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# THE IMPACT OF TECHNICALLY-ORIENTED LEAN PRODUCTION PRACTICES ON OPERATIONAL PERFORMANCES IN MALAYSIAN MANUFACTURING INDUSTRIES

**[1]Rosman Iteng, & [2]Mohd Akhir Ahmad**
*[1,2]School of Technology Management and Logistics, College of Business, Universiti Utara Malaysia, UUM*

*Corresponding author: rosman@uum.edu.my*

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## ABSTRACT

The primary purpose of this paper is to investigate the relationships between technically-oriented lean production practices and operational performance in Malaysian manufacturing industries. Grounded by the Socio-technical System Theory and the Program Theory, this study formulates and examines a conceptual model that links technically-oriented lean production practices and operational performance. This study utilizes two hundred and five manufacturing companies, selected randomly from the Federation of Malaysian Manufacturers Directory. The study measures senior production or lean managers' perception of the lean production practices and the level of operational performances in their companies. This study applies SPSS package for data analysis. The result indicates that technically-oriented lean production practices namely quality at source, just-in time, flow system and technology & innovation are significantly associated with the operational performance of the companies. This study presents empirical evidence in the field of management, particularly in the context of operations management. The findings would further enrich the existing knowledge in this field. Finally, this study would provide useful guidance for the managers to plan and maintain lean production in the organization as well as to generate new measures of lean production in order to enhance operational performance at the company level.

**Keywords:** Lean production practices, operational performance, quality at source, just-in time, flow system, technology & innovation

## INTRODUCTION

Lean production has received a lot of attention in the manufacturing companies worldwide and in academic research since 1980s (Monden, 1981; Womack, Jones & Roos, 1990; Katayama & Bennett, 1996; Liker 2004; Li, Ragu-Nathan, Ragu-Nathan & Subba Rao, 2006; Shah & Ward, 2007; Matsui, 2007; Pham, Pham & Thomas, 2008). It is also claimed to be the universal practices for the 21st century (Womack et al., 1990). The core of lean production practices lies on the premise that it has brought changes in management practices by enhancing customer satisfaction as well as improving organizational effectiveness and efficiency (Ferdousi & Ahmed, 2009). The findings from extensive reviews of past literature on operation management have suggested that empirical research on lean production is still at an immature stage.

For example, Ferdousi and Ahmed (2009) claim that the empirical study of lean production is still at the early stage. Furthermore, Wong, Wong and Ali (2009) also affirm that the study of lean production is not fully explored, especially in the context of Malaysian manufacturing industry. To the best of researcher's knowledge, there is no explicit empirical evidence verifying the relationship between lean production, operational performance and business performance in the scope of Malaysian manufacturing industries up to this point of time (Wong et al., 2009; Arawati & Rosman, 2013). In other words, the study of the association of these constructs is yet to be empirically established in Malaysia. Furthermore, Cua, McKone and Schroeder (2001), Papadopoulou and Ozbayrak (2005), Shah and Ward (2003), Shah and Ward (2007) and Pettersen (2009) affirm that the level of the empirical studies on lean production and business performance is still yet to be fully explored. Therefore, the primary objective of this study is to examine relationships between technically-oriented lean production practices and operational performance in manufacturing industries. Although the theories imply that there is a positive relationship between lean production practices with organizational performance, some results from recent studies suggest that the relationship is not conclusive (Arawati & Rosman, 2013; Ferdousi & Ahmed, 2009).

## LITERATURE REVIEW

Liker (2004) defines lean production as a manufacturing philosophy that when implemented, is able to reduce the lead time from customer order to delivery by eliminating sources of waste in the production flow. It is claimed that lean production is the only system that considered the expenses of resources for any goal other than the creation of value for the end customer to be wasteful. Theoretically, lean production has two fundamental goals, namely waste reduction and respect for people. Meanwhile, Shah and Ward (2007) describe lean production as an integrated social-technical system, whose main objective is to eliminate waste by concurrently reducing or minimizing variability in supplier, customer and internal processes. Thus, they suggest lean production should be regarded as a configuration of practices or tools that is aimed to reduce variability in all aspects of business processes. Hence, lean production should be regarded as a system that composes of multi-component structure (including tools and practices) that should be implemented in totality in order to realize its benefits. This study defines lean production as a manufacturing strategy that integrate social (human) and technical (technology) practices with the primary goal of enhancing business performance through increasing operational performance by continually reducing and eventually eliminating all forms of waste in the production process.

Table 1 outlines the matrix table showing various lean production practices as proposed by different researchers from past literature. Having extensive reviewed of previous studies on lean production, this study incorporates eight elements that have been mostly cited in the literature as lean production practices, namely: (i) Supplier focus, (ii) Employee focus, (iii) Continuous improvement, (iv) Customer focus, (v) Quality at source, (vi) Just-in time, (vii) Flow system and (viii) Technology and innovation.

**Table 1.**

Lean production practices and their appearance in key references.

| Lean Practices | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Supplier focus | * | * | * | | * | * | * | * | * | * | |
| 2. Employee focus | * | * | | * | * | | * | * | * | * | |
| 3. Continuous improvement | * | * | * | * | * | | * | * | * | * | * |
| 4. Customer focus | * | * | | | * | | * | | | * | * |
| 5. Quality at source | * | * | | | * | | * | | | * | * |
| 6. Just-in time | * | * | | | * | | * | * | * | * | |
| 7. Flow system | * | * | * | * | * | | * | | * | * | * |
| 8. Technology and innovation | | * | | | * | | * | | * | | * |

Notes: (1) Shahram (2008); (2) Shah and Ward (2007); (3) Bhasin and Burcher (2006); (4) Woorley and Doolen (2006); (5) Liker (2004); (6) Wu (2003); (7) Shah and Ward (2003); (8) Sanchez and Perez (2001); (9) Cua et al. (2001); (10) Karlsson and Ahlstrom (1996); (11) Arawati and Rosman (2013).

**Socio-Technical System Theory (STS)**

The basic principle of Socio-Technical Systems Theory (STS) is that a joint optimization of practices that are socially and technically oriented should lead to good performance (Cua et al. 2001). Based on the principle, Rehder (1989) states that the importance to build manufacturing competitiveness upon the integration and coordination of strategy, structure, culture, and human resource subsystems within a complex, changing environment. Consequently, Rehder (1989) indicates that the success of Japanese companies operating outside Japan is reflected from the practices of the concept of a balanced between the social and technical system in all subsystems of the business processes. Therefore, grounded by the Socio-technical System Theory (STS), this study classified lean practices into two main dimensions, namely Socially-oriented Lean Production (SLEAN) and Technically-oriented Lean Production (TLEAN). Additionally, this study incorporates Customer Focus (CF), Supplier Focus (SF), Employee Focus (EF) and Continuous Improvement (CI) into Socially-oriented Lean Production (SLEAN); meanwhile, Just-in time (JIT), Flow System (FS), Quality at source (QAS) and Technology & Innovation (TI) are grouped under Technically-oriented Lean Production (TLEAN).

For the purpose of this paper, only technically-oriented lean production practices will be studied namely quality at source (QAS), just-in time (JIT), flow system (FSS) and technology and innovation (TNI).

## Quality at Source (QAS)

Quality at source is defined as '*Autonomation'* or *'Jidoka'* in Japanese, whereby '*Autonomation'* is regarded as any equipment or machines that are endowed with human intelligence to stop by itself when a problem occurs in the manufacturing process (Womack and Jones 1996; Liker 2004; Carreira 2005). Sometimes, Liker (2004) views 'quality at source' as 'in-station quality', whereby 'in-station quality' is delineated as preventing problems from being passed down the line. Subsequently, he claims that it is much more effective and less costly by preventing problems from occurring rather than inspecting and repairing the problems after it occur. In lean production system, 'quality at source' functions in a manner when equipment or machine shuts down, flag or light, usually with accompanying music or an alarm, is used to signal that the help is required to solve a quality problem at the particular work station or 'cell' (Liker 2004; Carreira 2005). The signaling system is referred as *'Andon'* in Japanese term whereby '*Andon'* is regarded as the light signal for help (Ohno 1988; Liker 2004). Moreover, in lean production practices, worker at the station is given an authority to stop the whole assembly line immediately if problems appear that he or she cannot fix it (Ohno 1988; Liker 2004). Consequently, the whole team members will come over to work on the problem at the source. This is actually the spirit of quality at source (Liker 2004).

## Just-in-Time (JIT)

According to Ohno (1988), Womack and Jones (1996), Liker (2004), and Carreira (2005), just-in-time (JIT) is very well known and common practice in lean companies. Just-in-time (JIT) is defined as "a set of principles, tools, and techniques that allows a company to produce and deliver products in small quantities" (Liker 2004), with shortest lead times, to meet specific customer needs (Ohno 1988; Womack and Jones 1996; Liker 2004). Specifically, Liker (2004) defines JIT as "delivering the right items at the right time in the right amounts". The significance of JIT is that it allows companies to be "responsive to the day-by-day shifts in customer demand" (Liker 2004). Ohno (1988), Womack and Jones (1996) and Liker (2004) argue that in order to achieve the goal of always having the right part in the right amount at the right time, various practices and principles can be utilized such as 'pull system' and '*Kanban*' system.

Pull system involves scheduling for production as per customer's demand or order driven scheduling (Womack & Jones, 1996; Liker, 2004; Carreira, 2005). The basic idea behind the system is that the manufacturer produces exactly what is required by the customer's demand only; neither more nor less (Ohno, 1988; Womack & Jones, 1996; Liker, 2004). Accordingly, Liker (2004) defines 'pull' as the ideal state of just-in-time manufacturing which implies giving the customers "what they want, when they want it, and in the amount they want" (Liker, 2004). Meanwhile, Ohno (1988) states that the basic idea behind pull system is that "things are done when they are required to be done, not before" (Ohno, 1988). This implies that pull system is actually a consumption-driven or customer demand-driven system, not a forecast-driven system (Carreira, 2005). Another tool that is used in the lean production system to achieve the ideal state of just-in-time with actual usage or consumption is a *'Kanban'* system. In practical terms, a '*Kanban'* system means a simple signal in the form of cards, empty containers, bins, signboard and so on in order to notify that the refill or replenishment with a specific amount of demand is required (Ohno, 1988; Womack & Jones, 1996; Liker, 2004; Carreira, 2005).

Referring to Ohno (1988), Womack and Jones (1996) and Liker (2004), another perspective of JIT is that it commonly used to describe a '*stockless'* production system. In this system, only the right parts are completed and delivered to customers at the right time (Ohno, 1988). Consequently, it is also expected that the right part is received from suppliers at the right time as well (Ohno, 1988, Liker, 2004). Explicitly, Liker (2004) proposes that JIT should compose of four basic principles, namely: (1) produce at the right time, (2) at the right place, (3) in the right quantity, and (4) with the right quantity. In short, JIT is simply about "producing at the right time, at the right place, in the right quantity, and with the right quantity" (Liker, 2004).

**Flow System (FSS)**

The basic concept of the flow system is that the part or sub-assembly does not stop except for it to be processed or for value-added work (Shah & Ward, 2003). A flow system can be visualized through value stream mapping (VSM) (Liker, 2004; Carreira, 2005). A value stream mapping (VSM) is applied to identify bottlenecks and help to understand the process flow better (Womack & Jones, 1996; Liker, 2004; Carreira, 2005). Originally, Ohno (1988) defines a flow system as "designing and organizing equipment or machineries to follow the flow of material as it is being transformed into a product". Later, this concept is refined and became popular as '*lean cell'* or cellular manufacturing principle (Liker, 2004; Carreira, 2005).

The cellular manufacturing principle takes into account the arrangement of equipment or machine in the station or "cell". According to Liker (2004) and Carreira (2005), this arrangement shall take into consideration of efficient movement of people or ergonomics, smooth flow of materials and good communication. In order for a flow system to be effective, people need to be multi-skilled (Liker, 2004) and should be able to work across different functions or stations (cells) in the manufacturing process (Liker, 2004; Carreira, 2005). In addition, Davis and Heineke (2005) claim that a flow system shall be coupled with the concept of "takt" time logic. The "takt" time logic refers to the frequency of which customer consumes a unit of product (Liker, 2004; Carreira, 2005; Davis & Heineke, 2005). In other words, takt time logic is referred as the amount of time that is needed to produce a unit of product to meet the demand of customer (Liker, 2004; Carreira, 2005; Davis & Heineke, 2005).

**Technology and Innovation (TNI)**

According to Liker (2004), technology and innovation has contributed a major role in our daily activities. Generally, we have reached "the point where one can push a button and be immediately abundant with technical and managerial information" (Liker, 2004). The fact that today we are living in the world of technological edge (Liker, 2004). However, in the lean production setting, the principle is that the adoption of new technology in manufacturing processes must support people, process and values, not vice-versa (Liker, 2004). Therefore, lean production utilizes only a reliable and thoroughly tested technology that serves people and process (Liker, 2004). Accordingly, Liker (2004) states that "a tested technology involves both the existing technology and the new or cutting-edge technology that one has thoroughly evaluated and piloted to prove it works".

Ideally, the deployment of a tested or proven technology leads to a company's better performance with lesser risk (McKone, Schroeder & Cua, 2001; Cua et al., 2001; Liker, 2004). Consequently, McKone et al. (2001) and Cua et al. (2001) suggest that "companies that develop their technological base are able to capitalize on technology's ability to make a positive contribution to the performance". Technology can improve company's performance in a manner that it facilitates workers to perform their job. As a result, the job becomes easier and faster to deliver with less stress to the people and higher quality product (Liker, 2004). The utilization of technology in lean production setting will also improve the skill of employees or people in the company as they have to continually learn to keep abreast with the never-ending changing technology. As Cua et al. (2001) have claimed that "lean production can improve the technological base of a company by enhancing equipment technology and improving the skill of employees"; this study expects that by utilizing and improving the technology of a plant will enhance the company's performance as well.

**Program Theory**

The theory describes the explicit and implicit assumptions made by program stakeholders about the actions required to obtain greater efficiency, and how these actions will lead to specific outcomes that result in the program accomplishing its goals. Rogers, Petrosino, Huebner and Hacsi (2000) define the Program Theory as the underlying assumptions about how a specific program is expected to work. The Program Theory specifies more than just a simple input and output, and it is not simply a "to do" list of program activities. Instead, the Program Theory is a model showing a series intermediate outcome, and moderating variables that lead to the desired outcomes. Cervero (1985) suggests that by including such mediators or moderators, the results of the outcome will be more comprehensive. As a result, the understanding of the organizational conditions, individuals, and characteristics of programs being implemented are more inclusive. Consequently, the channels through which the program achieves the desired results or vice versa can then be mapped. Applying the Program Theory in the implementation of lean production, the practices being implemented should be considered as a program designed by the stakeholder to achieve the specific goals. The Program Theory implies that the desired outcome does not come from the direct input of the program, but it emerges from a series of intermediate outcomes. The program investigated in this study is 'lean production' whereby the outcome here refers to 'operational performance' and 'business performance'. For the purpose of this study, the implementation of lean production in the workplace is expected to improve the internal processes and assists to enhance 'operational performance'. As a result, it will ultimately improve the 'business performance' against its competitors (Arawati, 2011; Arawati & Rosman, 2013).

**Operational performance**

Operational performance is defined as how well the process in the company performed in accordance with its operational standard (Cua et al., 2001; Shah & Ward, 2007). There are many ways of measuring operational performance in the company, however as Cua et al. (2001) assert, the most cited approach in the literature to measure operational performance in the manufacturing industry is to use 'cost', 'quality', 'delivery' and 'flexibility' as the four basic dimensions.

For the purpose of this study, operational performance is viewed from three perspectives, namely quality performance, delivery performance and operational effectiveness.

## Quality performance

Cua et al. (2001) defines quality performance as product conformance, product performance and product reliability. For the purpose of this study, product conformance is referred as the level of effectiveness of the design and production functions in effecting the product manufacturing requirements and process specifications, while meeting process control limits, product tolerances, and production targets (Cua et al., 2001). Meanwhile, product performance is referred as products that meet written requirement that describe the functional performance criteria required for the particular product (Cua et al., 2001). On the other hand, product reliability is referred as the probability that a product will satisfactorily perform its intended function under given circumstances, such as environmental conditions, limitations as to operating time, and frequency and thoroughness of maintenance for a specified period of time (Cua et al., 2001).

## Delivery performance

Liker (2004) claims that delivery performance is a key indicator for the level of a company's performance from the customer point of view. Delivery performance indicates the ability of a company to provide the correct and in-time deliveries to its customers (Liker, 2004). As such, Cua et al. (2001) and Li et al. (2006) define delivery performance as "the percentage of orders delivered on time and the manufacturing lead-time from when an order is placed until it is delivered".

## Operational effectiveness

Liker (2004) defines "effectiveness" as "getting the right things done". Therefore, the effectiveness of the operation is regarded as the 'increased in productivity', 'reducing the manufacturing cycle time' and 'reducing cost and variability' in the manufacturing process (Cua et al., 2001; Liker, 2004).

## The conceptual framework: The model and hypothesis

The development of the conceptual framework for this study is hold by Program Theory which accentuates that organizational goal can be achieved through an effective operational process with the implementation of superior management practices. Program theory links inputs (lean production practices) with activities to outcomes (operational performance). Consequently, this study proposed a conceptual framework as depicted in Figure 1. The proposed model is based on two main constructs namely, Technically-oriented Lean Practices (TLEAN) and Operational Performance (OP).

For the purpose of this paper, four hypotheses have been proposed. Callen, Fader and Krinsky (2000) state that by "adopting a range of lean production practices bears a direct relationship to the improvement in performance". Specifically, they claim lean production is associated with improved inventory performance and higher profitability (business performance). Additionally, Liker (2004) claims lean production aids competitiveness through market competitive positioning, customer relationship and quality constraints. This is supported by Avittathur and Swamidass (2007) who claim just-in-time (JIT) which is a component of lean production practices is significantly associated with aggregate performance which consist of market performance and financial performance (business performance). Therefore, this study hypothesizes the following:

H1: Quality at source (QAS) is positively related to operational performance (OP).
H2: Just-in time (JIT) is positively related to operational performance (OP).
H3: Flow system (FSS) is positively related to operational performance (OP).
H4: Technology and innovation (TNI) is positively related to operational performance (OP).

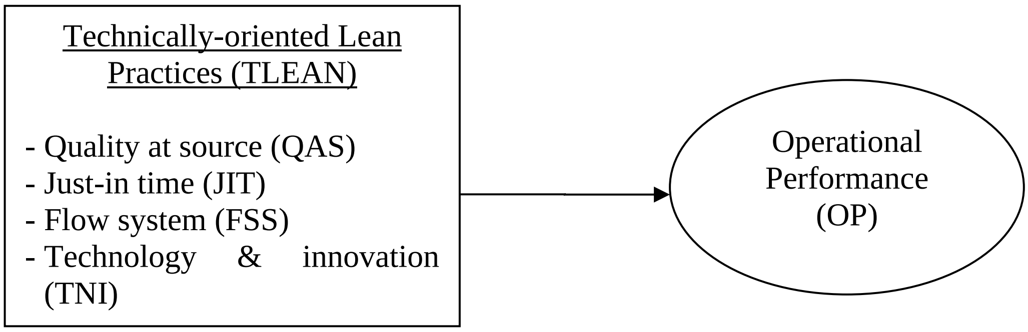


**Figure 1.** *The conceptual model showing the relationship between technically oriented lean production practices and operational performance*

## METHODOLOGY

This study deployed a quantitative, cross-sectional research methodology utilizing primary data collection. The unit of analysis chosen for this study was company level and each company was represented by senior manager as the respondent. The sampling frame was derived from the Federation of Malaysian Manufacturing Companies Directory. The samples were randomly selected using a simple random sampling method. Two hundred and five useable responses were analyzed using SPSS package.

The research instrument used in this study was a structured survey questionnaire, which was designed to assess the companies in term of the described dimensions. The survey instrument designed consisted of three major parts. The first part comprised several constructs measuring lean production practices, and the second part captured several performance measurements. The last part retrieved information about each company's profile. To enable respondents to indicate their answers, seven–point interval scales were used in measurement. The performance measure namely operational performance also used a seven-point interval scale, representing a range of agreement with statements whether over the past three years these performances were high relative to competitors after implementing lean production. The primary data were collected through various means such as face-to-face interview, ordinary mail service, email, telephone call and fax.

Validity and reliability tests were used to select and assess the final items of the main constructs that were used for further statistical testing. The critical variables of lean production in this study had content validity because an extensive review of the literature was conducted in selecting the measurement items and the critical constructs; and all the items and factors had been evaluated and validated by professionals in the area of operation management or lean production (face-content validity). In addition, the draft questionnaire was pre-tested with academicians to check its content validity and terminology and modified accordingly. Before creating the final scales, the data were checked for normality and outliers; and were found to be satisfactory.

## RESULTS AND DISCUSSION

This study utilized SPSS to analyze the linkages between technically-oriented lean production practices (TLEAN) and Operational Performance (OP). Having confirmed that data are normal, correlation and regression analysis were conducted to examining the relationship between operational performance (OP) and technically-oriented lean production practices. Table 2 summarizes the descriptive statistics and analysis results. As can be seen from the Table, each of the technically-oriented lean production practices (QAS, JIT, FSS and TNI) is positively and significantly correlated with operational performance (OP), indicating that companies that practice quality at source, just-in time, flow system and technology & innovation in a bundle tend to be better in term of their operational performance.

The multiple regression model with all four predictors (QAS, JIT, FSS and TNI) produced $R^2 = 0.346$, $F(4, 200) = 26.43$, $p < 0.001$. As can be seen in Table 2, the continuous improvement (CI) and customer focus (CF) had significant positive regression weight ($p<0.01$), indicating companies that practice quality at source (QAS) and technology & innovation (TNI) program were expected to have high level of operational performance. Meanwhile, the regression weight of flow system (FSS) program had moderately affect the operational performance ($p<0.05$). On the other hand, just-in time (JIT) program does not significantly contribute to the regression model ($p>0.05$), indicating that just-in time (JIT) program does significantly affect operational performance of the manufacturing companies

**Table 2.**

Summary statistics, correlation and results from regression analysis.

| Variable | Mean | Std. deviation | Correlation with OP | Multiple regression weights Standardized Coefficients ,β | Results |
|---|---|---|---|---|---|
| OP | 5.473 | .666 | - | - | |
| QAS | 5.026 | 1.082 | .447** | .173** | H1: supported |
| JIT | 5.134 | 1.102 | .377* | .085 | H2: not supported |
| FSS | 5.553 | .692 | .323* | .108* | H3: supported |
| TNI | 5.277 | .942 | .545** | .369** | H4: supported |

*p<0.05; **p<0.01

## CONCLUSION AND IMPLICATION

Although several researchers have provided empirical evidences on the linkage between lean production practices and performance, some might have overlooked the technical aspect of it.

This study recognized that lean practices particularly the technically oriented lean practices have significant impact on company's performance. Companies that implement quality at source (QAS) and apply technology and innovation (TNI) as well as practice flow system (FSS) would enjoy a significant positive impact on operational performance indicators i.e. increase in quality performance, delivery performance and operational effectiveness (reducing cycle time in the process). However, companies should be more careful in giving attention to just-in time (JIT) program as it does not significantly contribute to the operational performance. The limitation of this study is that it employs a cross-sectional design in which data are collected from respondents at a single point in time. One of the weaknesses in this method is that it does not allow us to draw firm conclusion regarding the causal direction of the relationships among the predictor and outcome variables. Given this limitation, future research should utilize longitudinal designs which will ensure the continuity of the response.

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