Journal of Modern Accounting and Auditing, March 2022, Vol. 18, No. 3, 115-130
doi: 10.17265/1548-6583/2022.03.002

The Impact of Lean Manufacturing Practices on Sustainability Performance: A Natural Resource-Based View

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Drawing upon a Natural Resource-Based View (NRBV), this paper aims to propose a quantitative model that could be used to investigate whether Lean Manufacturing (LM) practices/tools can improve the three aspects of corporate sustainability performance (economic, environmental, and social). This paper is based on a theoretical study to develop a new model by reviewing the literature and proposing new ideas according to the Natural Resource-Based View (NRBV). Reviewing the literature showed that there is a significant association between LM practices/tools implementation and the improvement on three aspects of corporate sustainability performance (economic, environmental, and social). This paper provides insights to manufacturing managers about the ability of LM practices to reduce cost of operations and maximize the value provided to customers. Further, it highlighted the importance of LM practices implementation to manage organizations' activities responsibly in terms of their environmental, social, and economic effects. By proposing such a quantitative model according to a NRBV, this study contributes to a broader understanding of how LM practices affect three pillars of sustainability.

Keywords: Lean Manufacturing (LM), sustainability, economic performance, environmental performance, social performance, Natural Resource-Based View (NRBV)

Introduction

In developed countries, organizations have been facing increasing and severe competition since the 1980s of the 20th century. In this setting, Lean Manufacturing (LM) has been broadly adopted in which customers have become more demanding and versatile. There are numerous targeted objectives of LM adoption including waste reduction and value improvement, manufacturing products with fewer flaws, robust production

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operations, customer oriented (high quality, short time, low cost), and cost minimization (Pettersen, 2009).

Recently, environmental and social issues have growingly become important concerns in our economies and communities as well as the economic issues. Recently, the concept of sustainable development focuses on meeting the needs of the present generation without affecting the ability of future generations to meet their own needs (WCED, 1987). A sustainable company is the one that focuses on sustainable growth by jointly providing economic, environmental, and social outcomes or what has been called “the triple bottom line” (Norman & MacDonald, 2004). Many authors (Thanki, Govindan, & Thakkar, 2016; Ng, Choong Low, & Song, 2015; Cherrafi et al., 2016; Faulkner & Badurdeen, 2014; Chiarini, 2014b; Martínez-Jurado & Moyano-Fuentes, 2014; Pampanelli, Found, & Bernardes, 2014) argued that lean production tends to have a substantial impact on decreasing environmental effects, such as water, air, and soil pollution, as well as consumption efficiency of energy and water. Indeed, when a lean practice or principle is implemented, environmental management benefits often emerge. Nevertheless, it is not obvious specifically what type of relationship arises between each lean practice and the environmental effects, and whether this relationship can be measured.

Value Stream Mapping (VSM) is considered one of the most important practices of LM that has a vital impact on sustainability performance. VSM practice has successfully achieved the integration of both production and environmental targets in one management approach for the manufacturing sector (EPA, 2007). VSM is a lean technique that initially managed production problems in manufacturing organizations. Then, VSM was modified to deal with environmental problems in manufacturing organizations using a green approach (EPA, 2007). Consequently, it is argued that VSM offers a green-lean approach for management of production processes, while at the same time achievement both production and environmental objectives (Helleno, Isaias de Moraes, & Simon, 2016).

The next section of this study includes the background, the third section presents literature review, the theoretical framework is addressed in the fourth section, a proposed model of the study is introduced in the fifth section, and finally, conclusion and future research are presented in the sixth section.

Background

Lean thinking has been broadly established in the manufacturing and service industries (Abdul Wahab, Mukhtar, & Sulaiman, 2013). Womack, Jones, and Roos (1991) firstly used the term Lean Manufacturing to express the Toyota Production System (TPS). Despite there is a number of previous studies related to LM concept, there is no identical definition of that concept. Some definitions focused on the principles and practices of LM (Womack & Jones, 2003; Vinodh, Arvind, & Somanaathan, 2011; Sundar, Balaji, & Satheesh Kumar, 2014; Sharma, Dixit, & Qadri, 2016), and some other definitions focused on the main objective of its implementation (Cherrafi et al., 2016; Aguado, Alvarez, & Domingo, 2013; Abdul Wahab et al., 2013; Fercoq, Lamouri, & Carbone, 2016), while others attempted to make a link between practices of LM and the objectives of its implementation (Anvari et al., 2010; Martínez Leon & Calvo-Amodio, 2017).

LM contains five common principles: determining the value from customer perception; mapping the value stream to accomplish the predetermined value; generating the flow through the value chain; building pull system; and striving perfection (Womack & Jones, 2003). Abdul Wahab et al. (2013) and Fercoq et al. (2016) concentrated on the main goal of implementing lean production which is to eliminate and manage waste for decreasing lead times, increasing productivity, enhancing quality, and reducing cost. Therefore, it may be considered that the best description of LM system is that link between principles/practices and the key target of its implementation, as a manufacturing system include some principles and practices/tools to identify and eliminate all types of waste within all the firm's processes and activities, hence, improving product quality, reducing the cost, and maximizing the value provided to customer (Martínez Leon & Calvo-Amodio, 2017).

The regions and the industries, in which the companies operate, along with managerial expertise and skills in some cases, appear to be significantly associated with the deployment of Contemporary Management Accounting Practices (CMAPs) such as LM. In particular, the central and western regions exhibit significant associations with the deployment of several CMAPs (Pollanen & Abdel-Maksoud, 2010). Although Womack and Jones (2003) indicated that principles of lean can be implemented in any industry, few organizations attained significant improvements by applying lean. Baker (2002) stated that the percentage of effectiveness in lean implementation by UK organizations is less than 10 percent. It is assumed that there is an incomplete understanding of lean concept and lean practices and purposes. This misunderstanding strongly restricts lean implementation and decreases its potential benefits for the organization (Mostafa, Dumrak, & Soltan, 2013).

There are many common practices/tools of Lean Manufacturing that are presented in Table 1 (Sharma et al., 2016; Chiarini, 2014b; Sundar et al., 2014).

Table 1

Lean Manufacturing Practices (Tools)

Lean practices	Meaning
Value Stream Mapping (VSM)	The process of mapping the flows of materials and information needed to manage the processes carried out by manufacturers, suppliers, and distributors to offer products to customers.
Cellular Manufacturing	The grouping of various machines to produce the family of parts. VSM offers route map for each part family of products. Different machines are grouped together to form a cell based on these route map. This is called group technology in lean.
Continuous Improvement (CI)/Kaizen	Establishment and design of a process with zero inventories reveals waste including inventory, inactive time, waiting time, and resource problems. Management requires establishing stabilized staff with an organizational awareness base to minimize this waste. CI based on the understanding of personnel, incentives, adaptation, training, team work, initiative, and leader involvement.
5S	Include five steps: sorting, setting in order, shining and cleaning up, standardizing, and sustaining the workplace. A well-organized workplace leads to more secure, more productive, and more efficient operations.
Total Productive Maintenance (TPM)	Make the maintenance of equipments and machines before their actual breakdown. Thus, decreasing failures of it.
Just in Time (JIT)/Pull system	A system where the movement of inventory items or production is started as needed by the utilizing division or the customer. The critical attribute is that production and delivery are driven by demand, zero or minimal inventory is preserved, and specific orders are responded.
Single Minute Exchange of Die (SMED)	Techniques for conducting setup operations in a few minutes represented in a single digit. It allows an organization to quickly convert a process or machine to make various types of product and enhance productivity.
Visual Control	This is a practice applied in many areas and settings whereby monitoring of an operation or procedure needs to be made simpler or more efficient through the intentional use of visual signals.
Total Quality Management (TQM)	A structured and comprehensive approach that aims to enhance the products and services quality by continuing improvement responding to persistent feedback. It is focused on managing quality from the customer's perspective.
Six Sigma	A structured framework to decrease variation in organizational operations by the use of improvement experts, a systematic method, and performance indicators to achieve strategic objectives. Five stages termed the DMAIC cycle (Define, Measure, Analyze, Improve, and Control) are included in the Six Sigma problem solving framework.
Error Proofing/ Poka-Yoke	A poka-yoke system is any tool that either avoids an error or reveals it at a glance.

Regarding the sustainable development, this concept was first originated in 1972 (Rogers, Jalal, & Boyd, 2008). The most well known concept of sustainable development is that of the World Commission on Environment and Development (1987) that focuses on meeting the needs of the present generation without compromising—or affecting—the ability of future generation to meet their own needs.

In the manufacturing sectors, sustainability seeks to manufacture products which employ practices and processes that increase earnings, mitigate negative environmental effects, preserve energy and natural resources, and are secure for workers, customers, and societies (Martínez Leon & Calvo-Amodio, 2017). Thus, sustainability performance includes three interrelationship dimensions as: economic (profit), environmental (planet), and social (people) (Rezaee, 2016).

Literature Review

Prior studies related to LM and sustainability performance can be categorized into three groups. The first group discussed the relationship between LM and economic (financial/operational) performance; the second group investigated the relationship between LM and environmental performance, whereas the third group emphasized the relationship between LM and social performance.

LM Practices and Economic Performance

Globalization, information technology, and firm size have a significant influence on implementation of management accounting innovative practices such as LM practices (Halbouni & Nour, 2014; Abdel-Maksoud, 2011). Regarding the relationship between lean practices and economic (financial/operational) performance (the first group), the objective of Fullerton, Kennedy, and Widener (2014) is to propose approach for implementation of Lean Management Accounting Practices (LMAP) rather than Traditional Management Accounting Practices (TMAP) to meet the requirements and goals of lean organizations. They argued that TMAP concentrates on reducing average cost of product. Thus, TMAP causes operations managers to make decisions that are inconsistent with lean goals. On the contrary, it is simpler and easier to understand the financial control offered by LMAP. LMAP allows operations managers to make decisions that decrease inventory and better utilize capacity, move their emphasis to optimize the value provided to customer and the value stream efficiency, and encourage them to struggle for continuous improvement. They used survey data from 244 U.S. manufacturing firms. The most significant result of their study is that the extent of LM implementation is associated with the use of LMAP. Then, the extent of LM practices implementation directly affects the operations performance. LM practices also influence operations performance indirectly through LMAP.

Using data generated by 121 U.S. manufacturing executives, Fullerton and Wempe (2009) examined how the relationship between LM and financial performance is influenced by the use of Non-financial Manufacturing Performance (NFMP) measures. The results provided evidence that LM indirectly affects the financial performance (profitability) through utilization of NFMP measures as a mediator. Then, they confirmed that LM practices promote the usage of NFMP measures. Also, utilization of lean practices NFMP measures that linked to quality improvement initiatives, setup time reduction, and cellular manufacturing directly affects the profitability.

Also, using survey of 711 firms for various industries from 23 countries, and collecting data during 2005-2006, Demeter and Matyusz (2011) pointed out that firms that broadly implement lean practices have greater turnover of inventory than those that do not implement these practices. Okeke, Okere, Dafyak, and Abiahu (2022) indicated that inventory turnover has a significant positive effect on financial sustainability. Similarly, Hofer, Eroglu, and Hofer (2012) empirically investigated the impact of the mediating role of inventory leanness on the relationship between LM implementation and financial performance. Analyzing of a collection of secondary data and survey indicated that inventory leanness partially mediates the impact of LM on financial performance. Additionally, there is clear evidence that the simultaneous adoption of both internally-oriented and externally-oriented lean practices yields better benefits of performance than selective implementation of lean production.

Yousef, Abd-Elrahman, and Hendy (2015) aimed to measure the possible operational and financial improvements of implementing LM using lean accounting tools. Using a case study in Egypt on the cement factory of Misr Cement Co. (Qena), they developed lean accounting tools (Box Scores and Value Stream Cost) to measure the overall expected benefits of lean enhancements. The results showed expected improvements in the production flow due to the elimination of waste and getting rid of bottlenecks, hence, increasing the customer response speed and decreasing the product cycle time. There were also potential improvements in the product quality due to the potential elimination of reworking and defects. This result is similar to the result of Meade, Kumar, and White (2010) that they were opposing standard cost accounting systems in favor of lean production implementation concerning its impact on reported profits of the firm.

On the other hand, Biscontri and Park (2000) aimed to investigate the impacts of Lean Manufacturing implementation on earnings. Using telephone interview with manufacturing, purchasing, and quality assurance managers of 93 firms implemented lean production during 1989 to 1994 and a control sample of 93 non-implemented firms, the result showed that there are paradoxical effects (both positive and negative) of Lean Manufacturing implementation on earnings. Then, reduced non-value-added activities, better utilization of plant, increased flexibility of manufacturing, enhanced product and process quality, and improved operating performance through productivity improvement, lead to increased operating profit. On the contrary, the big initial investment in Just in Time (JIT) as well as increased costs of new training and raw material causes reduction of income for lean firms. Nevertheless, the study indicated that, in the long run, planned cost savings from inventory reduction, overhead costs, storage space, waste, inefficiency, and personnel would all lead to improved financial performance.

Harris and Cassidy (2014) aimed at investigating whether lean firms achieved higher profitability performance on various measures of financial-performance than non-lean firms. Using secondary (archival) data about three measures of profitability and three measures of cash-flows for each of compared firms for three fiscal years of data: 2008, 2009, and 2010, the results showed that Returns on Total Assets (ROA), Returns on Net Operating Assets (RNOA), cash adequacy ratios, and operating cash flows were higher for lean firms than for non-lean firms. These results were guided by the larger lean firms. For lean firms, the financing-assets ratios and profit margins were also relatively higher than for non-lean firms.

After reviewing previous literature regarding the relationship between LM practices and economic (financial/operational) performance (first group), it could be noticed that most of these studies were applied to manufacturing industry (Fullerton & Wempe, 2009; Demeter & Matyusz, 2011; Fullerton et al., 2014; Harris & Cassidy, 2014; Yousef et al., 2015). Also, there is diversity in the implementation environment, such as Egypt

(Yousef et al., 2015), USA (Fullerton & Wempe, 2009; Fullerton et al., 2014), different countries (Demeter & Matyusz, 2011). Regarding data collection, some studies relied on primary data via a questionnaire (Demeter & Matyusz, 2011; Fullerton et al., 2014), telephone interviews (Biscontri & Park, 2000), or both a questionnaire and interviews (Yousef et al., 2015). While some studies relied on secondary data extracted from internal reports or published financial reports (Harris & Cassidy, 2014), other studies based on a mixture of secondary data and survey (Hofer et al., 2012). Regarding the results of these studies, some studies found a positive direct impact of LM practices implementation on the operational and financial performance (Harris & Cassidy, 2014), while some other studies found a positive indirect impact of LM practices implementation on the financial performance through nonfinancial performance measures (Fullerton & Wempe, 2009; Demeter & Matyusz, 2011; Hofer et al., 2012; Yousef et al., 2015). Few studies found paradoxical effect (positive and negative) of that relationship (Biscontri & Park, 2000).

Therefore, it is clear that this group of studies tried to identify the relationship between LM practices implementation and the economic performance of sustainability, but the results of these studies were mixed. Also, rare studies were applied to the Egyptian context to assess this relationship. Example of these studies is the study of Yousef et al. (2015), which based on a case study.

LM Practices and Environmental Performance

Environmental concerns have driven organizations to play a crucial role in developing products that are environmentally friendly and recyclable to accompany changes in product environmental standards. In this context, many previous studies found that lean practices adoption can contribute to environmental advantages such as pollution reduction.

Many authors (Van Hoof & Lyon, 2013; Cheah et al., 2013; Chiarini, 2014a; Bracci & Maran, 2013) proposed the examination of new techniques and strategies to improve environmental performance, such as waste management, Life-Cycle Assessment (LCA), reuse, and reproduction, and ISO 14001 certification. However, the adoption of Lean Manufacturing practices was not explicitly suggested by those authors.

On the other hand, some authors (Cherrafi et al., 2016; Fercoq et al., 2016; Ng et al., 2015; Chiarini, 2014b; Pampanelli et al., 2014; Faulkner & Badurdeen, 2014; Martínez-Jurado & Moyano-Fuentes, 2014) suggested that Lean Manufacturing tends to have significant influences on the minimization of environmental negative impacts such as efficiency of water and energy consumption, as well as emissions into the water, air, and soil.

King and Lenox (2001) claimed that Lean Manufacturing can decrease pollution costs, and particularly, it is supplementary to the reduction of pollution and waste. Their study is based on a quantitative inquiry performed from 1991 to 1996 within a sample of US companies. The results confirmed theories that linked a company's Lean Manufacturing activities to its practices of environmental management. Nevertheless, the study did not examine the way by which a particular lean practice can improve the company's environmental performance.

Chiarini (2014b) empirically observed five European firms that produce motorcycle components and are also dedicated in lean and environmental management. The environmental effects of the manufacturing activities of the five firms were identified and evaluated before and after the adoption of five lean practices: Value Stream Mapping (VSM), Cellular Manufacturing, 5S, Total Productive Maintenance (TPM), and Single Minute Exchange of Die (SMED). Quantitative results of that comparison revealed that VSM can be useful for identifying the environmental effects of production operations, Cellular Manufacturing can help in decreasing energy consumption, 5S can be used to reduce oil leaks and promote waste management, whereas TPM can contribute to a reduction in numerous effects of the machines, such as emissions of dusts and oil leakage and chemical fumes into the atmosphere. By contrast, after implementation of SMED, no considerable improvement in environmental impacts was observed. On the other hand, the EPA (2003) explained the relationship between the seven wastes of lean and their environmental effects as shown in Table 2.

Table 2

Environmental Impacts Linked With Manufacturing Waste

Waste type	Environmental impact
Defects	• Raw materials used to make flawed products. • Recycling or disposal of defective components. • Rework and repair need more space, increasing energy consumption for lighting, heating, and cooling.
Waiting	• Possible material spoilage or component damage causes waste. • Production downtime cause wasted energy from lighting, cooling, and heating.
Overproduction	• More raw materials used in producing unnecessary products. • More products may be damaged or become obsolete needing disposal.
Transportation and movement	• More consumption of energy for transportation. • Emissions from transportation. • More space needed for Work-in-Process (WIP) movement, growing the need for light, heat, cool, and energy consumption. • More packages needed for components protection during movement.
Inventory	• More packaging required for WIP storage. • Waste from damage for WIP storage. • Extra materials required for replacing damaged WIP. • More consumption of energy for heating, cooling, and lighting inventory space.
Over processing and complexity	• More raw materials and parts used per unit of production. • Needless processing lead to increasing wastes, emissions, and energy consumption.
Creativity unused	• Fewer solutions and ways to minimize waste and pollution.

Source: EPA, 2003.

Faulkner and Badurdeen (2014) concentrated on the environmental effects of an important Lean Manufacturing tool called Sustainable VSM (SVSM). SVSM represents an extension to traditional VSM by combining energy-related indicators to value stream maps. So the aim of their study was to establish a systematic methodology for SVSM through the identification of appropriate methods and indicators to present it visually. A case study of a local producer of TV satellite dishes supported the SVSM approach. The most important result of the analysis is that the proposed SVSM approach is viewed as a successful tool in the visual assessment of the sustainability performance of production lines.

Furthermore, Pampanelli et al. (2014) introduced a new model that incorporates environmental sustainability into lean philosophy, called the lean and green model. The model presented adopts a Kaizen technique to enhance the flows of mass and energy in LM settings. The model was developed for, and restricted to, the cell level, which is the first stream level of a manufacturing company that promotes lean thinking principles. Using a case study of a large global engineering firm that serves the automotive and aerospace industries in Brazil in 2011, the model was verified. The significant result of their analysis is that, this model improved the productivity as it could decrease usage of resources by an average of 30-50 percent and had the capability to decrease the overall cost of mass and energy flows in a cell by 5-10 percent. Further, the model has reduced the effects of manufacturing processes on the environment.

Similarly, Vinodh et al. (2011), Chiarini (2014b), and Cherrafi et al. (2016) reported, as shown at Table 3, some lean principles/tools and their sustainable benefits.

Table 3

Environmental Benefits of Lean Principles/Practices

Lean principle/practice	Sustainable benefits
Pull approach/Just in Time	Decrease of WIP, removal of possible waste from defective products, and lesser usage of floor space.
Cellular Manufacturing	Decrease of set-up times and adjustments over time. Thus, low consumption of resources and energy and decrease of defects.
Value Stream Mapping	Decrease in waste due to fewer defects, less scraps, low energy consumption, etc.
5S	Decreasing in lighting demands because of clean windows, and decreased material and chemical usage.
Total Preventive Maintenance	Less dangerous waste because of reduced leakage and spills, and improved equipment durability.
Six Sigma	Fewer defects. As a result, reduced waste, improved product longevity and reliability contribute to increased lifespan of product.
Pre-Production Planning	Decreasing of waste at design phase, use of appropriate machinery, and reduction the complexity of product design and manufacturing processes.
Kaizen	Removal of concealed wastes and unnecessary processes.
Visual Controls	Determination and removal of undesirable entities. Thus, less resource use and waste.
Lean Supplier Networks	Suggestion of lean application to current suppliers will contribute to a greater recognition of the environmental advantages.
Poka-Yoke	Decrease in defects. Thus, less scrap, low use of energy, less waste.

Source: Vinodh et al., 2011; Chiarini, 2014b; Cherrafi et al., 2016.

Similarly, Ng et al. (2015) suggested one metric called “Carbon-Value Efficiency”, which combined lean and green metrics together. Using a case study of metal stamped parts production, the findings indicated that Carbon-Value Efficiency can be enhanced by 36.3%, leading to enhancement in lead time of production by 64.7% and a decrease in ecological footprint by 29.9%.

Further, Thanki et al. (2016) applied an analytical hierarchy process approach in Indian SMEs to examine the effect of selected lean (5S, TPM, and Kaizen) and green (DFE, ISO 14001, and 3R) practices on the comprehensive performance. Data were collected via a questionnaire for a sample of an academic expert and 11 industrial experts in some Indian SMEs. The results revealed that Total Productive Maintenance (TPM) is considered as the most significant lean practice, while the most effective green practice is ISO 14001. In addition, quality control and on-time delivery are the most crucial criterion for leanness while energy consumption and emissions reduction are the most crucial criterion for greenness.

Although the environmental benefits of lean practices are supported by many researchers, there are some existing differences between lean and green manufacturing that may lead to negative effects on the environment. The results of Dieste, Panizzolo, Garza-Reyes, and Anosike (2019) and Sanchez Rodrigues and Kumar (2019) suggested that JIT (in lean approach) may have negative effect on carbon emissions. JIT approach needs distribution in small batches but at more frequent time (at the right quantity, place, and time). More frequent replenishment, however, can help in reducing inventory at the customer end but substantially leads to CO_2 emissions. In addition, environmental investments cost is a major obstacle to lean and green integration, particularly in the short term. Further, Raval, Desai, and Bhatt (2021) suggested negative but insignificant impact of carbon emissions on financial performance. However, environmental sensitivity was found to have a strong positive moderating effect on this relationship, indicating that negative impact of carbon emission is more intense for environmentally sensitive firms.

Therefore, many researches such as Carvalho, Govindan, Azevedo, and Cruz-Machado (2017), Chiarini (2014b), and Dües, Tan, and Lim (2013) do not appear to be in agreement with the idea that JIT practices contribute to environmental advantages. However, it can be said that lean practices can be a part of the green system and vice-versa. Since lean and green practices share similar objectives, the evaluation framework supposes that both systems should be perceived as only one integrated system (Farias et al., 2019).

Prior studies that investigated the association between lean practices and environmental performance highlight some important conclusions. Some of these studies addressed the association between one or more lean practices and the environmental performance (Faulkner & Badurdeen, 2014; Thanki et al., 2016), while other studies addressed the relationship between lean production as a whole (all practices) and environmental performance (King & Lenox, 2001; Vinodh et al., 2011; Chiarini, 2014b; Ng et al., 2015; Pampanelli et al., 2014; Cherrafi et al., 2016; Thanki et al., 2016). These studies were applied to diverse business environments. Among these environments are United States of America (USA) (King & Lenox, 2001), Europe (Chiarini, 2014b), India (Thanki et al., 2016), and Brazil (Pampanelli et al., 2014). Wide range of research methodologies and data collection techniques was applied. Some studies relied on questionnaires in collecting data through survey (King & Lenox, 2001; Thanki et al., 2016), while most studies collected data using questionnaire or interviews through case studies (Chiarini, 2014b; Pampanelli et al., 2014; Faulkner & Badurdeen, 2014; Ng et al., 2015). Regarding the results of this group of studies, some studies showed that there is a positive relationship between LM practices as a whole and the environmental performance improvements (Pampanelli et al., 2014; Faulkner & Badurdeen, 2014; Thanki et al., 2016; Ng et al., 2015), other studies concluded that there is a positive relationship between only one or some of the LM practices, but no relationship for other lean practices (Chiarini, 2014b), and some other studies do not tend to the thought that lean practices result in environmental benefits (Dües et al., 2013; Chiarini, 2014b; Carvalho et al., 2017).

It is clear that this group of studies (second group) has tried to investigate the relationship between LM practices implementation and the environmental performance of sustainability. However, there is a research gap regarding this area of research that there are environmental advantages if a lean tool or principle is implemented. Nevertheless, it is not obvious precisely what type of link exists between each particular lean practice and the environmental effects and whether this link can be measured. Another research gap is that some findings are mixed in these studies. Also, to the best of our knowledge, there is no study addressed this relationship in Egypt.

LM Practices and Social Performance

With regard to studies that addressed the relationship between lean practices and corporate social performance (third group), previous studies pointed out that sustainability ensures not only that businesses make a profit, but also ensures that industrial processes do not cause social harm. Social performance means the real improvement and maintenance of human life quality by organizations without ignoring environmental effects (Helleno et al., 2016). This means that environmental practices contribute to improved working conditions which, in turn, enhance workers' motivation and productivity.

Gunarathne, Samudrage, Wijesinghe, and Lee (2016) aimed to determine the effectiveness of safety controls and accounting in corporate social sustainability management in order to meet different requirements and demands of stakeholders in the mining sector in Sri Lanka. The case study methodology is applied in their study. Data collection is primarily based on semi-structured interviews, and on-site evaluations and reviews of documents. The most vital result of the study is that the employees' working conditions quality and their health and safety were the most significant of the studied dimensions.

Furthermore, previous studies addressed the aspects or indicators of social performance related to lean production. For example, Bonavía and Marín-Garcia (2011) aimed to examine the effect of Lean Manufacturing on the human resource management policy, and to identify whether Lean Manufacturing related human resources practices explain the difference in organizational performance. Based on a questionnaire for data collection from 76 establishments specializing in single-fired ceramic tiles in Spain, they concluded that firms that implement most practices of Lean Manufacturing are also those that pay attention for workers training in applying these practices and improve their employment safety. Also, the combination of Lean Manufacturing and human resources practices reduces inventory and increases productivity.

In the same direction, Uhrin, Bruque-Cámara, and Moyano-Fuentes (2017) aimed to investigate the role that workforce development plays in the relationship between the extent of Lean Manufacturing implementation and operational performance. Data were collected through a survey sent to 84 manufacturing plant of 216 plants of Original Equipment Manufacturers in the Spanish automotive industry.

Moreover, in a semiconductor manufacturing company, W. P. Wong and K. Y. Wong (2014) aimed at proposing a framework to discuss human integration in lean thinking for sustaining processes. Based on a case study of a multinational semiconductor manufacturing company in Malaysia, they concluded that people can be incorporated in lean through a scientific approach. Further, horizontal and vertical directions synergies of human integration may contribute to value development within the organization.

On the other hand, Martínez-Jurado and Moyano-Fuentes (2014) relied on a theoretical analysis to evaluate the associations between lean management, supply chain management and sustainability. It aimed at identifying and classifying the related literature carried out and extended from an internal emphasis to an entire emphasis on the supply chain, and at the same time, the three main aspects of sustainability have been considered for determining the existing gaps hence drawing conclusions to dimensions that need further research. They concluded that there is an important research gap concerning social sustainability in lean supply chain management. So, these major social performance indicators need to be determined.

Reviewing prior studies that investigated the association between lean practices and corporate social performance (third group) highlight some significant conclusions. These studies were applied to a variety of business environments. Among these environments are Sri Lanka (Gunarathne et al., 2016), Spain (Bonavía & Marín-Garcia, 2011; Uhrin et al., 2017), Malaysia (W. P. Wong & K. Y. Wong, 2014). Several data collection techniques were used at these studies such as questionnaires (Bonavía & Marín-Garcia, 2011; Uhrin et al., 2017), interviews (W. P. Wong & K. Y. Wong, 2014), or mixture of on-site assessments and documentation reviews (Gunarathne et al., 2016).

Moreover, results of this group are mixed. Most of these studies found direct positive relationship between lean practices implementation and human resource practices (social performance) (Bonavía & Marín-Garcia, 2011; W. P. Wong & K. Y. Wong, 2014; Uhrin et al., 2017), and some others found that there is a positive indirect relationship between lean practices adoption and the social performance of sustainability through the environmental performance improvement. This means that lean practices implementation supports the environmental initiatives that contribute to better working conditions which, in turn, improve the productivity and motivation of the employees (Helleno et al., 2016). On the other hand, few studies found that there is an important research gap concerning social sustainability in lean supply chain management. So, main indicators of social performance need to be determined (Martínez-Jurado & Moyano-Fuentes, 2014).

It is clear that this group of studies (third group) has tried to identify the association between implementation of LM practices and the sustainability social performance. However, there is a limited research dealing with social impact compared to the two other aspects of sustainability performance (economic/environmental) in the lean environment. Another gap is that there is no studies investigated this relationship in Egypt.

Based on the previous discussion of the three groups of literature, it is clear that although there are several studies addressing the impact of lean practices implementation on one dimension of sustainability performance pillars (economic/environmental/social), there is a lack of studies that aim to investigate the effect of these practices on the sustainability performance as a whole (the three dimensions together). Further, most of the previous studies focused on the environmental performance aspect, with less interest in other aspects (economic/social). Another gap in these studies that need more research is that there is no study addressing the impact of lean practices implementation on sustainability performance as a whole in a developing country. Finally, most of prior studies addressed the relationship between lean practices and any of sustainability performance dimensions, based on a case study or survey, but it can be implemented also by an experimental study.

Theoretical Framework

Lean practices focus on waste reduction through preservation of resources. According to the Resource-Based View (RBV), valuable, rare, non-substitutable, and inimitable resources lead to achievement of the competitive advantage (Barney, 1991). The comprehensive concept of resources includes the tangible (e.g., equipments, physical technology, funds) and intangible resources (e.g., organizational process, knowledge, skills, and information) that improve efficiency and effectiveness. These various resources together create organizational capabilities (Barney, 1991). Hart (1995) expanded to the RBV by including natural resources and mediating natural environment between organizations' resources and their sustainable performance. He developed the NRBV and recommended that capabilities such as product stewardship, pollution prevention, and sustainable development can contribute to sustainable competitive advantages. Accordingly, this study applies the Natural Resource-Based View (NRBV) as the theoretical basis for investigating how lean practices enhance sustainable performance.

Lean practices and sustainability initiatives can be viewed as specific of these resources and capabilities included within customers and suppliers. Firms that adopt lean practices and sustainability initiatives with their partners of supply chain meet stakeholders' demands and take environmental preservation concerns into consideration in day-to-day processes during the product life cycle. They can gain social legitimacy and build complex and inimitable resources and capabilities that increase scales of sustainable performance (Guang Shi, Lenny Koh, Baldwin, & Cucchiella, 2012). Furthermore, lean practices and sustainability initiatives represent capability of pollution prevention. Firms that adopt these practices with their partners of supply chain can reduce waste and emissions and eliminate non-value-added activities by continuous improvement of process. Lean practices can enhance sustainable performance with lower costs, shorter lead times, and less negative environmental impacts (Huo, Gu, & Wang, 2019).

Lean practices are derived from the concept of resource efficiency and waste reduction in an organization's processes, work culture, strategy, and human resource. Also, lean implementation reduces cost whilst improves quality and delivery performance, which increases customer value. In addition, the impact of these practices can be quantified by the physical economic profits. Hence, they are valuable (Jakhar, Rathore, & Mangla, 2018). Furthermore, implementation of lean practices is an ongoing activity which operates around permanent efforts and continuous improvements (Kaizen). No other organizations can emulate them because their implementation is very distinctive and inimitable. In addition, in a world of ever-decreasing economic returns, ever-decreasing product life cycles with ever-increasing competitors compete with the view that the organization's processes operate on limited resources and dispose of minimum waste is essential. In that competitive setting, lean approach is non-substitutable (Jakhar et al., 2018). It is observed that lean practices have all the components valuable of being a key competence not just for the organization, but for the whole supply chain. So, the effect of lean practices on sustainable performance should be measured comprehensively by taking all supply chain activities together in the consideration.

The conceptual framework, showed in Figure 1, includes the main relationships of this study.

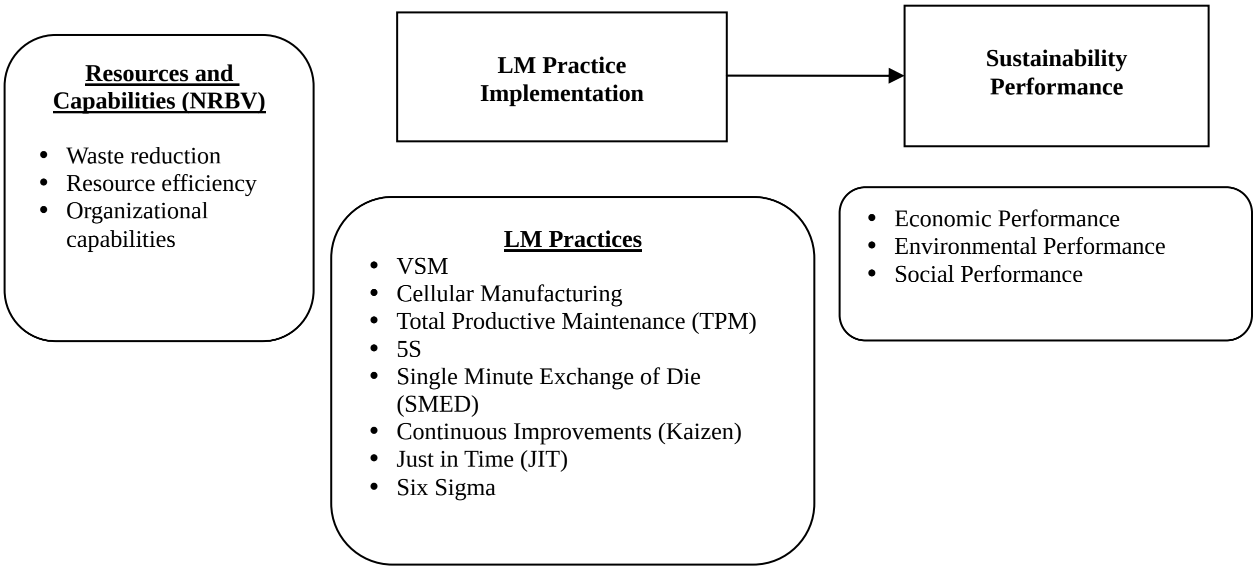

Figure 1. The conceptual framework.

The Proposed Model

Drawing upon related prior studies and their indicators used to measure sustainability performance aspects and LM, this paper suggests a quantitative model to measure LM system and overall sustainability performance (with its three pillars) in the firms that implement LM practices, hence filling the gap in the literature. The model is based on a set of financial and non-financial measures. The model is shown as follow:

Model 1 examines the relationship between lean practices and sustainability performance as a whole.

$$SP = \alpha + \beta LP + \varepsilon \quad (1)$$

where:

SP = the sum of economic performance, environmental performance and social performance,

LP = inventory turnover rate, equipments and machines setup duration.

Model 2 examines the relationship between lean practices and economic performance.

$$EcP = \alpha + \beta LP + \varepsilon \quad (2)$$

where:

EcP = Return on Net Operating Assets (RNOA), Returns on Total Assets (ROA), inventory cost, productivity rate and customer response rate.

Model 3 examines the relationship between lean practices and environmental performance.

$$EnvP = \alpha + \beta LP + \varepsilon \quad (3)$$

where:

EnvP = resource and energy consumption rate per unit, renewable raw material usage to total used raw material, waste of per produced unit, CO_2 emission, and best benchmark of environmental management.

Model 4 examines the relationship between lean practices and social performance.

$$SocP = \alpha + \beta LP + \varepsilon \quad (4)$$

where:

SocP = number of workforce work hours, rate of employee turnover (work absence days), rate of employee work environment safety, average employee training hours per year, extent of environmental and social consideration for supplier selection.

Concluding Remarks

Despite the growing importance of sustainability performance in recent years, more research is needed to recognize and measure sustainability performance in firms that implement LM practice. Companies compete in markets with increased need to customers' response and maximizing value to them and, the same time, the need to improve financial and operational performance of the firm within limited resources. This has encouraged firms to responsibly manage their operations by the implementation of sustainable practices. One of the most important ways to achieve that objective is the implementation of LM practices.

This study provides a proposed quantitative model for measuring the effect of LM practices implementation on three aspects of sustainability performance (economic/environmental/social). The proposed model has been built on related previous studies, as well as its variables metrics and indicators. In the proposed model, most common LM practices/tools are: Value Stream Mapping (VSM); Total Productive Maintenance (TPM); Cellular Manufacturing; 5S; Six Sigma; Just in Time (JIT); Continuous Improvements (Kaizen); and Single Minute Exchange of Die (SMED). Sustainability performance consists of economic (financial/operational) performance, environmental performance, and social performance. The model attempts to measure sustainability performance within LM firms based on the data that most of them are not publicly available.

The study provides a theoretical framework, based on Natural Resource-Based View (NRBV), designed to promote a more precise and inclusive interpretation of the effect of LM practices on sustainability performance. Further research is required to empirically verify the theoretical framework and model proposed in this study. This can be done via a cross-sectional study using a sample of Egyptian LM firms or by an experimental study comparing sustainability performance of LM firms with that of firms that do not implement lean practices. Hence, future research is encouraged to apply the suggested model in different settings.

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