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A Lean Production Framework for Malaysian Automotive and Heavy Machinery Industry

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Abstract: Lean production (LP) has become a potentially valuable way of securing competitive advantage. However, lean production practices have been subject to number of researches but little researches, if any, have directly addressed the relationship between type of industry and lean requirements practices. This study tries to provide a selective practices for conducting lean production in both Automotive and heavy machinery industries. It was aimed to abstain from introducing relatively unimportant lean practices and aid managers to implement lean production with lower cost. This study used a structured questionnaire derived from the literature and employing email surveys to collect responses form a group of 45 firms in Malaysia. The results of testing the hypotheses predicted that type of industry has a positive effect on lean requirements practices. Providing information about each industry, indicating lean practices in automotive industry start with quality control related practices and followed by planning and process related practices respectively. In contrast, heavy machinery industry commenced by process related practices while quality control practices have less priorities.

Key words: Automotive Industry · Framework · JIT · Lean Production (LP) · Manufacturing · Malaysia

INTRODUCTION

Since industrial revolution onwards, companies have been looking for advancement of their competitive advantage to guarantee their survival and profit making. Nowadays problems such as globalization has increased competitive pressures and due to resource scarcity, the complex techniques and the specialized tasks in order to achieve waste reduction, have been applied. However, the names used for these management practices were not consistent, i.e., just-in-time manufacturing, total enterprise manufacturing, world class manufacturing and lean production [1-4].

Lean production has gained a great deal of attention in diverse sectors especially in the automotive industry. It has been seen these manufacturers somehow due to acceleration changing in their competition environment and unreliability about future and increasing costs need to be "lean". Therefore managers are looking for a way to implement the lean production practices with low investments to get benefit of it.

Within the LP, there are number of practices for JIT,TQM, in which a consistent set of techniques lead to continuous improvement. In terms of the Malaysia, the practices of LP is still a new concept. Since the mid-1980s, the Malaysian economy has metamorphosed from a commodity-based to a manufacturing-based economy. Therefore, in this paper we make a survey on automotive and heavy machinery companies in Malaysia to extract a general pattern for implementing JIT practices. In this paper, we developed a framework for Lean requirements practices within this two industry. Within the Lean Production, TQM and JIT have similar fundamental goals of continuous improvement and waste reduction [1, 5, 6].

In the following section, we review the literature and our integrated framework will be discussed. Then in Section 3 we discuss on our theoretical framework and our hypotheses. In Section 4, we describe the data used for the analysis. Subsequently, we describe our method of analysis. Finally, we discuss the results and present the conclusions in Sections 5 and 6, respectively.

Literature Review: Managers incrementally applied new management practices to improve their global competitiveness with refinement and systematic integration of these new practices [7]. This management practices introduced as lean production [8]. Lean production is an integrated system which is structured

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with consistent set of elements and practices including Just-in-time, team works, quality systems, cellular manufacturing, etc. [8].

The term "lean production" was coined by the researchers who conducted the international motor vehicle program in the world motor industry [3]. Besides, lean production and lean manufacturing used interchangeably [3]. Recently, lean principles implementation have become the paradigm for many companies. Both researchers and practitioners have a consensus that lean production if adopted and carefully implemented can undoubtedly form the roadmap to world class manufacturing [9].

JIT as a subset of lean program is a manufacturing practice aimed at continuously reducing and eliminating all forms of waste [6], through JIT production and involvement of the work force [1, 6]. Anand and Kodali [10] claimed that many lean manufacturing initiatives have failed due to the lack of it's understanding by managers and employees. Therefore, a comprehend framework for lean manufacturing that integrates the practices in different areas are required to allow practitioners understand clearly the requirements for implementing lean manufacturing [11].

A comparison of number of empirical studies on lean [12-19] leads to the identification of 17 practices that are frequently cited as lean practices. These are multifunction employee, quality circle, set up time reduction, 5S, kanban, continuous flow, preventive maintenance, small lot size, TQC, kaizen(CI), cell layout, standard operation, training, focused factory, supplier management, visual control, teamwork. besides, there are some other practices including setup time reduction, pull system production, JIT delivery by supplier, functional equipment layout, daily schedule adherence, committed leadership, strategic planning, cross-functional training and employee involvement [20].

Im and Lee [21] develop a portfolio model for implementing JIT practices, including setup time reduction, plant compression, quality circles, preventive maintenance, JIT purchasing, kanban, Small lot sizing, Flexible workforce, Dedicated lines, Mixed model production, Level production, U-shaped layout, Cellular manufacturing, Autonomation.

There are number of key areas in lean manufacturing including: scheduling, inventory, material handling, equipment, work processes, quality, layout, employees, suppliers, customers, safety and ergonomics, management and culture and product design [11]. The area can be improved depending on the priority of the management in every company. Finally, the circle signifies that lean is a never ending journey that keeps going on, with the arrows on the circle indicating continuous improvement [11].

There were some researchers who surveyed JIT practices. In Table 1 the summary of these researches regarding to different practices has been illustrated.

Table 1: Recommended for lean practices

	JIT Literature*							
Framework Practices or Techniques	1	2	3	4	5	6	7	8
Multifunction employee		X			X	X	X	
Quality circle		X		X	X	X		
Set up time reduction		X	X			X		
5S	X			X		X		
Kanban						X	X	X
Continuous flow	X					X		
Preventive maintenance		X				X		
Small lot size	X					X		
TQC		X				X		
Kaizen(CI)		X	X					
Cell layout			X			X		
Standard operation	X	X						
Training			X				X	
Focused factory							X	
Supplier management			X					
Visual control		X						
Teamwork								

* References:(12) Real R.et al., (2007),(13)Bonavia et al.,(2006),(14)Gyampah et al.,(2001), (15)Gunasekaran(2000), (16)White et al.,(1999),(17)Lee, C.Y., (1997),(18)Gupta S.M. and Brennan, L., (1995),(19). Sohal et al., (1992)

Theoretical Framework

Type of Industry: In an effort to emulate the success, first two type of industry including automotive and heavy machinery industry due to their success in implementation of LP, JIT practices and number of samples inside the Malaysia were chosen. This paper can be useful for this two type of industry and this research provides a guide line for such an industry to follow the general pattern and become successful in terms of the conducting of JIT practices.

Practice identification for Lean Production (framework)

- Define the type of industry,
- Identify general practices for implementing JIT,
- Determine lean requirements practices,

Identify General Practices for Implementing JIT: This step determines general practices for implementing JIT. In terms of the practices, various classification has been done, but most are similar regarding to their criteria, including time reduction, Kaizen, QCC, Kanban, etc. The model chose in this study among all the models, which were discussed in literature review was Im and lee [21] (1988) model which covers the common practices for implementing JIT. this model was most practical in all industry and thus, it was adopted here.

Determine Lean Requirements Practices: Managers apply lean and JIT practices through a series of trial and error efforts. In order to avoid extra investment for JIT practices, managers prefer to jus implement those practices which lead them to gain more benefits and waste reductions. Therefore, with the model will be developed, we help managers to extract the necessary requirements for implementing the LP and JIT practices in their own fields. In this paper, the major focus is on the relationship between type of industry and the lean requirements practices. This process was developed from a literature review and therefore for additional verification using empirical data was needed. Consequently, the following two hypotheses were proposed for this.

Hypothesis 1: Type of industry have a positive impact on identifying applicable JIT practices.

Hypothesis 2: Identifying applicable JIT practices have a positive impact on determination of lean requirements practices.

Methodology: Current paper examined a cross-sectional field of study by using survey in two manufacturing environments, across a variety of Automotive manufacturing and heavy machinery industry, which has a plant of production in Malaysia. Unfortunately, most companies were not inclined to publicize their information and probably exaggerate examples of their successful implementations while deemphasized their failure. As a result, in order to avoid bias about implementation success of JIT practices, survey was conducted among hands-on experience and knowledgeable middle and upper-level managers in JIT. These respondents were sought because of their broad perspective of the organization's activities and because of their knowledge of associated implementation issues. The data in this paper was collected through convenience sampling procedure among automotive and heavy machinery manufacturers which have a successful experiences of implementation JIT in Malaysia. The contacts and related information of these companies were obtained from SIRIM organization in addition to the Federation of Malaysian Manufacturers (FMM) directory 2010 of Malaysian manufacturers [22] as well as SME corporation Malaysia [23]. In this study we investigate JIT implementation among automotive manufacturers and heavy machinery industry in Malaysia. The methodology for this work overlaps the one used by Im and Lee [21] because the variable analyzed for this study used the same model.

Questionnaire: A two page questionnaire constructed survey instrument. The structure of the questions used to collect information on each of the key variables assessed in this study included, industry type, implementation status of JIT practices and sequences associated with JIT implementations. The survey instrument contains a four-part questionnaire. The first part uses a nominal scale, while the rest use seven-point Likert scales. Information was collected about organizational characteristics, including industry, annual revenue, number of employees and implementing JIT practices, together with respondent's characteristics, including education, experience and position. Besides, there were some questions used to collect information about type of Industry.

General Practices Used for Implementing JIT: These practices were adapted from the model was discussed in Im and lee [21]. This portfolio model was

developed for implementing JIT practices, including 13 criteria such as plant compression, quality circles, preventive maintenance, JIT purchasing, kanban, Small lot sizing, Flexible workforce, Dedicated lines, Mixed model production, Level production, U-shaped layout, Cellular manufacturing, Autonomation.

Implementation Status of JIT Practices: Each of the 13 JIT practices, represent the part of understanding JIT systems and formed an item, used to collect information on implementation status of JIT practices. Definitions for each of these JIT management practices were used in data collection to reduce any misunderstandings that may exist. These definitions were adopted from [16].

Pretest, Validation: In order to clarify items and further develop for comprehensiveness of the instruments on the questionnaire a pilot study was used. In addition, follow-up interviews with the respondents from the pretest allowed for additional clarification of ambiguous items and getting their feedback. Then answer was reviewed and necessary revisions were made to the questionnaire prior to data collection.

To measure reliability and validity the pretest used a representative sample of 28 companies. It is reliable if it supplies consistent results, as measured by Cronbach alpha [24]. According to Price and Mueller [25], a value of 0.60 or higher is generally viewed as acceptable for the measure. In this study, validity is of two types: content and construct validity. The content validity is the extent to which it provides adequate coverage of the topic. The construct validity attempts to identify the underlying construct (s) being measured and determines how well the test represents them. Factor analysis was used for the analysis of construct validity. The rule of eigenvalue greater than 1 as the criterion extracts the factors. The second, third and fourth parts of the questionnaire was all adapted from the literature and have been reviewed carefully by practitioners; thus, content validities should be relatively acceptable. Construct validities were confirmed using principal component analysis as the defined factors/criteria in the second and third parts of the questionnaire: they all have eigenvalues greater than 1.98 and the percentage variance accounted for greater than 70.3. The Cronbach's α all are 0.72 and above. The fourth part of the questionnaire was converged to one factor with eigenvalue of 3.18 and the percentage variance accounted for of 74.5%. The Cronbach α is 0.88.

Data Collection: The data collection process consisted of employing mail survey. Two mails with interval of approximately 5 weeks was performed. Out of the 45 companies were initially surveyed by mailing questionnaire, a total of 34 surveys were completed and returned for an overall response rate of 77.2%.

Within this 34 companies,119 person including production managers, materials managers, production planners of these companies in terms of implementation of JIT practices were answered the questionnaire completely, Examining the responding data across this three groups of respondents shows a pattern of relative consistency in the firms' experience. A review of the data allowed for identification of data omitted from the final sample for the following: completed surveys that had incomplete data pertaining to any of the key variables assessed in this study (N = 1). Since the focus of the study was on this two type of industry, 3 cases were omitted because they have overlap and cannot put just in one category.

Analysis and Findings

Demographics: The total number 180 questionnaire to 45 companies were sent, 34 replied, one incomplete and three overlap responses were deleted, resulting in a total sample of 30 firms for a 66.6% response rate. The responding sample consisted of 12 heavy machinery manufacturing firms (40%) and 18 automotive part and component companies (60%). This shows that in Malaysia mostly automotive manufacturing are implementing lean production and willing to answer questions. The relatively low response rate raised a concern of non-response bias. A test for it was conducted using two sub-samples: early and late respondents. They were correlated on their JIT practices experiment. There was no significant non-response bias in the sample.

Identify General Practices for Implementing JIT: The relationship between Industry category and general practices which are needed for implementing JIT can be explained in terms of 13 practices and use them as dependent variables and a portfolio of Industry category as one independent variable with two categories. The dependent variables are of metric attributes while the independent variable is not.

In order to analyze this relationship structure, MANOVA was performed. The test shows that Wilks' □ is 0.56 and the equivalent F statistic for the Wilks' 1 value is 19.5 with the probability less than 0.01.

Table 2: Univariate tests for JIT practices across different Industry (adopted from Im and lee [21])

JIT Practices	F	P-value	Different Industry (mean) 1	2
Plant compression	7.83	0.012*	1.29	5.33
U-shaped layout	6.63	0.031*	2.02	5.12
Cellular manufacturing	13.23	0.000*	1.37	3.43
Dedicated line	5.33	0.031*	2.76	3.11
Small lot sizing	5.52	0.028*	4.65	3.67
Mixed model production	9.34	0.009*	4.27	1.88
Level production	6.93	0.029*	4.23	1.75
Kanban	7.75	0.013*	6.54	3.54
Preventive maintenance	5.41	0.034*	6.78	2.87
Quality circle	7.13	0.027*	6.85	3.08
Autonomation	2.12	0.21	1.27	1.65
Flexible workforce	7.69	0.022*	1.42	1.31
JIT purchasing	4.93	0.035*	3.25	1.56

(1)Automotive Parts Manufacturer; (2) Heavy Machinery.

* $P < 0.05$.

Table 3: The effect of JIT practices on the performance of requirements determination

	d.f.	SS	MS	F	P
Regression	7	32.68	4.69	8.71	0.00
Residual	27	96.08	0.52		
Total	34	154.85			

As a result, Hypothesis 1 is accepted and the impact is positive. Univariate F statistics were further examined to understand how the 13 practices varying across the two type of industry. The testing results are reported in Table 2. It may be seen that Autonomation practice is not statistically significant across the two type of industry. Insignificant of Autonomation can be explained by firm's need to great deal of confidence regarding to their quality system and preventive maintenance whiles in Malaysia there is not such a confidence till now. Moreover, In the automotive industry the practices dominantly started with quality control practices including quality circle, preventive maintenance. This maybe because of dissimilarity and variety of process for automotive manufacturers and more engagement of human factor and surging the possibility of error took place. In concern with heavy machinery industry, predominant practices are process related including what is called U-shape layout or plant compression. In conclusion, the results show that developing different categories of industry would create different effects on the choice of JIT practices, however to somehow in some industries the practices are similar, but overall different industries need different models.

Determine Requirements Practices: This step was aimed to be used in assessing the significance of relationship among the industry and JIT requirements practices, in the light of the prior decisions. However, the need for validating this framework in terms of the effect of identified general JIT practices on the quality of requirements determination should be taken in our consideration. Their relationship involves the quality of system requirements analysis as one dependent variable with metric attribute and JIT practices as 13 independent variables with metric attribute. Multiple regression analysis was used to examine the type of relationship structure. The results are presented in Table 3.

Therefore, hypothesis 2 is accepted and the impact is positive. More specifically, this study purposed at exploring the impact of the two industries on the different requirements practices for implementing JIT systems and lean production.

The overall results are summarized in Table 4. For determining the emphases on the general JIT practices, a t-test for a seven-point Likert scale was used to examine the significance of this practices for each of the two industry categories.

Table 4: The impact of Different Industry on sequence of JIT practices

JIT Sequences	Automotive Industry	Heavy Machinery
Early stage;	Quality control-related practices (4.30*)	Process related practices (3.39*)
Middle stage;	planning-related (4.06*)	
Final stage;	process-related (1.99*)	Quality control-related practices (2.97*)

Planning Practices : Cellular manufacturing, Dedicated line, small lot sizing, Mixed model production, Level production, Kanban

Quality Control Practices: Preventive maintenance, Quality circle,

Process Practices: Plant compression, U-shaped layout, Flexible workforce, JIT purchasing

*: Significance of practices

The performance of requirements elicitation was estimated by averaging the data of the clustered firms for each of the two industries. The results were also examined by making a t-test. This indicates that the industry categories significantly influence the requirements practices determination through an intervening factor.

CONCLUSIONS

However, JIT was recognized as an significant issue in lean production, the selection of an ideal JIT practices would be a critical advantage to a firm and can be assumed as a method to achieve competitive advantage. This justifies the need for better choosing JIT practices. Implementing JIT involves relatively complex processes and without the support of precise selection of practices, it would not be accomplished easily. Besides, the selection among the all practices, through different models which have been provided by different researcher is a tough responsibility for managers. In this proposed approach, a three-step process was developed. First, define the type of industry then Identify general JIT practices and finally determine practices requirement.

In general, the Automotive manufacturing firms in Malaysia use a portfolio of different types of JIT practices in different models rather than rely on only one model. Successful selection of JIT practices, therefore, should be base of industry categories. There are significant differences in the choice of JIT practices for various manufacturing firms, the major implication for academicians lies in that the particular connection of industry types and identify general JIT practices for commonly determining requirements practices for implementing JIT is unique in literature. Moreover, this study contributes not only in developing a well-defined process of user requirements determination but also determining useful techniques to implement it effectively.

In conclusion, the new approach fundamentally overcomes the impact of problem unstructured issues associated with give priority to practices domain on user requirements determination for implementing JIT. The implications for practitioners are as below. Additionally, industry type analysis in terms of the JIT application is important because firms are not able to adopt all practices and their capabilities in implementation of practices are limit and maybe just need some specific practices, so they should know their priorities to meet their needs. Thus, it should be identified the type of industry first. Moreover, the emphases on JIT practices can, therefore, be determined from this analysis of the relationship between industry categories and general JIT practice. Besides, automotive parts and heavy machineries industry, are against each other in terms of priority to kanban practices, first one give the most priority to quality oriented practices while it gets the least attention in heavy machinery industry. Finally, the practices requirement for the particular JIT would be determined in a more efficient and effective way. However this study has produced some interesting results, but still there is some limitations. First, usually companies want covert their process and do not want to share their practices. Second, however production managers, materials managers, production planners from larger firms were chosen to be the participants in this survey; but some questionnaires might have been completed by subordinates and thus the data may include bias and third is limited type of industries that were studied.

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