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Hybrid Lean Practices Integrated with IR 4.0 and Sustainability in Malaysia Food and Beverages Companies: Conceptual Framework and Hypothesis Development

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ABSTRACT

The growing competition within manufacturing practices has motivated organizations to upgrade their conventional production system to a smart, sophisticated systems. This study evaluates the impact of lean manufacturing practices (LMP) and industrial revolution 4.0 technologies on sustainability in the food and beverages industry. Past literature has revealed that lean practices significantly affect sustainable performance. However, the integrated effects of lean manufacturing practices and IR 4.0 technologies on sustainable performance have not been examined empirically. In order to fill the void of this gap, this study intends to have a preliminary investigation of the combined effects of LMP and IR 4.0 technologies on sustainable performance, specifically in the food and beverages industry. Furthermore, the study aims to confirm the future direction of the food industry that is recently employing new technologies in its manufacturing systems. This study is underpinned by the theories of contingency and practice-based view by highlighting the contributions of operations management practices to implement successful strategies in enhancing sustainability performance in food and beverages companies through performance variations. This study extends the current literature on IR 4.0 technologies and lean manufacturing practices as enablers of economic, environmental, and social sustainability. Also, the study provides implications and future direction for industry consultants, practitioners, and academicians.

Keywords: Food and beverages, industrial revolution 4.0 technologies, lean manufacturing practices, sustainable performance

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INTRODUCTION

Sustainable performance in the service and manufacturing sectors has gained attention in various business practitioners' research documents and projects. The practice and theory of sustainable performance have become a critical issue in the dynamic business market within manufacturing practices. There is urgency in discussion regarding sustainability in manufacturing industries. However, this discussion was mainly focused on the societal level—and sometimes on environmental issues; it is now obvious there is an increase in its relevance for manufacturing companies worldwide. Many organizations have taken these opportunities to implement sustainable practices in product quality, competitive positioning, customer relationship, environmental management and supply chains management, environmental costs, operational practices, strategic plan and action, material selection, and continuous growth and expansion. However, studies have revealed an insufficient number of research that elucidate the limitations of lean manufacturing practices. The emerging trend of industrial revolution 4.0 provides the necessary platforms for both academic and industrial sectors to grow further on this methodology in solving problems as lean practices have been adopted by different industries. However, barriers and constraints such as social, financial, capacity, and steering factors are created by sustainability for professional practices to successfully implement sustainable practices (Ali & Alkayed, 2019). Therefore, this study intends to systemically review past literature to identify the emerging trends followed by developing a conceptual framework, questionnaire development, and hypothesis development.

LITERATURE REVIEW

Food and Beverages Industry in Malaysia

Food production and consumption are major causes of global environmental degradation (Salim et al., 2018). The agro-based industries are major providers of income and employment worldwide. In recent decades, food and beverage companies (FBC) have significantly grown in which the agricultural development policies have changed from a production-oriented approach to a broader system that emphasizes agro-food chain coordination, value creation, and institutional strategies under which the chain operates (Konig et al., 2013). However, agro-allied industries face challenges to survival due to the unfriendly operating environment and global economic meltdown. The concern for sustainability can be traced back to the third Malaysia plan between 1976 and 1980 when the country built its economic foundation. Through environmental stewardship, the Worldwide Fund (WWF) revealed that in 2007, 57% of the population was reported to have good environmental behavior in Malaysia. In recent times, the food processing and the agro-allied industries are becoming prominent with the eradication of certain food grades and their importation as enjoined by the government policy, according to the Malaysia Competition Commission (MyCC, 2019).

According to Glover et al. (2014), sustainability practices in food and production are critical, precisely in productivity. Currently, the food industry must adapt alongside other industries to the new challenges of sustainable production (Glover et al., 2014). The production index of FBC has increased by 4.4% as a result of strong domestic demand within the sector with a significant increase in the record of productions of sugar confectionery, cocoa and chocolate (15.5%), sugar refineries (1.4%), biscuit (12.2%), and other processed food (8.8%), according to Saleh and Ndubisi (2006). With the yearly importation of more than 12 billion ringgit, Malaysia is still a net importer of food products despite the fact that the export performance of this sector has multiplied over the year (FMM, 2017). Few attempts, however, have been made to provide a holistic approach to the identification of the potential pathways, drivers, and barriers to overcome the challenges (Boiral et al., 2017).

Sustainable Performance

The main inductors of sustainability in any organization are the internal strategic practices and organizational factors that must be considered from the upper management to the lower management (Caiado et al., 2018). Sustainable performance is achieved in business when a firm or company builds continuous values for its shareholders and stakeholders while abiding by environmental regulations (Brent & Labuschagne, 2004). The sustainable performance value has a few essential parts: making the shareholders and customers happy and, more importantly, performing well for the environment and society (Hassan et al., 2018). In addition, sustainable performance comprises practices that socially facilitate the useful life of an organization, promoting the capacity to renew and maintain the viability of the ecosystem, provide for the living beings, and promote the ability of a society to sustain itself in solving the major crisis and maintain decent welfare, personal freedom and participation for human present and future generation (Dunphy, 2011). Furthermore, sustainable performance is a product of executing transactions, and business toward a sustainable enterprise creates a constructive and innovative corporate culture (Hassan et al., 2018).

The developed healthy culture can then create an enabling environment and high performance to maximize the use of available assets to lead to good outcomes within the economy and society (Dunphy, 2011). There are three categories of sustainable performance: social, environmental, and economic sustainable performance (Akanmu et al., 2017). As confirmed by the European Commission, sustainable development strategies emphasize the significance of economic growth, environmental protection, and social cohesion (Pei et al., 2010). Sustainable management is addressed by Guan et al. (2010) as a modern pattern of management focusing on the joint integration of the environment, economy, and society through processes such as procurements, production, packaging, storage, consumption, transportation, and end-life product disposal as enhanced by technologies with the final goals to achieve economic, societal and environmentally sustainable development.

Lean Manufacturing Practices

Lean manufacturing is a methodology designed to reduce the cost of production and waste minimization (Alhuraish et al., 2016). Similarly, lean manufacturing is a business method or strategy that facilitates process performance and increases customer satisfaction and triple-bottom-line results (Snee, 2010). Lean manufacturing started with the Toyota production system (TPS), where the system was integrated with practices such as Just-in-time to improve time delivery and quality. Nordin et al. (2014) affirmed that the TPS started the lean manufacturing concept, and it aimed to improve quality and reduce cost through non-value added and waste minimization. Lean manufacturing is formed from different practices (Yang et al., 2017). Similarly, the lean manufacturing practices cluster includes human resources management, productive maintenance, just-in-time, total quality management, total preventive maintenance employee involvement, and controlled processes. Recent studies have proven the importance of customer participation and downstream collaboration (Martinez-Jurado & Moyano-Fuentes, 2014). Lean practices are product design, customer relationship, supplier relationship, manufacturing planning and control, process and equipment, and human resources. These categories are suitable for all industries (Bergmiller, 2006). Therefore, forward coordination with the customers and backward coordination with the suppliers is important to implement lean manufacturing practices successfully. In that manner, the products are designed, produced, packaged, and specifically delivered to meet the operational and environmental objectives (Dües et al., 2013). These objectives seeking to achieve lean management performance include natural environment, sustainable and ecological performance dimensions.

Industrial Revolution 4.0 Technologies

In the last 30 years, the history of the industrial revolution has highlighted a shift in power from power sources to automated production, information technology, and connectivity. Notably, the industrial revolution revolves around three main categories: technologies, processes, and people, with one of these driving the change and initiating a circular pattern of mutual influence. According to Ahuett-Garza and Kurfess (2018), Industrial Revolution 4.0 is the digital manufacturing system provided by successfully incorporating information technologies, techniques, and production processes. The main objective of Industrial Revolution 4.0 (IR 4.0) is to improve the efficiency and responsiveness of the manufacturing systems. The IR 4.0 technologies operating on vertical and horizontal manufacturing system integration are influenced by real-time data interchange between many partners in a manufacturing value chain (Fatorachian & Kazemi, 2018). Additive manufacturing (AM), the internet of things (IoT), robotic systems (RS), big data analytics (BDA), augmented reality (AR), cloud computing (CC), and cyber-physical system (CPS) are identified as the significant Industrial revolution 4.0 technologies that promote process integration, leading to sustainable performance (Kamble et al., 2018a).

METHODOLOGY

It is imperative to carefully design the questionnaire items to reflect and measure the variables employed for the research framework. The items for the questionnaires are developed from past studies—adapted or adopted (Zikmund et al., 2010). Items measuring the lean manufacturing practices (i.e., continuous flow, employee involvement, supplier involvement, setup time reduction, customer involvement, just in time, supplier development, total productive maintenance, statistical process control and pull system), IR 4.0 technologies, and sustainable performance of the company are divided into three sections. The survey instrument is constructed using related literature as guidance. Meanwhile, supporting literature is cited adequately in places with newly developed items.

Sustainability Performance Dimensions

Sustainability performance is measured using social, economic, and environmental performance. A total of twenty items are adopted from the study of Brent and Labuschagne (2004) and Akanmu et al. (2021). The last three years are designated as the assessment period for the companies. Table 1 presents the items measuring sustainability performance and their respective coding.

Table 1
Sustainable performance coding

Economic Sustainability Performance Items In the last three years, our company has achieved:	Code
Reduced costs of production	EP01
Improved profits	EP02
Reduced product development costs	EP03
Decreased energy costs	EP04
Reduced inventory costs	EP05
Reduction in rework and rejection cost	EP06
Decrease in the purchase cost of raw material	EP07
Decrease in the cost of the waste treatment	EP08
Social Sustainability Performance	
Improved condition of work	SP1
Improved safety in the workplace	SP2
Improved health of the employees	SP3
Improved relations on labor	SP4
Improvement in morale	SP5
Decrease in work pressure	SP6

Table 1 *(Continue)*

Economic Sustainability Performance Items In the last three years, our company has achieved:	Code
Environmental Sustainability Performance	
Reduced solid wastes	EVP01
Reduced liquid wastes	EVP02
Reduced gas emission	EVP03
Reduction in energy wastes	EVP04
Decreased consumption of toxic/hazardous/harmful materials	EVP05
Improved environmental condition of the company	EVP06

Lean Manufacturing Practice Dimensions

The construct domain specification and item generation are developed using the first set of lean manufacturing practice constructs proposed by Shah and Ward (2007). These constructs are continuous flow, employee involvement, supplier involvement, set-up time reduction, customer involvement, just in time, supplier development, statistical process control, pull system, and total productive maintenance, as indicated in Table 2.

Table 2

Lean manufacturing practices coding

Item	**Code**
Supplier Involvement	
Our organization is in close connection always with the suppliers	SI1
Our company provides feedback to the suppliers on delivery and quality performance	SI2
Our company applies utmost efforts in creating a long-term relationship with the suppliers	SI3
Just-in-time	
All our key suppliers involved in a new process of product development	JIT1
Our organization is delivered by our suppliers on a just-in-time basis	JIT2
Our organization has a supplier certification program in place	JIT3
Supplier Development	
Our company's supplier strives to achieve cost reduction annually	SD1
Our key supplier is situated in close vicinity to our organization	SD2
We have established a system to convey important issues to the suppliers	SD3
Our company makes an effort to have a lesser number of suppliers in every category	SD4
The inventories are managed by the key suppliers	SD5
Supplier evaluation is not done per unit price but on the total cost purchase	SD6

Table 2 *(Continue)*

Item	Code
Customer Involvement	
Our organization is in close relationship with the customers	CI1
Our company gets feedback on delivery and quality performance from the customers	CI2
Our firm involves customers in new and existing product development and improvement process	CI3
The customers/clients participate in the existing and new product development and improvement process	CI4
The customers share their future and present demands with our organization	CI5
Continuous Flow	
Our products are categorized into classes with the same processing criteria	CF1
Our products are categorized into classes with the same routing criteria	CF2
Our equipment is classified to provide continual flows of products	CF3
Our product determines the factory layout	CF4
Pull System	
Our productions are pulled by the shipments of the completed products	PS1
Our productions are at workstation are pulled by the present requirement of the next workstation	PS2
A production system of pull is adopted	PS3
Our company uses a container of signal or Kaban for production control	PS4
Total Productive Maintenance	
Our company is daily dedicated to planning activities related to equipment maintenance	TPM1
Our company carries out daily maintenance of all equipment	TPM2
Our company maintains excellent conditions for all equipment	TPM3
Our company posts records of equipment maintenance for active sharing with the employees	TPM4
Statistical Process Control (SPC)	
Our company covers most of the process/equipment under SPC	SPC1
Our company uses statistical techniques to control the process variance	SPC2
Our company uses charts as tools to show defect rates	SPC3
Our company uses fishbone illustration to identify causes of quality problem	SPC4
Our company conducts research on process capability before product launching	SPC5
Employee Involvement	
Our company believes that employee plays a significant role in solving problems	EI1
Our employees motivate the company through a suggestion program	EI2
Our employees do lead the process/product improvement efforts	EI3
Our company provides cross-functional training for the employees	EI4

Table 2 *(Continue)*

Item	**Code**
Setup Time Reduction	
Our company provides various practices on setup reduction techniques for our employees	STR1
Our company works continuously towards setup time reduction	STR2
Our company has a high setup time of equipment	STR3

Industrial Revolution 4.0 Technologies Dimensions

Most organizations are yet to explore the sophisticated features of IR 4.0 technologies; therefore, they are uncertain about what benefits of IR 4.0 Technologies would be in the future (Tortorella & Fettermann, 2018). Furthermore, Kamble et al. (2018b) posit that the adoption of IR 4.0 technologies in manufacturing industries is still at the infant stage but slowly gathering momentum. Therefore, the degree of implementation of IR 4.0 Technologies are aimed to be measured by items but not the successful level of its implementation. Table 3 presents the measuring items for IR 4.0 Technologies as adopted from the Kamble et al. (2020) study.

Table 3

Industrial revolution 4.0 technologies coding

Items	Code
Our company is planning to implement cloud computing	IR1
Our company is planning to implement big data analytics	IR2
Our company is planning to implement the internet of things	IR3
Our company is planning to implement additive manufacturing	IR4
Our company is planning to implement a robotic system	IR5
Our company is planning to implement augmented reality	IR6

Therefore, from the theoretical background of the trending issues, the framework of this study is developed, as illustrated in Figure 1.

The theories of practice-based view (PBV) and contingency are adopted from the theoretical background to develop the research hypotheses. According to Sousa and Voss (2008), the theory of contingency provides guidelines on the distinctive selection of sets of practices in operations management that are most suitable in a particular context of an organization. In other words, Bromiley and Rau (2016) posit that PBV is adopted as some organizations do not make use of all the existing practices that are beneficial; thus, performance variations are explained based on the use of a particular practice.

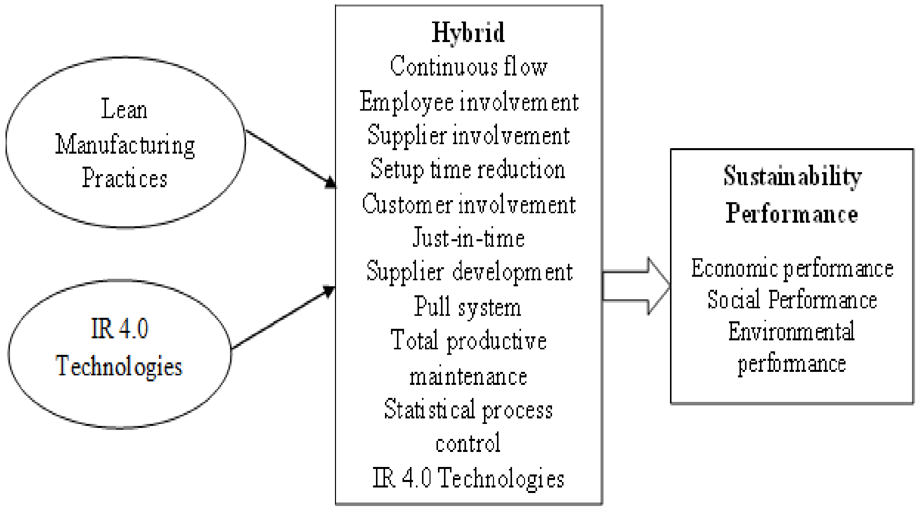

Figure 1. The development stage of the conceptual framework of the study

RESULTS AND DISCUSSION

From the past studies, the hypotheses formulation of this study is highlighted as follows:

Relationship Between Lean Manufacturing Practice and Sustainability Performance

Relationship Between Supplier Involvement and Sustainable Performance. Past literature (e.g., Vachon, 2007; Zhu et al., 2010) has shown that sustainability performance is significantly affected by supplier involvement in an organization. The collaboration with suppliers by an organization environmentally and economically improves sustainability performance (Vachon & Klassen, 2006). Vachon (2007) added that collaborative relationship with suppliers leads to effective adoption, development, and lean manufacturing towards social contribution. Companies can be disciplined by the stakeholders when they become aware of unacceptable sustainability-related conditions among suppliers arguing that buyers are capable of averting such wrongdoings through supplier selection and involvement (Hofmann et al., 2014; Busse et al., 2016).

Bussie (2016) reported that supplier involvement is related to economic and environmental goals (e.g., waste reduction or energy efficiency), and social-ethical goals are directly tied to sustainability-related conditions of the company. The importance of the relationship between supplier involvement and sustainability performance is also reported by Zhu et al. (2010). The study showed that the absence of supplier collaboration weakens the sustainability improvement performance among manufacturing companies. Following the past mentioned above studies, it is proposed that:

H1: supplier involvement has a positive and significant relationship with sustainable performance

Relationship between Just in Time and Sustainable Performance. According to Bicheno and Holweg (2009), JIT and autonomation are the two pillars required to support the Toyota Production System. Similarly, Zelbst et al. (2014) mentioned that JIT is a part of lean manufacturing practices that needs timely and accurate information sharing to be successfully implemented. In lean manufacturing, accurate inventory data are important as safety stocks, and large buffers are removed. Zelbst et al. (2014) reported that a digitized sustainable supply chain provides accurate and timely data about the locations and levels of inventories. In addition, JIT provides machine intelligence to distinguish between abnormal and normal operations. Thus, a machine will stop if a problem cannot be sustained to avoid producing defective products (Buer et al., 2018). The implementation of JIT provides machine intelligence for production, therefore facilitating autonomation. Thoben et al. (2014) categorially state that with JIT, the machines can report and analyze deviations and causes faster and automatically initiate measures.

Furthermore, JIT is also one of the tools of lean practice that offers organization assistance by providing strategies on waste reduction besides kaizen events, statistical process control, cellular manufacturing, supplier relationship, value stream mapping, visual management, and plant layout reconfiguration, analytic tools, and everyday work. Chiarini (2014) reported that JIT has effects on reducing manufacturing companies' social and environmental impact. Therefore, many organizations have adopted the tool to make more social and environmental progress (Cherrafi et al., 2016). With the above discussion, this study hypothesized that:

H2: Just in time has a positive and significant relationship with sustainable performance

Relationship between Supplier Development and Sustainable Performance. Supplier development is "any activity undertaken by a buying firm to improve either supplier performance, supplier capabilities, or both, and to meet the buying firm's short- and/or long-term supply needs" (Krause et al., 2000). Conventionally, supplier development focuses on economic sustainability and poses to grow the economic capabilities and performance of the suppliers as related to quality: cost and delivery. From the concept of the triple bottom line, supplier development comprises attaining environmental goals (e.g., waste reduction or energy efficiency), economic goals, and socio-ethical goals (e.g., abstinence from dysfunctional behavior or fairness of wages) (Busse et al., 2016). Similarly, supplier development in terms of social and environmental goals implies indirect "enlightened self-interest" of the buyer and is directly tied to the buyers' interests in terms of the economic goals (Busse, 2016).

According to Foerstl et al. (2015), supplier development has recently attracted scholarly studies in response to the organization's stakeholders' requests for practical, sustainable situations. Some past studies (e.g., Blome et al., 2014; Sancha et al., 2015) focused on green practices that enable suppliers to reduce the adverse effect of the natural environments on social practices. Based on the arguments presented by Haigh and Hoffmann (2014) that sustainability measures can influence stakeholder reactions and Busse (2016) stated that both are in the enlightened self-interest of the buyers, it is therefore hypothesized that:

H3: Supplier development has a positive and significant relationship with sustainable performance

Relationship between Customer Involvement and Sustainable Performance. According to Danarahmanto et al. (2020), a business model needs to support customer involvement or participation to achieve sustainable performance. A past study by Chen et al. (2012) showed that customers are ready to liaise to achieve environmental sustainability with the manufacturers and willing to patronize environmentally responsible companies. The study shows a significant relationship between customer involvement and sustainable performance where these technology-oriented customers access newly developed technological features of a product or service through purchase. Organizational sustainability performance is affected by economic, social, and environmental performance (Chen et al., 2012).

Also, Andic et al. (2012) reported that customer involvement determines an organization's economic performance and competitive advantage. Eltayeb et al. (2011) added a significant and positive relationship between customer involvement and sustainability performance. Customer involvement is always important when a new product is introduced, as the features of the products need to be presented and clearly defined by manufacturers (Chan et al., 2012).

In addition, Ellram et al. (2008) emphasize that the relationship between the customers and the manufacturers can lead to sustainable organizational performance. Simpson et al. (2007) added that the collaboration level of customers has a significant relationship with environmental and social sustainability performance. Similarly, researchers such as Chang and Taylor (2016) and Joo and Shin (2017) found a significant relationship between customer involvement and sustainable performance. This study, therefore, hypothesized that:

H4: Customer involvement has a positive and significant relationship with sustainable performance

Relationship between Continuous Flow and Sustainable Performance. According to Benavent et al. (2005), lean manufacturing practices increase customer satisfaction through the continuous process flow. In order to effectively integrate every aspect of the organizational process, such as the management styles and activities, every organization should create continuous improvement practices. Baker (2003) posits that the expected final result is to achieve a high level of customer satisfaction. Sagandira et al. (2022) reported that continuous flow of advanced inline flow downstream processing, artificial intelligence, robotics, in-process monitoring by process analytical technology in flow and flow automation dramatically enhances quality, agility, flexibility, and efficiency for sustainable manufacturing.

Furthermore, Escrig-Tena (2004) states that although there are many factors such as the top management support and effective information system for enhancing and facilitating continuous improvement practices in an organization, quality-conscious customers and critical innovation are the drivers of continuous sustainable flow. Iranmanesh et al. (2019) added that continuous flow of waste reduction is a prerequisite factor for achieving the aim of lean manufacturing, which is the foundation of successful sustainable lean practices. Studies showed that continuous flow has a significant and positive effect on an organization's long-term competitive position, sustainable performance, and productivity (e.g., Fotopoulos & Psomas, 2010; Yusuf et al., 2007). However, the study of Burli et al. (2012) reported no significant effect between continuous flow and sustainable performance. Thus, this study hypothesized that:

H5: there is a significant relationship between continuous flow and sustainability performance

Relationship between Pull System and Sustainable Performance. Womack et al. (2007) argued that the introduction of the pull system is part of the five methodologies: value expectation from the customer perspective when the flow is not possible as part of the lean, identification of the value stream to each service or product to remove or reduce wastes, implement continuous flow, and finally achieve perfection. The pull system consists of squares, Kanban, and signal containers for production controls. Similarly, the pull system comprises those practices with the lowest adoption. Therefore, the low applicability of a pull system support in the food industry can lead to difficulty implementing the pull construct (Panwar et al., 2017).

Akkerman and van Donk (2007) reported that production is often continuous or in batch in the food industry. Abdulmalek et al. (2006) added that the beverages industry often embraced continuous production. The authors added that although tools such as the Kaban pull system in a continuous environment may not be realistic, the availability and reliability of the equipment are critical. Therefore, practices such as pull are very crucially useful for sustainability. Hallam and Contreras (2016) reported that lean is promulgated by a pull system to align production capabilities with customer rate of demands and pursue sustainability to remind that the process of transitioning to lean should never end. The adoption of pull practices is also affected by the equipment used in the process. There is less need for equipment to be used in other products or services or fast changeover practices as the equipment becomes specialized more for a particular product or production (Abdulmalek et al., 2006).

H6: Pull system has a positive and significant relationship with sustainable performance

Relationship between Total Preventive Maintenance and Sustainable Performance. According to Shah and Ward (2002), lean manufacturing is a synergetic integration of different reinforcing practices classified into four complementary practices: human resources management, total preventive maintenance, total quality management, and JIT. Some lean tools in a manufacturing company are more applicable largely than others. The tools such as team-based problem solving, value stream mapping and work standardization, total productive maintenance, 5S, and quality management programs do not depend on the process characteristics. Nevertheless, companies that adopt total preventive maintenance and pursue social and environmental sustainability can align their practices to avoid contradictory impacts. Herrero et al. (2002) reported that total preventive maintenance is related to social practices concerning social sustainability. Thus, there should be a parallel between safety principles and quality.

According to Longoni and Cagliano (2015), the strategic alignment of the lean manufacturing bundles (such as HRM, TPM, TQM, and JIT) is affected by work involvement and cross-functional executive participation with social and environmental practices and goals. In particular, the effect of TPM on the practices of lean manufacturing aligns with social and environmental sustainability. Thus, the implementation of lean manufacturing as aligned with social and environmental sustainability is positively affected by preventive maintenance. Kovilage (2020) stated that preventative maintenance is the dominant lean practice that determines sustainable performance. In addition, Kovilage (2018) reported that total preventive maintenance lessens the likelihood of unexpected equipment breakdown when regularly performed.

Moreover, Herrero et al. (2002) stated that many industries had been explored TPM practices with the advanced manufacturing model to develop their organizational social, and environmental performance. For instance, operation executives design TPM to identify and address safety, environmental and health issues while monitoring social and environmental indicators. Thus, TPM is equally designed to reduce material waste and energy loss. This study therefore proposed:

H7: There is a positive and significant relationship between total preventive maintenance system and sustainable performance

Relationship between Statistical Process Control and Sustainable Performance. Kumar et al. (2006) found that lean practices play important roles in minimizing non-value-added activities and wastes across organizational levels by applying statistical techniques and tools that can take organizations to improved performance or process. Laureani and Antony (2017) reported that lean practices require tools from statistical process control to derive the best outcome and increase accuracy and speed. Finally, Neuman and Cavanagh (2000) showed that lean manufacturing has developed into a flexible and comprehensive system of maximizing, achieving, and sustaining a successful business, uniquely driven by a mutual understanding of customer satisfaction, diligent attention to reinventing, managing, and improving business performance and discipline use of data, fact and statistical analysis.

According to Aziz (2015), the dimensions of statistical process control are among the least adopted practices by any sector. Financial capabilities are required by the practices to get the belt team trained. These practices are challenging in sectors with a low margin that is constantly looking for ways to minimize costs and rely on knowledge of statistical techniques and are relatively considered too advanced and complex for the sector. The sector less considers these practices in the first instance, but their adoption increases with the statistical process control, showing that they are suitable for the sector. After considering the literature above, it can be empirically proposed that:

H8: Statistical process control has a positive and significant effect on sustainable performance

Relationship between Employee Involvement and Sustainable Performance. Employee involvement is one of the lean manufacturing practices that comprise employee participation, employee empowerment, and employee training. Yusuf et al. (2007) posit that employees need the motivation to involve in the financial breakthrough, decision making, and problem-solving of an organization. Furthermore, it indicates that every employee can be involved in the corporate business and aware of the organization's economic performance's current and possible future situation (Diekola, 2016). Therefore, employees can be more closely involved in the core business and positively contribute to sustainable organizational performance.

Employees are motivated by being allowed to practice, thereby becoming closer to the objectives and the organizational goals. In lean manufacturing practices, employee involvement is a critical element. Therefore, a model of lean manufacturing practices that comprises employee involvement should be developed to support the employees and successfully achieve sustainable performance. Additionally, lean manufacturing practices are related positively to sustainable organizational performance with the support of employees (Akdere & Yilmaz, 2006). Employees can add value to the organization if they are given enough training, empowerment, and teamwork involvement, as they are considered the live asset of the organization (Akanmu et al., 2020). Therefore, employee involvement is one of the major drivers of any successful implementation of lean manufacturing practices in any organization. Arawati (2005) reported a significant relationship between employee involvement and sustainability performance in the same view. Therefore, it can be proposed that:

H9: Employee involvement has a positive and significant relationship with sustainability performance

Relationship between Set-up Time Reduction and Sustainable Performance. A well-organized environment in any industry requires a continuous implementation of lean manufacturing practice with setup time reduction (Dora et al., 2013). The adoption of lean manufacturing affects any sector's setup time reduction characteristics to a certain level. For example, the compulsory clean process, which must be performed properly, affects the setup time reduction in the food and beverages sector to ensure food safety and avoid contamination. The setup time reduction is adopted mostly by companies with a high percentage of specialized equipment, focusing on sustaining the equipment's availability and reliability criticality (Dora et al., 2013). However, the setup time reduction practice is rarely adopted despite the company's characteristics.

Green et al. (2012) reported that internal cooperation and collaboration among the firms lead to overall effective, sustainable performance through setup time reduction. Economic goals can be achieved through effective internal integration of setup time reduction by adopting lean manufacturing practices. Many organizations that incorporate setup time reduction into their practices have the chance of increased profitability and the ability to create competitive market shares (Chien & Shih, 2007). Zhu et al. (2010) added that the lack of internal practice like setup time reduction leads to economic failure. Jakhar et al. (2018) reported that set-up time reduction from the operations point of view is an important factor related to inventory optimization leading to improve performance concerning the environment. Dev et al. (2020) found that reducing resources and time consumption is part of the decision-making process for environmentally sustainable operations.

Furthermore, Eltayeb et al. (2011) reported a significant relationship between internally integrated set-up time reduction and environmentally sustainable performance. Therefore, the environmental management system affects the operations performed in production and time waste reduction. Zhu et al. (2012) also posit that profit, income, and employees' welfare are all improved through integrated sustainable design practices within the manufacturing industry. Similarly, Zhu et al. (2010) discovered that internal coordination mechanisms such as requiring employees to attend to environmental issues, reducing set-up time, and exposure to cross-functional cooperation have a significant impact on social sustainability performance (e.g., high involvement and participation, increased happiness, motivation, and social commitment, and safer working environment). Thus, this study proposes that:

H10: Set-up time reduction has a positive and significant relationship with sustainability performance.

Relationship Between Industrial Revolution 4.0 Technologies and Sustainable Performance

According to Kolberg and Zuhlke (2015), lean practices provide huge potential to implement innovative automotive technologies in a manufacturing system. Sanders et al. (2016) reported that IR 4.0 technologies enhance manufacturing companies to overcome the modern challenges of lean manufacturing. The real-time information facilitated by IR 4.0 technologies is useful for preparing accurate value stream maps that are considered the initial step in lean manufacturing practices and implementation (Meudt et al., 2017).

Technologies such as the value stream map are employed to set activities that take products and services to the customers from the initial stage. These technologies analyze the present problem and design the future state to reduce waste (Meudt et al., 2017). Furthermore, the IR 4.0 technologies positively affect sustainable performance (Tortorella & Fettermann, 2018). Thus, the following hypothesis is proposed:

H14: There is a positive and significant relationship between Industrial Revolution 4.0 technologies and sustainable performance

CONCLUSION

Modern organizations continuously seek new methods to perform their activities, remain competitive, and improve performance. Continuous improvement initiatives such as lean practices help organizations reach a high level of performance, remain competitive, and make quick or cohesive process changes by incorporating operations processes. These practices, coupled with IR 4.0 technologies, focus on creating more value for the customers by removing waste activities and adding products and services. In addition, these modern technologies are integrated into manufacturing practices to assess and get rid of mistakes and defects in business processing by concentrating on effective results to sustain the organization's social, environmental, and economic performance. Similarly, the hybrid lean practices with IR 4.0 technologies have synergized the strength of both distinctive practices to increase the performance of any organization through customer satisfaction while improving the triple bottle line result.

Moreover, researchers have shown that integrating IR 4.0 technologies into hybrid lean manufacturing practices are among the least adopted practices by organization as many manufacturing companies are still in the infant stage of smart system. Understandably, these practices require financial resources, which poses constraints, especially for low-margin companies that are constantly seek ways to minimize costs and rely on statistical knowledge. Therefore, this unique integrated system's relatively complex and advanced has called for further study in the manufacturing industry.

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