | Quality | Depend-ability | Flexibility | Cost | TQM | JIT |
|---|---|---|---|---|---|---|
| **Mean** | 5.62 | 5.01 | 4.80 | 4.81 | 3.99 | 4.43 |
| **Standard Deviation** | 0.71 | 0.69 | 0.91 | 0.89 | 0.94 | 0.78 |

Source: Dean and Snell (1996)

Due to the differences in the way the items are constructed and in the response scales, we were not able to directly compare the competitive priorities and the NMP levels between the two countries. Considering the distribution pattern we just examined for the core competences and the practices between the countries, however, one can state that companies in the two countries are very comparable to each other in strategic directions and manufacturing practices.

### 4.1 The Company's Environmental and Structural Characteristics and Its Strategic Directions

Before analyzing the impact of NMP and company's environmental and structural characteristics on performance, we examine whether these characteristics affect a company's choice of strategies. The complexity, competition, and automation can affect companies' decision as to how to emphasize each component of core competence to obtain competitive advantage. Ordinary least square (OLS) regression was used to examine the possible relationship between the degree of emphasis as the dependant variable and the structural and environmental characteristics as the independent variable.[6]

**Table 5**

***Company's characteristic variables and the degree of emphasis of each core competence***

| Dependent Variables | Coefficients of the independent variables (p-value) | | | $R^2$ | F (Sig. Level) |
|---|---|---|---|---|---|
| | Competition | Complexity | Automation | | |
| **Distribution cost efficiency** | 0.420** (0.006) | 0.046 (0.746) | 0.041 (0.684) | 0.155 | 2.991 (0.030) |
| **Post-sales service cost efficiency** | 0.450* (0.011) | 0.121 (0.461) | 0.112 (0.338) | 0.159 | 3.083 (0.036) |
| **Indirect manufacturing personnel efficiency** | 0.156 (0.283) | 0.320* (0.023) | -0.018 (0.851) | 0.137 | 2.584 (0.064) |
| **Facility usage efficiency** | 0.039 (0.789) | 0.571** (0.000) | -0.015 (0.876) | 0.269 | 6.002 (0.001) |

6 Since there could be differences in the relationship between the independent and dependent variables across industries, we included dummy variables in regression analysis to control for possible industry effect. But, the industry effect was insignificant, and we present only the results of the analysis without the dummy variables.

| | | | | | |
|---|---|---|---|---|---|
| **Quality** | 0.056 (0.615) | 0.074 (0.486) | 0.052 (0.496) | 0.025 | 0.422 (0.738) |
| **Flexibility** | 0.307* (0.016) | 0.120 (0.311) | -0.085 (0.315) | 0.158 | 3.067 (0.037) |
| **Dependability** | -0.063 (0.523) | 0.143 (0.132) | -0.017 (0.797) | 0.054 | 0.926 (0.435) |

****Significance level below 1%, * Significance level below 5%, +Significance level below 10%**

Table 5 shows that degrees of emphasis on cost and flexibility appear to be influenced by the characteristic variables while those on quality and dependability do not. Specifically, complexity is positively related to emphasizing indirect personnel and facility efficiency, which is consistent with the claim that overhead cost increase due to production complexity requires more attention to cost management.

Higher competition means higher speeds of customers' preference changes and competitors' development and innovation changes. Hence, higher competition would entail companies to raise service level and flexibility. The results are consistent with this assertion in that companies with higher competition pay attention to distribution and post-sale service cost, and flexibility more compared to other companies

As mentioned above, Korean manufacturing companies place quite high priorities to quality and dependability. The results in Table 5 might imply that almost all companies emphasize product quality and dependability so highly that the levels of emphasis for quality and dependability are not much different among companies regardless of the levels of competition and complexity.

### 4.2 Company's Strategic Directions and New Manufacturing Practices.

A company's production technologies can affect its choice of a strategy (Hayes, 1985). At the same time, production technologies are basically determined by its strategy (Skinner, 1969). In other words, strategy and production literatures emphasize the alignment of manufacturing practices with strategy in such a way of improving those core competences which are suitable to its manufacturing environment. In order to examine whether strategic directions are related to the executional levels of NMP, regression analysis is made, and the results are presented in Table 6.

**Table 6**
***The relationship between the importance of core competences and the practice scales***

| Dependent variables | Coefficients of independent variables (p-value) | | | | | $R^2$ | F (Sig. Level) |
|---|---|---|---|---|---|---|---|
| | Direct cost efficiency | Indirect cost efficiency | Flexibility | Depend-ability | Quality | | |
| **TQM** | 0.222 (0.222) | -0.214 (0.325) | -0.052 (0.799) | 0.398+ (0.092) | 0.159 (0.477) | 0.118 | 1.252 (0.300) |
| **JIT** | -0.231 (0.102) | -0.149 (0.374) | -0.016 (0.921) | -0.052 (0.774) | 0.691** (0.000) | 0.284 | 3.735 (0.006) |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **FMS** | 0.082<br>(0.595) | -0.389*<br>(0.040) | -0.025<br>(0.887) | 0.341+<br>(0.092) | 0.347+<br>(0.074) | 0.17<br>8 | 2.030<br>(0.092) |

****Significance level below 1%, * Significance level below 5%, +Significance level below 10%**

Table 6 shows that the executional levels of JIT and FMS are associated with the company's strategic directions whereas the regression regarding TQM is not statistically significant. In particular, the results regarding JIT seem interesting. The executional level of JIT is positively associated with the degree of emphasis on quality. This result is consistent with previous studies in industrialized countries that companies adopt JIT mainly to secure product quality (Zipkin, 1991). The executional level of FMS is associated with the degrees of emphasis on dependability and quality. This is also consistent with the findings of a study regarding the US companies by Small and Yasin (1997). On the other hand, companies emphasizing indirect cost efficiency tend to have low FMS practice scale.

Like the current study, a survey of US companies by Dean and Snell(1996) also did not find significant relationship between company's strategic directions and the practice scales. These results may seem inconsistent with the assertions and findings of prior studies that NMP boost various core competences (Belohlav, 1993; Tampa, 1991; Zygmont, 1989; Swamidass and Newell, 1987; Small and Yasin, 1997). Such inconsistency may result, however, when responding companies have different opinions as to which component of the core competences could be improved by each NMP even if NMP and the strategic directions do have relationship.

### 4.3 Execution of New Manufacturing Practices and Core Competence Performance

In order to analyze how execution of NMP improves performance of a company, we measure performance by two groups of proxy variables, achieved levels of core competences and financial performances. In this subsection the analysis is made regarding the core competence performance, and the achieved level is taken as the dependant variable of the regression. Among the various achieved level variables, we present the result of regression with the quality variable in Table 7-1. The analysis is repeated for three different sets of the independent variables. The first column reports the case where the independent variables consist of the companies' characteristic variables only. The second column reports the case where the independent variables consist of the company's characteristic variables, the executional levels of NMP and the infrastructure variables. Rather than including both the teamwork and the employee empowerment as separate variables in the regression, we define and use the average of them as INFRA.[7]

The third column reports the case of analyzing the interaction effect between the companies' characteristics and NMP. Three multiplicative variables are added to the

7 These two variables are highly correlated. In fact both systems are very related and complementary to each other in that they are promoted to enhance effective problem-solving in today's complex and competitive environment. And, their coefficients are not significant in any regression equations we ran. Therefore, rather than trying to explicate the effect of the individual variable unsuccessfully, we want to examine the effect of the infrastructure as a whole.

second set of the variables. They are three interaction terms between the average executional level of TQM, JIT and FMS and each of the three characteristic variables. There are several reasons why we use the average practice scale for the interaction effect terms. First, the constructs of the practice scales reflect very complex and diverse features of production and, therefore, effective measurement is difficult. No matter how well the questionnaire items are developed, measurement errors are inevitable. Averaging the three scales may reduce the possible measurement errors, and enhance the validity of the practice scale in representing the executional levels of NMP. If one wants to measure the interaction effect of each characteristic variable with each and every practice variable, there have to be nine interaction variables. Due to a relatively small sample size, we did not attempt to include that many variables in regression. Finally, as one can see in Table 3, the three NMP variables show very high correlations. Therefore estimating and interpreting the interaction effect for each NMP variable may not be valid due to possible confounding effect among the NMP variables.

When the independent variables consist of the characteristic variables only, the regression shows no significant results. Competition, complexity and automation levels by themselves may not be related to companies' core competence performance. On the other hand, when the executional levels of NMP are added for the second set of the independent variables, the regression shows a significant F-value and a considerable $R^2$. The coefficients for TQM and JIT are also significant. As for the interaction effect of the NMP with the characteristic variables, the third column shows no significant coefficients for the interaction variables.

**Table 7-1**

***Analysis of factors affecting companies' achieved level of product quality***

| Independent Variables | Regression coefficient of independent variables (P-value) | | |
|---|---|---|---|
| | Achieved level of quality | | |
| **Competition** | -0.010 (0.926) | -0.057 (0.559) | -1.195 (0.247) |
| **Complexity** | 0.023 (0.816) | 0.023 (0.788) | 0.441 (0.483) |
| **Automation** | 0.099 (0.178) | 0.017 (0.802) | 0.148 (0.792) |
| **TQM** | - | 0.314* (0.025) | 0.163 (0.743) |
| **JIT** | - | 0.212 (0.103) | 0.095 (0.860) |
| **FMS** | - | -0.263 (0.163) | -0.490 (0.362) |
| **INFRA** | - | 0.177 (0.285) | 0.161 (0.342) |
| **Competition ×PRS++** | - | - | 0.338 (0.255) |

| | | | |
|---|---|---|---|
| **Complexity ×PRS++** | - | - | -0.137 (0.452) |
| **Automation ×PRS++** | - | - | -0.037 (0.820) |
| $R^2$ | 0.036 | 0.379 | 0.414 |
| **F** | 0.621 | 4.011 | 3.035 |
| **Significance level of F** | 0.605 | 0.002 | 0.005 |

**++PRS: Average practice scale (Average of TQM, JIT, and FMS)**
****Significance level below 1%, * Significance level below 5%, + Significance level below 10%**

Although not listed in a separate table, the same regression analyses were repeated using the achieved levels of cost, dependability, and flexibility as the dependent variables. Unlike the case of quality, the regression results for the other core competences are not significant for any of the three sets of the independent variables.

It is interesting to note that companies' performance in dependability, flexibility and cost competence cannot be explained by their NMP variables whereas the performance in quality is significantly related to the executional levels of NMP. One may state that Korean manufacturing companies are to some extent successful in achieving the quality competitiveness via implementation of NMP but not so successful in achieving the higher- rank core competences. As noted at the beginning of this section, Korean companies in general highly recognize the importance of quality and dependability, but not that of flexibility and cost. Viewing from the cumulative theory that the upper dimension competitiveness can be built based on lower ones, Korean companies have reached only the level of obtaining basic core competence, quality, but have not been successful yet for the higher-rank core competences, flexibility and cost through the execution of NMP.

## 4.4 Execution of New Manufacturing Practices and Financial Performance

As explained in Section 3.2, financial performance measures are divided into two categories.[8] The first category is relative performance compared with rival companies for the year of 1997. The relative performance is measured in three variables: cost of goods sold ratio, ROI and operating income ratio. The second part is to measure the improvement in financial performance over the two-year time span of 1996-97. The improvement performance is measured in five variables: market share, sales, cost of goods sold ratio, ROI, and operating income ratio. To analyze how financial performance is affected by the implementation of NMP and other factors, we take each performance variable as the dependant variable of the regression. Also included as the dependent variables are the average relative performance and the average improvement performance.

Results are presented for selected financial performance variables. Table 7-2 shows

8 As explained in Section 3.1, we take a factory not a whole company as a unit of subject for our analysis. Since archival data are usually available only for a whole company, it is impossible to use published financial data to measure a factory's performance.

the results regarding the relative performance in cost of goods sold ratio and the average relative performance. Table 7-3 shows the results regarding the improvement in market share, improvement in ROI, and the average improvement performance. As we did for the achieved levels of core competences, for each dependent variable the analysis is repeated for three different sets of the independent variables. The first column reports the case where the independent variables consist of the companies' characteristic variables only. The second column reports the case where the independent variables consist of the company's characteristics, the executional levels of NMP and the infrastructure variables. The third column reports the case of analyzing the interaction effect between the companies' characteristics and the average executional level of TQM, JIT and FMS. Three interaction terms between each of the three characteristic variables and the average practice scale are added to the second set of the variables.

### *How companies' financial performances are affected by the environmental and structural characteristics*

When the independent variable consists of the companies' characteristic variables only, they do not show significant relationships with companies' performance except for the case of market share improvement performance. In particular, they account for almost none of the variance in ROI improvement performance. Similar to the case of core competence performance, the result shows that competition, complexity and automation levels by themselves do not affect companies' financial performance.

Although statistically not significant, it is interesting to note that the regression coefficients of the complexity and automation variables are negative for all the regressions. It is possible that, as the company's production becomes complex and the investment in automation increases, there is a tendency to post unfavorable results in cost, profitability, and sales. An intuitive interpretation may be that, as the production complexity increases, the additional cost burden particularly in terms of overhead costs pointed out by Miller and Vollman (1985) adversely affects the company's results without commensurating benefits high enough to yield net profit increase for the company. Companies may raise the automation level for various reasons. It seems, however, that automation itself may have a negative influence on companies' financial performance. More on these will be discussed below.

**Table 7-2**
***Analysis of factors affecting companies' relative performance***

| Independent variables | **Regression coefficients of independent variables (P-value)** | | | | | |
|---|---|---|---|---|---|---|
| | **Relative performance in CGS ratio** | | | **Average relative performance** | | |
| **Competition** | 0.475* (0.010) | 0.579** (0.001) | 2.386 (0.174) | 0.146 (0.281) | 0.255 (0.051) | 1.584 (0.210) |
| **Complexity** | -0.091 (0.589) | -0.123 (0.418) | -1.936+ (0.074) | -0.139 (0.277) | -0.118 (0.300) | -1.753* (0.027) |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Automation** | -0.072 (0.553) | -0.235+ (0.055) | -0.883 (0.353) | -0.155+ (0.097) | -0.279** (0.003) | -0.541 (0.430) |
| **TQM** | - | 0.521* (0.034) | 0.236 (0.780) | - | 0.216 (0.234) | -0.060 (0.921) |
| **JIT** | - | -0.042 (0.853) | -0.481 (0.599) | - | 0.382* (0.029) | -0.041 (0.950) |
| **FMS** | - | 0.809* (0.017) | 0.709 (0.436) | - | 0.488+ (0.053) | 0.408 (0.535) |
| **INFRA** | - | -0.655* (0.028) | -0.577* (0.048) | - | -0.507* (0.024) | -0.440* (0.037) |
| **Competition ×PRS++** | - | - | -0.553 (0.270) | - | - | -0.414 (0.254) |
| **Complexity ×PRS++** | - | - | 0.562+ (0.073) | - | - | 0.509* (0.026) |
| **Automation ×PRS++** | - | - | 0.185 (0.502) | - | - | 0.072 (0.717) |
| $R^2$ | 0.128 | 0.376 | 0.454 | 0.079 | 0.346 | 0.473 |
| **F** | 2.446 | 3.959 | 3.576 | 1.436 | 3.481 | 3.852 |
| **Significance level of F** | 0.075 | 0.002 | 0.002 | 0.243 | 0.004 | 0.001 |

**++PRS: Average practice scale (Average of TQM, JIT, and FMS)**
****Significance level below 1%, * Significance level below 5%, + Significance level below 10%**

**Table 7-3**
***Analysis of factors affecting companies' improvement performance***

| Independent variables | Regression coefficient of independent variables (P-value) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Improvement in market share** | | | **Improvement in ROI** | | | **Average improvement performance** | | |
| **Competition** | 0.360* (0.044) | 0.505** (0.006) | 0.973 (0.598) | 0.107 (0.627) | 0.212 (0.350) | -0.103 (0.966) | 0.230 (0.156) | 0.298+ (0.071) | -0.163 (0.923) |
| **Complexity** | -0.399* (0.020) | -0.351* (0.029) | -2.294* (0.047) | -0.227 (0.227) | -0.155 (0.439) | -1.582 (0.284) | -0.265 (0.087) | -0.207 (0.154) | -1.945+ (0.065) |
| **Automation** | -0.106 (0.376) | -0.202 (0.110) | -1.976+ (0.054) | -0.028 (0.854) | -0.117 (0.465) | -2.042 (0.123) | -0.099 (0.370) | -0.161 (0.164) | -1.898* (0.044) |
| **TQM** | - | -0.004 (0.987) | -0.974 (0.279) | - | -0.082 (0.796) | -1.123 (0.336) | - | -0.118 (0.605) | -1.277 (0.123) |
| **JIT** | - | 0.548* (0.023) | -0.570 (0.557) | - | 0.771* (0.013) | -0.366 (0.771) | - | 0.567* (0.011) | -0.724 (0.416) |
| **FMS** | - | 0.533 (0.123) | -0.442 (0.647) | - | 0.252 (0.562) | -0.900 (0.473) | - | 0.322 (0.306) | -0.899 (0.311) |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **INFRA** | - | -0.581 + (0.059) | -0.478 (0.119) | - | -0.336 (0.383) | -0.250 (0.525) | - | -0.209 (0.450) | -0.113 (0.683) |
| **Competition ×PRS++** | - | - | -0.158 (0.765) | - | - | 0.080 (0.908) | - | - | 0.115 (0.811) |
| **Complexity ×PRS++** | - | - | 0.568+ (0.087) | - | - | 0.399 (0.350) | - | - | 0.497 (0.102) |
| **Automation ×PRS++** | - | - | 0.516+ (0.081) | - | - | 0.562 (0.142) | - | - | 0.506+ (0.063) |
| $R^2$ | 0.152 | 0.323 | 0.382 | 0.026 | 0.189 | 0.230 | 0.088 | 0.275 | 0.338 |
| **F** | 2.988 | 3.132 | 2.659 | 0.438 | 1.532 | 1.281 | 1.603 | 2.490 | 2.192 |
| **Significance level of F** | 0.040 | 0.009 | 0.013 | 0.727 | 0.181 | 0.271 | 0.200 | 0.030 | 0.037 |

**++PRS: Average practice scale (Average of TQM, JIT, and FMS)**
****Significance level below 1%, * Significance level below 5%, + Significance level below 10%**

### *How companies' financial performances are affected by the characteristics and the executional levels of NMP*

When the executional levels of NMP are added for the second set of the independent variables in addition to the characteristic variables, the regressions show significant F-values and considerable $R^2$'s except for the case of ROI improvement performance. The coefficients of the NMP variables are also significant in many cases. In particular, the executional level of JIT, except for the case of the relative performance in cost of goods sold ratio, is significantly related to companies' financial performance in all cases at the significance level of about 1% to 5%.

The results for TQM and FMS coefficients are somewhat unstable in the sense that the significance levels vary and the signs of the coefficients change across the regression equations. As in Table 3, the three NMP variables show very high correlations. The instability of the NMP variable coefficients may be due to possible confounding effect among the NMP variables. Therefore, it is not possible to clearly interpret the results for the individual NMP variables, particularly for the TQM and FMS. It can be claimed, however, that new manufacturing practices collectively contribute to enhancing companies' financial performance. More specifically, one can argue that the effort to successfully execute JIT through lean production, multi-skilled workers and bottle-neck management is significantly related to financial performance. The executional level of FMS can also be claimed as a significant factor for financial performance.

Companies' financial performance can be compared to their achieved level of core competences in relation to NMP implementation. In Section 4.3 we noted that companies' performance in dependability, flexibility and cost competence cannot be explained by their NMP variables whereas the performance in quality is significantly related to the executional levels of NMP. Viewing from the cumulative theory, we asserted that Korean companies have reached the level of obtaining only basic core competence, quality. Though Korean companies have not been successful yet for the higher-rank core competences, flexibility and cost, through the execution of NMP, they did benefit from NMP implementation. In other words, the results show the value of NMP, and particularly, the value depends on the executional levels of the new practices being implemented.

The instability of the individual coefficients of the NMP variables may be due to the small sample size of the study. If we had had a larger sample, one might have obtained rather consistent coefficient behavior across various regression equations, particularly given significant improvement in terms of F-value and $R^2$ obtained for the regression with the second set of the independent variables compared to that with the first set. In order to clarify the impact of the NMP, particularly the impact of each individual practice, a study with a larger sample is necessary.

One of the limitations of the current study is not taking proper steps to ensure the NMP-performance relationship is not spurious. One legitimate concern would be a self-selection bias that 'good' companies adopt and implement NMP to a greater extent compared to not-so-good companies. In other words, higher performance of good companies could be due to some other attributes of those companies which are correlated to the NMP variables but not due to NMP themselves. One possible way of dealing with such problems is to include a control sample. Due to research scope constraints, however, we were not able to pursue such an avenue. As an alternative way of evaluating the self-selection bias, we checked some correlation measures. In general, the size of a company can be regarded as a surrogate measure indicating how well the company is managed. For example, as an industry leader, a bigger company is likely to perform various activities to enhance performance. If correlations between the size and the NMP variables are significant, the association we observed between the NMP and performance may be, in fact, due to other factors of 'big' companies not due to the execution of NMP. The results of correlation analyses, however, are very insignificant for most of the performance variables. That is, it cannot be claimed that the association between NMP and performance is because big companies self-select to have high NMP executional levels.

The coefficient of INFRA is significantly negative, particularly for the relative performance. This is contradictory to previous studies by Ward *et al*. (1994), Boyer *et al*. (1997), Sakakibara *et al*. (1997) and many others which supported the positive effect of the infrastructures. More on this will be discussed in the next subsection.

***How the impact of NMP on companies' financial performances is moderated by the charateristic variables***

The questionnaire items we used to measure the executional levels of NMP are developed based on those which have been used and tested in many previous studies. Noting the response reliability and construct validity measures presented in Table 2, one can claim that we effectively measured the executional levels. Significant coefficients of the NMP variables we obtained for the second set of the independent variables can also give support to this claim. But, as mentioned in Section 2.2, the executional levels represent the effectiveness of the execution of NMP from a "general" point of view. A company's successful executional level of a practice is not determined only by the effectiveness of the execution itself. The successful executional level may also be influenced by its structural and environmental characteristics. In other words, the relationship between NMP and performance may be moderated by the level of competition, complexity and automation. The third column in Table 7-2 and 7-3 reports the results of the regression equations analyzing the interaction effect between the companies' characteristics and the average executional level of TQM, JIT and FMS.

Table 7-2 and Table 7-3 show that there exist significant interaction effect between the company's characteristics and the executional levels of NMP. In particular, the moderating effect of the complexity is shown to be significant for all regressions, and that of automation is shown to be significant in the case of the improvement performance in market share and the average improvement performance.

Note that the direct effect of complexity on performance is negative. The moderating effect of complexity with the average NMP variable on performance, however, is positive, and furthermore, the magnitude of the positive moderating effect is large enough to offset the direct negative effect. In other words, a company with high production complexity can take advantage of that complexity as an opportunity to improve its financial performance if it responds with appropriate execution of NMP. On the other hand, if a company with high complexity does not properly execute NMP, the consequence will be a performance loss

A similar interpretation can be made for the case of automation. Even though automation by itself can have a negative effect on company's performance, the company can take advantage of it as a competitive weapon when NMP are appropriately adopted and executed. In sum, the results show that companies need to respond properly to their manufacturing characteristics, and NMP can be adopted and implemented as effective measures to improve performance.

As we mentioned above, the coefficient of INFRA is significantly negative, and it is contradictory to the findings of previous studies. Many researchers, however, advocated the importance of teamwork and employee empowerment in today's manufacturing environment (e.g., Banker, et al., 1993). In an environment where technologies keep changing and complexity of operation is high, employees need team approach to solve difficult problems. Employee empowerment is also important to let the employees find and solve problems for themselves. Therefore, it is asserted that the infrastructures should have not only direct impact but also indirect impact on performance by positively moderating NMP's impact on performance. Though we do not present the result, regression analyses for which the interaction term of INFRA and PRS was added to the third set of the independent variables were made to test the moderating effect. But, the coefficient of the interaction term was not significant for none of the dependent variables.

Like the case of NMP variables, the questionnaire items used to measure the teamwork and employee empowerment variables are developed based on those which have been used and tested in many previous studies. Referring to the response reliability and construct validity measures in Table 2, one can claim that the variables are effectively measured.[9]

Given the positive evidences in previous studies (e.g., Sakakibara *et al*. (1997), etc.) and the validity of measurement, the negative result we obtained is surprising. One plausible reason is that in Korean manufacturing companies teamwork and employee empowerment are not adopted well enough to the degree that they can be effective or they do not play the roles asserted in the literature. A further research is necessary to

9 As for the reliability of the responses, Table 2 shows that the teamwork and the employee empowerment variables have Cronbach's alpha coefficients higher than 60%. The factor analysis also supports the claim that the two variables represent valid constructs.

investigate the issue.

## 5. Summary and Conclusion

Production and strategy literatures advocated and examined matches between strategic directions (core competences) and NMP. In other words, the focus of the literatures was to examine whether companies align NMP with strategic directions and whether the alignment leads to core competence improvements. Their results, however, were not as clear as they expected. Based on a moderate size sample of Korean manufacturing companies, we also find a similar result that matches between strategic directions and NMP are not significant although the executional level of NMP positively affects performance.

Rather than concentrating on the matches, we investigated the moderating effect of company characteristics on NMP-performance relationship. Among company characteristics, complexity is one of the key structural aspects of today’s companies emphasized by many researchers in management accounting. Secondly, unlike the prior studies examining the performance impact in terms of core competences, we investigated whether NMP lead to improvement in financial performance which measures the ultimate performance companies try to achieve as well as improvement in core competences.

Our analysis found that the structural characteristics (the complexity of production and the level of automation) adversely affect performance while the competitive environment does not have a significant impact. The result that a higher level of automation leads to lower performance implies that automation itself is not what enhances the competitiveness and growth of a company.

As for the interaction effect of the structural and environmental variables, we find that the positive impact of the new practices is greater for the companies with higher levels of the complexity and automation. In other words, the need for successful execution of the new practices is greater for those companies. This finding is important in that it implies how a company should respond to today’s changing environment. When a company builds a manufacturing structure of higher complexity and automation, it cannot fully capitalize the structure unless it successfully implements NMP. The competition, however, does not show a positive interaction effect with the executional level of the new practices.

Few studies have dealt with the impact of NMP in emerging economies. Most studies involve the U.S. companies. We showed that the positive impact of NMP can be found in the case of Korean companies also. It remains, however, as an interesting issue to explore whether the moderating effect of complexity and automation on NMP-performance relationship can be found for U.S. and other developed countries’ companies.

Many researchers advocated the importance of teamwork and employee empowerment in today’s manufacturing environment. We investigated whether teamwork and employee empowerment positively affect NMP’s impact on performance. Unlike the findings of previous research, however, we do not observe any positive effect of teamwork and employee empowerment on performance. In addition to teamwork and employee empowerment, performance evaluation system and human-resource management system are considered to be important elements of the infrastructures. Further research is necessary to evaluate the role of infrastructures on performance, particularly in relation to the performance impact of NMP.

The current study evaluates various complex aspects of manufacturing and performance, and it was inevitable to use questionnaire instruments due to the rich construct nature of the variables measured. The validity of the findings, however, is critically hinges on the reliability of the measurement. Several approaches can be taken to enhance the validity of the current study. Data consistency and construct validity can be evaluated and increased by using actual financial and non-financial data from various sources as complementary and supplementary data. Conducting comparative studies across several countries could be another way of improving the validity of the analysis.

# Appendix

## List of questionnaire items and response scales

***1. Environmental and structural characteristics***

**1-1. Competition**

1a. Speeds of customer preference changes (1 = very slow ~ 5 = very fast)
1b. Rival companies' product development and innovation speed
(1=very slow ~ 5 = very fast)

**1-2. Complexity**

2a. Number of Product Types (1 = very few ~ 5 = very many)
2b. Product differences in designs and functions (1 = very little ~ 5 = very big)
2c. Degree of planned production (1 = very planned ~ 5 = very unplanned)
2d. Predictability of product demands (1 = very high ~ 5 = very low)

**1-3. Automation level**

(1 = use of some automated machines ~ 5 = plant-wide integrated automation)

***2. Core competence: Degree of Emphasis and Achieved level:***

**A. Response scale for Degree of emphasis:**

(1 = not emphasize at all ~ 5 = very emphasize)

**B. Response scale for Achieved level:**

(compared to rival companies: 1 = much lower ~ 5 = much higher)

***2-1. Cost***

1. Material costs
2. Labor costs
3. Distribution costs
4. Post-sales service costs
5. Efficiency in indirect manufacturing personnel
6. Efficiency in facility usage

**2-2. *Quality***

1. Reliability
2. Durability
3. Exceptional product performance
4. Conformance to specifications
5. Free from defects

***2-3. Flexibility***

1. Adapting to changes in product mix
2. Adapting to changes in production quantities
3. Flexibility in developing new products
4. Speed and ease in product changeover
5. Flexibility in redesigning and modifying products
6. Flexibility in facilities and human resources

***2-4. Dependability***

1. Delivering exact items ordered
2. On-time delivery
3. Improving pre-sale services
4. Improving post-sale services

***3. Practice scales of new manufacturing practices and infrastructure***

Whether each of the following items is consistent with manufacturing practices at the factory:
(1 = not consistent at all ~ 5 = very consistent)

**3-1. Total Quality Management (TQM)**

1. Encourage quality circles
2. Promote participation by sales, purchases and production personnel in product development & design
3. Importance of design for manufacturability &quality
4. Compensate workers for quality improvement
5. Use of statistical process control
6. Use of process value analysis, quality function deployment, etc.
7. Use of quality control chart, Pareto diagram, etc.
8. Close relationship with a few high quality suppliers

**3-2. Just-In-Time (JIT)**

1. Training for multi-skilled workers
2. Encourage communications among manufacturing processes
3. Effort to improve bottle- neck manufacturing processes
4. Demand-pull production
5. Frequent delivery of materials to workplace in small quantities as needed

**3-3. Flexible Manufacturing System (FMS)**

1. Productivity loss due to schedule changes is low
2. Possible to perform various activities at low change-over costs
3. Try to improve plant layout, tooling, etc. to reduce setup time
4. Evaluate capacity to efficiently plan and use facilities and personnel
5. High link between FMS and marketing function
6. Continuous effort to improve design for manufacturability
7. Short time required to double the output of the system
8. Efficient material handling system
9. Productivity loss due to breakdown of some facilities is low

**3-4. Use of team system**

1. Easy to form teams
2. Contribution by small group meetings is important
3. Potential to contribute as a team member is important
4. Higher weight to team performance in evaluation
5. Emphasize diversity of team members

**3-5. Empowerment of employees**

1. Employees can carry out many tasks without superior’s approvals
2. Active involvement of employees in process improvement programs
3. Encourage employees to identify problems and solutions for themselves
4. Let workers implement their own improvement ideas

## *4. Various performance measures*

**A. Relative performance compared to rival companies for the year ‘97:**

(1 = very lower ~ 5 = very higher)

1. CGS ratio (reverse scale)
2. ROI (operating income/total asset)
3. Operating income ratio (operating income/total sales)

**B. Improvement performance during the two-year period of '96 and '97 :**

(1 = big decrease ~ 5 = big increase)

1. Market share
2. Sales
3 .CGS ratio (reverse scale)
4. ROI (operating income/total asset)
5. Operating income ratio (operating income/total sales)

## References

Banker, R, G. Potter, and R. Schroeder, 1993. Reporting Manufacturing Performance Measures to Workers, *Journal of Management Accounting Research*, 33-55.

Belohlav, J. A., 1993. Quality, Strategy, and Competitiveness, *California Management Review*, 55-67.

Boyer, K., G. Leong, P. Ward and L. Krajewski, 1997. Unlocking the Potential of Advanced Manufacturing Technologies, *Journal of Operations Management,* 15, 331-347.

Ciampa, D., 1991. *Total Quality: A User's Guide to Implementation*. Addison-Wesley, Reading, MA.

Dean, J., and S. Snell, 1996. The Strategic Use of Integrated Manufacturing: An Empirical Examination, *Strategic Management Journal*, 17, 459-480.

Dess, G.., and D. Beard, 1984. Dimensions of organizational task environments, *Administrative Science Quarterly,* 29, 52-73.

Ferdows, K. and A. De Meyer, 1990, Lasting Improvements in Manufacturing Performance: In Search of a New Theory, *Journal of Operations Management* , 9, 168-183.

Gupta, Y., and T. Somers, 1996. Business Strategy, Manufacturing Flexibility, and Organizational Performance Relationships: A Path Analysis Approach, *Production and Operations Management*), 204-233.

Hayes, R. H., 1985. Strategic Planning: Forward in Reverse, *Harvard Business Review,* 63-6, 111-119.

Ittner, C., and D. Larcker, 1995. TQM and the Choice of Information and Reward System, *Journal of Accounting Research* (Supp), 1-40.

Kang, S., 1997. Factory automation in Korean manufacturing companies, *Korean Journal of Operation Management*, 171-201.

Lawrence, J., and M. Hottenstein, 1995. The Relationship between JIT Manufacturing and Performance in Mexican Plants Affiliated with U.S. Companies, *Journal of Operations Management,* 13, 3-18.

Maffei, M., and J. Meredith, 1995. Infrastructure and Flexible Manufacturing Technology: Theory Development, *Journal of Operations Management* , 13, 273-398.

Marucheck, A., R. Pannesi and C. Anderson, 1990. An Exploratory Study of the Manufacturing Strategy Process in Practice, *Journal of Operations Management,* 9, 101-123.

Meredith, J., 1987. The Strategic Advantages of New Manufacturing Technologies for Small Firms. *Strategic Management Journal,* 8 (3): 249-258.

Parthasarthy, R. and S. Sethi, 1992. The Impact of Flexible Automation on Business Strategy and Organizational Structure, *Academy of Management Review*, 17(1), 86-111.

Sakakibara, S., B. Flynn, R. Schroeder, and W. Morris, 1997. The Impact of Just-in-Time Manufacturing and Its Infrastructure on Manufacturing Performance, *Management Scienc*, 1246-1257.

Sanchez, R., 1995. Strategic Flexibility in Product Competition, *Strategic Management Journal* , 16, 135-159.

Schonberger, R. J., 1987. Integrated Manufacturing: Nothing Succeeds like Successful Implementation, *Production Engineering*, 4-32.

Skinner, W., 1969. Manufacturing: Missing Link in Corporate Strategy, *Harvard Business Review*, 47, 136-145.

Small, M., and M. Yasin, 1997. Advanced Manufacturing Technology: Implementation Policy and Performance, *Journal of Operations Management* , 15, 349-370.

Snell, S. A. and J. W. Dean, Jr., 1992. Integrated Manufacturing and Human Resource Management: A Human Capital Perspective, *Academy of Management Journal*, 35-3, 467-504.

Swamidass, P. M. and W. T. Newell, 1987. Manufacturing Strategy, Environmental Uncertainty and Performance: A Path Analytic Model, *Management Science,* 33, 509-524.

Suarez, F., M. Cusumano, and C. Fine, 1995. An Emprircal Study of Flexibility in

Manufacturing, *Sloan Management Review*, 25-32.
U. S. Department of Commerce, Malcolm Baldridge National Quality Award 1994 Award Criteria, U.S. Department of Commerce.
Ward, P. T., G. K. Leong and K. K. Boyer, 1994. Manufacturing Pro-activeness and Performance, *Decision Science*, 25-3, 337-358.
Ward, P., R. Duray, G. Leong, and C. Sum, 1995. Business Environment, Operations Strategy, and Performance: An Empirical Study of Singapore Manufacturers, *Journal of Operations Management* , 13, 99-115.
Wheelwright, S. C., 1981 Japan, Where Operations Really are Strategic, *Harvard Business Review*, 59-4, 67-74.
Xenophon, K., and M. Vonderembse, and W. Doll, 1998. Developing Measures of Time-Based Manufacturing, *Journal of Operations Management* , 16, 21-41.
Zipkin, P. H., 1991.Does Manufacturing Need a JIT Revolution?, *Harvard Business Review*, 69-1, 40-50.
Zygmont, J., 1989. Just-in-time Controls more than Inventory, *Automation*, 30-32.