The Effect of Continuous Improvement on Waste Elimination for Implementing Lean Manufacturing in the Apparel Industry of Bangladesh

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ABSTRACT

Lean Manufacturing (LM) is an advanced manufacturing philosophy used for the improvement of organizational performance in a competitive business environment. The primary objective of lean manufacturing is to eliminate the waste (non-value added activities) from the production processes. Lean manufacturing consists of several lean parameters such as top management commitment, people management, process management, just-in-time production, total quality management, total productive maintenance and continuous improvement. The impacts of each of the lean parameters on the organizational performance need to be verified. This paper addresses the effect of continuous improvement as a lean parameter on the waste elimination in the apparel industry of Bangladesh.

Keywords: Apparel industry, Lean manufacturing, Lean parameter, Continuous Improvement, Organizational Performance.

INTRODUCTION

The apparel industry has made a significant contribution in the economic development of Bangladesh. Despite the remarkable success, the garments manufacturers are facing various challenges to meet the customers demand and expectations. The buyers are expecting high quality products at a lower cost with high variation in demands. The buyers are also expecting less manufacturing and delivery lead time. Due to the raise of global competition and unstable market conditions, there is a constant search for new manufacturing techniques to meet the buyer's expectations. Lean Manufacturing (LM) is one of the most advanced manufacturing techniques used for the improvement of performance and competitiveness (Nawarnir, Kong Teong & Norezam Othman 2013). The basic principle of LM is the elimination of waste from the production processes. LM originated from Toyota Production System (TPS). The basis of Toyota production system is the absolute elimination of waste (Taichi Ohno 1988). The story of lean production with its benefits compare to Ford mass production system was summarized in a book *"The machine that changed the world"* (Womack and Jones 1990). LM consists of various lean parameters. But, there is no general agreement about the lean parameters. Different authors have listed different lean parameters in their studies. Some of the common lean parameters are Just-in time (JIT), Total Quality Management (TQM), Total Productive Maintenance (TPM), Continuous Improvement (CI), Top Management Commitment (TMC), Visual Management etc. This research paper examines the effects of continuous improvement on waste elimination.

LITERATURE REVIEW

LM is an advanced manufacturing techniques used for identifying and eliminating waste through continuous improvement. According to Womack and Jones (1994), the main trust of lean is the total elimination of waste (Pakdil &Leonard 2015). LM system makes the company leaner, flexible and more responsive by reducing waste (Wilson 2010a). The implementation of LM improves the productivity performance (Fullerton & Wempe 2009). CI is a lean culture and improvement initiatives that increases success and reduces the failures. CI is an improvement initiative targeting the elimination of waste from all processes of the organization. Kaizen is one of the key driver of LM (Sisson & Elshennawy, 2015).

Waste is anything that does not add value to the product and interferes with the smooth flow of production (MacDuffie &Helper 1997). Ohno (1988) categorized seven basic type of waste.

Figure 1: Seven Waste of Lean

Over Production

Over production means producing more than the customer demands. Over product is costly, because, overproduction interfere the smooth flow of production and degrades the quality and productivity (Islam et. al., 2013). Over production is the most important of the 7 types of waste because, over production actually drives all of the other six types of waste as well. The excess product now has to be stored somewhere which means excess motion, transportation and inventory. Over production increases the risk of obsolescence and risk of producing wrong thing (Capital, 2004)

Waiting

Waiting means workers or machine is waiting for materials and it makes the production line unbalanced. Waiting is perhaps the most obvious of the 7 wastes of lean manufacturing. It is easily identifiable as lost time due to poor flow: parts shortages, bottlenecks, and equipment breakdowns. The waste of waiting includes small delays between processes due to bottlenecks or inefficient production flow on the shop floor (Capital, 2004).

Transportation

Transport is the movement of materials from one location to another location and the unnecessary movement of materials that does not add value to the product is the transportation waste. The excess motion is the wasted movement of people, but unnecessary transportation is excess motion of work in process. The excessive movements and double handling of materials are likely to cause damage and deterioration with the distance of communication between processes (Hines and Rich, 2007).

Excess inventory

Excess inventory takes up space, adds no value but costs money and gets damaged eventually. Excess inventory tends to hide problems in the shop floor, which need to be identified and resolved in order to improve operating performance. Excessive inventory leads to inventory holding cost, inventory financing cost and higher defects rates (Capital, 2004). Excess inventory increases manufacturing lead times, consumes productive floor space, acts as a barrier to identify the problems, and inhibits communication.

Over processing

Over processing means processing a product beyond the customer wants. Many organizations use expensive high precision equipment where simpler tools would be sufficient. Poor plant layout results inappropriate processing because preceding or subsequent operations are located far apart. Over processing generates from complex solution and over complexity discourages ownership (Hines and Rich, 2007). Toyota is famous for their use of low-cost automation, combined with immaculately maintained, often older machines. Investing in smaller, more flexible equipment where possible; creating manufacturing cells; and combining steps will greatly reduce the waste of inappropriate processing.

Motion

The worker or equipment moving or running more than required to perform a task is a motion waste. Resources are wasted in the work station when workers have to bend, reach or walk distances to do their jobs. Excess motion is the results of poor ergonomics of the work station design, where operators have to stretch, bend and pick up even such motions can be avoided (Rawabdeh, 2005). Workplace ergonomics assessment needs to be conducted to design a more efficient work station. Jobs with excessive motion should be analyzed and redesigned for improvement with the involvement of plant personnel.

Defect

According to Monden (1983), quality is a performance variable. Producing defective products requires costly repairing or rework, product replacement and inspection. In many organizations, the total cost of defects is often a significant percentage of total manufacturing cost. Producing more defective products will waste material and subsequently create material shortages (Rawabdeh, 2005). The practice of Continuous Process Improvement (CPI) creates huge opportunities to reduce the defects at many organizations.

Continuous Improvement

Continuous improvement is the ongoing improvement of products, services or processes through incremental and breakthrough improvements. These efforts can seek “incremental” improvement over time or "breakthrough" improvement all at once. The purpose of CI is to meet the customer requirements through measuring success and it continues to check the customers' requirements to find the improvement areas (Chang, 2005). CI contributes to the organizational efficiency and effectiveness through the continuous practice of Total Productive Maintenance (Cooke, 2000).CI is viewed as a set of routine activities that can help the organization to improve the organizational performance (Bessant et al., 2001).

Among the most widely used tools for continuous improvement is a four-step quality model: The model is known as the Plan-Do-Check-Act (PDCA) cycle. This is also known as Deming Cycle or Shewhart Cycle:

- **Plan:** Identify an opportunity and plan for change.
- **Do:** Implement the change on a small scale.
- **Check:** Use data to analyze the results of the change and determine whether it made a difference.
- **Act:** If the change was successful, implement it on a wider scale and continuously assess your results. If the change did not work, begin the cycle again.

CONCEPTUAL FRAMEWORK

The conceptual research framework (Figure 2) shows the causal relationship between independent and dependent variables. The main objective of this research is to examine the effect of continuous improvement on waste elimination. Following are hypotheses developed for investigating the relationships.

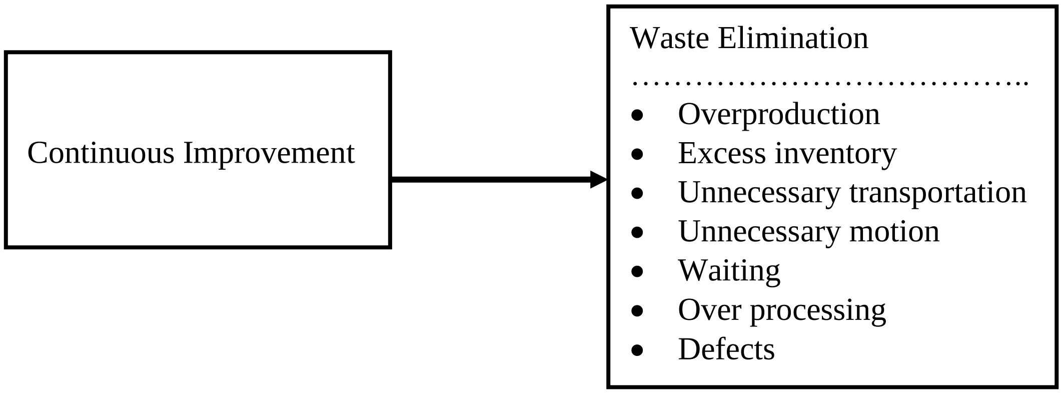

Figure 2: Conceptual Research Framework

Hypothesis Formulated for Testing Causal Relationship.

H1: CI has a significant and direct effect on EOW

H2: CI system is significantly related with its first-order construct process management

H3: CI is significantly related with first-order construct tools and techniques used.

METHODOLOGY

This is a quantitative research of deductive approach. Data has been collected from 238 garments industries. Cross-sectional data has been collected using structured questionnaire. A five point Liker scale was used for collecting empirical data. A non-probability convenient sampling was used. After data screening process, a sample size of 227 is used for data analysis. The target respondents were the production managers, factory managers, industrial engineers, quality managers and the others directly related with the production. Data has been collected from the factories located in Dhaka, Gazipur, Saver, Narayangonj and Chittagong roads. SPSS 20.0 and AMOS 20.0 for SEM were used for quantitative data analysis.

FACTOR ANALYSIS

Exploratory Factor Analysis is a data reduction process where minimum number of factors represents the maximum variance of the measurement. KMO (Kaise-Meyer-Olkin) test result represents an adequate sample size (KMO = 0.831). Three factors were extracted using Principal Component Analysis (PCA) representing 57.622% of the variance extracted (Table I). The factors were rotated using Varimax rotation (Table II). Table III shows the factor name, factor loadings, the value of cronbach's alpha and the item descriptions. The reliability and the internal consistency of the factors are satisfactory.

Table I: Factor Extracted using PCA

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.305	33.114	33.114	4.305	33.114	33.114	3.891	29.928	29.928
2	2.105	16.195	49.308	2.105	16.195	49.308	2.024	15.568	45.496
3	1.081	8.314	57.622	1.081	8.314	57.622	1.576	12.126	57.622
4	.821	6.319	63.941						
5	.798	6.138	70.079						
6	.716	5.507	75.587						
7	.608	4.679	80.266						
8	.575	4.421	84.687						
9	.540	4.155	88.842						
10	.465	3.576	92.418						
11	.399	3.067	95.485						
12	.307	2.362	97.847						
13	.280	2.153	100.000						

Table II: Rotated Component Matrix

	Component		
	1	2	3
EOW3	.786		
EOW2	.770		
EOW4	.756		
EOW6	.739		
EOW7	.712		
EOW5	.704		
EOW1	.688		
CI3		.772	
CI2		.693	
CI4		.685	
CI1		.518	
CI5			.837
CI6			.744

Table III: Naming the Factors

Factor Name	Items	Loadings	Cronbach's alpha	Items description
CIP: (Continuous Improvement Process)	CI1	.518	**0.665**	This organization encourages continual study and improvement of all its products, services and processes.
	CI2	.693		We frequently measure the product and process quality.
	CI3	.772		Continuous improvement makes our performance a moving target.
	CI4	.685		We believe that improvement of a process is never complete; there is always scope for more improvement.
CIT: (Continuous Improvement Tools)	CI5	.837	**0.568**	Our company uses the QC tools (bar chart, histogram, cause-effect diagram, Pareto chart, control charts etc) extensively for process control and improvement.
	CI6	.744		Our company uses PDCA (plan-do-check-act) cycle extensively for process control and improvement.
EOW: Elimination of Waste	EOW1	.688	**0.866**	The current rate of defective garment production is very low
	EOW2	.770		Producing garments more than customer requirement is very low
	EOW3	.786		Unnecessary and excess transportation of materials is very low
	EOW4	.756		The inventory level of fabric, incomplete and finished garments are very small
	EOW5	.704		Waiting time for materials, tools and accessories are very low
	EOW6	.739		Any unnecessary motion for pick-up and stack garments are very low
	EOW7	.712		Unnecessary and over processing of garments is very low

DATA ANALYSIS AND FINDINGS

The measurement model of the constructs is shown in the figure 3. Table IV shows the correlation between the constructs. The results reveal that the constructs are significantly correlated without any multi-collinearity (correlation coefficient greater than 0.9) and singularity problems (correlation coefficient=1).

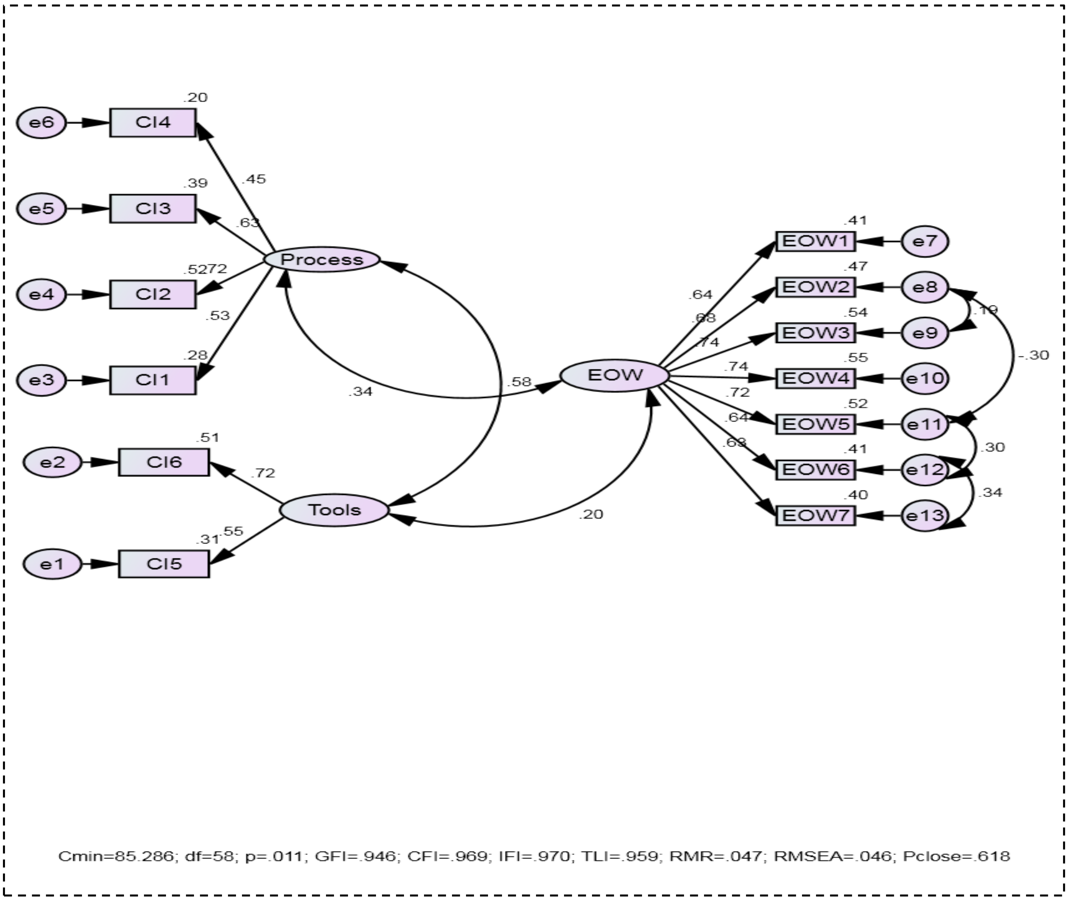

Figure 3: Correlation between the Constructs

Table IV: Correlations between the Constructs

Correlation			Estimate	P-VALUE
Process	<-->	Tools	0.575	***
Process	<-->	EOW	0.34	***
Tools	<-->	EOW	0.202	0.035

THE EFFECT OF CONTINUOUS IMPROVEMENT ON ELIMINATION OF WASTE

The successful implementation of LM improves organizational performance through elimination of waste. But it is interesting to examine the effect of continuous improvement on the elimination of waste of the manufacturing process. The SEM structural model is shown in the figure 4. The CI is a second order construct and consists of two sub-constructs namely PM and Tools. The EOW is a first order construct measured through 7 indicator variables.

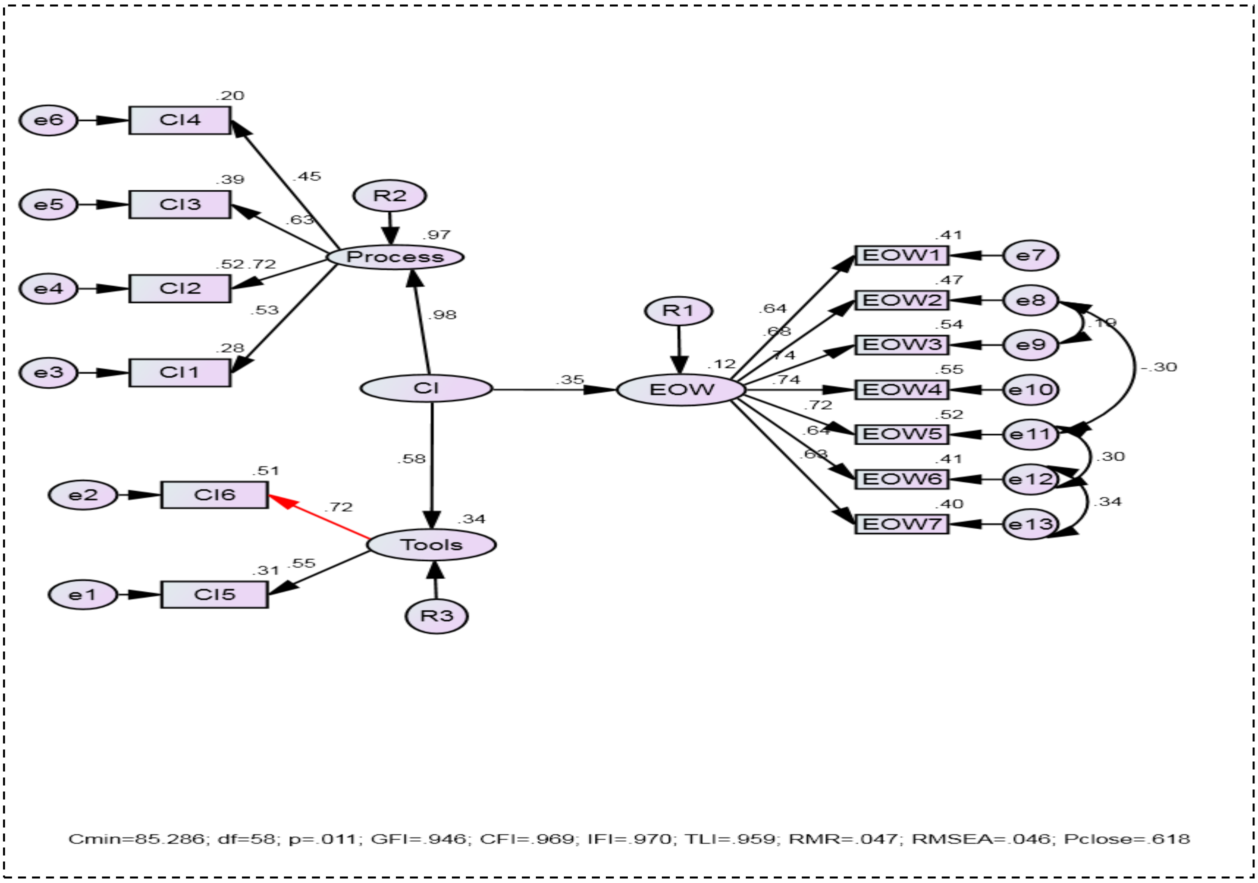

Figure 4: The effect of CI on EOW (The SEM model)

The AMOS graphic of SEM is shown in the figure 4. This graphic model shows the causal relation between two main constructs CI and EOW. This graphic model also shows the relationship between the second order main construct CI and its sub-constructs PM and Tools. These relationships can be translated into a set of equations as follows.

Casual relationship between CI and EOW

$$\eta = \beta_{12}\zeta + R1 \ldots\ldots\ldots\ldots. (1)$$

$$= 0.35 \text{ CI} + R1$$

Here,

η = Elimination of Waste (EOW)

ζ = Continuous Improvement

β_{12} = Coefficient in the structural Model

R1= Residual variance

The equation (1) represents the structural model of SEM. The testing of hypothesis for the effect of CI on EOW is given as follows.

Hypothesis

H1: CI has a significant and direct effect on EOW

Table V: Regression Path Coefficient and its Significance (H1)

Hypothesis	Construct	Path	Construct	Standardized Beta Estimate	S.E	C.R	P-Value	Comments
H1	EOW	<---	CI	0.35	0.141	2.194	0.028	Significant

The standardized beta estimate is the direct effect of CI on EOW (β_{12} =0.35). Therefore, if CI goes up by 1 standard deviation, the EOW goes up by 0.35 standard deviations. Since the p-value < 0.001, the relationship is highly significant. So the hypothesis is supported. The value of the coefficient of determination is o.12 (Figure 4). This value indicates that 12% of the variance of EOW is accounted for by the CI. Meaning is that the contribution of CI in estimating the EOW is 12%. This results shows that there is a direct significant positive effect of CI on EOW.

RELATIONSHIP BETWEEN CI AND ITS SUB-CONSTRUCTS

The relationship between the CI (second order construct) and its sub-constructs (first order constructs) can also be translated into a set of equations as follows.

$$F1 = \lambda_{12}\, \zeta + R2 \ldots\ldots\ldots\ldots\ldots (2)$$

$$F2 = \lambda_{22}\, \zeta + R3 \ldots\ldots\ldots\ldots (3)$$

Here

F1 = Process Management (PM)

F2 = Tools and Techniques

λ_{12}, λ_{22}, are the factor loadings (Coefficient of measurement model) of CI on PM and Tools respectively. R2, R3 are the residual variance of the two sub-constructs of CI. Replacing the value of λ_{12}, λ_{22} from the graphic model (Figure 8.24) equations (2)-(3) can be written as

$$\text{Process} = 0.98\text{LSF} + R2 \ldots\ldots\ldots\ldots\ldots (4)$$

$$\text{Tools} = 0.58\text{LSF} + R3 \ldots\ldots\ldots\ldots (5)$$

The results show that CI loads well on its 2 sub-constructs namely PM and Tools. The factor loading (regression weights) of CI on PMC and Tools are 0.98, and 0.58 respectively. The coefficients of determination (R^2) for al sub-constructs are also high. The value of R^2 for PM is 0.97 and R^2 for Tools is 0.34.

The equations (2) - (3) represent the measurement model of SEM. The testing of the hypotheses for the effect of CI on its sub-constructs are follows:

Hypothesis:

H2: CI is significantly related with its first order sub-constructs

H_{2a}: CI has a direct and significant effect on its sub-construct PM

H_{2b}: CI has a direct and significant effect on its sub-construct Tools and Techniques

The regression path coefficient between CI and its sub-constructs are shown in the table 8.50

Table VI: Path Coefficient and its Significance (CI on its Constructs)

Construct	Path	Construct	Standardized Beta Estimate	S.E	C.R	P-Value	Comments
Tools	<---	CI	0.584	0.336	2.25	0.024	Significant
PM	<---	CI	0.985	Reference point			Significant

The output of the regression path coefficient shows the effects of CI on all sub-constructs are positive and significant. Based on the value of R^2 of all sub-constructs and standardized regression weights of CI on its constructs, it can be concluded that CI is well supported by its two sub-constructs PM and Tools.

MODEL FIT TEST

After analyzing and examining the casual relationship, it is necessary to observe the model fit indexes. The results of the model fit indexes are shown in the following table (Table VII). The fit index indicates that the model is not consistent with the observed data. Since Chi-Square value is sensitive to the sample size (sample size > 200) this test result can be ignored. The value of Chi-square/df, RMR, SRMR, RMSEA, TLI, IFI, GFI, AGFI, PGFI, PNFI exceeds the threshold values of each individual index and hence the model is a good fit model.

Table VII: Model Fit Index

Index Category	Index Name	Cutoff Value or Level of Acceptance	Model Result	Comments
Absolute fit	Chi-Square	p-Value > 0.05	λ^2(58, N=227)=85.286, P=0.011	The model is not consistent with the observed data
	Chi-Square/df	Chi-Square/df ≤ 5	1.470	Good Fit
	RMSEA	RMSEA ≤ 0.08	0.046	Good Fit
	PCLOSE	PCLOSE ≥ 0.05	0.618	Null hypothesis accepted. Close Fit Model
	RMR	RMR ≤ 0.08	0.047	Good Fit
	SRMR	SRMR ≤ 0.1	0.0592	Good Fit
	GFI	GFI ≥ 0.90	0.946	Good Fit
	AGFI	AGFI ≥ 0.85	0.915	Good Fit
Incremental Fit	CFI	CFI ≥ 0.90	0.969	Good Fit
	TLI/NNFI	TLI/NNFI ≥ 0.90	0.959	Good Fit
	IFI	IFI ≥ 0.90	0.970	Good Fit
Parsimony Fit	PNFI	Around 0.5	0.678	Good Fit
	PGFI	Around 0.5	0.603	Good Fit

CONCLUSION

This study shows the direct effect of continuous improvement as a lean parameter on elimination of waste. The direct effect of CI on EOW is 0.35 (35%) which is statistically significant (p 0.05). The coefficient of determination is 0.12 which means that 12% of the variance of EOW accounted for by the CI. All the constructs are significantly correlated. The results also show that the independent variable CI is well supported by its sub-constructs. Therefore, the practitioners/managers of the organization can address the practice of CI more confidently and make the organizations more benefitted through the elimination of waste.
The outcome of this study believed to provide a significant contribution in terms of generating knowledge and recognizing LM values. The theoretical implication of this study is recognizing CI as a key lean parameter for the elimination of waste while implementing LM system. This research has presented a new dimension to the understanding of the factors affecting the implementation of LM. Therefore, CI is an integral part of LM system and it contributes to the organizational performance through EOW.

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