SCRUTINIZING THE IMPACT OF ESSENTIAL LEAN METHODS ON SUSTAINABLE PERFORMANCE IN MALAYSIAN MANUFACTURING FIRMS

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Graphical abstract
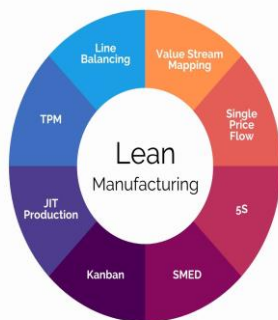
Abstract

Despite the fact that Malaysian manufacturing firms have implemented lean manufacturing principles to reduce resource waste and focus on customer demand, they still lack statistically validated lean manufacturing models to guide them in enhancing the sustainability of their businesses. This paper conducts empirical research of the multi-dimensionality of essential Lean Manufacturing (LM) methods (i.e., Total Productive Maintenance (TPM), Continuous Improvement (CI), and Just-In-Time (JIT)) and their association with sustainable performance (SP). 69 of 121 respondents' usable surveys were collected from manufacturing sectors that are recognised by the Negeri Sembilan Investment Centre (NSIC). They are made up of small, medium, and large businesses. The structural relationship of constructs was validated using the Structural Equation Modelling (SEM). For direct linkages between LM Methods with Sustainable Performance, the JIT is the most significant determinant, and for the inter-relationship between LM Methods, the Continuous Improvement and TPM, both were significantly inter-connected, depend on one another. In terms of LM implementation, the developed model contributes to the well-being and comprehension of practitioners engaged in top management. Sustainable indicators have to be prioritized for manufacturing organization decision makers to ensure that the LM implementation is compatible with the sustainability impact.

Keywords: Lean Manufacturing, Structural Equation Modelling, Total Productive Maintenance, Continuous Improvement, Just-In-Time, Sustainable Performance

Abstrak

Walaupun firma pembuatan Malaysia telah melaksanakan prinsip pembuatan kejat untuk mengurangkan pembaziran sumber dan memberi tumpuan kepada permintaan pelanggan, mereka masih kekurangan model pembuatan kejat yang disahkan secara statistik untuk membimbing mereka dalam meningkatkan kemampanan perniagaan mereka. Kajian ini menjalankan penyelidikan empirikal tentang pelbagai dimensi kaedah Pembuatan Kejat (LM) yang penting (iaitu, Jumlah Penyelenggaraan Produktif (TPM), Penambahbaikan Berterusan (CI) dan Just-In-Time (JIT)) dan kaitannya dengan prestasi lestari (SP). 69 daripada 121 tinjauan responden

yang digunakan adalah daripada sektor pembuatan yang diiktiraf oleh Pusat Pelaburan Negeri Sembilan (NSIC). Mereka terdiri daripada perusahaan kecil, sederhana, dan besar. Hubungan struktur telah disahkan menggunakan Pemodelan Persamaan Struktur (SEM). Untuk hubungan langsung antara Kaedah LM dengan Prestasi Lestari, JIT ialah penentu yang paling signifikan, dan untuk hubungan antara Kaedah LM, Penambahbaikan Berterusan dan TPM, kedua-duanya saling berkaitan secara signifikan, bergantung antara satu sama lain. Dari segi pelaksanaan LM, model yang dibangunkan menyumbang kepada kesejahteraan dan kefahaman pengamal yang terlibat dalam pengurusan atasan. Garis pandua lestari akan diutamakan bagi pembuat keputusan organisasi pembuatan bagi memastikan pelaksanaan LM serasi dengan impak lestari.

Kata kunci: Pembuatan Kejat, Pemodelan Persamaan Struktur, Jumlah Penyelenggaraan Produktif, Penambahbaikan Berterusan, Just-In-Time, Prestasi Lestari

1.0 INTRODUCTION

Today, the majority of manufacturing firms face increased competitiveness as a result of unavoidable globalization, which presents both opportunities and challenges for all sectors of those firms. Cost containment and productivity growth continue to be critical drivers of manufacturing competitiveness. A business's survival and long-term growth are contingent upon its ability to compete in the marketplace [1]. Research conducted by [2] argued that the main aim of lean technology (LT) is to improve profits and create value by minimising waste. Pinto and Mendes [3] stated that lean manufacturing is a business strategy that has been proven to improve a company's performance.

Apart from that, the primary impediments to LM adoption include a lack of experience and awareness of LM among practitioners at the operational level [4], [5]. Moreover, Rose *et al*. [4] stated that there are no readily available standard practices for Malaysian SMEs to adopt and that all SMEs share a common objective of functioning with the least amount of investment. From a standpoint of sustainable performance, the question arises as to the ability of Lean Manufacturing to create snowball effects for managing social, economic, and environmental performance [6]. Additionally, there is a dearth of research addressing the social difficulties associated with manufacturing operations, the social consequences of LM adoption, and manufacturing techniques in general [7], [8]. Certain research publications hypothesized that correlations between LM and state sustainability transportation performance (SSTP) do not encompass all three triple bottom line (TBL) pillars, but rather consider sustainability for environmental implications in addition to operational performance (OP) [9]. Various approaches, including Continuous Improvement (CI), also known as Kaizen, Total Productive Maintenance (TPM), and Just-in-Time (JIT),

were deemed to be the most critical components of the lean business approach [10].

In addition, many companies now see sustainability as a source of competitive advantage that must be included into their fundamental business operations in order to get that competitive advantage [6]. Because of the present unpredictability of the economic climate, Sustainable Performance (SP) has become more important measurement to a wide range of businesses in all sectors.

Malaysian manufacturing companies must constantly improve their operational efficiency, environmental implications and social stability in order to remain viable in the face of intense competition. Therefore, the main objective of this study is to examine whether the sustainable performance of Malaysian manufacturing companies has a positive impact from the implementation of essential Lean Method specifically Total Productive Maintenance (TPM), Just-in-Time (JIT) and Continuous Improvement (CI).

TPM, JIT, CI and SP were the variables derived from the theory for this study. A comprehensive review of the literature was conducted in order to develop the constructs for the conceptual research model. The study's goal was to answer the two research questions.

1. Is there a model that effectively connects the CI, JIT, TPM, and SP dimensions in Malaysian manufacturing firms?
2. How could sustainable performance of Malaysian manufacturing firms be improved through implementation of TPM, CI and JIT?

Six hypothesis were tested after the variables of the constructs defined as a measurable indicator. The Structural Equation Modelling (SEM) used to authentic the interrelationship between the constructs in the developed model. The findings of

this study suggested three hypotheses regarding the direct relationship between essential LM Methods and SP, with the JIT being the most significant determinant. The structure of this paper as follows; it starts with this introduction describing the problem and goals identified. Followed by reviewing the contemporary literature review of LM and sustainability components. Next, the methodology is elaborated and hypotheses testing are conducted through SEM. Discussion and conclusion are illustrated in section five. Finally, recommendations, implications, limitations and future agenda are included.

2.0 LITERATURE REVIEW

The main purpose of this section is to highlight the existence of the fundamental concept of the proposed model. It is inception idea based on the foundation of the correlation of the Lean Methods implementation with sustainable performance concertedly. Rocha *et al.* [10] consider these lean methods as the most essential methods of the lean approach.

2.1 Integration of Essential LM Methods and Sustainable Performance

Yadav *et al.* [11] developed an impact model of lean practices on the operational performance among Indian SMEs using structural equation modelling (SEM). The study indicates the positivity impact of lean implementation towards operational performance. Eight practices such as customer involvement, 5S, pull system, employee involvement, SMED, production levelling and statistical process control that found out to be as primary tools deriving in a positive impact on operational performance. Apart from that, the research study taking into consideration on the organizational structure of SMEs which is very simple with the very few levels issuing in high accessibility and visibility from top to bottom hierarchy of management [12], [13]. Besides that, other characteristics of SMEs that having a non-complex control system and operation planning [14] and results orientation [13] enhance the positivity environment for the implementation of lean.

According to Belekoukias *et al.* [15], JIT and automation have a greater influence on operational performance (cost, speed, reliability, quality, and flexibility) than TPM, while KAIZEN and VSM seem to have a negligible effect. Meanwhile, a study [16] on the impact of lean methods and tools on manufacturing organizations' environmental performance shows that TPM and JIT have the greatest impact on environmental performance (i.e., material use, energy consumption, non-product output, pollutant releases), despite continuous improvement/kaizen only having an impact on the release of pollutants and the use of materials.

According to Lean Six Sigma (LSS) framework developed by Ruben *et al.* [17] indicates the significance role of kaizen activities in the analysis process to attain the sustainable manufacturing environment. The developed framework offered business synergetic benefits in general and integrated the value of human and process components to ensure the success of organizations. Basically, efficiency always been an objective of lean manufacturing comprises systematic process of elimination wastes. According to Yang and Modi [18], JIT, TQM and employee involvement have a positive impact environmental management practice (EMPs) and environmental performances. Figure 1 illustrates the research conceptual model framework which defined the inter-relationships between variables (i.e., JIT flow, Quality management, employee involvement, lean manufacturing, EMPs, environmental performance, market performance and financial performance). In term of managerial perspective, the researcher argued that LM and EMPs are commonly synergistic in reducing inefficiency and waste, while Kleindorfer *et al.* [19] stressed that both practices were distinct and impact differently on business performances outcomes.
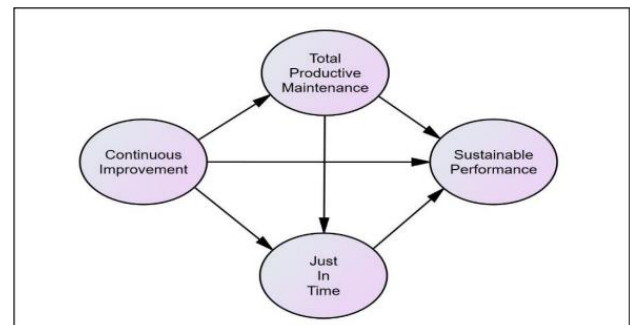

Figure 1 The conceptual model of essential LM Methods and SP

2.2 Development of Lean-SP Model and Postulated Hypotheses

In this section, author scrutinized the literatures on the relationship among the lean methods emphasized in this study such as Continuous Improvement (CI), Total Productive Maintenance (TPM) and Just-in-Time (JIT). Several previous studies conducted indicates the existence of integration between these Lean methods and the assimilation resulted in different forms (i.e., framework and integrated model). The examination on the past research framework and model of the lean methods integration helps the author develop the hypotheses and assumptions in this study. The following sections demonstrated the linkages among the essential lean methods. Nine hypotheses that indicates the interrelationships are presented as follows:

2.2.1 Total Productive Maintenance and Sustainable Performance2

Yadav *et al*. [20] developed an impact model of lean practices on the operational performance among Indian SMEs using structural equation modelling (SEM). The study indicates the positivity impact of lean implementation towards operational performance. Eight practices such as customer involvement, 5S, pull system, employee involvement, SMED, production levelling and statistical process control that found out to be as primary tools deriving in a positive impact on operational performance. Apart from that, the research study taking into consideration on the organizational structure of SMEs which is very simple with the very few levels issuing in high accessibility and visibility from top to bottom hierarchy of management [21, 22].

According to Belekoukias *et al*. [23], JIT and automation have a greater influence on operational performance (cost, speed, reliability, quality, and flexibility) than TPM, while KAIZEN and VSM seem to have a negligible (or even negative) effect. Meanwhile, a study by Reyes *et al*. [24] on the impact of lean methods and tools on manufacturing organizations' environmental performance shows that TPM and JIT have the greatest impact on environmental performance (i.e., material use, energy consumption, non-product output, pollutant releases), despite continuous improvement/kaizen only having an impact on the release of pollutants and the use of materials [24]. Thus, the following hypothesis formulated:

H1: TPM practices have positive impact on SP aspects.

2.2.2 Total Productive Maintenance and Just in Time

An integrated manufacturing programs (IMP) framework was created by Cua *et al*. [25] and includes 17 manufacturing practices such as JIT techniques, and TPM techniques as well as common manufacturing practices. Furthermore, this study concluded a theory that explained the effective deployment of JIT, TPM and TQM integration models in the manufacturing industry. In addition, the framework emphasizes critical aspects including TQM methods and procedures, JIT, and TPM, as well as the overall fitness of the program and its results. They also claimed that the fundamental methods of TQM, TPM, and JIT are dimensions of an IMP, and that the connection between these techniques and basic metrics of manufacturing performance is likewise an IMP dimension (i.e. cost efficiency, quality, delivery and flexibility). With a route coefficient of 0.36, the framework shows a substantial and favourable connection between practice integration and cost efficiency at the 0.01 level. Aside from that, better manufacturing performance was linked to better deployment of manufacturing operations. IMP

components have various roles in ensuring that improvement efforts may be executed effectively, according to the findings. Beyond providing managers with guidance on how to begin a new program inside a new environment, the business benefits from continuing to use the old program without being distracted by the IMP's technical and human strategic initiatives. Apart from that, according to Abdallah and Matsui [26], the level of JIT implementation in a country or industry accounted for a large part of the variation and JIT procedures, TPM practices, JIT performance and competitive performance were established. TPM was studied to see how it affected JIT implementation and development, as well as how it affected both JIT efficiency and competitiveness. In conclusion, JIT production has a substantial and beneficial effect on JIT performance metrics, according to the authors (i.e., inventory turnover and cycle time) and TPM has a significant impact on overall competitive performance measures, and JIT is one of these. The TPM has also aided and influenced how much JIT is implemented.

Teeravaraprug *et al*. [27] discussed on several supporting practices were interrelated with JIT, TPM and TQM. 5S and preventive maintenance acted as a foundation of the three core practices followed by KAIZEN or Continuous improvement, quality control (QC) tools, poka yoke and visual control. Kanban is required to support the implementation between TQM and TPM. The association of the practices were tested using Analytic Hierarchy Process (AHP) technique to ensure the correctness of the model. Hence, the following hypothesis is formulated:

H2: TPM practices have positive impact on JIT aspects.

2.2.3 Continuous Improvement and Total Productive Maintenance

Hailu *et al*. (2018) [28] concerned on the effectiveness of integration model consist of continuous improvement (KAIZEN) and TPM. The implementation activities such as zero breakdown, shortest lead time, improved OEE, reliable supplier, process control, were compulsory to be part of the integration 3T's process. Furthermore, empirical study conducted by Habidin *et al*. [29] shows the significant impact of TPM with the mediating of Kaizen event the performance in Malaysian automotive industry. In addition, Kaizen based maintenance system explored by Lal and Singh [30] discover how lean thinking impact that focus on maintenance in the automobile manufacturing which improve the productivity inputs. Their findings support the idea of complementarity in enterprises that adopt both practices. Hence, the following hypothesis is formulated:

H3: CI practices have positive impact on TPM aspects.

2.2.4   Just in Time and Sustainable Performance

Green *et al.* [31] noted that the lean manufacturing aspect of JIT could contribute to improved environmental performance, but found the relationship between green practices and environmental performance to be weaker in firms having more JIT practice adoption. Also, Bashar and Hasin [32] and Phan [33] discovered that flexibility in JIT will lead to effective operational performance in manufacturing. Therefore, we propose that:

H4: JIT practices have positive impact on SP aspects.

2.2.5   Continuous Improvement and Just in Time

In the case of CI also known as Kaizen and JIT, study conducted by Chan and Tay [34] shows their significant relationship on the inventory reduction impact and thus, enhance the productivity improvement. On the other hand, the linkage between these two through Lean-Kaizen concept significantly contributed to major rejection cost in Indian manufacturing industry Dhingra *et al.* [35]. Kumar *et al.* [36] indicated that investment in CI leads to better inventory management and process improvement, and argued that limited studies conducted in order to determine the relationship between CI and JIT perspective. He raised the following question of which features of CI can have a positive influence on the enterprises' inventory management effectiveness. Thus, this study hypothesizes that:

H5: CI practices have positive impact on JIT aspects.

2.2.6   Continuous Improvement and Sustainable Performance

According to Zahoor and Walid [37], CI and sustainability share common overall goals and objectives. These include minimizing waste, optimizing resource utilization, and ensuring long-term operational efficiency. Hussain *et al.* [38] examined the perceived benefits of CI implementation and the associated sustainability issues. Glover *et al.* [39] examined the potential effects of CI tools on financial and environmental sustainability and concluded that CI reduces waste and increases sustainability by improving financial impact and profitability margins. Meanwhile, in Malaysian beverage industry, CI as one of the quality practices in TQM discovered as significant variable on sustainable performance through the effectiveness of organizational excellence and environmental regulation [40]. As these are available in a variety of scenarios pertaining to the sustainability and excellence of Malaysian industries, this study hypothesizes the following:

H6: CI practices have positive impact on SP aspects.

As a result of reviewing previous conceptual models and frameworks, the researcher gained some new insights and a better understanding of the relationship between lean manufacturing methods and sustainable performance, as well as between lean manufacturing methods and sustainable manufacturing performances. TPM, JIT, and CI and SP have been suggested as a conceptual model to explain the interrelationships among lean techniques in Malaysia's sustainable manufacturing environment. As seen in Figure 1, the conceptual model included four latent constructs, each of which showed how the other constructs were related. Examining how these three LM techniques and SP context practices interact is critical for improving Malaysian industry's sustainability and competitiveness, particularly for startup Malaysian manufacturing firms. An integrated and comprehensive research approach is intended to fill the knowledge gap and address current issues. According to Vinodh's definition, a latent construct is a theorized notion that may be made up of variables that can be measured or observed. With regards to a dependent and independent variable, exogenous latent variables are used interchangeably [41]. This Lean-SP model incorporates endogenous (i.e. Sustainable Performance) and exogenous (i.e. Continuous Improvement) factors, as well as mediating variables (i.e. Total Productive Maintenance and Just in Time). These variables have both direct and indirect impacts inside the conceptual model (refer Figure 1) because of its dual function with other connections [42].

The derived hypotheses are presented below:

Hypothesis 1: TPM impact on SP aspects in Malaysian manufacturing firms.
Hypothesis 2: TPM practices have positive impact on JIT aspects in Malaysian manufacturing firms.
Hypothesis 3: CI practices have positive impact on TPM aspects in Malaysian manufacturing firms.
Hypothesis 4: JIT practices have positive impact on SP aspects in Malaysian manufacturing firms.
Hypothesis 5: CI practices have positive impact on JIT aspects in Malaysian manufacturing firms.
Hypothesis 6: CI practices have positive impact on SP aspects in Malaysian manufacturing firms.

3.0 RESEARCH METHODOLOGY

Authors reviewed the theoretical and empirical literature on TPM, JIT, CI, and SP. The theories of resource-based and knowledge-based capability were discussed, as well as the existing theoretical models and concepts applicable to TPM, JIT, CI, and SP. This study employed exploratory research design for its survey research. Exploratory research is defined as the investigation of an undefined problem [43]. It was conducted in order to gain a better understanding of the existing problem, as the primary objective of this research was to examine the

relationship between the variables TPM, JIT, CI, and SP. The purpose of this study was to determine whether implementing essential lean methods has a beneficial effect on SP.

3.1 Determination of Focus Group and Sample Size

According to Singh and Masuku [24], the statistical power of a study due to its significance of sample size. Besides that, the nature and attributes of the population should be represented by the selected sample group [44]. As specified by Negeri Sembilan Investment Centre (NSIC), an institution which comprises of well-established manufacturers that recognized by Federation Malaysian Manufacturers (FMM) as they cope with the manufacturing standard and reserved quality certificates, the number of populations of manufacturing organizations registered in 2018 was only 121 organizations. There are several strategies that highlighted by previous researcher in determining sample size and one of them was using sample size of a similar study [45]. Due to small sample size of the population, the researcher used sample size of a similar study particularly on the methodology part using structural equation modelling (SEM) specifically in Lean Manufacturing and Sustainable Performance. Table 1 shows the earlier studies from 2017-2019 involve the number of populations, number of respondent and the percentage of the respondent.

Table 1 Earlier studies indicate the number of populations, number of respondent and the percentage of the respondent

No	Authors	Population	Respondent	Percentage of respondent
1	[25]	250	100	40.0
2	[21]	900	365	40.5
3	[26])	710	140	19.7
4	[10]	618	250	40.4
5	[27]	430	139	32.3
6	[28]	1327	186	14.0

3.2 Research Instrument

Questionnaires are possibly the most widely used primary data collection method in quantitative surveys [45]. The justification for using questionnaires is that they are mostly easy to analyze, and provide the possibility to transform the data into quantifiable facts and results. In this study, each item in the opinion-related sections of the questionnaire was measured on an ordinal Likert-type scale with five categories (numbered 1-5). By summating the responses of these items (related to the same issue), the researcher created a more continuous type of variable. Variables like these (continuous) lend themselves to more sophisticated and multivariate statistical analysis techniques [46]. The landscape of the data and the association between the method and the research objectives were carefully considered when

selecting the right statistical methods for this study.

3.3 Data Collection and Data Screening

In this study, the data collection process consists of two types, the primary data, and secondary data. The primary data collected quantitatively through developed structural questionnaire based on the constructs in the conceptual model, and point-views by 3 experts from academic and 4 industrial backgrounds. Then, the primary data will be analyzed through Statistical Package for Social Science (SPSS 23) software and Structural Equation Modelling (SEM) through AMOS 24 software. Apart from that, Negeri Sembilan Investment Centre is one of the sources of secondary data of the research besides thesis, journals and related books that help in gathering data process. Finally, the observational study in the manufacturing industry in Negeri Sembilan also part of the primary data resources.

Generally, numerous issues must be resolved prior to entering collected data into the AMOS 22 software and conducting data analysis [47]. They emphasized three critical points: missing data, outliers, and data normality. IBM SPSS frequencies are used to check for data entry accuracy, missing data, skewness, and kurtosis in the data set. Before analyzing the real data and testing the hypotheses, the researchers in this study considered these issues.

3.4 Data Analysis Technique

The analyses that were conducted in this study are shown in Table 2 and 3.

Table 2 Descriptive Analysis

Frequency Distribution	**All items linked with four (4) latent constructs were measured using the created model and improved questionnaire, and the researcher calculated the means and standard deviations for each**
Reliability Test (Cronbach's Alpha)	Coefficient of determination that indicates how positively correlated the items in a set are. It is calculated as the average of the intercorrelations between the items used to measure the concept. The closer (a) is to 1, the more reliable the internal consistency. It is regarded as a suitable internal consistency reliability test [48]

Table 3 Inferential Analysis

Exploratory Factor Analysis	To determine the fundamental principle underlying the variables being studied [49]
Confirmatory Factor Analysis (CFA)	A method for determining the precision with which a smaller number of constructs are represented by measurable variables [28]. It served as a validation tool for the factor structure generated by the EFA.
Structural Equation Modelling (SEM)	To test the hypotheses and the proposed model.

In testing the hypotheses in this study, the researcher followed [50] recommendations, which state that any hypothesis can be accepted and supported if it meets the threshold values specified in Table 4.

Table 4 Hypotheses Testing Thresholds

Statistical significance	p-value (Probability value)	Less than or equal 0.05
	C.R (Critical Ratio) = Z value • Dividing regression weight estimate by estimate of the standard error (S.E.) gives value of Z= C.R.	More than 1.96
Practical significance	β (Standardized regression weight)	More than 0.2

To begin, the frequencies and/or descriptive terms associated with each item or question were recorded. On the system, no incorrect data entries were permitted. Users were limited to selecting between 1 and 5 on Likert scales [48]. If no option was chosen for a specific question, the system displayed an error. The emailed questionnaires were double-checked for accuracy. Additionally, the captured and stored responses were checked for accuracy. The data were analyzed using the statistical processing software package Statistical Packages for the Social Sciences (SPSS). In general, path diagrams are an excellent way to summarize SEMs, because they depict observed variables as boxes and latent variables as circles or ellipses [51]. When one variable is believed to be the cause of another, the relationship between the variables is depicted as a directed or one-headed arrow from cause to effect. The coefficients between two variables are also included as SEM, with the variables connected by a curved, two-headed arrow. There can be an estimated loading or weight for each arrow.

The CFA-derived factors were used in the construction and analysis of the SEM, which was done using analysis of moment structures (AMOS) graphics [52]. AMOS is a statistical software package that works as an add-on module to SPSS. It is particularly useful for performing SEM, path analysis, and confirmatory factor analysis. Additionally, it is referred to as causal modelling software. However, data analysis was performed using the SEM for multivariate analyses with ordinal data. A correlation matrix was used to determine the overall relationship between LM techniques and SP. SEM may consist of one or more linear regression equations that illustrate the relationship between various variables [53]. A linear regression model is a mathematical equation in which the left-hand side contains the dependent variable and the right-hand side contains the independent variables. The model is fitted to ascertain the independent variables' effects on the dependent variable. These are called structural equations, and their collection is referred to as the SEM. The coefficients that describe the relationship between dependent and independent variables are occasionally referred to as path coefficients.

4.0 RESULTS AND DISCUSSION

4.1 Response Rate and Respondent's Profile

The response rate for this actual study is 57.0 percent. The manufacturers that meet the standard FMM in repository of NSIC is 121 firms. The 68 reliable responds were returned and used to proceed with analyzing phase. The majority of the respondents is under the category of production department, 59.4 percent of total respondent. Most of the respondents, 58.0 percent are practicing in the Electrical industry. Additionally, the respondents have average of one to ten years of experience as these have largest percentage. While 60.9 percent of respondents were engineers or executives, which has the highest percentage of the respondents.

4.2 Assessment of Outliers

In this study, the researcher examined both univariate and multivariate outliers, as it was hypothesized that these would affect the results. When univariate outliers were examined using SPSS 22, standardized Z-values for the five latent constructs were obtained; the values should surpass the variant of +/- 3.29. As a result, as illustrated in Table 5, six univariate outliers were detected. These six instances were omitted from further examination.

Table 5 Outliers of the Latent constructs

Latent constructs	Case of outliers	Z-Value	Questionnaire (ID)
TPM	3 outliers	Z= 3.51757 Z= 3.52862 Z= 3.52865	6 8 46
CI	2 outliers	Z = 3.31270 Z = 3.31270	90 30
JIT	1 outlier	Z= 3.63273	21
SP	no outliers	-	-

The Mahalanobis d-squared distance was used to identify multivariate outliers. The researcher used the AMOS 22 program to examine actual data for possible multivariate outliers. According to the analysis, 19 cases were classified as multivariate outliers because their p-values were less than 0.05.

4.3 Descriptive Statistic

Table 6 summarizes the descriptive statistics for the four (4) practices examined in this study, revealing that the mean values for all major constructs (as a group) were significantly higher than the national average [48].

Table 6 Descriptive statistics for the four constructs

Construct	Mean	Std. deviation	Maximum	Minimum
TPM	3.3366	.44115	4.00	2.00
JIT	3.1913	.43105	4.00	2.50
CI	3.2673	.46533	4.00	2.11
SP	3.2627	48038	4.00	1.88

Next, 36 items of the constructs were performed with EFA presented in Table 7. Factor loading which has at least 0.50 of factor was considered and justified. Only 1 item discovered (TPM7) with poor factor loadings of less than 0.50, and its latent variable were discarded [42]. The results showed the significant factors of the constructs after undergoes the Varimax rotation EFA. It indicates that the variables have significant factor loadings on their single factor. Besides that, the Kaiser-Meyer-Olkin (KMO) which measure the adequacy for all items was greater than 0.761, others value range of 0.761 to 0.864, showing sufficient inter-correlations. The Bartlett's test of sphericity was greater and significant for all the factors, ranging between 218.630 to 363.251.

In conclusion, it is undeniable such that all items are reliable measures of the constructs. Finally, the internal consistency of the measures was evaluated using Cronbach's Alpha and all values were found to

be greater than the recommended threshold of 0.60 (i.e., TPM= 0.902; JIT = 0.861; CI = 0.904; and SP = 0.862).

4.4 Factor Analysis

Table 7 shows the derivation of the factors and measurement model of each construct

Table 7 Factors derivative and measurement model of each construct

Latent construct	Items	Factor loading	Cronbach alpha	Convergent validity CR > AVE AVE > 0.5 CR > 0.7	
				CR	AVE
TPM	The promotion of TPM philosophy and understanding	0.785	0.894	0.949	**0.697**
	The TPM policy and master plan development	0.822			
	In organizing the TPM secretariat	0.983			
	Organize technical and quality training	0.876			
	Introduce the skills related to the effective autonomous maintenance	0.795			
	TPM deployment on all production facilities	0.927			
	Deploy the training from existing equipment to new system	0.762			
JIT	Scaling down in time delivery	0.912	0.760	0.923	**0.604**
	Reduction in Raw Material inventory	0.832			
	Decreasing of Finished Goods inventory	0.731			
	Reduction in space requirement	0.866			
	Improvement on faster and dependable deliveries	0.857			
CI	Good communication integration at every levels of management (top to bottom)	0.807	0.901	0.918	**0.598**
	Systematic	0.811			

Latent construct	Items	Factor loading	Cronbach alpha	Convergent validity CR > AVE AVE > 0.5 CR > 0.7	
	documentation and evaluation of manufacturing process and production using advanced technology IT system				
	Innovative and team-oriented of organization culture in every department	0.787			
	Effective performance management system	0.831			
	Clear vision and strategy of company within the top management and the workers	0.786			
	Quality circles and project team within employee's participation	0.820			
SP	Productivity improvement	0.739	0.846	0.881	**0.524**
	Reduction of lead time and total cycle time	0.700			
	Reduction of operation, labor and material cost	0.704			
	Improvement in demand flexibility, delivery flexibility and production flexibility	0.817			
	Uphold gender equity policies	0.718			
	Reduction of accident cases within health and safety of employees	0.785			

Legend:

		Threshold value
CR	Composite reliability	CR ≥ 0.7
AVE	Average variance extracted	AVE ≥ 0.5

4.5 SEM Analysis – Assessment Model and Hypotheses Testing

SEM was applied to analyse the structural relationships. This research method is the combination of factor analysis and multiple regression analysis. It is used to analyse the structural relationships between measured variables and latent constructs. Using the comprehensive LM literature review and the previous researchers' suggestions in Lean Manufacturing and Sustainable performance, direct hypotheses were developed for this study. As shown in Table 8, the standardized regression weights of the hypothesis testing latent components were derived from the AMOS 23 output. The revised version full-fledged structural model, as illustrated in Figure 2, demonstrates that all normed chi square, CFI, and RMSEA values have been reduced to acceptable levels. Each of these has a value of 0.953, 1.000, and 0.000. Additionally, factor loadings are acceptable for all items. As a result, it is a validated model. The fitness indices in Table 9 correspond to the initial and refined full-fledged structural models.

Table 8 Hypotheses Tested

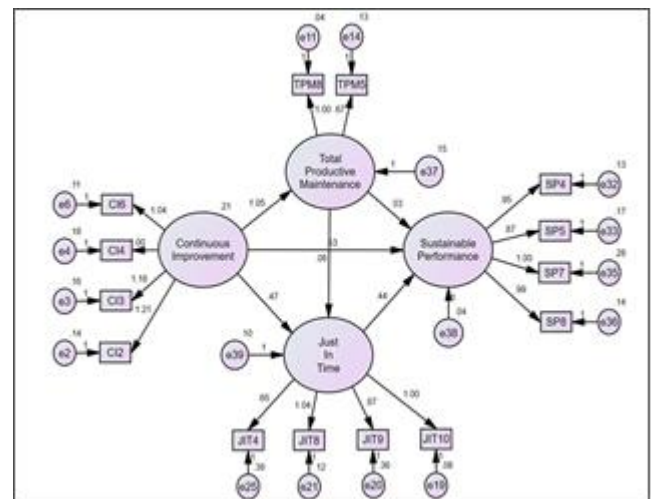|	Construct	Construct	β standardized	S.E.	C.R = Z	P-Value	Result
H1	TPM ⟶ SP		0.036	0.135	0.195	.846	Not significant
H2	TPM ⟶ JIT		0.532	0.146	0.054	0.589	Not Significant
H3	CI ⟶ TPM		0.622	0.175	5.989	***	Significant
H4	JIT ⟶ SP		0.404	0.165	2.688	0.007	Significant
H5	CI ⟶ JIT		0.293	0.212	2.233	0.026	Significant
H6	CI ⟶ SP		0.533	0.219	2.439	0.015	Significant

Figure 2 Revised version full-fledged structural model

Table 9 Comparison fitness indexes of initial hypothesized and final full - fledged structural model

Name of Category	Name of Index	Initial model	Revised model	
Absolute fit	Chi square	1036.443	67.676	
	df	554	71	
	P Value	0.000	0.590	
	RMSEA	0.113	0.000	< 0.08
Increment al fit	CFI	0.694	1.000	> 0.9
Parsimonio us fit	Normed chi square	1.871	0.953	< 5

4.0 DISCUSSION OF FINDING

As hypothesized in hypothesis 1, is to ascertain the relationship between TPM and SP. There is no significant relationship between TPM and SP in the final refined structural model. It is not supported because the critical ratio obtained from AMOS output falls below the 1.96 threshold value. In other words, Z equals 0.195. The standard deviation is 0.036, the correlation coefficient is 0.195, and the P-value is 0.846, according to the results. This finding indicates that implementing TPM, which includes establishing a TPM secretariat and providing high-quality training, has a negative effect on SP aspects such as operational, environmental, and social performance. The training was conducted by trainers who have lack of knowledge and experienced in TPM dimension. Their study discovered that TPM is one of eight critical practices that have a positive effect on the operational performance of small and medium-sized enterprises in India. Additionally, this finding contradicts Reyes *et al.* [67], who discovered that implementing TPM enabled them to reduce non-value-adding energy consumption, resulting in a positive impact on material use, energy consumption, non-product output, and pollutant releases.

Hypothesis 2 is motivated by an unmet need in the LM literature, as little research or knowledge exists regarding the effect of TPM on JIT. Due to the lack of a clear model or guidelines for manufacturers to follow when integrating these practices, additional research is required, which prompted the researcher in this study to investigate this ambiguous relationship by attaching TPM requirements to various JIT clauses. Based on the final refined structural model, this hypothesis utilizing TPM aspects as an exogenous latent construct and JIT as an endogenous latent construct is not supported. The empirical evidence in this study indicates that standardized=0.532, CR=0.054, and P=0.589. The findings of this study contradict [54] assertion that TPM improves JIT implementation levels in a variety of manufacturing industries, including automotive, electronics, and machinery, through preventive maintenance (PM), maintenance support, and team-based maintenance. This finding also contradicts numerous

scholars' arguments, including the efficacy of maintenance roles in just-in-time (JIT) production systems [55] and the effectiveness of PM tools in reducing defect rates [56]. Adopting and implementing TPM in a developing country like Malaysia remains a significant challenge due to the presence of several unfavorable environments [57].

Next, as hypothesized in hypothesis 3 and based on the final refined structural model, the existence of a significant relationship supports the hypothesis of using CI aspects as the exogenous latent construct and TPM as the endogenous latent construct. This demonstrates that CI practices in Malaysian industries have an effect on TPM. The structural path analysis reveals that standardized=0.622 exceeds the 0.2 threshold, the Critical Ratio (CR) is 5.989, and the P-value is 0.00, which is highly significant because it is less than 0.05. The hypothesis is supported because the Z-value exceeds the threshold of 1.96. This is done in a practical and statistically significant manner. Additionally, this empirical study's findings indicate that continuous improvement, or Kaizen, is a critical determinant of TPM. This demonstrates how continuous activities benefit all employees in Malaysian businesses by enhancing internal maintenance programs by providing opportunities for employees to gain new insights, develop new competencies, manage ideas, and continuously improve operational processes. The findings of this study corroborate those of [58], who discovered that combining Kaizen and TPM technologies enables manufacturing SMEs to reduce order fulfilment failures. Our findings support [5], [59], [60] in demonstrating that maintenance training and development can significantly improve an organization's performance. In summary, this study's findings regarding the connections between CI and TPM bolster [61] argument that TPM should be combined with the philosophy (CI) and methods of TQM. Additionally, it has practical implications for industry practitioners in terms of determining their system's strengths and weaknesses, as well as opportunities for improvement.

In hypothesis 4, the results indicated that three components namely faster delivery, improvement in customer order compliance and scaling down time delivery are necessary to fully comprehend and define this construct. The scatter plot diagram and greater-than-one eigenvalues indicated that three components are required to fully comprehend and define this construct. When combined, these components, according to feedback from Malaysian practitioners via a structured questionnaire in the preliminary study, can help improve the sustainability and leanness of their operations. Among them are the following: The term "reduction" refers to the process of reducing the amount of space required. It is critical because it significantly contributes to the efficient implementation of these standards and system by reducing inventory costs and scheduling production effectively within a pull-production system. The second extracted component is the

downscaling of time delivery. This finding is consistent with that of [62], who discovered that JIT has a significant impact on environmental performance (i.e. material use, energy consumption, non-product output, and pollutant releases), whereas continuous improvement/kaizen had an effect on only pollutant releases and material use. Additionally, our findings corroborated [18] research on a conceptual model framework that defined the relationships between variables (i.e., JIT flow, quality management, employee involvement, lean manufacturing, EMPs, environmental performance, market performance, and financial performance), indicating that JIT is one of the Lean Methods with a positive impact on financial performance.

Next as hypothesized in hypothesis 5, based on the final refined structural model presented in before, the existence of a significant relationship supports the hypothesis of using CI aspects as the exogenous latent construct and JIT as the endogenous latent construct. This demonstrates that TPM tools have an effect on continuous improvement in Malaysian industries. The structural path analysis reveals that standardized=0.293 exceeds the 0.2 threshold value, the Critical Ratio (CR) is 2.233, and the P-value is 0.026, which is highly significant because it is less than 0.05. As the Z-value exceeds the threshold of 1.96, the hypothesis is supported. This is done in a practical and statistically significant manner. Additionally, the findings of this empirical research indicate a significant relationship between CI and JIT. This demonstrates that CI's role in integrating training and education across departments, systematic documentation, advanced IT system usage, quality circles and projects, employee involvement, and an effective performance management system all contribute to the success of JIT implementation in terms of time delivery, space requirements, and raw material inventory reduction. Across departments, integrated training will assist in standardizing understanding of the requirement, the person responsible for JIT implementation, and the objective. This practice facilitated communication between the scheduler, manufacturing production, and logistics management, which resulted in an increase in customer demand. Reduced delivery times, reduced raw material inventory, and increased space utilization are all related to and dependent on the effectiveness of each manufacturing department's information technology system. As an integrated core, the scheduler required a robust information technology system, such as Enterprise Resource Planning (ERP), that could centralize communication across all departments, including quality control, production, and warehouse, as well as suppliers and customers. The findings of this study corroborate those of [63]; [64]; [65]; and [66] when it comes to the effectiveness of ERP in implementing JIT in a manufacturing environment. In summary, the findings of this study regarding the relationships between CI and JIT are consistent with [67], who assert that the competitiveness and success of manufacturing firms are contingent on their ability to implement these practices.

Finally, in hypothesis 6, the finding supported by the final refined structural model, this hypothesis is supported and accepted as statistically and practically significant when CI is used as the exogenous latent construct and SP is used as the endogenous latent construct. The Z-score is 2.439. The results indicate that the standard deviation is 0.533, the correlation coefficient is 2.439, and the P-value is 0.015. As determined by the results of SPSS 22's factor extraction. For CI initiatives, four components were identified. These factors contribute to the complexity and saturation of this construct for implementation. If properly implemented in a real-world environment, it is regarded as a guide for Malaysian manufacturers. This encourages manufacturers to be leaner in the competitive Malaysian market of the twenty-first century. Continuous Improvement, also known as Kaizen, is a lean method that focuses on gradual improvements over time. It describes how top management's primary concern is a complex and wholesale change that will result in infinite improvements and values. Effective performance management system (EPMS) was identified as a critical component, requiring Malaysian managers to maintain awareness of this assessment system when planning critical performance targets and monitoring progress toward those targets. The system is comprised of critical organizational processes such as planning, quality control, finance, production, and purchasing. Additionally, production delays caused by the non-availability of purchased material are rare and rarely interrupt production. This result emphasized the importance of performance at all levels of the organization, from the top to the bottom. In terms of acquired knowledge in EPMS, this finding is consistent with [68], who found that knowledge creation and integration have a greater impact on performance.

Additionally, this finding is consistent with the findings of [69], who recommend that managers of SMEs engage employees directly in issues related to production, processes, and service delivery, emphasizing the importance of employee involvement in influencing innovative work behavior in manufacturing SMEs. Our findings corroborate those of [70], indicating that job satisfaction is a significant factor influencing employee loyalty and commitment. They recommend that stakeholders in these sectors place a higher premium on employee loyalty and commitment, as this will boost productivity and help these sectors survive the current competitive environment. Additionally, Ariussanto *et al.* [71] and [72] emphasized the importance of leadership style, which is an interaction between top management and employees that can impact employee engagement and work environment, as well as have a significant impact on employee performance. The findings of this study are consistent with those of [73], who discovered a positive relationship between

teamwork and organizational performance. The findings suggest that management of SMEs should institutionalize such work practices in order to strengthen the managerial employees' culture of teamwork.

Additionally, they emphasized the importance of trust in enabling team members to understand and assist themselves, when necessary, team cohesion in enabling team members to focus on achieving their team goal, and teamwork as a suitable initiative for management to adopt in order to improve organizational performance. Following that, a critical component is the systematic documentation and evaluation of manufacturing processes and production using advanced information technology systems. The integration of advanced information technology with industry 4.0, intelligent manufacturing, and the industrial internet of things (IoT). All of these terms refer to the nexus of operational and information technology that is used to monitor physical processes in manufacturing and to use data to make predictive, corrective, and adaptive decisions to reduce operational costs. This finding is consistent with those of [74], who discovered that green IT implementation is positively associated with environmental performance, such as reduced IT equipment energy consumption, as well as operational profitability. Our findings indicate that the sampled companies place a high premium on information technology application, with appropriate company-wide training provided to employees at all levels. Utilizing information technology as the primary technology to implement the system can help manufacturing enterprises make more effective and scientific decisions. The final critical component of the JIT construct on SP is the integration of training and education programs across departments. This finding corroborated [75] work, which emphasized the importance of knowledge, specialized training, and manager awareness in achieving sustainability in SMEs.

On the other hand, our findings are consistent with those of [76], who concluded that several efforts on education and training of employees are necessary to sustain the rapid development of manufacturing under the industry 4.0 paradigm. Additionally, [77] discovered that social practices such as 'training and education' and 'establishing a health and safety system' enable manufacturing firms to improve their economic and environmental sustainability. Thus, managers of Malaysian manufacturing firms should consider prudent resource allocation in order to maximize their ability to manage their customers' needs while also improving their management of skill and education levels within the company. All managers in all departments who interact with employees on a daily basis are required to integrate the education program to ensure that knowledge is distributed evenly, problems are resolved quickly, and the company's productivity is increased. The literature clearly contains a range of conclusions and findings, as there are contradictory definitions for JIT, resulting in multiple attempts to define SP and the significant negative correlation between these practices. To summarize, a firm grasp of the JIT and SP terminologies enables a succinct description of these paradigms' perceived benefits.

5.0 CONCLUSION

In conclusion, this research examined the impact of essential Lean Methods namely TPM, CI and JIT on Sustainable Performance of Malaysian manufacturing firms specifically in Negeri Sembilan state. The inclusion of three important LM techniques in a single study exemplifies the validity of this research, since they are often ignored. Additionally, it helps to further explore how JIT, TPM and CI are intertwined when it pursues sustainability. This research is one addition to the present understanding of LM disciplines since it uses a single package model in different situations linked to the Malaysian climate in Southeast Asia. Malaysia, which wants to expand its economy and industrialize, may use this more comprehensive multi-mediator approach. These issues will be addressed by utilizing and defining a broader spectrum of SP that goes beyond environmental concerns and tackles with the three bottom lines that have led to competitive and innovative sectors, as well. A contribution to the development of new theoretical methods and empirical research in the areas of LM and SP is the discovery of conceptual links between these practices and long-term performance. By integrating these three critical LM practices with SP, a single flexible model for Malaysian managers is proposed, providing a tool for benchmarking long-term sustainability. Additionally, the success factors for the LM tools and techniques discussed in this research generate marketable perceived benefits for industries that are still in the early stages of implementing LM, quality, and sustainability.

On the basis of these results, the researcher recommends rethinking the starting point of future research. Research may be done in service organizations, for example. According to [78], Lean methods have spread from manufacturing plants to a variety of organizations, including insurance, healthcare, government agencies, IT operations, retail purchasing groups, and publishing firms. This research should be repeated in other industrialized nations utilizing a longitudinal study method in order to reflect the long-term nature of many LM practices. Since only one answer was received per business, this research may have had responder bias when analyzing each company's current status quo in light of the factors under consideration. To overcome this problem, the author recommends that future studies concentrate on a diverse group of people from different companies instead of just one. The results of this cross-sectional research should be re-examined, and a replication would help with that. The

relationships discovered in this research will be put to the test in other nations to see whether there is any validity to them. A future study should focus on the effect of the model in terms of each component of sustainability individually by implementing sustainable performance, says the researcher. By doing so, consumers will be able to see more clearly and concisely the real values of a company's long-term social, environmental, and financial health. To better comprehend the interrelationships between latent constructs in a sustainable ecosystem, the researcher believes that more dimensions should be added.

Besides that, this research defined the stages and development of a model for implementing lean manufacturing practices in Malaysian manufacturing firms through the use of LEAN-SP concepts. This research included multiple reviews of previously published literature on critical Lean methods for Malaysian manufacturing firms, investigation of appropriate tools and methods for use, development of structural equation models, and practical model validation processes. In general, this study could well have addressed the research questions raised and thus met the objectives. It is hoped that the research conducted will contribute significantly to the practical development of efficient production management in Malaysian manufacturing firms.

Acknowledgement

References

[1]   Arya, C., Amiri, A., & Vassie, P. 2015. A New Method for Evaluating the Sustainability of Bridges. *Proceedings of the Institution of Civil Engineers-Structures and Buildings.* 168(6): 441-453.
DOI: https://doi.org/10.1680/stbu.14.00069.

[2]   Jobin, M. V., Ramanan, T. R., & Sridharan, R. 2021. Forecasting Structural Equation Modelling of Lean Manufacturing Using High Order Statistical Functions. *International Journal of Integrated Supply Management.* 14(3): 291-305.
DOI: https://www.inderscienceonline.com/doi/abs/10.1504/IJISM.2021.117240.

[3]   Pinto Junior, M. J. A., & Mendes, J. V. 2017. Operational Practices of Lean Manufacturing: Potentiating Environmental Improvements. *Journal of Industrial Engineering and Management (JIEM).* 10(4): 550-580.
DOI: http://dx.doi.org/10.3926/jiem.2268.

[4]   Rose, A. N. M., Ab Rashid, M. F. F., Mohamed, N. N., & Ahmad, H. 2017. Similarities of Lean Manufacturing Approaches Implementation in SMEs Towards the Success: Case Study in the Automotive Component Industry. *MATEC Web of Conferences.* EDP Sciences. 87: 02024.
https://doi.org/10.1051/matecconf/20178702024.

[5]   Ahmad, N., Hossen, J., & Ali, S. M. 2018. Improvement of Overall Equipment Efficiency of Ring Frame through Total Productive Maintenance: A Textile Case. *The International Journal of Advanced Manufacturing Technology.* 94(1): 239-256.

[6]   DOI: https://link.springer.com/article/10.1007/s00170-017-0783-2.

[6]   Henao, R., Sarache, W., & Gómez, I. 2019. Lean Manufacturing and sustainable Performance: Trends and Future Challenges. *Journal of Cleaner Production.* 208: 99-116.
DOI: https://doi.org/10.1016/j.jclepro.2018.10.116.

[7]   Cherrafi, A., Elfezazi, S., Chiarini, A., Mokhlis, A., & Benhida, K. 2016. The Integration of Lean Manufacturing, Six Sigma and Sustainability: A Literature Review and Future Research Directions for Developing a Specific Model. *Journal of Cleaner Production.* 139: 828-846.
DOI: https://doi.org/10.1016/j.jclepro.2016.08.101.

[8]   Geng, R., Mansouri, S. A., & Aktas, E. 2017. The Relationship Between Green Supply Chain Management and Performance: A Meta-analysis of Empirical Evidences in Asian Emerging Economies. *International Journal of Production Economics.* 183: 245-258.
DOI: https://doi.org/10.1016/j.ijpe.2016.10.008.

[9]   Verrier, B., Rose, B., Caillaud, E., & Remita, H. 2014. Combining Organizational Performance with Sustainable Development Issues: The Lean and Green Project Benchmarking Repository. *Journal of Cleaner Production.* 85: 83-93.
DOI: https://doi.org/10.1016/j.jclepro.2013.12.023x.

[10]   Rocha-Lona, L., Alvarez-Reyes, S. E., Eldridge, S., Garza-Reyes, J. A., & Kumar, V. 2013. Lean Six Sigma Supply Chain Case Study: Aircraft Shipment Improvement in a Pharmaceutical Company. *Advances in Sustainable and Competitive Manufacturing Systems.* Springer, Heidelberg. 1475-1487.
DOI: https://doi.org/10.1007/978-3-319-00557-7119.

[11]   Yadav, V., Jain, R., Mittal, M. L., Panwar, A. and Lyons, A. 2019. The Impact of Lean Practices on the Operational Performance of SMEs in India. *Industrial Management & Data Systems.* 119(2): 317-330.
DOI: https://doi.org/10.1108/IMDS-02-2018-0088.

[12]   Laufs, U., Filipiak, K. J., Gouni-Berthold, I., Catapano, A. L., Mandraffino, G., & Benlian, P. 2017. Practical Aspects in the Management of Statin-associated Muscle Symptoms (SAMS). *Atherosclerosis Supplements.* 26: 45-55.
DOI: https://doi.org/10.1016/S1567-5688(17)30024-7.

[13]   Carlos Pinho, J. 2008. TQM and performance in small medium enterprises: The Mediating Effect of Customer Orientation and Innovation. *International Journal of Quality & Reliability Management.* 25(3): 256-275.
DOI: https://doi.org/10.1108/02656710810854278.

[14]   Ates, A., & Bititci, U. 2011. Change Process: A Key Enabler for Building Resilient SMEs. *International Journal of Production Research.* 49(18): 5601-5618.
DOI: https://doi.org/10.1080/00207543.2011.563825.

[15]   Belekoukias, I., Garza-Reyes, J. A., & Kumar, V. 2014. The Impact of Lean Methods and Tools on the Operational Performance of Manufacturing Organisations. *International Journal of Production Research.* 52(18): 5346-5366.
DOI: https://doi.org/10.1080/00207543.2014.903348.

[16]   Garza-Reyes, J. A., Kumar, V., Chaikittisilp, S., & Tan, K. H. 2018. The Effect of Lean Methods and Tools on the Environmental Performance of Manufacturing Organisations. *International Journal of Production Economics.* 200: 170-180.
DOI: https://doi.org/10.1016/j.ijpe.2018.03.030.

[17]   Ben Ruben, R., Vinodh, S., & Asokan, P. 2017. Implementation of Lean Six Sigma Framework with Environmental Considerations in an Indian Automotive Component Manufacturing Firm: A Case Study. *Production Planning & Control.* 28(15): 1193-1211.
DOI: https://doi.org/10.1080/09537287.2017.135721.

[18]   Yang, M. G. M., Hong, P., & Modi, S. B. 2011. Impact of Lean Manufacturing and Environmental Management on Business Performance: An Empirical Study of Manufacturing Firms. *International Journal of Production Economics.* 129(2): 251-261.

DOI: https://doi.org/10.1016/j.ijpe.2010.10.017.

[19] Kleindorfer, P. R., Singhal, K., & Van Wassenhove, L. N. 2005. Sustainable Operations Management. *Production and Operations Management*. 14(4): 482-492.
DOI: https://doi.org/10.1111/j.1937-5956.2005.tb00235.x.

[21] Laufs, U., Filipiak, K. J., Gouni-Berthold, I., Catapano, A. L., Mandraffino, G., Benlian, P. (2017. Practical Aspects in the Management of Statin-associated Muscle Symptoms (SAMS). *Atherosclerosis Supplements*. 26: 45-55.

[22] Pinho, J. C. 2008. TQM and Performance in Small Medium Enterprises: The Mediating Effect of Customer Orientation and Innovation. *International Journal of Quality and Reliability Management*. 25(3): 256-275.

[23] Belekoukias, I., Garza-Reyes, J. A., & Kumar, V. 2014. The Impact of Lean Methods and Tools on the Operational Performance of Manufacturing Organisations. *International Journal of Production Research*. 52(18): 346-5366.

[24] Garza-Reyes, J. A., Kumar, V., Chaikittisilp, S., & Tan, K. H. 2018. The Effect of Lean Methods and Tools on the Environmental Performance of Manufacturing Organisations. *International Journal of Production Economics*. 200: 170-180.

[25] Cua, K. O., McKone-Sweet, K. E., & Schroeder, R. G. 2006. Improving Performance through an Integrated Manufacturing Program. *Quality Management Journal*. 45-60.

[26] Abdallah, A., & Matsui, Y. 2007. JIT and TPM. Their Relationship and Impact on JIT and Competitive Performances, Yokohama National University, International Graduate School of Social Sciences, Yokohama National University. 1(9): 1-18.

[27] Teeravaraprug, J., Kitiwanwong, K., & Saetong, N. 2011. Relationship Model and Supporting Activities of JIT. *TQM and TPM*. 33(1): 101-106.

[28] Hailu, H., Mengstu, S., & Hailu, T. 2018. An integrated Continuous Improvement Model of TPM, TPS and TQM for Boosting Profitability of Manufacturing Industries: An Innovative Model & Guideline. *Management Science Letters*. 8(1): 33-50.

[29] Habidin, N. F., & Yusof, S. M. 2013. Critical Success Factors of Lean Six Sigma for the Malaysian Automotive Industry. *International Journal of Lean Six Sigma*. 4(1): 60-82.

[30] Kaur, M., Singh, K., & Ahuja, I. S. 2013. An Evaluation of the Synergic Implementation of TQM and TPM Paradigms on Business Performance. *International Journal of Productivity and Performance Management*. 62(1): 66-84.

[31] Green, K. W., Inman, R. A., Sower, V. E. and Zelbst, P. J. 2019. Impact of JIT, TQM and Green Supply Chain Practices on Environmental Sustainability. *Journal of Manufacturing Technology Management*. 30(1): 26-47.

[32] Bashar, Abul, and Ahsan Akhtar Hasin. 2019. Impact of JIT Production on Organizational Performance in the Apparel Industry in Bangladesh. *Proceedings of the 2019 International Conference on Management Science and Industrial Engineering*. 184-189.

[33] Phan, Anh Chi, Ha Thu Nguyen, Hao Anh Nguyen, and Yoshiki Matsui. 2019. Effect of Total Quality Management Practices and JIT Production Practices on Flexibility Performance: Empirical Evidence from International Manufacturing Plants. *Sustainability*. 11: 3093.

[34] Chan, C. O., & Tay, H. L. 2018. Combining Lean Tools Application in Kaizen: A Field Study on the Printing Industry. *International Journal of Productivity and Performance Management*. 67(1): 45-65.

[35] Dhingra, A. K., Kumar, S., & Singh, B. 2019. Cost Reduction and Quality Improvement through Lean-Kaizen Concept Using Value Stream Map in Indian Manufacturing Firms. *International Journal of System Assurance Engineering and Management*. 10(4): 792-800.

[36] Kumar, S., Dhingra, A., & Singh, B. 2018. Lean-Kaizen Implementation: A Roadmap for Identifying Continuous Improvement Opportunities in Indian Small and Medium

Sized Enterprise. *Journal of Engineering, Design and Technology*. 16(1): 143-160.

[37] Zahoor, S., Abdul-Kader, W., Ijaz, H., Khan, A. Q., Saeed, Z., & Muzaffar, S. 2019. A Combined VSM and Kaizen Approach for Sustainable Continuous Process Improvement. *International Journal of Industrial Engineering*. 1(2): 125-137.

[38] Hussain, K., He, Z., Ahmad, N., & Iqbal, M. 2019. Green, Lean, Six Sigma Barriers at a Glance: A Case from the Construction Sector of Pakistan. *Building and Environment*. 161: 106225.

[39] Glover, W. J., Farris, J. A., & Van Aken, E. M. 2015. The Relationship between Continuous Improvement and Rapid Improvement Sustainability. *International Journal of Production Research*. 53(13): 4068-4086.

[40] Akanmu, M. D., Hassan, M. G., & Bahaudin, A. Y. B. 2020. A Preliminary Analysis Modeling of the Relationship between Quality Management Practices and Sustainable Performance. *Quality Management Journal*. 27(1): 37-61.

[41] Vinodh, S., & Joy, D. 2012. Structural Equation Modelling of Lean Manufacturing Practices. *International Journal of Production Research*. 50(6): 1598-1607.
DOI: https://doi.org/10.1080/00207543.2011.560203.

[42] Khalili, A., Ismail, M. Y., & Karim, A. N. M. 2017. Integration of Lean Manufacturing and Quality Management System through Structural Equation Modelling. *International Journal of Productivity and Quality Management*. 20(4): 534-556.
DOI: https://www.inderscienceonline.com/doi/abs/10.1504/IJPQM.2017.082835.

[43] Creswell, J. W. 2011. Controversies in Mixed Methods Research. *The Sage Handbook of Qualitative Research*. 4: 269-284.

[44] Cua, K. O., McKone, K. E., & Schroeder, R. G. 2001. Relationships between Implementation of TQM, JIT, and TPM and Manufacturing Performance. *Journal of Operations Management*. 19(6): 675-694.
DOI: https://doi.org/10.1016/S0272-6963(01)00066-3.

[45] Singh, A. S., & Masuku, M. B. 2014. Sampling Techniques & Determination of Sample Size in Applied Statistics Research: An Overview. *International Journal of Economics, Commerce and Management*. 2(11): 1-22.

[46] Yusoff, S and Sazali Said. 2018. Lean Manufacturing Implementation from the Perspective of Small and Medium Enterprises. *International Journal of Innovative Science and Research Technology*. 3(10): 446-450.

[47] Belekoukias, I., Garza-Reyes, J. A., & Kumar, V. 2014. The Impact of Lean Methods and Tools on the Operational Performance of Manufacturing Organisations. *International Journal of Production Research*. 52(18): 346-5366.

[48] Zainuddin, A. 2014. Research Methodology and Data Analysis. Kuala Lumpur: Penerbit UITM Press.

[49] Masoumik, S. M., Abdul-Rashid, S. H., Olugu, E. U., & Raja Ghazilla, R. A. (2014). Sustainable Supply Chain Design: A Configurational Approach. *The Scientific World Journal*. 1-16. DOI: https://doi.org/10.1155/2014/897121.

[50] Khanchanapong, T., Prajogo, D., Sohal, A. S., Cooper, B. K., Yeung, A. C., & Cheng, T. C. E. 2014. The Unique and Complementary Effects of Manufacturing Technologies and Lean Practices on Manufacturing Operational Performance. *International Journal of Production Economics*. 153: 191-203.
DOI: https://doi.org/10.1016/j.ijpe.2014.02.021.

[51] Cooper, C. R. & Schindler, P. S. 2011. *Business Research Methods*. 11th ed. New York: McGraw-Hill.

[52] Hair, J. F., Tatham, R. L., Anderson, R. E. & Black, W. C. 1995. *Multivariate Data Analysis*. 4th ed. New York, NY: Prentice Hall.

[53] Tabachnick, B. G., Fidell, L. S., & Ullman, J. B. 2007. *Using Multivariate Statistics*. Boston, MA: Pearson. 5: 481-498.

[54]   Hair, J. F., Celsi, M., Ortinau, D. J., & Bush, R. P. 2010. *Essentials of Marketing Research*. Vol. 2. New York, NY: McGraw-Hill/Irwin.

[55]   Zainudin, A. 2015. *A Handbook on SEM for Academicians and Pratitioners*. Bangi: MPWS Rich Publication

[56]   Martinez-Conesa, I., Soto-Acosta, P. and Carayannis, E. G. 2017. On the Path Towards Open Innovation: Assessing the Role of Knowledge Management Capability and Environmental Dynamism in SMEs. *Journal of Knowledge Management*. 21(3): 553-570.
DOI: https://doi.org/10.1108/JKM-09-2016-0403.

[57]   Byrne, B. M. 2010. *SEM Modeling with AMOS: Basic Concepts, Applications, and Programming*. 2nd ed. New York, NY: Routledge.
DOI: https://doi.org/10.1108/JKM-09-2016-0403.

[58]   Kline, R. B. 1998. *Principles and Practice of Structural Equation Modeling*. New York, NY: Guilford Press.

[59]   Abdallah, A., & Matsui, Y. 2007. JIT and TPM. Their Relationship and Impact on JIT and Competitive Performances, Yokohama National University, International Graduate School of Social Sciences, Yokohama National University. 1(9): 1-18.

[60]   Alhamdi, M., Alnoor, A., Eneizan, B., Abdulla, M., & Abdulaali, A. R. 2019. Determinants of the Production System Time (JIT) on Reduce Waste: Case Study in a Salsal Water Company. *International Journal of Academic Research in Business and Social Sciences*. 9(7): 17-32.

[61]   Chiu, Y., Yang, C. H., & Lin, P. C. 2017. A Just-in-Time Inventory Model with Preventive Maintenance and Defect Rate. *International Journal of Information Systems and Supply Chain Management (IJISSCM)*. 10(4): 44-60.
DOI: 10.4018/IJISSCM.2017100103.

[62]   Zolkafli, U. K., Zakaria, N., & Danuri, M. S. M. 2021. The Adoption of Total Productive Maintenance (TPM) Concept for Maintenance Procurement of Green Buildings in Malaysia. *International Journal of Sustainable Construction Engineering and Technology*. 12(1): 40-55.
https://publisher.uthm.edu.my/ojs/index.php/IJSCET/article/view/6293.

[63]   Heredia-Mercado, R., Flores-Piñas, S., Chavez, P., & Raymundo, C. 2021. Lean Manufacturing Production Management Model Under a Change Management Approach to Enhance Production Efficiency of Textile and Clothing SMEs. *International Conference on Intelligent Human Systems Integration*. Springer, Cham. 766-772.
DOI: https://link.springer.com/chapter/10.1007/978-3-030-68017-6_114.

[64]   Okpala, C., Anozie, S., & Ezeanyim, O. 2018. The Application of Tools and Techniques of Total Productive Maintenance in Manufacturing. *Int. J. Eng. Sci. Comp.* 8(6).

[65]   Kapuria, T. K., Rahman, M., & Haldar, S. 2017. Root Cause Analysis and Productivity Improvement of an Apparel Industry in Bangladesh through Kaizen Implementation. *Journal of Applied Research on Industrial Engineering*. 4(4): 227-239.
DOI: https://dx.doi.org/10.22105/jarie.2017.108637.1025.

[66]   Habidin, N. F., Hashim, S., Fuzi, N. M. and Salleh, M. I. 2018. Total Productive Maintenance, Kaizen Event, and Performance. *International Journal of Quality & Reliability Management*. 35(9): 1853-1867.
DOI: https://doi.org/10.1108/IJQRM-11-2017-0234.

[67]   Reyes, J., Alvarez, K., Martínez, A., & Guamán, J. 2018. Total Productive Maintenance for the Sewing Process in Footwear. *Journal of Industrial Engineering and Management*. 11(4): 814-822.
DOI: http://dx.doi.org/10.3926/jiem.2644.

[68]   Erkayman, B. 2019. Transition to a JIT Production System through ERP Implementation: A Case from the Automotive Industry. *International Journal of Production Research*. 57(17): 5467-5477.
DOI: https://doi.org/10.1080/00207543.2018.1527048.

[69]   Mukwakungu, S. C., Mabasa, M. D., Mankazana, S., Mzileni, X., & Burakeye, S. A. 2019. The Impact of Just in Time (JIT) in Inventory Management–Perspectives from Two Case Studies in a South African Environment. *Proceedings of the International Conference on Industrial Engineering and Operations Management*. 5(7): 1271-1278.

[70]   Maheshwar, C. Y., & Javalagi, C. M. 2018. Application of Structural Equation Modeling to Establish Causal Relationships among Factors Affecting Enterprise Resource Planning (Erp) Implementation. *Int. Journal of Engineering Research and Application*. 8(3): 71-83.

[71]   Singh, T. P., & Ahuja, I. S. 2017. Evaluating Manufacturing Performance through Strategic Total Productive Maintenance Implementation in a Food Processing Industry. *International Journal of Productivity and Quality Management*. 21(4): 429-442.
DOI: https://www.inderscienceonline.com/doi/abs/10.1504/IJPQM.2017.085253.

[72]   Tesfaye, G., & Kitaw, D. 2017. A TQM and JIT Integrated Continuous Improvement Model for Organizational Success: An Innovative Framework. *Journal of Optimization in Industrial Engineering*. 22: 15-23.

[73]   Mardani, A., Nikoosokhan, S., Moradi, M., & Doustar, M. 2018. The Relationship between Knowledge Management and Innovation Performance. *The Journal of High Technology Management Research*. 29(1): 12-26.
DOI: https://doi.org/10.1016/j.hitech.2018.04.002.

[74]   Frempong, L. N., Agbenyo, W., & Darko, P. A. 2018. The Impact of Job Satisfaction on Employees' Loyalty and Commitment: A Comparative Study among Some Selected Sectors in Ghana. *European Journal of Business and Management*. 10(12): 95-105.

[75]   Ariussanto, K. A. P., Tarigan, Z. J. H., Sitepu, R. B., & Singh, S. K. 2020. Leadership Style, Employee Engagement, and Work Environment to Employee Performance in Manufacturing Companies. *SHS Web of Conferences*. EDP Sciences. 76: 01020.
DOI: https://doi.org/10.1051/shsconf/20207601020.

[76]   Ozoekwe, Christiana, and K. T. Konya. 2021. Leaders' Emotional Intelligence and Workplace Harmony in Manufacturing Companies in Port Harcourt, Rivers State, Nigeria. *International Journal of Management Sciences*. 9(1): 59-72.

[77]   Adil, M. S., & Ab Hamid, K. B. 2020. Effect of Teamwork on Employee Performance in High-Tech Engineering SMEs of Pakistan: A Moderating Role of Supervisor Support. *South Asian Journal of Management*. 14(1): 122-141.

[78]   Badar, M. Z., & Sari, D. K. 2019. Impact of Teamwork and Compensation on Employee Performance in Manufacturing Companies in Pasuruan, Indonesia. *Indonesian Journal of Law and Economics Review*. 4.