LEAN PRODUCTION SYSTEM TO ENHANCE PERFORMANCE IN OPERATIONS: AN EMPIRICAL STUDY OF MALAYSIAN CONSTRUCTION INDUSTRY

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ABSTRACT

The construction industry consumes large amount of natural resources. These resources, if not properly utilized, will lead to a generation of waste. These wastes do not add value and affect the construction industry's performance globally. The aim of this research is to improve operational performance of Malaysian construction industry by the application of Lean Production System (LPS) that has a significant impetus in reduction of waste. The assessment of construction practices against Lean Production System principles was carried out through structured questionnaires to the G7 construction organizations, that is, organizations which have no limit to tender for construction jobs. These organizations are registered with the Construction Industries Development Board (CIDB), Ministry of Works Malaysia. The data revealed that the G7 construction organizations have integrated some form of LPS principles in day-to-day operations at the macro level; however knowledge of LPS is not fully conceptualized. The application of LPS principles has improved operational performance because findings revealed that there is a correlation between Lean Production System (LPS) and operational performance (OP).

KEY WORDS

Malaysian construction industry, lean production system (LPS), operational performance, lean construction (LC).

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INTRODUCTION

The construction industry consumes large amount of natural resources. These resources, if not properly utilized, will lead to a generation of waste such as unproductive time, nonconformity, errors and alterations, rework, poor quality of work, delays, waiting for resources, poor material allocation, wastages of material and unnecessary material handling. These wastes do not add value and affect the construction industry's performance globally. Numerous reasons contributed to the poor performance but the identification and reduction of waste has always been left aside. Construction industry performance is important because it is an element to the national wealth creation as it acts as a catalyst for, and has a multiplier effect to the other sectors of the economy such as manufacturing, professional services, financial services, education and others. Furthermore, Client(s) in the public and private sectors demand for faster construction, lowest construction cost, and increased profits to implement the projects. Hence, improvement in the operational performance of the construction industry has been subject of much research and there remains much need for further improvement (Wong 1991, Egan 1998, Tan Sri Dato Zaini Omar 2000, CIDB Master Plan OSHA 2004).

The problems and their improvements (Latham 1994, Egan 1998) in the construction industry were never ignored and several solutions have been proposed in the past. For instance, Quality Assurance has been advocated for poor quality (BSI 1987), computerised integration of designs and procurements for low productivity (Betts et. al. 1994) and electronic data interchange for poor coordination (Dynn and Levitt 1991). These solutions were adapted from the manufacturing sector and modified to suit the conditions of the construction industry. This means that manufacturing has been a source of inspiration for performance improvement in the construction industry. However, at least up till now, there have been no signs of major improvement resulting from these solutions (Koskela 1992). Whereas, LPS has brought improvement in many areas of manufacturing and Egan (1998) has recommended that construction had much to gain by its application and it is a solution to improve in operational performance.

DESCRIPTION OF PROBLEM STATEMENT

The Malaysian construction industry has carried out several mega projects in the past two decades but most of these projects were not cost, time and quality effective (Ron Pratt 2000, Abdul-Rahman and Berawi 2002, Hussein 2003, Chong 2005, Abdul-Rahman et. al. 2006a, 2006b). The CEO CIDB Malaysia in an interview proclaimed that in 2002, about 45 percent of projects were delayed by six months while 14 percent were delayed by more than 12 months (Dato Ir Hamzah Hassan 2003). This has not only resulted in waste of resources (6 M's) but also delayed delivery of projects that has affected the construction sector's contribution to the economy.

LITERATURE REVIEW

LPS is a technique in operations management and is a long established operations management research priority (Bodek 2002, Slack et. al. 2004). It is defined as reduction of non-value added activities called waste through continuous improvement and thereby reducing time from customer order to the collection of cash (Ohno 1988, Spear and Brown 1999). The literature describing various viewpoints of LPS is extensive. However, a review of the literature highlights a common theme (Schonberger 1982, 1986, Womack et. al. 1990, Womack and Jones 1996): LPS is an integrated set of principles and practices designed to maintain a high quality and low costs through reducing work-in process inventories, involving workers at all levels in the decision-making process and integrating all participants from suppliers to customers in the manufacturing process.

It has been applied in manufacturing, automotive, aviation, industrial equipment, furniture, fixture, consumer goods, ceramics, software, healthcare (Womack and Jones 1996, Imtiaz, G. and Ibrahim, A.R. 2006a, Moore and Gibbons 1997) and results showed significant improvements in the operational performance such as cost, quality, on-time delivery, inventory level and value added per employee (Berry et. al. 2003). More recently LPS has been studied in construction and the seminal author is Lauri Koskela (Koskela 1992). The application of LPS in construction is termed as lean construction or LC (Ballard and Howell 1998), however lean construction is a philosophy based on the principles of LPS (Connaughton and Nile 1998, Alarcon et. al. 2004).

The careful review of literature revealed that LPS principles are: elimination of waste, multifunctional teams, continuous improvement, just-in-time production and delivery, integration of suppliers, flexible information systems, zero defect, pull instead of push and decentralisation (Ahlstrom and Karlsson 1996, Koskela 2000, Ahlstrom and Karlsson 2000, Sanchez and Perez 2001, Horacio and Forrester 2002, Kilpatrick 2003) are defined below.

Elimination of Waste

The main purpose of LPS is to lower costs of the product and this is done through the elimination of waste. The waste is defined as everything that does not add value to the product (Monden 1983, Womack and Jones 1996).

Continuous Improvement

If the elimination of waste is the most fundamental principle of LPS, then continuous improvement can be said to come second (Karlsson and Ahlstrom 1996). The production system is being constantly improved its products and processes; perfection is the only goal (Hayes 1981, Oakland 1993).

Multifunctional Teams

The most salient feature of LPS work organizations is the extensive use of multifunctional teams. These organizations greatly facilitate task rotation and flexibility to accommodate changes in production levels (Sanchez and Perez 2001). It is a group of employees who are able to perform many different tasks (Karlsson and Ahlstrom 1996).

Just-in-Time Production and Delivery

JIT philosophy implies the delivery of any part in the necessary quantity and at right time. This practice is widely adopted among the suppliers in the automotive industry (Hines 1996, Azariah 2002).

Integration of Suppliers

The manufacturing commentators have recognised the positive impact of closer working relationships with suppliers on product quality (Womack and Jones 1996), whilst construction industry commentators advocate the use of this principle to improve relationship (CII 1991, Latham 1994, Egan 1998) and it has become an increasingly popular form of business relationship within construction over the last decade (Crane et. al. 1997).

Flexible Information System

This LPS principle implies a decentralization of responsibilities to the production line workers and a decrease of the hierarchical levels of the company. The LPS organization requires the diffusion of information to all levels (Womack et. al. 1990, Womack and Jones 1996).

RESEARCH DESIGN

Survey research methodology was employed to collect data because it is difficult to gain access to the construction sites in Malaysia. The sampling frame is taken from Construction Industry Development Board, Malaysia and a structured questionnaire was despatched to thirteen hundred G7 companies. These organizations have no limit to tender the jobs, handling large, uncertain and complex construction projects (Ibrahim, AR and Imtiaz, G 2005, Imtiaz, G et. al. 2006b). LPS in construction is suitable for complex and large construction jobs like hospitals, airports and terminals; amusement parks (Business Times, 6th August 2004) and should reap the greatest savings. The respondents to this survey are Senior Managers.

RESEARCH HYPOTHESES

This research is testing two hypotheses. These are:

LPS Integration Hypothesis

LPS principles (as measured by elimination of waste, EW; continuous improvement, CI; just-in-time production and deliveries, JIT; multifunctional teams, MFT; integration of suppliers, IS and flexible information systems, FIS) are integrated by the construction companies (as measured by degree of integration, DOI).

Operational Performance Hypothesis

LPS (as measured by elimination of waste, EW; continuous improvement, CI; just-in-time production and deliveries, JIT; multifunctional teams, MFT; integration of suppliers, IS and flexible information systems, FIS) have influence in operational performance (as measured by OP).

SURVEY INSTRUMENT DESIGN

The survey questionnaire developed by the other researchers (Karlsson and Ahlstrom 1996, Angel and Manuala 2001, Horacio and Forrester 2002, Zoe and Morris 2002, Yen 2003, Imtiaz, G. et. al. 2006b) in LPS area was consulted before designing instrument for this research and a pilot study was also conducted to address validity and reliability issues.

There are two dependent and six independent variables. The dependent variables are degree of integration (DOI) and operational performance (OP). The independent variables are elimination of waste (EW), continuous improvement (CI), just in time (JIT) supply production and delivery, multifunctional team (MFT), integration of suppliers (IS) and flexible information system (FIS).

The first dependent variable is DOI and was measured by asking respondents to: "rate the degree of integration of lean production system principles", followed by a list of six principles of the lean production system. The respondent rated their answers on a seven-point scale with scores ranging from 1 (Total adoption), 2 (Very significant adoption), 3 (Significant adoption), 4 (partial adoption), 5 (Insignificant adoption), 6 (Very Insignificant adoption) and 7 (No adoption). The mean and standard deviation were computed with the scores of these six answers. The mean is the value of the dependent variable DOI. Theoretically derived determinants lying behind these independent variables were also developed.

The second dependent variable is operational performance (OP). This was measured by asking respondents: "how do you rate the performance of projects in your company in terms of time, cost and quality?" The respondent rated their answer on a five-point scale with scores ranging from 1 (very poor) to 5 (very good), with a score of 3 (Fair) as middle point of the scale. The mean and standard deviation were computed with the scores of these answers. The mean is the value of the dependent variable OP. The research model is shown in figure 1.

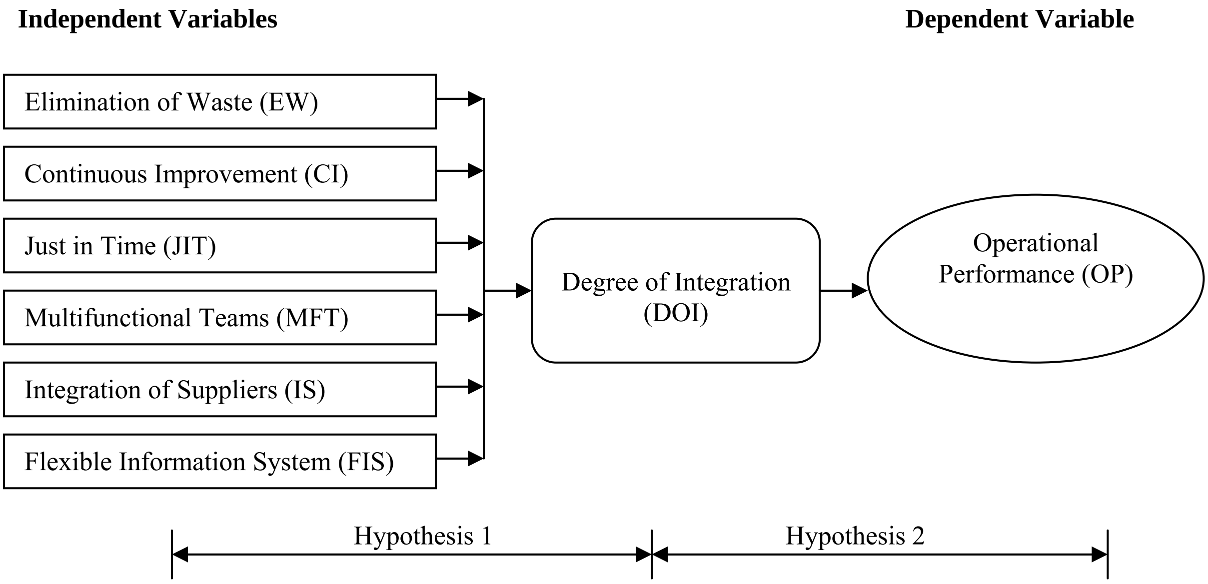

Figure 1: Research Model

DATA ANALYSIS AND DISCUSSION

The response rate was 22.7%. Table 1, Table 2 and Table 3 shows integration of LPS principles, descriptive statistics and statistically significant correlation respectively.

Table 1: Integration of LPS Principles

LPS Principles	*High Integration*	*Low Integration*	*No Integration*
Continuous Improvement	240 (81.1%)	48 (16.2%)	8 (2.7%)
Multifunctional Teams	216 (73.0%)	72 (24.3%)	8 (2.7%)
Elimination of Waste	212 (71.6%)	76 (25.7%)	8 (2.7%)
Just-in-Time	208 (70.3%)	72 (24.3%)	16 (5.4%)
Integration of Suppliers	180 (60.8%)	104 (35.1%)	12 (4.1%)
Flexible Information Systems	180 (60.8%)	104 (35.1%)	12 (4.1%)
Degree of Integration	172 (58.1%)	116 (39.2%)	8 (2.7%)

Table 2: Descriptive Statistics

Variables	***Mean***	***Std Dev***	***Skewness***	***Kurtosis***
Continuous Improvement	2.69	1.327	1.042	1.606
Multifunctional Teams	2.92	1.345	0.754	0.636
Elimination of Waste	2.95	1.347	0.803	0.934
Just-in-Time	3.07	1.439	0.899	0.960
Integration of Suppliers	3.34	1.341	0.792	0.586
Flexible Information Systems	3.36	1.403	0.695	0.401
Degree of Integration	3.03	0.956	0.871	1.137
Operational Performance	2.82	1.779	- 0.147	- 1.405

Table 3: Correlation Coefficient Matrix – Main Variables

Variables	***DOI***	***OP***	***EW***	***CI***	***MFT***	***JIT***	***IS***	***FIS***
DOI	1.00							
OP	-.301**	1.00						
	(.000)							
EW	.568**	-.047	1.00					
	(.000)	(.424)						
CI	.522**	-.146*	.481**	1.00				
	(.000)	(.012)	(.000)					
MFT	.730**	-.071	.573**	.547**	1.00			
	(.000)	(.223)	(.000)	(.000)				
JIT	.598**	-.208**	.556**	.609**	.584**	1.00		
	(.000)	(.000)	(.000)	(.000)	(.000)			
IS	.546**	-.273**	.558**	.456**	.537**	.536**	1.00	
	(.000)	(.000)	(.000)	(.000)	(.000)	(.000)		
FIS	.705**	-.182**	.565**	.625**	.742**	.592**	.537**	1.00
	(.000)	(.002)	(.000)	(.000)	(.000)	(.000)	(.000)	

*Significant at the 0.05 level and **Significant at the 0.01 level

The multicollinearity, linearity, homoscedasticity and normality were checked and satisfied before employing multiple regressions. The value of R, R^2 and adjusted R^2 were 0.792, 0.627 and 0.619 respectively, while the standard error was 0.590 for LPS integration hypothesis and LPS principles accounted for 61.9 percent of the variance (see Table 4). While, for operational performance hypothesis value of R and R^2 and adjusted R^2 were 0.361, 0.130 and 0.112 respectively, while the standard error was 1.484 and LPS principles accounted for 11.2 percent of the variance in operational performance (see Table 5).

Table 4: Result of Multiple Regressions – LPS Integration: Hypothesis 1

Independent Variables	***Unstandardized Coefficients***		***Standardized Coefficients***	***t***	***Sig.***
	B	Std. Error	Beta		
(Constant)	0.550	0.138		3.994	0.000
Flexible information systems	0.250	0.057	0.261	4.370	0.000
Multifunction team	0.361	0.058	0.358	6.243	0.000
Just-in-time	0.121	0.045	0.139	2.685	0.008
Integration of suppliers	0.094	0.049	0.091	1.928	0.055
Elimination of waste	0.089	0.049	0.090	1.827	0.069
Continuous improvement	- 0.005	0.041	- 0.006	- 0.120	0.904

Dependent Variable: Degree of Integration (DOI); Significant at 0.05 level.

Table 5: Result of Multiple Regressions – Operational Performance: Hypothesis 2

Independent Variables	***Unstandardized Coefficients***		***Standardized Coefficients***	***t***	***Sig.***
	B	Std. Error	Beta		
(Constant)	4.275	0.346		12.346	0.000
Flexible information systems	- 0.306	0.144	- 0.195	- 2.131	0.034
Multifunction teams	0.368	0.145	0.222	2.536	0.012
Just-in-time	- 0.244	0.113	- 0.171	- 2.158	0.032
Integration of suppliers	- 0.524	0.122	- 0.310	- 4.288	0.000
Elimination of waste	0.333	0.123	0.203	2.715	0.007
Continuous improvement	0.003	0.104	0.002	0.028	0.978

Dependent Variable: Operational Performance (OP); Significant at 0.05 level.

The sample regressions lines are:

DOI = 0.550+0.250 FIS+0.361 MFT+0.121 JIT+0.094 IS+0.089 EW–0.005 CI

OP = 4.275–0.306 FIS+0.368 MFT–0.244 JIT–0.524 IS+0.333 EW+0.003 CI

The results from the survey revealed that 58.1% of the construction firms level integration (see Table 1) of LPS principles at mean score equals three (see Table 2). This indicates a significant emphasis on integration of LPS principles; however the intensity of integration varies from firm to firm. Though some of LPS principles are already integrated by organizations at macro level in day-to-day activities but knowledge of LPS is not fully conceptualized. The research also revealed that 41.9% of organizations need to adopt LPS principles in order to improve performance. The construction organizations need to give importance to identify and eliminate waste from all facets of construction operations. This can be done through the use of planning production process and workflow. It will help organizations to further enhance operational performance. The organizations also need to apply LPS holistically in construction by focusing on improving whole processes and construction supply chain have to commit, involve and work together to realise significant improvements in operations.

The correlation between each LPS principles and DOI are all significant at $\alpha = 0.000$ (see Table 3 and is positively correlated. The regression analysis showed that the LPS principles were significant at 0.05 level ($F = 80.862$, $p = 0.000$) and accounted for 61.9 percent of the variance in DOI. Taken together, these findings provide positive support and there is enough evidence to accept LPS integration hypothesis. This result is consistent with the other studies conducted by Dulaimi and Tanamas (1999), Imtiaz, G. *et. al*. (2006b), Mohan and Iyer (2005), Santos et. al. (2002) and Zoe and Morris (2002) in the Singapore, Malaysian, United States, Brazilian and the United Kingdom construction industries respectively.

As for the second hypothesis, Table 3 showed that degree of integration of LPS principles is highly significantly correlated with the operational performance and Table 5 presents multiple regression results predicting the influence of LPS principles in the operational performance. Thus, there is enough evidence to accept second hypothesis. This result is consistent with the assertions of Mohan and Iyer (2005) and Zoe and Morris (2002) in the USA and the UK construction companies respectively.

CONCLUSION

Using survey research methodology the researchers have collected real data from G7 Malaysian construction organizations and this research has demonstrated that the organizations have integrated some of the principles of LPS in construction, but with variations. Some of the LPS principles are incorporated more frequently than others. Out of the six LPS principles the most in use is continuous improvement, followed by multifunctional teams, elimination of waste, just-in-time, integration of suppliers, and flexible information systems. The regression analysis showed that the model is highly significant. Interestingly, LPS principles have influence in operational performance. Though some of LPS principles are already integrated by organizations at macro level in day-to-day activities but knowledge of LPS is not fully conceptualized. The organizations need to give importance to identify and eliminate waste from all facets of construction operations. This can be done through the use of planning production process and workflow. It will help organizations to further enhance operational performance. They also need to apply LPS principles holistically in construction by focusing on improving whole processes and construction supply chain have to commit, involve and work together to realise significant improvement in operations.

This research has found a correlation between LPS principles and operational performance. It is also found that Malaysian construction organizations have integrated some of the LPS principles and it has improved operational performance, thus giving a useful contribution to the industry, academia and the society. Future agenda is to improve construction industry performance by implementing LPS that requires government/university/ industry initiative.

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