Lean Impact Analysis Assessment Models: Development of a Lean Measurement Structural Model

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Abstract—The paper is aimed at developing a model to measure the impact of Lean manufacturing deployment on organizational performance. The model will help industry practitioners to assess the impact of implementing Lean constructs on organizational performance. It will also harmonize the measurement models of Lean performance with the house of Lean that seems to have become the industry standard. The sheer number of measurement models for impact assessment of Lean implementation makes it difficult for new adopters to select an appropriate assessment model or deployment methodology. A literature review is conducted to classify the Lean performance model. Pareto analysis is used to select the Lean constructs for the development of the model. The model is further formalized through the use of Structural Equation Modeling (SEM) in defining the underlying latent structure of a Lean system. An impact assessment measurement model developed can be used to measure Lean performance and can be adopted by different industries.

Keywords—Impact measurement model, lean bundles, lean manufacturing, organizational performance.

I. INTRODUCTION

AN attempt to evaluate and compare the impact of Lean implementation on the performance of the diverse organizations that have been reported to have implemented Lean manufacturing is very difficult and quite unproductive. This is due to lack of a standard model of implementation of Lean as well as the absence of a commonly accepted model of performance measurement. This problem seems to be pervasive across the Lean literature and even the industry. This has led to confusion when the new adopters want to implement the improvement philosophy. The purpose of this paper is to classify the impact assessment models from literature and develop a standard measurement model that can be used by different industries to measure the impact of Lean implementation on organizational performance.

The reasons for lack of a standard model are that lean has been treated as an open structure, whereby adopters choose practices that suit their enterprise [1]. There is no manufacturing practice database for use during Lean implementation [2], leading to haphazard implementations of Lean practices as organizations rush to become lean. Different companies have implemented different Lean manufacturing practices making it difficult to compare various organizations on the effect of Lean implementation on their organizational performance. The adoption of different practices during lean implementation causes researchers to develop diverse assessment methods. Based on [3], [1], the different impact assessment models that have been developed by researchers can be classified under different categories such as qualitative models [4]-[8], quantitative models [9]-[13], graphical models [14], [15], and simulation models [1], [16]-[18]. Reference [19] states that there is no standard that has been set for the use of Lean metrics, thus it becomes difficult to compare the impact of the philosophy among different industries. This has led to confusion about what to do and what to expect when new Lean adopters want to implement the philosophy. This research aims to review the different measurement models of Lean manufacturing that are available in literature and propose a measurement model based on a construct that seems pervasive from the industry perspective, which is the house of Lean [20]. The literature search conducted by researchers showed that most industry practitioners use the house of Lean for implementing Lean manufacturing; however, no impact measurement models have been built around the house. The following research objectives were developed after an extensive literature review on Lean Manufacturing measurement models:

1. To evaluate the different impact performance models used for measuring Lean implementation success;
2. To develop a Lean impact measurement model that is tied around the House of Lean, which seems to be popular in many industries.

The benefit of a standard impact measurement model is that it helps new adopters of Lean Manufacturing to anticipate and also assess the impact of Lean manufacturing on their operational performance. Measurement models can also be used to manage organizational leanness since managers would be able to measure its impact on organizational performance and prove if their goals are being met. Furthermore, Lean measurement models will also help to compare the impact of Lean implementation among different adopters. Section I of the paper gives the introduction, Section II reviews literature on the Lean impact measurement models, Section III presents the methodology, Section IV gives the proposed model, and Section V is the conclusion for the paper.

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II. LITERATURE REVIEW

A. Impact Analysis of Lean Manufacturing

In this section, a review of the literature on the models of assessment of the impact of Lean implementation on an organization's operational performance is presented. As has been stated earlier on, Lean measurement models can be grouped under four categories which are quantitative, qualitative models, graphical and simulation based.

1) Qualitative Approaches

Qualitative Lean measurement models use survey questionnaires to measure the impact of Lean tools on an organization. Questions are designed to help Lean adopters to assess the impact of Lean tools on organizational performance. Researchers advocate for the use of qualitative Lean models because of their ability to measure the overall Lean manufacturing implementation success. However, the use of survey questionnaires is subjective because it depends on the individual opinion and hence could be biased. The score obtained from the questionnaire shows the level of compliance between the organization and Lean indicator, hence it is not a quantitative score of the real performance of the organization [3]. Examples are [4] who developed a Structural Equation Model (SEM) to measure the impact of eight Lean tools on Quality and Productivity Improvement (QPI). The eight Lean tools considered were quality at the source, poka yoke, variability reduction, kaizen, Total Quality Management (TQM), 5S, visual control and Root Cause Analysis (RCA). The results showed that the Lean tools had a positive relationship with QPI. Reference [5] conducted a study to show the impact of Lean strategies on five performance measures which were quality, speed, dependability, flexibility and cost. Analysis of JIT, autonomation, kaizen, TPM and Value Stream Mapping (VSM) on operational performance was done using SEM, correlation and regressions. The results suggested that JIT, autonomation, and kaizen had an impact on operational performance, whilst TPM had no impact and VSM had negative impact. Other authors used multivariate analysis methods such as SEM: [6], [7], [21]-[26]; regression: [27], [28]; cluster analysis: [8]; Analysis of Variance (ANOVA): [29] and hierarchical linear model: [30]; to show the impact of Lean Manufacturing on operational performance.

2) Quantitative Lean Measurement Models

The quantitative models measure the impact of Lean manufacturing based on observable performance metrics of a company. This method uses types of metrics that are different from the qualitative models for measuring Lean manufacturing success thus allowing decisions to be made. The major advantage of the method is that measurements are more objective, thus does not depend on the evaluator's opinion unlike in qualitative models. However, the disadvantage is that it is difficult to get the data because of protection of company information. A study by [10] presented fictitious results for the cost of labor per hour, the injection machine cost per hour and factory price per meter because of privacy issues.

Reference [12] used work measurement to assess the impact of 22 Lean strategies for a three-wheeler accessory manufacturing entity in Sri Lanka. Productivity improved by 44.14% after changing the layout and work method. Reference [10] also conducted a research to show the impact of Value Stream Mapping (VSM) in an automotive manufacturing company. From the time study results, the author developed and implemented a future state map that reduced cycle time from 370s to 140s and inventory level by 25%. The major disadvantage of the study was that it did not give actual measures for financial benefits. Other researchers such as [9], [11], [13] have also presented quantitative models that show the impact of Lean manufacturing on operational performance.

3) Simulation Based Models

Simulation models can be developed to show the impact of Lean practices on for organizations. Discrete event simulation models have been used to measure and analyze the impact of Lean practices among themselves, and their effect on the overall system. Reference [31] used simulation to quantify the benefits of applying Lean methods for a steel manufacturing company. A simulation package, Arena, was used to analyze the potential impact of the future state map on the performance of the system. They anticipated a reduction in the inventory level and lead time by 90% and 70% respectively. Reference [1] used systems dynamics to show the impact of the Single Minute Exchange of a Die (SMED) on the overall setup. The system variables were internal setup time and external setup time. The results showed that there was a decrease in setup time by 20% which showed the effectiveness of SMED on the overall system. The major disadvantage of the model was that it analyzed subsections of the system, hence there was a need to create and combine different models to find the mutual interdependence. Studies conducted by [1], [17], [18], [32] also used simulation to show the effect of Lean manufacturing on organizational performance.

4) Graphical Models

These models give a graphical representation of the process, showing its value added activities and non-value added activities within the system [3]. A study by [15] used graphical method to show the impact of implementing Lean tools for an Apparel production company in Sri Lanka. The Key Performance Indicators (KPI) used were Dock-To-Dock (DTD), raw material on time delivery, first time through, plant efficiency, fabric utilization ratio, floor space savings, and orders delivered on time and delivered in full. The Lean practices deployed caused a 10% reduction in cost, 20% increase in plant efficiency and the lead time reduction of 30%. A cost-time graph was also developed by [14] to illustrate the effect of Lean methods on items such as production activities, material approvals, delays and their relevant costs. The area under the graph showed the cost per unit of time that could be used for the analysis of organizational performance after the implementation of Lean manufacturing. Table I gives the types of measurement models created by authors and their areas of application.

B. Impact of the Diversity of Lean Measurement Models

There has been an increasing interest by researchers, both in the industry and academia, to measure the impact of Lean Manufacturing on the performance of an organization. As a result, different measurement models have been built for Lean performance measurement. However, these models are principally different from each other such that it becomes difficult for new Lean adopters to select a model to use. Hence, it is important to develop a measurement model that can be used in different industrial sectors to measure the overall performance of Lean Manufacturing. The impact of having different measurement models are:

1. It becomes difficult to compare the performance of Lean manufacturing for different companies and in different industrial sectors. This is because different industries implement different practices, thus an attempt to compare their performance impact gives problems. Reference [34] attempted to give the basic and main Lean practices, but agreement on these practices is still lacking.
2. It creates confusion because contradictory findings have been postulated by different researchers. The differences in results obtained by researchers may be due to the use of different models.

TABLE I
MEASUREMENT MODELS AND AREAS OF APPLICATION

Author	Model type	Instrument	Techniques /tools/practices/ strategies/methods used	constructs/ bundles/ dimensions
1. [4]	Qualitative	Structural Equation Modelling (SEM)		Poka yoke, variability reduction, kaizen, TQM, 5S, visual control, quality at the source and Root Cause Analysis (RCA)
2. [5]		Linear Regression and SEM	JIT, autonomation, kaizen, TPM and Value Stream Mapping (VSM)	
3. [6]		Multi-group structural equation and cluster analysis	Pull production, kanban, SMED, TPM, Heijunka, mixed model, multi-skilled workforce, long term relationship with suppliers, job rotation, employee involvement, training and suggestion schemes.	JIT, HRM, supplier management and TQM
4. [7]		SEM	Daily schedule adherence, shop flow layout, supplier responsiveness, JIT deliveries, kanban, setup reduction, small lot sizes, statistical quality control, 5S, small group sessions, poka yoke, team work, continuous improvement and training	JIT, TQM and HRM
5. [8]		Cluster analysis and correlation analysis	Pull production, continuous improvement, quality programs, process focus and equipment efficiency.	JIT, TQM and HRM
6. [19]		Exploratory and confirmatory analysis	supplier/ customer feedback, pull production, quick changeover, total productive/total preventive maintenance, training, team building, production flow, supply chain coordination and involved customers	
7. [29]		ANOVA	5S, quality certifications, work standardization, visual management, JIT, TPM, benchmarking, continuous improvement, SMED, process mapping, VSM, cellular layout, one piece	
8. [22]		SEM	Setup time reduction, Quality improvement and Cellular manufacturing, and	Quality improvement, setup reduction, shop flow employee involvement and cellular manufacturing
9. [33]		SEM	Manufacturing cells, standardization, one-piece flow, reduced setup times, reduced lot sizes, 5S, reduced buffer inventories, Kaizen and kanban system.	Simplified and strategically aligned Management Accounting practices (MAP), Visual performance and value stream costing
10. [23]		SEM	Quality management programs, cycle time reduction, agile manufacturing, lot size reduction, JIT, process capability measurements cross functional workforce, self directed work teams and flexible, maintenance optimization, bottleneck/ constraint removal, reengineered process, predictive/ preventive maintenance, new process equipment or programs, competitive benchmarking, TQM, , formal continuous improvement, pull system, cellular manufacturing, focused factory production system, quick changeover, safety improvement programs, planning and scheduling programs,	JIT, TQM, TPM and HRM
11. [24]		SEM	Employee involvement, JIT flow, supplier development, cellular manufacturing, setup reduction and smooth information flow	Management responsibility, Manufacturing strategy, manufacturing management and workforce and technology leanness.
12. [30]		Hierarchical Linear Model (HLM) approach	Cellular manufacturing, process redesign, JIT, manufacturing throughput time redesign, setup reduction, SPC and waste reduction	
13. [25]		SEM	Closer customer relations, value analysis, JIT, design for manufacturability, cellular manufacturing, concurrent engineering, development, setup reduction, supplier partnering, supplier and standardization.	Relationship building, lean manufacturing and lean design
14. [28]		Regression	Problem solving, Visual management, Jidoka, TPM, pull production, standardized work, multi- functionality, one piece flow, setup reduction, and on and production levelling	TQM, JIT and TPM

Author	Model type	Instrument	Techniques /tools/practices/ strategies/methods used	constructs/ bundles/ dimensions
15. [35]		SEM	Employee empowerment, Autonomation, JIT, pull system, work load balancing, quick setup time, small lots, 5S, group technology, improve facility layout, visualization, kaizen, hoshinkanri, employee involvement, QFD, VSM, RCA, TPM, reward system, communication system, management support, performance measurement system, training, employee commitment, and leadership	Process factor, process time reduction, physical structure factor, waste elimination, customer value factor, motivation factor, internal and external customer satisfaction, error prevention and human factor
16.[36]		Regression	Quality at the source, small lot production, cellular layouts, supplier networks, flexible resources, pull system, TPM, quick setup and uniform production level	
17. [27]		Regression	Reduced setup time, JIT and equipment and workstation for production.	
18. [26]		SEM	Product tracking devices, workforce empowerment, continuous improvement, Computer systems, after sales technical support, customer service support, training, data management systems, autonomous teams and improvement teams.	Strategic customer service orientation, human lean practices and technical lean practices.
19. [36]		Multiple Regression analysis	Uniform production level, supplier networks, small lot production, cellular layouts, flexible resources, TPM, pull systems, quick set up and quality at the source.	
20.[37]		SEM and ANOVA	Setup time reduction, Kaizen, Pull production, Poka Yoke, Small lot size, employee suggestion system, inventory reduction, 5 Whys, One piece flow, Root cause analysis, Value stream mapping, 5 S, Cellular manufacturing, Process improvement and Preventive maintenance.	
21. [21]		SEM	Small lot sizes, setup time, pull production, short lead time and continuous improvement.	Lean Production, Product Quality Performance and business performance
22. [12]	Quantitative	Work measurement	Cell layout, JIT, brainstorming, Ishikawa diagram, Process analysis, Visual management, Teamwork, Value Stream Mapping, Work standardization, 5S, Production smoothing, Takt time/cycle time, Ergonomics work and Training.	
23. [10]		Time study	VSM	
24. [9]		Time study	VSM, Kaizen, FMEA and poka yoke	
25. [11]		Time study	5Whys, VSM and Root Cause Analysis (RCA)	
26. [13]		Work measurement	VSM, RCA, Kaizen, cause and effect diagram, 5S and 5 Whys	
27. [1]	Simulation	Systems Dynamics	Single Minute Exchange of a die(SMED)	
28. [17]		Flexism software and Minitab	5S, TPM and Kaizen	
29. [32]		Discrete event Simulation	VSM, Product Quality(PQ) analysis and Pareto analysis	
30. [18]		Opt Quest design and optimizing tool	VSM	
31. [31]		Factorial experimental design	Setup time reduction, TPM, pull production, VSM, 5S, visual systems, cellular manufacturing, JIT and Production levelling.	
32. [15]	Graphical		Training, hoshinkanri,SPC, worker empowerment, rewarding culture, VSM, 6S, visual management, error proofing, kanban, kaizen, line balancing, quick changeover and TPM	

Author	Qualitative Data Type	Quantitative Data Type	Industry used	operational/ organizational measures used
1. [4]	X		Various industries	Quality and productivity improvement
2. [5]	X		Manufacturing	Quality, speed, dependability, flexibility and cost
3. [6]	X		Various industries	Finished products managed, customization of products, batch size variation, production lead time, delivery reliability, percentage of finished product, response to warranty claim and percentage turnover
4. [7]	X		Manufacturing	Unit cost, conformance to product specification, on time delivery performance, fast delivery and flexibility.
5. [8]	X		Various industries	Inventory turnover
6. [19]	X		Manufacturing	Quality, inventory minimization, delivery, productivity, cost, sales and customer satisfaction.
7. [29]	X		Manufacturing	Efficiency and productivity
8. [22]	X		Manufacturing	Return on sales (ROS)
9. [33]	X		Manufacturing	Net sales, ROS, profit and market share
10. [23]	X		Various industries	Cycle time, scrap and rework costs, labour productivity, unit manufacturing costs, first pass yield, and customer lead time
11. [24]	X		Manufacturing	Cost, quality, flexibility and environment
12. [30]	X		Manufacturing	Cost, quality and delivery
13. [25]	X		Manufacturing	ROS, return on investment and return on sales
14. [28]	X		Manufacturing	Lead time, inventory, quality, on time and turnover
15. [35]	X		Service	Customer perception of product/service quality, Customer satisfaction, Employees satisfaction and their performance, Employees understanding of the process,

Author	Qualitative Data Type	Quantitative Data Type	Industry used	operational/ organizational measures used
				Identification and elimination of waste, Operational efficiency, Productivity, Reduction in costs, Freeing staff time, Lead time and cycle time and Human errors
16.[36]	X		Manufacturing	Profit, sales and customer satisfaction
17. [27]	X		Manufacturing	Quality, delivery, flexibility and cost
18. [26]	X		Different industries	Sales growth and market share, product quality and reliability, delivery speed, manufacturing cost, labour productivity, and employee satisfaction
19. [36]	X		Manufacturing	Quality, inventory minimization, delivery, productivity, cost, sales, customer satisfaction
20.[37]	X		Manufacturing	Product quality, delivery speed, delivery reliability, responding change requests, overall performance, sales growth, return on assets and market share.
21. [21]	X	X	Manufacturing	Profitability, market share, return on sales and return on assets
22. [12]		X	Manufacturing	Cycle time
23. [10]		X	Manufacturing	Cycle time and inventory level
24. [9]		X	Manufacturing	Lead time and productivity
25. [11]		X	Healthcare	Waiting time
26. [13]		X	Manufacturing	Inventory level and defect rate.
27. [1]			Manufacturing	Setup time
28. [17]		X	Manufacturing	Overall Equipment Effectiveness
29. [32]		X	Manufacturing	Delivery time
30. [18]		X	Service	Work in Progress (WIP) and service level
31. [31]		X	Manufacturing	Inventory level and lead time
32. [15]		X	Manufacturing	Dock To Dock (DTD), raw material on time delivery, first time through, plant efficiency, fabric utilization ratio, floor space savings, delivered on time and delivered in full

III. METHODOLOGY

A literature review was done to document the impact assessment models published by researchers. The databases used for the review were Science direct, Web of science, Emerald, Google scholar and Metapress. The keywords used for the search were Lean assessment methods, Lean manufacturing, impact measurement models, operational/ organizational performance, Lean construct and Lean bundles. Articles were filtered by focusing on publications with Lean performance measurement models. It was further noted that some models did not measure the impact of Lean practices/ bundles on operational performance, hence they were not considered in the review. Only the articles that contained how Lean manufacturing affected operational/organizational performances were selected and the search yielded 32papers. Instruments that were used to build and measure those models were categorized into four groups which are qualitative, quantitative, simulation and graphical. The study showed that 21papers used qualitative models to measure the impact of Lean manufacturing on operational performance. 47% of the papers under qualitative models used SEM for their analysis; SEM was also selected as an instrument for building this model because of its demonstrated advantage from literature.

A Pareto analysis for Lean constructs was developed in Fig. 2 in order to select the bundles that would be used for the model development. Three bundles, which are JIT, TQM and HRM were selected for building the model. These bundles are all linked to the house of Lean which seems popularly used by most industry practitioners. However, the house contains another construct that is not referenced by most academics, which is standardization/stability; it was also included in this model's development.

A. Graphical Representation of Models Reviewed in Literature

The literature search conducted by the authors showed that different impact measurement models have been developed by researchers. Fig. 1 shows the number of models developed for each instrument used out of a sample of 32papers filtered from literature. The graph shows that ten models were developed using SEM, followed by regression that had five models, cluster analysis and time study had three models each, ANOVA had two, and the rest of the instruments had only one model. This showed that most authors seem to have preferred using SEM. The reason could be that it allowed researchers to use latent variables to perform path analytic modeling [38] and can validate relationships between measured variables and latent variables.SEM also gives a set of relationships that are reliable and valid, providing the comprehensive explanation of the real scenario [24], hence it is well suited for both theory confirmation and theory development.
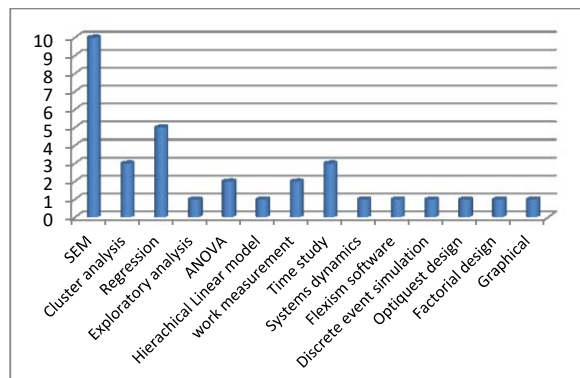

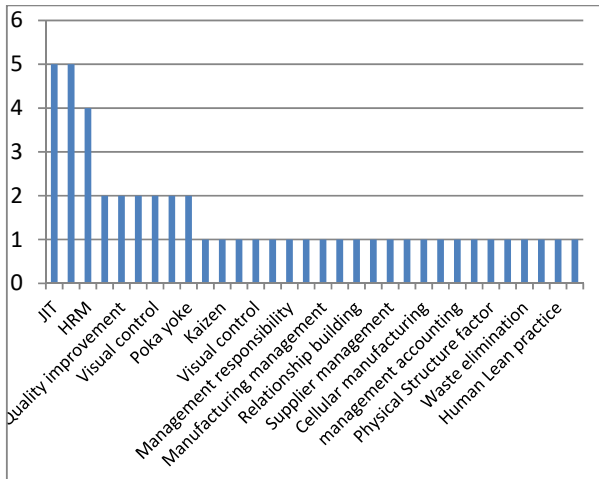Fig. 1 Number of models developed for each instrument

Fig. 2 Pareto analysis of the Lean terms

B. General Overview of Structural Equation Modelling (SEM)

Structural Equation modeling (SEM) can be defined as a statistical modeling technique that amalgamates regression path analysis and factor analysis [39]. Reference [40] also defines it as a technique that allows models of linear relationships to be specified and estimated. Reference [38] cited that the major benefit of using SEM is its flexibility that allows researchers to test relationships among multiple predictor and criterion variables and building unobservable latent variables. SEM also allows correlation among measurement errors and test theoretical and measurement assumption against empirical data. It has also been shown that SEM allows a single analysis to estimate multiple and interrelated depended variables [24]. Another benefit cited by the authors was that a relationship between sustainable programs and performance outcomes could be analyzed. A complex system can also be studied allowing casual relationships among latent variables to be explored. Hence, SEM was used for the development of the model in this study. The model would be tested in another paper.

IV. MODEL DEVELOPMENT

The purpose of implementing Lean manufacturing is to enhance organizational performance through the improvement of the underlying Lean latent constructs. The Lean constructs from the literature search were identified, and a Pareto chart for the constructs was conducted leading to the selection of TQM, JIT, and HRM. The constructs correlate to the house of Lean constructs which are Jidoka, Flow, and People integration, respectively. The model developed for measuring the impact of Lean manufacturing implementation on organizational performance is shown in Fig. 3.
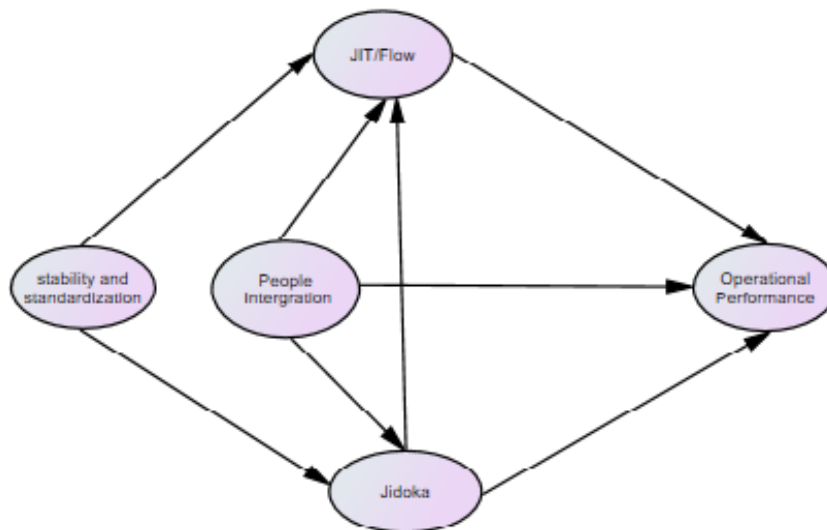

Fig. 3 Structural model for impact analysis

A. Hypothesis Development

1) Stability and Standardization Affects JIT/Flow and Jidoka

Stability and standardization are the backbone of flow within any system. When the process is not stable, pieces of information and materials will not flow. Stability enables a predictable process such that the availability of materials, methods, manpower and machines are always consistent. Standardization enables the process to be carried out in the right way each time. This ensures that quality products are produced. Most companies treat stability and standardization as the backbone of flow and reduction of defects. No research has been done to show how stability and standardization affects JIT/Flow and Jidoka, therefore researchers propose that:

- **H₁: Stability and standardization affects JIT/Flow**
- **H₂: Stability and standardization affects Jidoka**

2) People Integration Has a Positive Impact on JIT/Flow

It is important to recognize the impact of workers on the achievement of flow within a system. Reference [41] states that Human Resource Management practices are important for flow to improve in an organization. A study by [16] showed that HRM had a positive impact on JIT. Reference [42] also showed that HRM positively affect JIT, therefore the researchers hypothesized that HRM had a positive impact on JIT.

- **H₃: People integration has a positive impact on JIT/Flow**

3) People Integration Affects Jidoka

A study by [43] showed that HRM positively affects TQM. This is because all processes are conducted and managed by workers. Worker empowerment will allow them to stop the processes when defects are detected and the processes will run efficiently. Reference[44] showed that HRM practices had a positive impact on TQM in high tech companies in Taiwan. Similarly, researchers such as [45],[46] showed that HRM positively affects TQM, hence it is hypothesized that HRM affects TQM.

- **H₄: People integration has a positive effect on Jidoka**

4) JidokaHas a Positive Relationship on JIT

Reference [47] showed that TQM influenced JIT performance through the reduction of rework and process variation. This is because there is continual flow of products when quality is enhanced within a system. In our study, it is hypothesized that TQM has a positive effect on JIT.

- **H₅: Jidoka has a positive impact on JIT/Flow**

5) JidokaHas a Positive Impact on Operational Performance

TQM is aimed at eradicating quality defects within a system. It also focuses on quality processes within all the stages development and production, thereby aligning products and services to customer needs [48]. A study conducted by [49] in Turkish firms showed that TQM practices had a positive influence on different performance measures within these firms. Researchers such as [50],[51] have also shown that TQM practices have a direct impact on organizational performance, therefore it is postulated that Jidoka has a positive effect on operational performance.

- **H₆: Jidoka has a positive effect on operational performance**

6) Impact of People Integration on Operational Performance

Human resources form the bloodline of every organization, without employees, operations would not proceed. A study by[23] showed that HRM had a positive impact on operational performance. Reference [7] also showed that HRM affects operational performance through the mediating effect of TQM and JIT. In our study, it is hypothesized that People integration has a positive impact on operational performance.

- **H₇: People integration has a direct relationship with operational performance**

7) Impact of JIT/Flow on Operational Performance

This construct enables inventory and waste reduction as well as space utilization and production of the right item at the right time [5]. Their study also showed that JIT had a direct and positive impact on operational performance. A study by [7] also showed that JIT had a positive and direct impact on operational performance. Similar studies by [52], [53] also show the same results, therefore it is hypothesized that JIT has a positive impact on operational performance.

- **H₈: JIT has positive impact on operational performance**

V. CONCLUSION

A variety of lean performance measurement models have been described in this paper. However, it has been seen that the diversity of these models have caused confusion on how to measure Lean impact on operational performance. The model developed can be used to measure Lean performance and can be adopted by different industries. A model for evaluating the impact of Lean bundles on operational performance was developed based on the assessment of models discussed in literature. The model consists of Lean bundles that are linked together to form a structural model.

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