The Moderate Effect of SPC on the Relations Between Practicing JIT and Production Performance

Park Jeong Soo†

Visiting Researcher, The Institute of Management Research, Seoul National University
San 56-1, Shillim-dong, Kwanak-gu, Seoul, Korea

Abstract

Our goal of this study is to confirm whether manufacturing companies' practicing JIT production system have positive effect on production performances and to confirm that manufacturing companies' practicing SPC shows positive moderate effect on the relation between practicing JIT and their production performances.

Based on empirical study to manufacturing companies nationwide, we can conclude that taking JIT practices of sample companies has positive effect on production performances and, moreover, practicing SPC has positive moderate effect on the relation between JIT practices and production performances. These conclusion represents managerial implication that concurrent practicing JIT and SPC could generate more improved production performances.

Key Words: JIT, SPC, moderate regression

1. Introduction

Much of the literature addressing operations management and manufacturing strategy have been concentrated on understanding manufacturing practice-performance relationship (Flynn *et al.*, 1994, 1995, Narasimhan *et al.*, 2005, Swink *et al.*, 2005).

One of widely used production system in operations management nowadays is 'Just-In-Time' production system or 'Toyota' production system, which introduced by Japanese manufacturing companies, in particular Toyota Motor Company. Through the problem-solving practices for minimizing inventory and defects, JIT production system aims ultimately to improve manufacturing companies' profitability by achieving primary goals of minimizing cost and time in manufacturing process and eliminating waste in terms of material movement, work-in-process inventories and delays (Sakakibara *et al.*, 1997, Swink *et al.*, 2005).

In this respect, the first goal of this study is to confirm whether manufacturing companies' practicing JIT production system have positive effect on production performances.

Meanwhile, quality management, another important issue in operations management of man-

† Corresponding Author

ufacturing companies, the approach of '6 Sigma' has been interested by many researchers and practitioners. In 6 Sigma, SPC (Statistical Process Control) is an building block and an important method for improvement.

In this context, the second goal of this article is to confirm that manufacturing companies' practicing SPC shows positive moderate effect on the relation between practicing JIT and their production performances.

2. Literature Review

Just-In-Time production system was introduced, by Toyota Motor Company of Japan, as an approach for inventory control about late 1980's and have evolved enlarged its scope as 'a new production system.' We can summarize JIT as an approach and philosophy in operations management to improve profitability by preventing wastes in manufacturing process (Krajewski *et al.*, 2007, Stevenson, 2002).

Monden (1983) presented JIT's key factors including Kanban system, setup time reduction and Shingo (1981) contributed to the study of JIT by presenting careful description of the Toyota Production system.

Sakakibara *et al.* (1993) presented, as the dimensions of JIT practices, ① setup time reduction ② small-lot sizes ③ JIT delivery from suppliers ④ supplier quality level ⑤ multi-function workers ⑥ small-group problem solving ⑦ training ⑧ daily schedule adherence ⑨ repetitive master scheduling ⑩ preventive maintenance ⑪ equipment layout ⑫ product design simplicity ⑬ Kanban and ⑭ pull system. They reduce these 14 dimensions to 4 JIT practice categories of equipment layout, pull system support, supplier quality level and Kanban as major contributing factors to JIT performance.

Flynn *et al.* (1994) saw JIT as one building block of quality management and mentioned as components of JIT setup time reduction, lot size reduction, repetitive master schedule, JIT delivery from suppliers, Kanban, equipment layout, daily schedule adherence, preventive maintenance and pull system support.

Flynn *et al.* (1995) supposed that JIT is based on the concept of eliminating waste through the simplification of manufacturing processes. Such simplification includes elimination of excess inventories and too large lot sizes, which cause unnecessarily long cycle time. They divided JIT practices into 4 dimensions. First, Kanban system controls the movement of orders to work floor, in which a Kanban card have to be attached to every container of parts and controls the amount of inventory. Second, lot size reduction practice minimizes inventory and increase flexibility. As the third dimension of JIT practice, JIT scheduling activities include mixed model scheduling and scheduling daily production to meet demand fluctuation. Lastly, setup time reduction practices means reduction of the times required to

change machines over to work on a group of different parts, permitting closeness between production and demand.

According to Stevenson (2002), to achieve the goal of improving profitability through eliminating wastes, JIT production system constitute of 4 building blocks. The first one is 'product design', which includes standardized parts, modular design and quality. The second is 'process design', which includes small lot size, setup time reduction, manufacturing cells, limited work-in-process, quality improvement, production flexibility and little inventory storage. The third building block of JIT is 'personnel/organizational elements', which constitute of workers as assets, cross-trained workers, continuous improvement, cost accounting and leadership/project management. The last building block is 'manufacturing planning and control.' It includes level loading, pull systems, visual systems, close vendor relationships and reduced transaction processing.

Swink *et al.* (2005) presented, as Just-In-Time flow practices, lot-size reduction, setup time reduction, facility layouts to promote smooth flow, and pull or kanban-based production system, having the primary goal of eliminating waste in terms of material movement, work-in-process inventories and delays. According to the results of their research, JIT flow practice is more significantly associated with process flexibility rather than cost efficiency. Many JIT flow practices are founded upon improvements in process mobility. Moreover, JIT flow is also associated with new product flexibility.

SPC (Statistical Process Control) is used to confirm whether the output of a process conforms to intended design. For that goal, managers using SPC evaluate the output of a process to determine its acceptability. They take periodic samples from the process and compare them with standards determined earlier. When the sample results are not acceptable, they stop the process and take some corrective actions (Stevenson, 2002).

According to Krajewski *et al.* (2007), SPC is the application of statistical techniques to determine whether a process is delivering what the customer wants. In SPC, tools like control charts are used to detect defectives in quality or to indicate that the process has changed and that products or services will deviate from their design specifications unless some corrective actions are made. SPC can also be used to inform managers of process improvement.

Swink *et al.* (2005) mentioned about SPC (Statistical Process Control). As for process quality management practices, they included 'statistical quality control technique' with other practices of a focus on quality performance, measurement and communication of quality related data for improvement and control purposes.

3. Research Model and Measure

The first stage of this study is to confirm empirically whether taking JIT practices in

manufacturing companies has positive effect on their production performances in sample companies nationwide. In the second stage, we confirm whether practicing SPC in those companies has positive moderate effect on the relation between JIT practices and production performances. This process is represented as the figure of research model in Figure 1.

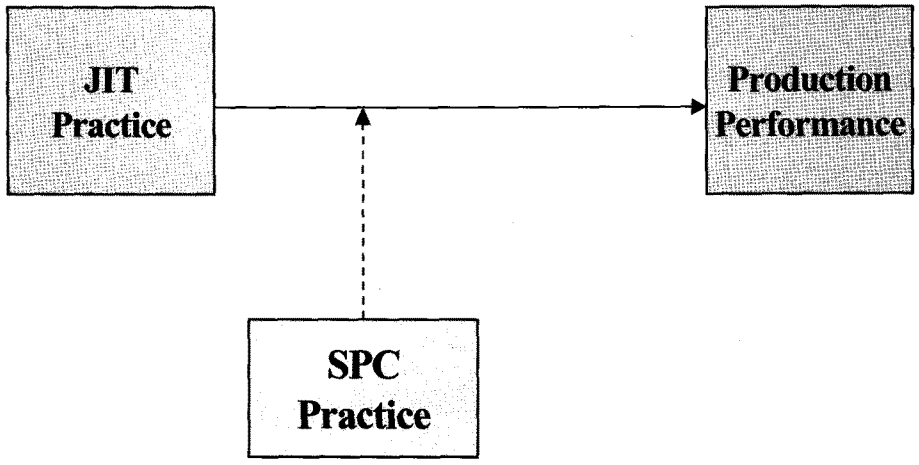

Figure 1. Research Model

To define JIT practices operatively, we use three variables, which are the effort level of reducing setup time (setup), the level of using Kanban system positively (Kanban) and the level of JIT procurement in raw material supply (proc).

Meanwhile, SPC is defined and measured as the level of using statistical models and methods in process management (SPC). Lastly, production performances are measured with the level of increase in product improvement ability (prodim) and in process improvement (proim) ability for each manufacturing company. These definitions and measures are summarized in Table 1 as follows. Measure are formatted using 7-point Likert type scale.

Table 1. Variable definition and measure

Definition	Measure	Related literature
JIT practices (JIT)	the effort level of reducing setup time (setup)	Stevenson (2002) Sakakibara *et al.* (1993)
	the level of using Kanban system positively (Kanban)	
	the level of JIT procurement in raw material supply (proc)	
SPC (SPC)	the level of using statistical models and methods in process management (SPC)	Stevenson (2002) Krajewski *et al.* (2007)
Production performances (prodper)	the level of increase in product improvement ability (prodim)	Flynn *et al.* (1997) Narasimhan *et al.* (2005)
	the level of increase in process improvement ability (proim)	

4. Empirical Study

1. Study Sample and Data Collection

As for the target samples for our study, 167 manufacturing companies nationwide in operation are selected and questioned with questionnaire. They are grouped into 40 electronics companies, 43 machinery companies, 24 chemical companies, 18 semiconductor and IT companies, 7 metalworking companies, 2 construction companies, 14 food processing companies, 8 medical supply companies and 11 other kind of companies.

2. Data Analysis

With data collected for manufacturing companies above, we carry out regression and moderate regression and Table 2 shows the results.

Figure 2. Regression (Model 1) and Moderate Regression (Model 2) Results

Variable	Model 1	Model 2
Constant	4.837**	5.182**
JIT	0.238**	0.012
JIT*SPC	-	0.028**
R^2	0.090	0.126
adj. R^2	0.084	0.116
F	16.263**	11.866**

Note : ** $p \leq 0.01$.
* $p \leq 0.05$.

As for Model 1, we set JIT practices as independent variable and production performances as dependent variable. Model 1's coefficient of determination, which means explanation level of the regression model, is 0.090 and adjusted coefficient of determination records as 0.084. F statistics, which shows relevance of the regression model, is 16.263 and indicates that data are significant enough at significant level of 1 percent. Both of constant term (4.837) and coefficient level (0.238) in regression model show significant results at significance level of 1 percent.

Model 2 is the moderate regression model that we add another independent variable representing moderate effect (JIT*SPC), which is calculated as the product of JIT variable in Model 1 and SPC variable. As we can see in Table 2, the moderate regression model is significant at significance level of 1 percent. Moreover, in particular, both Model 2's coefficient of determination, which records 0.126, and adjusted coefficient of determination,

which records 0.116 are higher than those of Model 1.

As the result of comparison Model 1 and Model 2, we can conclude that taking JIT practices of sample companies has positive effect on production performances and, moreover, practicing SPC has positive moderate effect on the relation between JIT practices and production performances. These conclusion gives us managerial implication that concurrent practicing JIT and SPC, in synergy, could generate more improved production performances.

5. Conclusion

The one goal of this study is to confirm whether manufacturing companies' practicing JIT production system have positive effect on production performances. And the other goal is to confirm that manufacturing companies' practicing SPC shows positive moderate effect on the relation between practicing JIT and their production performances.

With data collected for 167 manufacturing companies, we carry out regression and moderate regression. For Model 1, we set JIT practices as independent variable and production performances as dependent variable. Model 2 is the moderate regression model that we add another independent variable representing moderate effect. Both Model 1 and Model 2 are statistically significant. But, both of Model 2's coefficient of determination and adjusted coefficient of determination are higher than those of Model 1.

Based on these results, we can conclude that taking JIT practices of sample companies has positive effect on production performances and, moreover, practicing SPC has positive moderate effect on the relation between JIT practices and production performances. These conclusion represents managerial implication that concurrent practicing JIT and SPC could generate more improved production performances.

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