研究論文

생산전략모형의 진화: 품질의 관점

김 희 탁
상명대학교 경상행정학부

Evolution of Manufacturing Strategy Model: A Quality Perspective[1)]

Heetak Kim
Division of Economics, Business and Public Administration
Sangmyung University

Abstract

There is a significant discrepancy between manufacturing strategy and quality management. This paper attempts to review the literature of manufacturing strategy model in quality perspective. The objective of the paper is to clarify the quality aspect of manufacturing strategy models for a better understanding of the subject and to lay a foundation to integrate manufacturing strategy with quality management. The paper is organized as follows. First, the literature review on the issue is presented. The trade-off model, lean production model, cumulative model, sand cone model, quality staircase model are critically reviewed. Next, the discussion on the review model is brought. Finally, conclusions are presented.

1. Introduction

Since the late 1960s we have seen the rise of manufacturing strategy concept from the depressed environment of manufacturing sectors. Skinner(1969, 1974) formulated the initial concept and other scholars contributed much for the abundance of the concept. In this discipline, several models have been suggested, modified and examined.

During the last two decades academicians and practitioners in business

1) This paper was supported by the Sangmyung University Research Fund in 1999.

have focused increased attention on the subject of quality management. Many studies regarding better manufacturing are suggesting that quality management should be the key factors for the success of manufacturing firms 「Flynn et al. 1995, Roth and Miller 1992, Samson and Terziovski 1999 .

Though the increasing importance of the quality management has been emphasized, the quality issue in the manufacturing strategy has been ignored or not well noted. And there is a large room for the quality to play a significant role in the manufacturing strategy. There hasn't been any study for this issue and there is an urgent need for the study because the manufacturing strategy emphasized with quality can improve manufacturing operations significantly.

The objectives of this paper are to clarify the quality dimension of manufacturing strategy models to give a better understanding of the subject and to lay a foundation to integrate manufacturing strategy with quality management. The paper is organized as follows. First, the literature review on the issue is presented. The trade-off model, lean production model, cumulative model, sand cone model, and quality staircase model are critically reviewed. Next, the discussion on the review model is brought. Finally, conclusions are presented.

2. Manufacturing Strategy Models

2.1 Trade-off Model

In his classical article of 1969, Skinner(1969) argued that any company can not excel in every aspect of manufacturing in the fierce competition. He then asserted that since different production systems have different operating characteristics, they should compete in their own way and should not follow industry norm. His kernel of the paper was that the manufacturing task of a firm is to build a production system which reflects the priorities of the firm's strategy. It consequently dictates that there should be trade-offs among the manufacturing capabilities. Later he added 'focused factory' concept to the trade-off model. 「Skinner 1974」 Skinner's thought can be epitomized as the follows.

Trade-offs: Skinner and his followers argued that any production systems cannot be very good at every performance criteria. The manufacturing performance criteria are sometimes called as content or dimensions of manufacturing strategy. The manufacturing performance criteria are widely mentioned by many researchers of the field. The most important criteria which are agreed upon by most

researchers are cost, quality, delivery, and flexibility. [1, 2, 17, 18, 21, 35, 39, 41]

Some firms, for example, can be good at low cost while not so good at flexibility or others good at exact delivery instead of bad quality. According to Skinner and his followers, however, any firm's effort to excel in all four manufacturing performance criteria is fruitless because it will be eventually second best on each performance criterion to some other company. 「Hayes and Wheelwright 1984」 Thus, when managers design production systems, they have to choose which competitive criterion is the most important one. When some of these criteria conflicted with each other, they had to make delicate decision after a thorough analysis of the trade-offs between them. Naturally this concept led us to focused factory concept.

In his book, Hill(1989) introduced a notion of two criteria using the trade-off concept. Those are order-winning and oder-qualifying criteria. Order-qualifying criteria are minimum criteria with which a firm can enter a certain market. On the other hand order-winning criteria are criteria with which a firm can get orders in the market. We can say that order-qualifying and order-winning criteria are necessary and sufficient conditions to get orders, respectively. Since the difference between order-winning and oder qualifying criteria is quite distinctive, it is very useful concept in the planning process to articulate the thought of Skinner.

Hill's model has a distinctive feature. For example, the dichotomy of oder-qualifying and oder-winning criteria can help manufacturing managers to classify manufacturing tasks easily. Unfortunately, it appears that weaknesses come from the very distinctive feature. There is a certain critic that order-winning criteria are different from traditional competitive criteria of manufacturing strategy literature. The main point of the critic is that the order-winning criteria are not manufacturing, but marketing oriented criteria. 「Spring and Boaden 1997」

Hill's model assumes that tradeoffs in the manufacturing decisions are inevitable. Some of the manufacturing performance criteria should be chosen according to whether we want to enter a certain market (oder-qualifying criteria) or to get an order in the market (oder-winning criteria). If some criteria have been chosen, other criteria might be ignored because limited manufacturing resources should be put into the chosen criteria. Thus delicate trade-offs decisions are needed.

Focused Factory: In his article, Skinner(1974) suggested that, even though a factory was equipped with the most modern machinery and systems, it could

experience inefficiency due to the conflicts between the manufacturing task required by the business strategy of a factory and the manufacturing competence of the factory. That, argued he, would lead a loss of overall effectiveness when it attempted to serve two or more markets which required different competitive characteristics or to produce two or more product groups which required different manufacturing characteristics. Thus he asserted that we would regain consistency and effectiveness if we could build a new 'focused factory' or 'plants within plants (PWPs).' The article which emphasized simplicity, clarity, consistency, and reducing overhead has shown a insight that is naturally embedded in the notion of lean production system. 「Womack et al. 1990」

The basic concepts of his work has been considered still effective. 「Hayes and Pisano 1996」 A lot of firms have practiced focused factory and a major manufacturing strategy text book deals the concept of focused factory significantly. 「Hill 1989」 The trade-off concept, however, has faced considerable challenge. It had been unquestioned until the Japanese manufacturers manifested that they could achieve low cost with high quality without any conflict. 「Schonberger 1982, Hall 198 7」 Many American researchers suspected that the Japanese factory could do so with new automated machines but later found that the Japanese manufacturing practices was very efficient and effective in cost and quality at the same time. 「Hayes and Wheelwright 1984」

The quality was not emerged as the most important manufacturing criteria in the trade-off model. It is because the model was crafted during the late 1960s and at that time the quality issue was not a significant concern in the manufacturing practice in the United States. The practice, however, has been changed radically since 1980s.

2. 2 Lean Production Model

At the end of the 1970s, Japanese companies in several industries began to prove themselves formidable industry leaders in terms of cost, quality and dependability. Their success was direct result of sheer manufacturing excellence. Their successful emergence in the world market was primarily due to their low cos, low defects rate, reliability, and their capability to introduce new products quickly.

Japanese manufacturing excellence comes from their practice. The famous Just-In-Time(JIT) production system which epitomize Japanese manufacturing practice originally came from the Kanban system of Toyota motor company. The backbone of JIT production system is the mind to eliminate wastes and to stabilize the production 「Schonberger 1982, Hall

1987」.

In a factory, inventory is assumed the largest waste. The inventory consists of raw material inventory, work-in-process inventory, and finished goods inventory. The wastes related with the inventory are space to stock it, time and effort to count and keep them, and machines to be used in handling them.

The next largest waste is the quality related wastes. For example, the scrap and the rework are considered to exist due to a failure to make good products at the first time. JIT system requires all participants in the manufacturing system should complete their job perfectly at the first time of making the product.

To stabilize the production means to produce products smoothly. Smooth production comes from stabilized production schedule, reliable suppliers, and agile work force. For example, Toyota motor company uses a monthly stabilized production schedule which was frozen one month before. They use a very simple communication system which is called Kanban system on the factory shop floor. Kanban system is doing a role of controlling system as well.

The JIT has several ingredients. The first factor is setup time reduction. Setup time reduction make small lot production possible. Small lot production has many advantage. Since the lot is small, the firm can response the market very quickly. Also, we can have small inventory. Ideal lot size might be one. It requires very delicate supply schedule for suppliers. If we can reduce setup time as much as possible, we can obtain low WIP and finished goods inventory. Also reduced setup time will help us achieve stabilized production. Setup time reduction is the most important factor in the JIT.

The second factor is agile work force. To reduce setup time workers have to prepare the most efficient setup procedure and equipments to facilitate the procedure more easily. They practice the procedure until they can change setup in single digit minute after the work hour. The workers also learn to solve problems on the shop floor for the quality and efficiency and to improve their process gradually (i.e. Kaizen). Work forces are the most important asset in JIT production system.

The third factor is supplier relationship. Suppliers should follow assembler's production schedule. Since JIT production system emphasize the stabilized schedule, suppliers transport parts frequently to the line of assembler's factory directly. Thus it requires suppliers to be located near the assembler's factory. Also it needs that suppliers should produce perfect parts.

The fourth factor is quality issues. In JIT production system quality should be the all participants' job. It can be called as CWQC (Company Wide Quality Control). More recently it can be named

as TQM (Total Quality Management). It requires that the designer should design a product to be produced easily and the workers should assemble the product perfectly. Total quality management requires the management to master the organization skills to ensure that the company produce high quality product.

In the 1980s western researchers studied the Japanese management practice, they doubted that JIT production system could be transferred. It was considered to be very culture dependent production system. However, the Japanese owned factories in the United States had proven that the JIT production system can be practiced in any place in the world. Actually, after the JIT experience in the United States, a lot of firms from industrialized countries have adopted the JIT production system.

The American automobile industry was shocked by the Japanese car makers' manufacturing ability to make very dependable, low cost, and high quality cars. Since the early 1980s many American scholars studied the Japanese manufacturing management 「Schonberger 1982, Hall 1987, Woomack et al. 1990, Clark and Fujimoto 1991」.

Among the studies, 'The Machine that Changed the World' written by Womack et al.(1990) produced the most influential result. The authors argued that the Japanese manufacturing system can be transplanted and improved. They collected the examples of many modified types of Japanese manufacturing system which were used all around the world, and they called it "Lean Manufacturing System."

Lean manufacturing system is a compound of JIT production system and rapid product development system. Actually rapid product development system comes from Japanese auto makers, too. When the American automobile industry had a norm of sixty months of development period around the early 1980s, Toyota was able to develop a car within thirty six months. The Japanese development process was scrutinized and the secrets were identified as cross functional development team, early involvement of suppliers, and heavy weighted project team leader 「Clark and Fujimoto 1991, Wheelwright and Clark 1992」.

The major contribution of the lean manufacturing system is that it challenged the traditional manufacturing strategy in terms of trade-offs. Skinner's argument of the focused factory assumed the trade-offs between manufacturing performance measures. But Japanese manufacturers don't need the trade-offs because they can be good at every performance measures. Likewise lean manufacturing system pursues the excellence in every aspects of manufacturing performance. 「Womack et al. 1990」

The Japanese or lean manufacturing system were characterized as a superior production system which emphasizes cost, quality, flexibility, and fast response. The system became a panacea for any problems of manufacturing sector during the 1990s.

It appears that quality issue is not considered well in this model. It is because the quality aspect is embedded in the model. The model implicitly but strongly assumes that quality is the responsibility of all participants.

2.3 Cumulative Model

Nakane(1986) studied the manufacturing practice of Japanese manufacturers and found that they have a sequential order of manufacturing capabilities to gain manufacturing excellence. The order of the manufacturing capabilities to be placed in the model is quality, dependability, cost efficiency, and flexibility. First of all quality should be placed at the base. Any firm should enhance quality first and improve dependability once certain minimum level of quality is obtained. After that an effort to gain cost efficiency should be made while the efforts on both quality and dependability are put forth, Finally flexibility should be improved while the efforts on the previous three are further enhanced.

While Nakane's study was conducted *from 1983 to 1986*, his model was supported by the surveys conducted in Japan, North America, and Europe during the same period. 「Ferdows and De Meyer 1988, De Meyer et al. 1989」 In the 1986 survey of 574 firms, Europe and North America companies were focusing on consistent quality and high performance product but Japanese companies were focusing low prices and rapid design changes as their top two priorities. The orders of competitive priorities of the European and North American companies were very similar to each other but the order of competitive priorities of Japanese firms was entirely different from the above two. 「De Meyer et al. 1989」 The reason why Japanese top competitive priority is not quality is that Japanese firms have already reached certain amount of quality, dependability, and cost efficiency sequentially over time. Thus they can have enough time for American and European competitors to follow by spending time on the trade-off between flexibility and cost-efficiency. On the other hand North American and European companies were focusing on quality because they were still in the base stage of the cumulative model.

Following the cumulative model Hall(1987) suggested that any manufacturing firm should develop quality capability first. Then the sequence of improving dependability, cost, and flexibility should be followed. He noted

that improving quality should be continued for some years then the other capabilities can be pursued. Later Hall and Nakane(1990) proposed revised sequence as follows: first, the culture of a firm, then quality, dependability, waste reduction, flexibility, and innovation. They argued that Japanese firms had started to develope quality since 1950s and they were at the stage of improving flexibility capabilities at that time. Also the United States firms were concentrating on quality and cost.

Roth and Miller(1990) stated that winners among manufacturing business units(MBU) appear to compete on multiple capabilities simultaneously. That means the winner group of the MBU has better manufacturing capabilities than the loser group. And there was a statistically significant observed difference. A certain evidence of support for the cumulative model was shown in Roth and Miller(1992) but they also suggested that superior manufacturing capabilities are built simultaneously, not sequentially. And they asserted that developing strategic capabilities in manufacturing is dynamic.

Noble(1995) found some evidence for the cumulative model. She used a suvey result from 265 North American, 129 European, and 167 Korean factories. The most supportive data for the cumulative model came from Korea. Also she found that the managers from the three regions take different approaches for improving competitiveness. The better performing companies generally compete on the basis of multiple capabilities. She stated that the importance of quality management is self-evident by the fact that quality is at the base of cumulative model and is also among the multiple capabilities. Even though she couldn't find the full support for the cumulative model, she could acknowledge the improtance of quality managment in the global competition.

2.4 Sand Cone Model

Ferdows and De Meyer(1990) suggested sand cone model for manufacturing performance criteria. Actually it is considered modified cumulative model. They argued that the cost efficiency can be achieved after having improved quality, reliability, and flexibility sequentially. Their argument implies that quality should be in the very base of any firm's performance criteria. Once a firm achieves an minimum requirement in quality, then it can try to achieve the reliability goal. After the quality and reliability goals are accomplished, the program to improve flexibility can be started. Finally cost criterion can be pursued once three other performance criteria can be achieved.

They claimed that simultaneous improvement of the performance criteria is possible. Once a performance criterion goal is achieved, next goal can be tried. Then

during the time in which the next goal is achieved, the former criterion also can be improved. Likewise, while third criterion is tried, the former two criteria can be enhanced at the same time. Finally, they asserted that all the performance criteria can be achieved simultaneously.

The important claim with the sand cone model is that there doesn't need to be a trade-off to improve any manufacturing performance criterion. Especially, we can achieve a group of performance goal at the same time when we use a clever methods to gain cumulative competitive capability. The essential characteristic of the model has cumulative property. While we can achieve a performance goal of a certain stage, we can also improve a performance goal of the previous stage simultaneously. And this property is a good argument against the presumed trade-off model of the manufacturing performance criteria.

This model explicitly stresses the importance of quality as the basis of other manufacturing performance criteria. Ferdows and De Meyer(1990) observed that the companies of better-than-average group emphasized quality more than the companies of worse-than-before group. But the quality concept in their model means only 'conformance to design.' And the programs for the quality are: zero defects, vendor quality, and process *statistical quality control.*

Since the survey which their research was based on had been conducted on the year of 1988, the quality concept was somewhat old fashioned. The importance of the quality criterion, however, was especially emphasized for the first time in the manufacturing strategy model.

2.5 Quality Staircase Model

Kim et al. (1997) suggested a manufacturing strategy model with which we can improve our performance by using 'quality staircase'. Quality staircase model shows that any company which wants to compete in a market effectively might ascend the quality staircase. The quality staircase has steps in series which are conformance, reliability, performance, and customization.

The model came after the researchers studied the elements of quality emphasized by Japanese manufacturing over the last two decades. They used the data from GMFP(Global Manufacturing Futures Project) which was conducted in 1992 with the participating firms in United States, Japan, Korea, European Union, and Mexico. They compared the data with the results of the same kind of survey which had been held in early 1980s and mid-1980s. They asked Japanese firms about the five most important manufacturing capabilities a company must master to compete successfully. In the early 1980s the Japanese manufacturing

firms answered that conformance quality, reliability, on-time delivery, fast response, and the ability to compete in price-sensitive markets. In the mid-1980s the GMFP survey showed that the Japanese manufacturing companies added the third dimension of quality, product performance, to the top five manufacturing capabilities. Later, in the 1990s, customization was included as the fourth element of quality in the top five manufacturing capabilities.

The advocates of the quality staircase argues that any firms which wants to compete successfully in the market should start at step one, mastering the conformance quality. Then, step two which emphasizes the reliability should be followed. After that, the company should consider the performance enhancement to get into a high-priced goods market. Finally, customization stage should be mastered to be a world class manufacturer.

The importance of quality is becoming great in this study. Even in Japan which was supposed to have mastery in quality 「Ferdows and De Meyer 1990」, the number of dimensions in quality which are included in the portfolio of competitive capabilities has been ever growing.

3. Discussion

During the last three decades the trade-off model has not been fully rejected 「Ferdows and De Meyer 1990」 but its status had become weaker and weaker. The main reason of this phenomenon is that the Japanese manufacturing practice epitomized as lean production system with quality prevails among the global manufacturing practice. We can argue that the trade-off model has given us a useful thinking tool since the birth of manufacturing strategy concept, but the usefulness is becoming weaker.

The most important questions with the cumulative model and sand cone model are: (1) is there any evidence for the existence of cumulative model?; (2) if it is yes, then what are the ingredients and the order of them to be mastered by manufacturing firms?; and (3) are the manufacturing capabilities built sequentially or simultaneously?

The first question can be answered affirmatively by the survey results of GMFP. Nakane(1986), Ferdow and De Meyer(1988), De Meyer et al(1989), Hall(1987), Hall and Nakane(1990), Roth and Miller(1992), and Noble(1995) are the studies which support the cumulative model. The data used for the studies were survey data which means a cross section data. Even though there was a time series data for three years 「Nakane 1986, De Meyer et al. 1989」, the time series was not long enough to see any significant

trend.

The survey results of 1983, 1984, and 1985 showed that European and North American manufacturing firms considered consistent quality and high-performance products to be the first and the second competitive priorities. At that time Japanese firms considered consistent quality to be the third competitive priorities. By Kim et al.(1997) American manufacturers are in the third quality step which stresses conformance, reliability, and performance. It appears that Americans were persistent in the quality effort. Consequently, from 1983 to 1990s, Americans had evolved from consistent quality, i.e. conformance quality which is the first step of quality staircase to product performance which is the third step.

The second question of the components of the cumulative model and the order of them is quite complicated question because the results of the study on this issue are inconsistent. The following four elements among the competitive capabilities of the model are common to several studies: quality, dependability, cost, and flexibility. 「Nakane 1986, Hall 1987, Ferdows and De Meyer 1988, De Meyer et al. 1989, Ferdows and De Meyer 1990」 There are some studies inconsistent with the above. For example, Hall and Nakane(1990) suggested to add new goals at the beginning (company-developed culture) and at the ending (innovation). On the other hand Noble(1995) suggested another set of competitive capabilities. She added delivery and innovation to the four common competitive manufacturing capabilities mentioned above.

The research results on the order or sequence of the manufacturing capabilities are not consistent with each other either. While Nakane(1986) suggested the sequence of quality, dependability, cost efficiency, and flexibility, Ferdows and De Meyer(1990) proposed another sequence: quality, dependability, flexibility, and cost efficiency. When the final stage is cost efficiency, there should be a belief that costs will eventually come down once other three capabilities reach a certain level of accomplishment. On the other hand, the model with flexibility to be a final stage assumes that the speed is the final destination. It accords with the notion of time based competition. In that sense Nakane(1986)'s cumulative model preceded time based competition concept.

Are the manufacturing capabilities built sequentially or simultaneously? The question doesn't have definitive answer yet. Most of the studies on cumulative model stated that they are built sequentially 「Nakane 1986, Hall 1987, Ferdows and De Meyer 1988, De Meyer et al. 1989, Ferdows and De Meyer 1990」, but only Roth and Miller(1992) asserted that they are built simultaneously. The

difference of the two stream is supposed to come from the samples of the studies. The studies of the first stream used quite large sample from three or four different global regions, but the studies of the second stream used a sample of North American manufacturing executives. There is an plausible explanation why the North American manufacturing firms built the manufacturing capabilities simultaneously. It is because they may not have a enough time to follow the steps of cumulative models sequentially as the Japanese did. By doing this they can shorten the leadtime that the Japanese have over them.

4. Conclusions

We has seen the evolution of manufacturing strategy model in a quality perspective. The only factor which has affected the evolution most is the emergence of Japanese manufacturing system. The quality is the most important factor which is emphasized by the Japanese manufacturing system. Thus we tried to identify the influences of the quality on the evolution of manufacturing strategy model by critically reviewing related literature.

The study attempted to review the quality aspect of manufacturing strategy model. Since quality is an element of content of manufacturing strategy, the study had a scope of only content model of manufacturing strategy. And it might have had a bias towards cumulative model groups. It is, however, because of the characteristic of the manufacturing strategy to integrate the manufacturing performance criteria in its planning phase.

The study tried to bridge the manufacturing strategy and quality. In the manufacturing practice of the world the importance of quality has been growing since the birth of manufacturing strategy concept. In the early stage of manufacturing strategy development the quality was just one of the manufacturing performance criteria and it can be replaced with other criteria according to the business strategy choice. Nowadays, however, the quality is the sole cornerstone of manufacturing success. Thus the relationship between the manufacturing strategy and quality should be rebuilt to align the quality of increased importance with the manufacturing strategy.

It is not desirable that the quality aspects dominates the manufacturing strategy planning process, or the manufacturing strategy ignores the quality aspect. Many studies are required to search the desirable relationship between the two to compete successfully in the world market. This paper is hoped to lay a foundation to the issue.

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