A LONGIDUNAL CASE STUDY ON EVALUATING OPERATIONAL PERFORMANCE OF PRODUCTION INFORMATION SYSTEM IN SMALL AND MEDIUM-SIZED MANUFACTURERS

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ABSTRACT

Many small and medium-sized manufacturing enterprise(SMMEs) have introduced and operated production information system(PIS). Thus many studies investigated the impact of PIS. Most previous studies evaluated performance before and after system introduction, but only limited studies investigated the operational performance of PIS. Therefore, this study analyzes differences between performance carried out immediately after system implementation and performance after certain period of time. Furthermore, this study investigates what factors put a positive effect on the operational performance. The results shows downtime decreased more in the operation phase than in the establishment and stabilization phase. On the other hand, interest of CEO, user training, system improvement and maintenance, expertise and interest of person in charge of a system were identified as critical success factors influencing operational performance of PIS.

Keywords: production and information systems, small and medium-sized enterprise, operational performance

INTRODUCTION

As the global competition gets heated, prompt and efficient response to demand of customers and cost saving have become necessary conditions for small and medium-sized enterprise(SMEs) to sustain and develop themselves. Therefore, the SMEs have implemented the Production Information System(PIS) such as Point of Production(POP), Manufacturing Execution System(MES) in order for cost saving and efficient management of production. The PIS plays an important role in handling real-time data garnered from work places and controlling a production planning e.g., (ERP, MRP) and manufacturing sites (Choi and Kim, 2002). Many SMEs have introduced and operated the PIS but there have been insufficient studies on the operational performance over time. Hence, it is necessary to investigate factors influencing the operational performance (Park et al., 2006). In this regard, this study targeting the SMMEs which have introduced and operated the PIS, intends to compare and analyze the differences between the performance carried out after building the system and the operational performance made at some point after a certain period of time passed and to examine what factors are important for effective operation of PIS. In particular, this study has the following purposes: First, it analyzes the differences in performance depending on a certain period of time passed after introduction of the PIS through the longitudinal case study. In other words, in this study which targets the same company, the performance is divided into establishment & stabilization and operation phases and then the differences in performance of the PIS are analyzed. Second, it derives key success factors influencing the efficient operation of the PIS.

PREVIOUS STUDY

Definition of PIS

The PIS was originated from the Material Resource Planning (MRP) developed by IBM in 1960s with an aim to maximize the utilization of computing system. In 1970s when the informatization started together with multi-product, small-lot production, computer-using manufacturing system, Material Requirement Planning (MRP), Manufacturing Resource Planning (MRP Ⅱ) became generalized and the MRP Ⅱ had the function of making a plan on overall requirements and controlling inventory and production. However, due to problems such as delayed report of work results and inaccurate production information in manufacturing sites, the PIS was introduced as POP by Japan and as MES by the US.

Longitudinal Study

The longitudinal study is a way of researching consistently how characteristics of a research subject changes with times. In other words, the longitudinal research repetitively measures characteristics of same subject with times and investigates any change in estimates or variables affecting the change. The longitudinal study makes it possible to effectively analyze various study problems through recent research analysis technique.

The previous longitudinal study on evaluation of performance related to the information system tried mainly the quantitative approach focused on the financial performance as the previous studies. But, the problems this study has lies in the difficulties to evaluate pure performance resulted from the introduction of the information system. In other words, corporate performance is generally affected by other factors, such as economic situation, corporate innovation but financial analysis is conducted under the condition that these factors are same, thus being unlikely to be able to evaluate pure effects resulted from the introduction of information system.

Research Design

This study intends to derive factors influencing the operating performance of the PIS through the longitudinal case study and analyze the difference in the performance. In order to achieve the research purpose, a longitudinal case study is conducted in the phase of establishment, stabilization and operation.

Reason of Implementing A Case Study and Study Procedure

Case studies have been conducted in many MIS researches where technical change and innovation are employed. Benbasat et al.(1987) explained the reason why the case study methods are useful for researches in the MIS. First, a researcher can acquire knowledge on the most recent information technology in a real situation and develop a theory, based on knowledge accumulated from the relevant industry. Second, the case study is useful in offering answers to questions 'how' or 'why' regarding complicated processes in an actual working situation. Third, the case study is appropriate if there is no previous study. Lastly, it is useful

in ensuring insight by studying not controlled environments such as a laboratory but actual working sites in the MIS field which changes itself at a high speed. This study, which targets the SMMEs introducing and operating the PIS, compares and analyze the performance after establishment of system and the operational performance of system after a certain period of time passed and investigates what kind of factors put a positive effect on operational performance. Hence, in this study, the longitudinal case study is implemented, targeting a specific company.

Selection of a Case Company and Data Collection

In this study, the following criteria were set up in order to select a case company. First, a case company is required to successfully introduce the PIS or produce a certain level of performance. Second, as a case company is selected out of companies described in '2006 Case Report of Production Innovation Based on Informatization of Production Equipment in Small and Medium Enterprise' issued by the Small and Medium Business Administration, and a respondent is required to work for the company from the point of time when a research was conducted in 2006 till the present. Third, it should be possible to have an in-depth interview with person in charge, along with the collection of data. Based on these criteria, we selected a 'A' company.

Document

Documents including webpage and internal data of a case company, SMBA data and news articles were analyzed so as to examine introduction of the production informatization and operating process regarding the case company.

Interview

A face-to-face interview with persons directly and indirectly involved in building and operating the PIS of a case company was conducted. And if there is anything to be checked additionally, a telephone interview was adopted. During the interview conducted in an office of the participant, questions about company overview, project overview and content, operation status, operational performance, and future informatization promotion plan were raised, and other questions inferred based on the afore mentioned question were added and the operation of the production informatization was asked. Meanwhile, a 'A' manger belonging to production management department of the company is in charge of comprehensive management, press work management, progress management, labor management, and PIS management.

CASE ANALYSIS

Overview of A Case Company

The 'A' company, established in 1999, manufactures car parts and molds. Especially, the Ulsan factory, where the PIS is built, mainly produces back panels for vehicle as a primary supplier of OO automobile company built in 2004. This company, equipped with cutting-edge equipment such as transfer LINE, module production equipment, has built and operated an automatic system.

Establishment and Operation of PIS and Contents of a Subject Company

Project Overview and Background

The project to build PIS was carried out for six months between May 4th and October 8th of 2005. The number of personnel put into to the project was 14 and the persons in charge from the case company had position of manager and deputy general manager. At that time, the case company used ERP system. Thanks to characteristics of products, the production equipment in the working place achieved improvement in automation such as robot per unit process. However, daily production record was manually prepared and collected production outcome was manually put into ERP systems at the following day, accordingly reducing timeliness and reliability of data. In response, efforts to build the PIS was made so as to gather data in real time and then resolve the existing problems (delay in reporting results, inaccurate production information, unclear process management, etc).

Operational Performance

1) Quantitative Performance
The introduction and operation of PIS enabled an sales department to check real time production status, consequently being possible to maintain close relationships with customers. Additionally, productivity improved due to a potential sense of rivalry between day-shift and night-shift teams. As a result, the introduction and operation of the system resulted in qualitative and quantitative effects. < Table 1> and < Table 2> describe quantitative and economic effects disclosed in '2006 Case Report of Production Innovation Based on Informatization of Production Equipment in Small and Medium Enterprise' and the interview.

< Table 1> Quantitative Effect

Item	Before Introduction	Establishment & Stabilization Phase	Operation Phase	Improvement Effect *)
Downtime	20.14 hour/month	4.16 hour/month	2.19 hour/month	79% down (Establishment & Stabilization Phase) 53% down(operation phase)
Data Input time	120min./day	30min./day	Left Ditto	75% down
Paperwork Time	40min./day	15min./day	Left Ditto	63% down
Line-Specific Work Preparation Time	5min./day	0min./day	Left Ditto	100% down
Process In-Out Reliability	85%	98%	Left Ditto	13% up

1. Downtime : Factor of non-operation is examined.
2. Data Input Time /Paper Work Time : Time taken to register MFG (hour/day) manually and to collect monthly performance data, based on the existing daily work report
3. Line-Specific Work Preparation Time : From verbal delivery of work order(production plan) to automatic delivery of work order via computer
4. Process In-Out Reliability: Reliability related to PLC data collection from data gathered manually from a daily work report.

Source : SMBA's '2006 Case Report of Production Innovation Based on Informatization of Production Equipment in Small and Medium Enterprise', p.24

< Table 2> Economic Effect

Item	Before Introduction	Establishment & Stabilization Phase	Operation Phase	Improvement Effect	Formular (on a daily basis)*)
Total Downtime	2.4 hour/day	1.9 hour/day	Left Ditto	20.8% down	0.5H × 3,620 (hour wage on average) × 93 (persons) = 168,330
Data Input time	120 min./day	30 min./day		75% down	1.5H × 5,770 (general hour wage) × 1 (person) = 8,655
Paper Work Time	40 min./day	15 min./day		63% down	0.4H × 5,770 (general hour wage) × 2 (persons) = 4,616
181,601(daily amount improved) ×240(working days) = 43,584,240(on a yearly basis)					

1. Before the introduction(2005), a supervisor did the work on site during lunch and dinner time : 7(persons)×1.16(hour) = 8.12MH(day)
2. Surplus time resulted from reducing downtime is allocated to quality activity and equipment prevention activity.
3. Improve operator's mind set thanks to safety education and quality education time(3 hour/month) : Safety and quality education : 1 hour/month Up (compared to education 'Before Introduction')

Source : SMBA's '2006 Case Report of Production Innovation Based on Informatization of Production Equipment in Small and Medium Enterprise', p.24

In comparison to the year of 2006 (Establishment & Stabilization Phase), the downtime as of 2011 (operation phase) amounts to 2.19 hour/month, 53% down. At the time of introduction in 2006, only when a line shut downs for over five minutes, it was regarded as downtime. But, in the next operation phase, if a line shut downs for over three minutes, it was automatically recognized thanks to education and training, thus making it possible to take measures on the

working sites. However, it was found that there was no difference between 2006 and 2011, in terms of quantitative effect like data input time, paperwork time, line-specific preparation time and process in-out reliability and relevant economic effect. Unlike the corporate-wide system like ERP, users can use the PIS easily in a relatively short period of time and therefore, optimum performance is shown even in the stabilization immediately after the system is implemented

2) Qualitative Performance
The qualitative performance included information handling in real-time and optimum decision-making. And it was indicated that the performance made after the system introduction, such as optimization production process, improvement of working capability, response to PL law has been maintained so far like research in 2006.

< Table 3> Qualitative Performance

Before Introduction	Establishment & Stabilization Phase	Operation Phase
1. Low reliability of production quantity, downtime factor/time due to manual preparation of daily working report. 2. Unclear understanding of matters on line-specific equipment failure among departments (production/time-schedule). 3. Difficult to grasp situation on the overall lines on a real-time basis.	1. Effect of PLC DATA-based Collection 1) Improvement in Process In-Out Reliability thanks to accurate production quantity, 2) Accurate downtime factor/hour - reduction in downtime 2. Possible to make an efficient improvement as departments share details of equipment failure. 3. Effect of Real Time-Based Production Monitoring 1) Possible to take a immediate action to line shutdown 2) Possible to take an immediate action to urgent change by gathering information of production items in real-time.	Left Ditto

<Source : SMBA's '2006 Case Report of Production Innovation Based on Informatization of Production Equipment in Small and Medium Enterprise(SME)', p.25>

4.2.3 Analysis of Key Success Factors in Operation Phase

According to the interview, it was disclosed that the first operational success factor is CEO's support and interest. As for the case company, a proper level of investment was made in maintenance and operation of the PIS, thanks to CEO's active supports. Considering that CEO's strong will plays an important role in SMMEs, CEO's supports and interest are the

critical factors in the introduction and realization of the information system. In most cases, once system is established, it is regarded the system introduction project is done and accordingly, CEO's consistent supports deceases (Ha et al., 2010). However, also in the operation phase, CEO's supports and interest are still considered as an important factor from the perspective of system's absorbing capability and assimilation so that the information system can be fully established and effectively utilized (Grover, 1993; Liang et al, 2007).

The second success factor is to consistently provide education and training to users. In the case company, educational program for new employees was run separately and education and control of existing employees were carried out on supervisor's own account. No supervisor changed his job or moved into another department, thus causing no issue related to vacancy of work. Other studies indicated that user's education is required for utilization of information system and even in the operation phase, the education should go on (Allen, 2008; Häkinen et al., 2008). Also, it was discovered that inappropriate education and training can lead to a serious problem in the operation phase.

Meanwhile, at the initial stage of establishment, the PIS was likely to be accepted as a tool to watch out site employees. Therefore, the case company held a public hearing and provided education for them, based on which the proper function of system was promoted. Moreover, in the operation phase, the case company continuously implemented site-supervisor's monitoring and education and tried to bring a change to users' interface so as not to make users fall into mannerism. The company made efforts to reduce repulsion toward the information system operation by making a communication with workers on sites.

The third factor is improvement and maintenance of the system. The case company maintained the system on a regular basis based on the maintenance contract signed with a company which built the system for operation. As the maintenance service provider was close to the company, it was possible to take a rapid response to any problem through remote control or site visit. In addition, customized service was provided through the maintenance and hence, without dramatic version-up, the system was used on site conveniently. Park (2002) thought that the operation phase is a kind of improvement phase designed to take a proper response to organization's demand to enhance and develop further system function along with consistent maintenance. In other words, in the operation phase, consistent work improvement and upgrade of new software should be done in order to upgrade the system continuously and normally operate the system until being replaced by new system. Thus, he pointed out that it is important to realize system and solve problems.

The final factor is expertise and interest of person in charge of system. What is worthy of notice is that manager, deputy general manager, and general manager at the production management department who played a leading role at the time of introduction have so far taken responsibility of the same work without changing their jobs or moving their department. Park (2010) pointed out that due to the absence of experts in a company, if the PIS have errors, the company is forced to count production performance manually. Especially, in the case of local SMEs, it is not practically easy to secure professional human resource and many employees change their jobs, therefore being difficult to secure skilled experts in a consistent manner (Kim, 2004). And, as for a company which does not have an organization exclusive for

the system, it needs consistent system support so as to respond to business environmental change, system function, data error, utilization problems in the operation phase(Allen, 2008; Markus et al., 2000). When these problems are not solved, the level of reliability and utilization will be lowered (Ha et al., 2010). For preventing this result, it is necessary to give an appropriate level of support to persons in charge of system. For the case company, the persons in charge of system have been exclusively involved in the work of managing the system since the introduction and they belonging to the production management department understand the production site and have interests in and knowledge of IT.
At the initial stage of establishment, the case company communicated with the maintenance company via the computing department, thus having problems in communication and consuming a lot of time. However, at present, when a problem occurs, it can communicate directly with the SI company, accordingly being able to rapidly respond to any problem and improve satisfaction on sites. This result is consistent with the research result of Ha et al., (2010) who insisted that a company with organization exclusively responsible for the system takes improvement activities more than others.

In addition to the above operational factors, when it comes to the environment of building the system, it was not long ago that a factory was built newly and also it was easy to introduce the system because of few production line. In particular, as most employees were the young generation good at using PC, they showed little resistance to the system introduction and rapidly changed the way of thinking thanks to introduction of data processing. Also, they responded positively to individual performance. As a result, the effort to introduce the system was led mainly by top executives but since the system entered into the stabilization stage, the efforts have been made from bottom to top.

CONCLUSION

Implications and limitations

This study has the following implications. First, this study makes an academic contribution in that it is a longitudinal case study not confined to evaluation of performance at one point, unlike the performance evaluation research focused on the cross-sectional study. So far, most papers on performance evaluation have mainly focused on the cross-sectional study that measures the performance at one point as the longitudinal study tends to be difficult to secure homogeneity of respondents and to take a quite long time to do. In this sense, this study would be regarded as the first study which evaluates the performance of PIS through the longitudinal case study.
Second, the SMEs are required to utilize the information technology in production sites from process improvement to introduction of the PIS integrating the production & sales, with an aim to achieve cost saving through improvement of productivity. So, the top executive members have high interests in the PIS. However, most previous papers mainly focused on large-sized companies. This study, away from the research of information system evaluation concentrating on the large-sized companies, implements a cast study targeting the SME. Consequently, it is expected to induce following-up researches.
Third, from the practical point of view of a company, this study identified the main factors that

influence the efficient operation after establishment of the system, unlike most researches focusing on the effects resulted from building the system. These implications give a guideline about what kind of factors should be well managed for successful operation to working-level persons responsible for introducing and operating the PIS.
The limit of study lies in the external validity which means difficulty in terms of generalizing study results. Cases from a single company are covered for in-depth analysis of actual conditions and therefore, it would be inevitably hard to generalize the study results for all SMEs. If the longitudinal case studies on the operational performance of SMMEs are accumulated in the future, those studies will be utilized to conduct various studies.

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