Flexibility and Operational Performance: Examining the Mediating Role of Lean and Sustainability Practices

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Abstract

Over the last decades, the world is encountering an increase in global manufacturing competitiveness (GMC). Flexible Manufacturing Systems (FMS), a major pillar in achieving GMC, has lately witnessed a unique advancement and became a vital part of the intelligent manufacturing system. In order to preserve the industry's place with all the fluctuation in the market environment, an adoption of new manufacturing philosophies such as lean manufacturing systems (LMS) and FMS coupled with good sustainability practices remains mandatory. This paper would fill the reserach gap by exploring the relationship between FMS, LMS, Sustainability, and their impact on the textile industry's operational performance. Accordingly, the present paper discusses the effect of strategic, operational, and tactical flexibility dimensions, lean manufacturing, and sustainability practices (economic, social, and environmental) on different operational performance metrics (OPMs). A survey questionnaire was structured based on in-depth literature and was conducted in 82 US and European textile facilities. Hypotheses testing and polynomial regression coupled to response surface analysis were performed for model validation and detection of significant linear, quadratic, and mediating effects of the studied variables on sales, cost, and productivity. The data analysis carried out in the present pilot study showed that the LMS implementation played a major role in mediating the FMS-OPMs relationships ($p < 0.001$), while at a time sustainability practices significantly enhanced the positive effect of LMS on all OPMs and primarily on sales and productivity while drastically reducing costs ($p < .001$).

Keywords
Lean Manufacturing Systems, Flexible Manufacturing Systems, Sustainability Practices, Operational Performance, Response Surface Analysis.

1. Introduction

Leading countries have recently shown interest in the development of new technologies, innovation strategies (El-Kassar and Singh, 2019), and advanced manufacturing systems (Gorecki et al., 2020) leading to a dynamic change in the market and triggering a global manufacturing competitiveness (Biren Prasad, 1996; EL-Khalil, 2018). To cope with the unsettled business environment and its high risk as well as to gain a competitive advantage, an implementation of new policies and tools is crucial for the sustainability and viability of manufacturing industries (El-Khalil & Darwish, 2019a; Gunasekaran et al., 2001; Vecchiato, 2015; Yu et al., 2015). Therefore, flexibility, known as one of the main keys in the GMC, plays a fundamental role in navigating the industry through all the market threats (EL-Khalil, 2018).

In this context, the efficacy of flexible manufacturing systems was proven by several researchers showing that flexibility drastically improves the overall operational performance. For instance, a study conducted by El-Khalil & Darwish, (2019) showed that flexibility in US automotive facilities improves product's quality (24.7%), jobs per hour (16.5%) and productivity (27.9%) and it also reduces the cost (19.7%), lead time (14.3%) and the inventory levels (10.8%). Similar conclusions were also found by Ali & Saifi (2011). In addition, the relationship between flexible manufacturing systems and business performance in small to medium enterprises (SMEs) was discussed by Kaur et al. (2017). These authors demonstrated that machine flexibility reduces the cost of production, and the lead time while enhancing at a time the delivery performance. Other studies were focused on the impact of lean manufacturing system (LMS) on the OPMs. Based on the study of Singh et al. (2018), it was concluded that the overall production rate increased by 42.08% with the implementation of lean manufacturing practices. Additionally, some improvements were noticed throughout the study performed by Henao et al. (2019) when applying LMS. Such enhancements were mainly at the operational, environmental and social performance levels and covered more specifically resource consumption, product quality and safety. Moreover, an empirical investigation was achieved by Panwar et al. (2018) aiming at studying the impact of LMS on the operational performance in Indian industries. Results showed that the implementation of LMS has a positive effect on delivery, productivity, waste elimination and reduction of inventory and cost. However, a lack in the literature was noticed and it essentially concerns the potential mediating effect of lean manufacturing practices on the relationship between flexibility dimensions and OPMs, mainly across textile facilities that are one of the most vibrant manufacturing industries. Accordingly, the primary objective of this paper is to study such important relationships to better optimize the performance of these firms.

2. Conceptual framework and hypothesis development

2.1. Flexible manufacturing system and operational performance metrics

Flexibility is the ability of a firm to adapt and respond to multiple changes that may arise across the manufacturing system with less cost, effort and time in order to have an efficient productivity while preserving the end-products' quality (Ali & Saifi, 2011; Sethi & Sethi, 1990). Flexible manufacturing system is a bunch of precise machine tools linked by an automated assembly system all of which are controlled entirely by computers (Kostal & Velisek, 2011; Saab et al., 2021). FMS is divided into three dimensions: tactical, strategic and operational (El-Khalil & Darwish, 2019b). Operational flexibility is an automated production with the capacity of changing the manufacturing operations in order to increase the competitiveness by implementing new practices and producing new products (Yu et al., 2015).

Multiple papers focused on the link between flexibility and the operational performance (El-Khalil & Nader, 2020). For instance, Geyi et al., (2020) proposed that agile practices, including flexibility ones, have a direct positive effect on the operational performance (i.e. cost, innovation, quality). The hypothesis suggesting a positive relationship between the supply network flexibility and supplier flexibility with the firm's performance (cost, time-based performance) was supported by Liao et al., (2010). A study was conducted by Chahal et al., (2018) in the hospital sector showing the positive impact of operational flexibility on financial performance and productivity.

2.2. Lean manufacturing and operational performance metrics

Over the years, lean manufacturing practices and principles have evolved in the purpose of reducing wastes coming from overproduction, unnecessary processes, poor quality, waiting, new inventories with no added value while producing the same output in a continuous flow (Durán et al., 2018; Ghosh, 2012; Panwar et al., 2018). The practices of employee engagement, just-in-time, preventive maintenance, human resource management (customer, supplier) are some examples of lean manufacturing (Inman & Green, 2018). Many researchers have discussed the three dimensions of lean manufacturing which are: philosophy, set of tools and system and a rule guidance (EL-Khalil, 2018; Ghosh, 2012; Panwar et al., 2018). Many tools and techniques assist the lean philosophy in the identification and the elimination of wastes occurring throughout the operations. The aim is to produce products with high quality to satisfy the customers while reducing the cost and the production time (Singh et al., 2018). In addition, the application of rules facilitates the production flow and helps in promptly solving manufacturing problems that may be encountered.

Many studies were targeted on the impact of the implementation of lean manufacturing on the firm's performance. For instance, the implementation of lean practices in multinational corporates have improved the quality of the products, the productivity, the employee morale and at the same time have reduced lead time, downtime, reject rate and injury rate (El-Khalil, 2020). In addition, a study conducted by Marodin et al., (2019) has shown that a reduction in lead time and inventory was observed when applying total productive maintenance and just-in-time practices respectively.

2.3. Sustainability and operational performance metrics

Sustainability characterizes business models that still are, after a period of running-time, capable to operate with high adaptability and development at the level of strategies and individual behaviors; hence, allowing them to continuously produce benefits for the whole system in an ever-changing environment (Moore et al., 2017). The business sustainability is divided into three main dimensions: economic, social and environmental (Matthies et al., 2019; Munasinghe et al., 2017; Svensson et al., 2018). The economic sustainability aims to improve the product's quality and to achieve a long-term profitability (Dabbous and Tarhini, 2021) by lowering production costs, increasing market share, sales growth (Itani et al., 2019) of the firms while improving the customer satisfaction (Bansal and Roth, 2000). On the other hand, the social sustainability (Kouatli, 2019a; Kouatli, 2019b) ensures the safety and health of the employees as it respects their human rights. As a third dimension, the environmental sustainability focuses on saving the planet from global warming by reducing the wastes and the energy consumption (González-Márquez & Toledo, 2020).

To assess a firm's sustainability, the most important key indicator is the performance metrics (ul Haq & Boz, 2020). In this context, several researchers tried to link sustainability to firms' performance metrics (Domingo & Aguado, 2015; Epstein et al., 2015; El-Khalil and El-Kassar, 2018) and drew several conclusions.

The environmental sustainability was found to have a positive effect on the financial and operational performance of the firm (Molina-Azorín et al., 2009) and more specifically, it affects the sales growth (Ameer & Othman, 2012; García-Dastugue & Eroglu, 2019). Furthermore, the implementation of the environmental sustainability reduces the waste and energy consumption in industries leading to better economic performance (Munasinghe et al., 2017; Rabadán et al., 2019). On the other hand, many papers elucidated the link between a lean and green strategy pointing toward a reduction in delivery time, a faster response to high demands, a better quality of delivered products and a more effective and efficient process (Domingo & Aguado, 2015; Pavnaskar et al., 2003).

On the other hand, the implementation of both environmental and social dimensions in a company can enhance the operation strategies and boost the financial performance leading to competitive advantages (Longoni et al., 2015; Taliento et al., 2019). Pagell & Gobeli (2009) have discussed in their paper that performance and efficiency of the workers can be negatively affected by the bad environment in the workplace. Therefore, social sustainability insures better living quality and a safe and healthy environment rendering employees more engaged in their work and encouraging them to perform better (Hoang et al., 2020). In fact, implementation of good sustainability practices can boost the staff's morale, thus improving their productivity and retention (Kossek et al., 2014; Schoenherr & Talluri, 2013). On the other hand, the economic sustainability enhances the overall long-term financial performance by reducing unnecessary expenses, increasing profitability and maintaining the firm's position in the market (Jin et al., 2017).

2.4. Mediating effect of lean manufacturing systems and Sustainability practices on the relationship between flexibility and OPMs

As previously stated, "Flexibility" comprises operational, strategic and tactical practices that are being implemented in different types of industries. It usually positively affects the firm's performance at several levels such as efficiency, manufacturing cost, product quality, and employees health and safety. The application of Lean manufacturing practices may enhance the OPMs as well. Previous scholars revealed the improved positive impact of FMS on the performance metrics through LMS in automotive industries (EL-Khalil, 2018).

Moreover, many studies assessed the relationship between lean manufacturing and firm's performance (EL-Khalil, 2018; El-Khalil, 2020; Ghosh, 2012; Islam & Karim, 2011; Singh et al., 2018). It was concluded that LM has an impact on the financial, operational, social and quality performance in the studied sectors. On the other hand, Henao et al., (2019) have focused on the effect of LM practices on sustainability performance. Results have shown that an improvement in the main pillars were noted (i.e. quality, lead time, manufacturing cost, waste reduction, safety and employee's morale). Then, the implementation of the three dimensions of sustainability practices (i.e., economic, environmental and social) revealed signs of progress in the firms' operational and financial performance (Caldera et al., 2019; Croom et al., 2018; Molina-Azorín et al., 2009; Pagell & Gobeli, 2009; Yang et al., 2011; El-Khalil and Mezher, 2020). However, a lack of studies related to the enhancement of the relationship between LM and OPMs through a mediator is noticeable. Therefore, it is suggested that LMS and Sustainability practices (Haddad & Otayek, 2018) can affect the course and the strength of the association between the studied predictors and the OPM criteria. As a matter of fact, economic sustainability (ECO) practices can facilitate the internal strategies of the firm by enhancing the economic performance and reducing the internal risk (Shad et al., 2019). In addition, external factors such as Social and Environmental Sustainability (SOC and ENV) practices can also assist the company in reaching its goals and objectives. Therefore, the following hypotheses were developed:

H1: Lean manufacturing practices mediate the relationship between:
H1-a: operational flexibility and sales.
H1-b: operational flexibility and productivity.
H1-c: operational flexibility and cost.

H2: Lean manufacturing practices mediate the relationship between:
H2-a: tactical flexibility and sales.
H2-b: tactical flexibility and productivity.
H2-c: tactical flexibility and cost.

H3: Lean manufacturing practices mediate the relationship between:
H3-a: strategic flexibility and sales.
H3-b: strategic flexibility and productivity.
H3-c: strategic flexibility and cost.

H4: Sustainability practices mediate the relationship between:
H4-a: Lean manufacturing practices and sales.
H4-b: Lean manufacturing practices and productivity.
H4-c: Lean manufacturing practices and cost.

3. Research methodology and data collection

To analyze the relationships between flexibility, sustainability, lean manufacturing practices and the performance metrics, a case study was conducted in the textile facilities. After a thorough literature review, a conceptual framework with defined constructs and their indicators was developed. The indicators of the three flexibility latent variables (operational, tactical and strategic) were assessed through 7, 4 and 4 dimensions, respectively. Lean manufacturing practices were evaluated using 5 main constructs: material, process management tools, build in quality, equipment and production. Finally, the economic, social and environmental practices were the dimensions measured to determine the overall sustainability practices. Based on these scales, a questionnaire was designed and pretested by academics and managers for ambiguity. A 7-point Likert scale was used to measure each item of the survey, where 1 and 7 were "not applicable" and "highly applicable", respectively.

The data was collected via virtual interviews with 82 senior managers and professionals from international European and US textile industries. Then, data was loaded in Microsoft Excel, SPSS (IBM SPSS Statistics 26) and Statgraphics (Centurion 18, Windows XP) and further analyzed. At a preliminary stage, different statistical measures such as Cronbach's α, composite reliability (CR) and average variance extracted (AVE) were calculated to test the reliability and validity of the measurement scale. Then, a model was developed as shown in Figure 1 and hypothesis testing coupled with path analysis were performed. To test the significance of the constructs t-tests and analysis of variance (ANOVA) were carried out. After fitting a polynomial regression model to the observed values, the coefficient of determination (R^2) and the lack-of-fit test were computed to validate the adequacy of the empirical model. Furthermore, to confirm the mediation effects of Lean and Sustainability practices, a Sobel test was conducted calculating t-statistics and p-values. Then, the trend of variation of the selected OPMs (i.e. sales, cost and productivity) and their interactions were plotted using Response Surface Analysis method (Nader et al., 2021). ANOVA table was used to assess the most significant linear, quadratic, and interaction effects of the constructs. The main effects plots also permit to compare the direct effects to the indirect ones after inclusion of the mediating parameter.

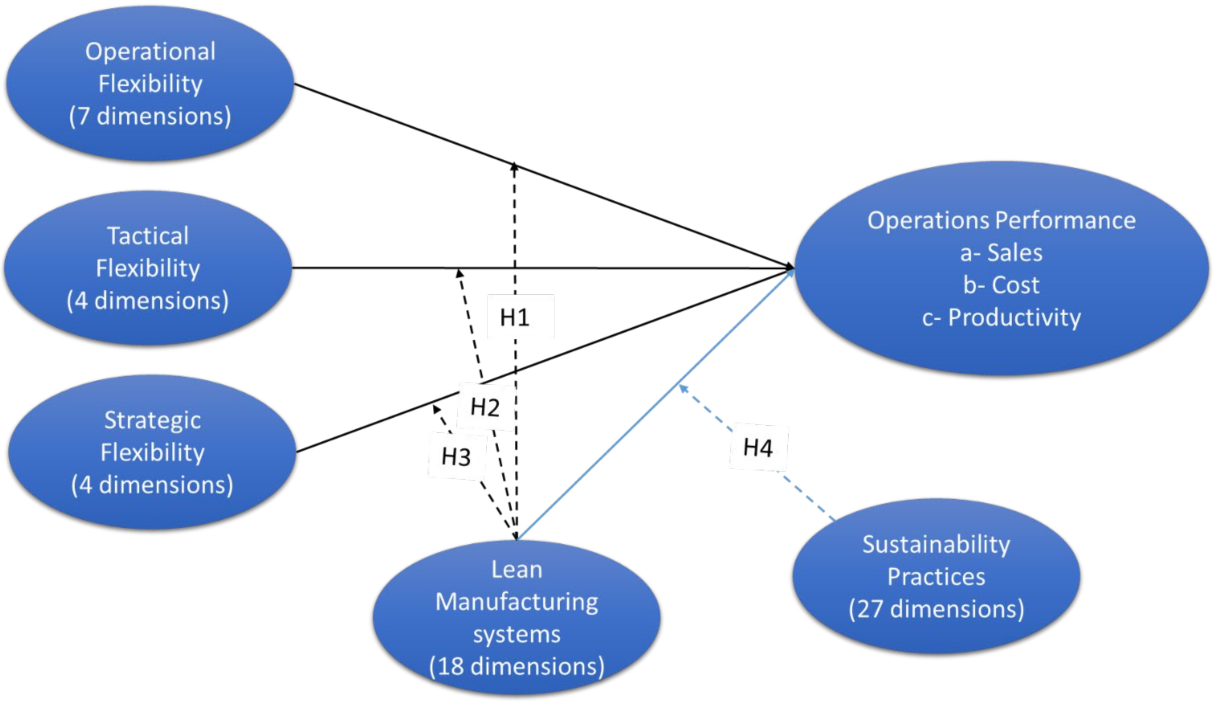

Figure 1. Conceptual framework

4. Results analysis

4.1. Measurement instruments: reliability, validity and goodness of fit

Prior to hypotheses testing, the reliability and validity of the measurement model were assessed. To ensure a good reliability, the loadings between the constructs and their measures must be higher than the threshold of 0.7 (Croom et al., 2018). Results showed that all items loadings were in the recommended range reflecting an acceptable reliability of the scales for all reported measurements. In addition, the values of Cronbach's α and CR, that are used to measure the construct reliability, were higher than 0.7 (Khalfallah & Lakhal, 2020). Then, the discriminant validity of the model was confirmed by all AVE and CR values that were greater than the squared correlations between the constructs. Furthermore, AVE for all constructs was greater than 0.5 (Katiyar et al., 2018), which confirms the convergent validity of the presented model.

Table 1. Descriptive statistics and Correlation matrix

	Mean	SD	Operational	Tactical	Strategic	LMS	SUS	Sales	Cost	Productivity
Operational	5.59	1.56	-							
Tactical	5.23	1.8	0.81***	-						
Strategic	5.05	1.81	0.80**	0.8**	-					
LMS	5.83	1.51	0.81***	0.79**	0.80**	-				
SUS	5.59	1.90	0.79**	0.78**	0.79**	0.83***	-			
Sales	5.51	1.91	0.78**	0.77*	0.78*	0.81***	0.81***	-		
Cost	2.62	1.89	-0.76*	-0.74*	-0.75*	-0.79**	-0.81***	-0.79**	-	
Productivity	5.41	1.82	0.77*	0.75*	0.74*	0.79**	0.80**	0.77*	-0.77*	-

Note: $*p < .05$; $**p < .01$; $***p<.001$

As a preliminary analysis of the relationships between the latent variables, a correlation matrix was generated. The Pearson product-moment correlations between the three flexibility constructs, lean, sustainability practices and the studied OPMs (cost, sales and productivity) were presented in table 1 along with the descriptive statistics (means and standard deviations) of the latent variables. All the correlation coefficients were below 90%, confirming the absence of any common method bias (Ardura & Artola, 2020). The strongest correlation was between lean and sustainability practices with a correlation coefficient of 0.83. However, lower correlations were observed between strategic flexibility and productivity (0.74) and between tactical flexibility and cost (-0.74). The latent variables show a significant positive correlation with OPMs except for the cost where the operational, tactical, strategic flexibility, lean and sustainability practices show significant negative correlations. The studied OPMs were positively correlated with each other except for the correlation between cost and productivity (-0.77).

The adequacy and validity of the empirical polynomial regression models were confirmed by high coefficient of determination (R^2 ranging between 65% and 73.4%) and a goodness of fit with p-value lower than 0.05. Furthermore, no significant difference was detected between the observed and the predicted values of the model (low Mean Squared Error). Therefore, an accurate estimation of OPMs can be achieved using the model equations with different combination of operational, tactical, strategic flexibility, lean and sustainability values within the test range.

The hypotheses H_1 (i.e., relationship between operational flexibility and OPMs), H_2 (i.e., relationship between tactical flexibility and OPMs), H_3 (i.e., relationship between strategic flexibility and OPMs), H_4 (i.e., relationship between lean and OPMs), are supported with a *p-value < 0.001*. These results affirm that flexibility, lean and sustainability positively affect the textile industries' operational performance.

Then, the aim was to find if lean and sustainability have a mediator effect in improving the performance. To accomplish the mediation analysis, two steps were required: path structure without mediation variable and then, path analysis while including the hypothesized mediator. To confirm the mediation effect of lean between flexibility and OPMs (i.e., $H_{1a,b,c}$, $H_{2a,b,c}$, $H_{3a,b,c}$) or sustainability practices between lean and OPMs (i.e., $H_{4a,b,c}$), the direct effect of the latent variables on OPMs without the mediation factor (in this case lean and sustainability practices, respectively) and the indirect effect including the mediation variable must be considerably divergent. Sobel test was conducted to validate the mediation effect by calculating t-statistics and p-value. The results are shown in Table 2. $H_{1a,b,c}$, $H_{2a,b,c}$, $H_{3a,b,c}$ and $H_{4a,b,c}$ are all supported and will be discussed in the following section.

Table2. Mediation analysis

Hypotheses	Direct effect without Mediation variable	With mediation variable		Sobel test statistics	Decision (Supported)
		Path	Std. error		
H1a	Operational →Sales (1.12***)	Operational → Sales (0.034) Operational → Lean (0.93***) Lean → Sales (1.18***)	0.11 0.023 0.11	10.29 (p-value <0.001)	Supported
H1b	Operational → Productivity (1.06***)	Operational → Productivity (0.21) Operational → Lean (0.93***)	0.13 0.023	6.97 (p-value <0.001)	Supported

		Lean → Productivity (0.92***)	0.13		
H1c	Operational →Cost (-1.04***)	Operational →Cost (0.004)	0.16	-6.39 (p-value <0.001)	Supported
		Operational → Lean (0.93***)	0.023		
		Lean → Cost (-1.1***)	0.17		
H2a	Tactical →Sales (0.97***)	Tactical →Sales (0.12)	0.075	11.22 (p-value <0.001)	Supported
		Tactical → Lean (0.78***)	0.025		
		Lean → Sales (1.07***)	0.089		
H2b	Tactical → Productivity (0.91***)	Tactical → Productivity (0.19*)	0.09	8.82(p-value <0.001)	Supported
		Tactical → Lean (0.78***)	0.025		
		Lean → Productivity (0.92***)	0.10		
H2c	Tactical →Cost (-0.89***)	Tactical →Cost (-0.025)	0.11	-8.17 (p-value <0.001)	Supported
		Tactical → Lean (0.78***)	0.025		
		Lean → Cost (-1.1***)	0.13		
H3a	Strategic → Sales (0.96***)	Strategic → Sales (0.09)	0.08	10.56 (p-value <0.001)	Supported
		Strategic → Lean (0.79***)	0.023		
		Lean → Sales (1.11***)	0.1		
H3b	Strategic →Productivity (0.89***)	Strategic →Productivity (0.02)	0.1	8.86 (p-value <0.001)	Supported
		Strategic → Lean (0.79***)	0.023		
		Lean → Productivity (1.1***)	0.12		
H3c	Strategic → Cost (-0.88***)	Strategic → Cost (0.04)	0.12	-7.61 (p-value <0.001)	Supported
		Strategic → Lean (0.79***)	0.023		
		Lean → Cost (-1.17***)	0.15		
H4a	Lean →Sales (1.2***)	Lean →Sales (0.45***)	0.14	5.6 (p-value<0.001)	Supported
		Lean → SUS (1.23***)	0.023		
		SUS → Sales (0.62***)	0.11		
H4b	Lean → Productivity (1.13***)	Lean → Productivity (0.03)	0.15	-6.02 (p-value<0.001)	Supported
		Lean → SUS (1.23***)	0.023		
		SUS → Productivity (0.89***)	0.12		
H4c	Lean → Cost (-1.13***)	Lean → Cost (0.075)	0.2	7.35 (p-value<0.001)	Supported
		Lean → SUS (1.23***)	0.023		
		SUS → Cost (-0.97***)	0.16		

5. Discussion

Based on an in-depth literature review, a comprehensive conceptual framework was developed to study the factors affecting the OPMs in the textile industry and their relationships. The latent variables chosen were operational, tactical, strategic flexibility, lean and sustainability practices and a scale was developed to measure the OPMs. Results showed that all the hypothesis (H_1, H_2, H_3, H_4) are supported. LMS mediates the relationship between: (a) operational flexibility and sales, (b) operational flexibility and productivity, (c) operational flexibility and cost. In addition, LMS was proven to mediate the relationship between: (a) tactical flexibility and sales, (b) tactical flexibility and productivity, (c) tactical flexibility and cost and the relationship between: (a) strategic flexibility and sales, (b) strategic flexibility and productivity, (c) strategic flexibility and cost. On the other hand, the sustainability practices mediate the following relationships: (a) LMS-sales, (b) LMS-productivity, and (c) LMS-cost. These findings demonstrate that the three flexibility dimensions, when implemented, will improve the lean manufacturing practices which eventually will enhance the OPMs. On the other side, the concurrent implementation of sustainability practices and LMS would substantially improve the performance indicators.

5.1. LMS as a mediator between the flexibility dimensions and OPMs.

Table 2 shows the results of the mediation effect of LMS and Sustainability practices (SUS) on the relationship between flexibility dimensions and OPMs, and between LMS and OPMs, respectively. First, it was proven that the implementation of operational flexibility (i.e., the ability to switch operations with minimal effort, production using alternative routes, change in the number of workers and the tasks performed, adding new tools or moving existing parts for easy processing) alone can significantly increase the sales, cost and productivity performance. Same results were obtained with the tactical (i.e., alternative process plans as a different way of production, easy transport of the materials to the manufacturing facility and to the operations within the facility) and strategic flexibility (i.e., automation, production of a variety of products with different dimension, increase the capacity and the capability when needed). These findings were in line with some literature supporting the positive link between manufacturing flexibility and firm's performance (Kaur et al., 2017; Khalfallah & Lakhal, 2020; Nabass & Abdallah, 2019; Yu et al., 2015) (Figure 2-A). The direct effect of operational flexibility on sales were significant without implementing LMS (β1.12, $p<0.001$) (Figure 2-A). On the other hand, the effects plots, response surfaces and table 2 showed no significant effect of operational flexibility when introducing LMS (β 0.034, $p>0.05$) (Figure 2-B). While exploiting the response surface, the importance of implementing both operational flexibility and lean practices simultaneously was evidenced. Accordingly, when the LMS are at their high level, and while increasing the operational flexibility, the textile firms would face an extensive sales growth. This could be interpreted by the fact that companies with flexible operations can cope and respond to every changes occurring, specifically in demand. Same positive mediating effect was noticed with the productivity (Figure 2). In fact, lean practices and operational flexibility have a synergistic effect to enhance the firm's productivity.

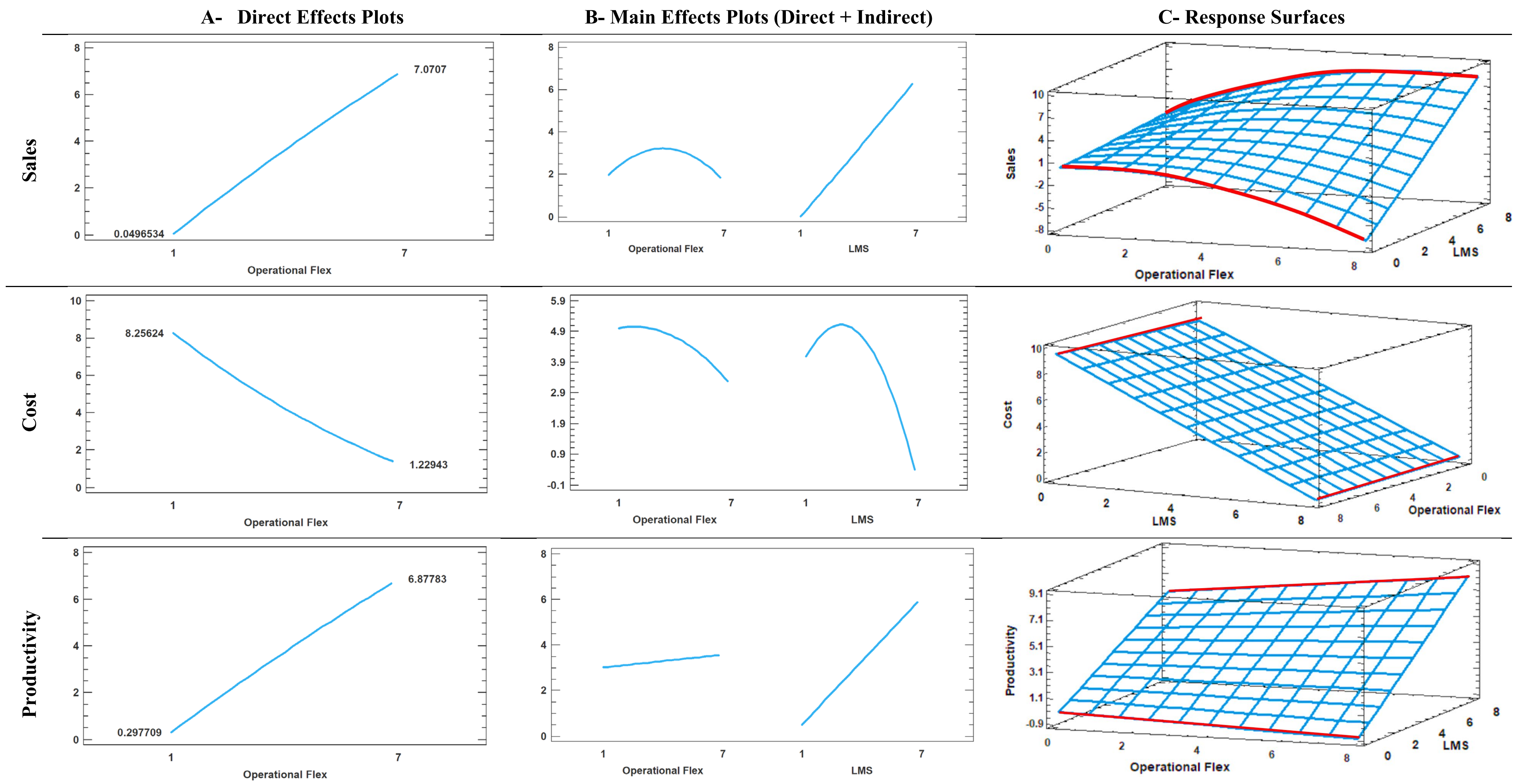

Figure 2. (A) Effect of Operational Flexibility practices without the LMS mediation parameter on sales, cost and productivity; (B) Effect of Operational Flexibility practices with the LMS mediation parameter on the operations performance metrics; (C) 3-D Response surfaces showing the mediating effect.

In this context, the implementation of manufacturing flexibility was found to be boosting the efficiency performance (Wei et al., 2017) and both lean and operational flexibility had a significant positive impact on productivity (El-Khalil, 2018).

Furthermore, the direct effect of operational flexibility (OP Flex) reduces the cost. However, when implementing both philosophies: LMS and OP Flex, lean practices take over in mediating the significant effect of the operational flexibility on costs. These findings were similar to those obtained by Panwar et al. (2018) who carefully explained the positive relationship between the adoption of lean practices, cost reduction and productivity. Based on the response surface, at low lean implementation levels, the production cost is at its highest level. Yet, at high lean levels, the cost decreased significantly with the increase in OP Flex measures. In fact, coupling the innovative managerial and workers skills to the advanced technology in flexible companies promotes a reduction of production cost (Nabass & Abdallah, 2019; Vázquez-Bustelo et al., 2007). The results were aligned with those of Inman et al., (2011) who discussed the improvement of OPMs while applying an indirect effect of operational flexibility through lean practices.

Thus, the hypotheses H1-a, b, c: “Lean manufacturing practices mediate the relationship between operational flexibility and sales, productivity and cost, respectively” are supported.

On the other hand, there was a significant direct effect of tactical flexibility (Tac Flex) on the studied OPMs (sales (0.97), productivity (0.91) and cost (-0.89)). The unstandardized estimate of indirect effects between Tac Flex and sales, productivity and cost through LMS were 0.12, 0.19, -0.025. This proved that there is a link between tactical flexibility and OPMs through LMS. Table 2 showed that tactical flexibility enhanced the LMS which eventually impacted the performance metrics. The implementation of tactical flexibility improves the sales, productivity and the reduction of cost however this trend changes when applying the lean practices. The effects plots illustrated the significant positive impact of lean on the OPMs where the tactical flexibility has insignificant effect after inclusion of the mediator. Similar conclusions were demonstrated in the automotive industry by El-Khalil (2018).

Accordingly, the hypotheses H2-a, b, c: “Lean manufacturing practices mediate the relationship between tactical flexibility and sales, productivity and cost, respectively” are supported.

As mentioned earlier, same results were obtained for the strategic flexibility where the unstandardized estimate of direct effect on sales, productivity and cost came as follows: 0.96, 0.89, -0.88, respectively and were highly significant (*p-value* < 0.001). Unstandardized β of indirect effect between strategic flexibility and OPMs were 0.09 for sales, 0.02 for productivity and 0.04 for cost.
Implementing strategic flexibility offers to the company the ability of producing low-cost products using internal and external capabilities leading to a reduction of cost (Gligor & Holcomb, 2012; Nabass & Abdallah, 2019). Additionally, strategic flexibility was found to have a significant positive impact on productivity (El-Khalil, 2018), cost (El-Khalil, 2018), and sales (Abbott and Banerji, 2003).

Consequently, the hypotheses H3-a, b, c: “Lean manufacturing practices mediate the relationship between strategic flexibility and sales, productivity and cost, respectively” are supported.

5.2. Sustainability as a mediator between LMS and OPMs.

As mentioned by Panwar et al., (2018) lean manufacturing practices have a positive effect on the financial and the productivity performance. Similar results were found in this study as it is shown in the main effects plots and the mediation analysis (Figure 2 and Table 2). Moreover, the unstandardized estimate of sales, productivity and cost changed between the direct (1.2, 1.13, -1.13 respectively) and the indirect effects (0.45, 0.03, 0.075 respectively) and based on the Sobel test, sustainability practices were found to have significant mediating effects. Results show that LMS can enhance organizational performance; however, if sustainability practices are added as a mediator, then the direct positive relationship between LMS and OPM will attenuate, in this case cost and productivity. Many research studies evoked the important role of lean in identifying and eliminating the waste in the manufacturing process. This reduction can be enhanced with the application of SUS practices and LMS. With this elimination, the quality of the products will be improves while the cost will be reduced (Singh et al., 2018). Moreover, LMS related to the relationships with the suppliers helps in avoiding possible shortages in raw and packaging material leading to an improvement of the productivity (Panwar et al., 2018). In addition, Henao et al., (2019) have mentioned in their study that advanced manufacturing systems can improve the operational performance and more specifically the cost and the productivity by means of reducing lead-times and fast delivery leading to an increase of goods supply.

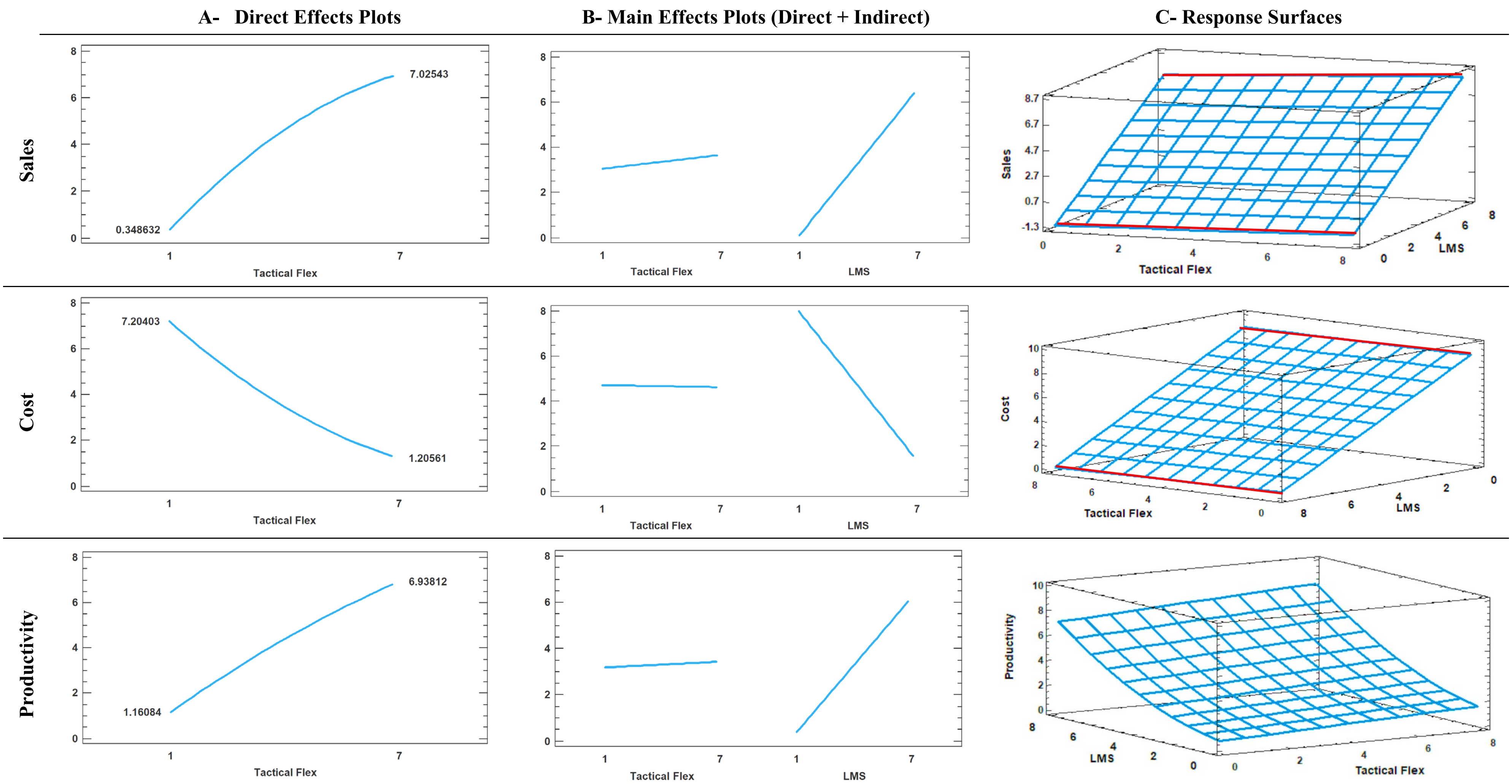

Figure 3. (A) Effect of Tactical Flexibility practices without the LMS mediation parameter on sales, cost and productivity; (B) Effect of Tactical Flexibility practices with the LMS mediation parameter on the operations performance metrics; (C) 3-D Response surfaces showing the mediating effect.

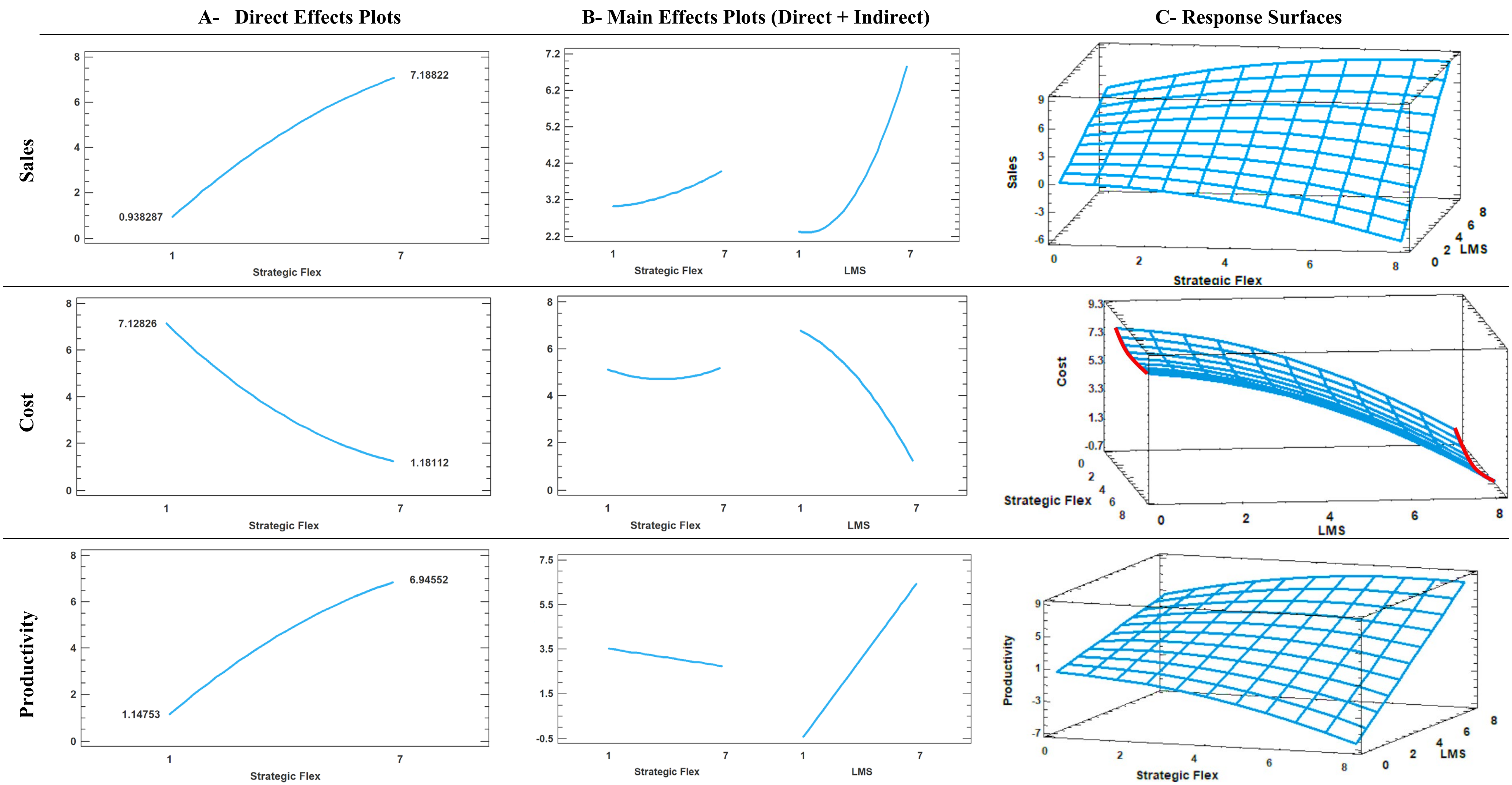

Figure 4. (A) Effect of Strategic Flexibility practices without the LMS mediation parameter on sales, cost and productivity; (B) Effect of Strategic Flexibility practices with the LMS mediation parameter on the operations performance metrics; (C) 3-D Response surfaces showing the mediating effect.

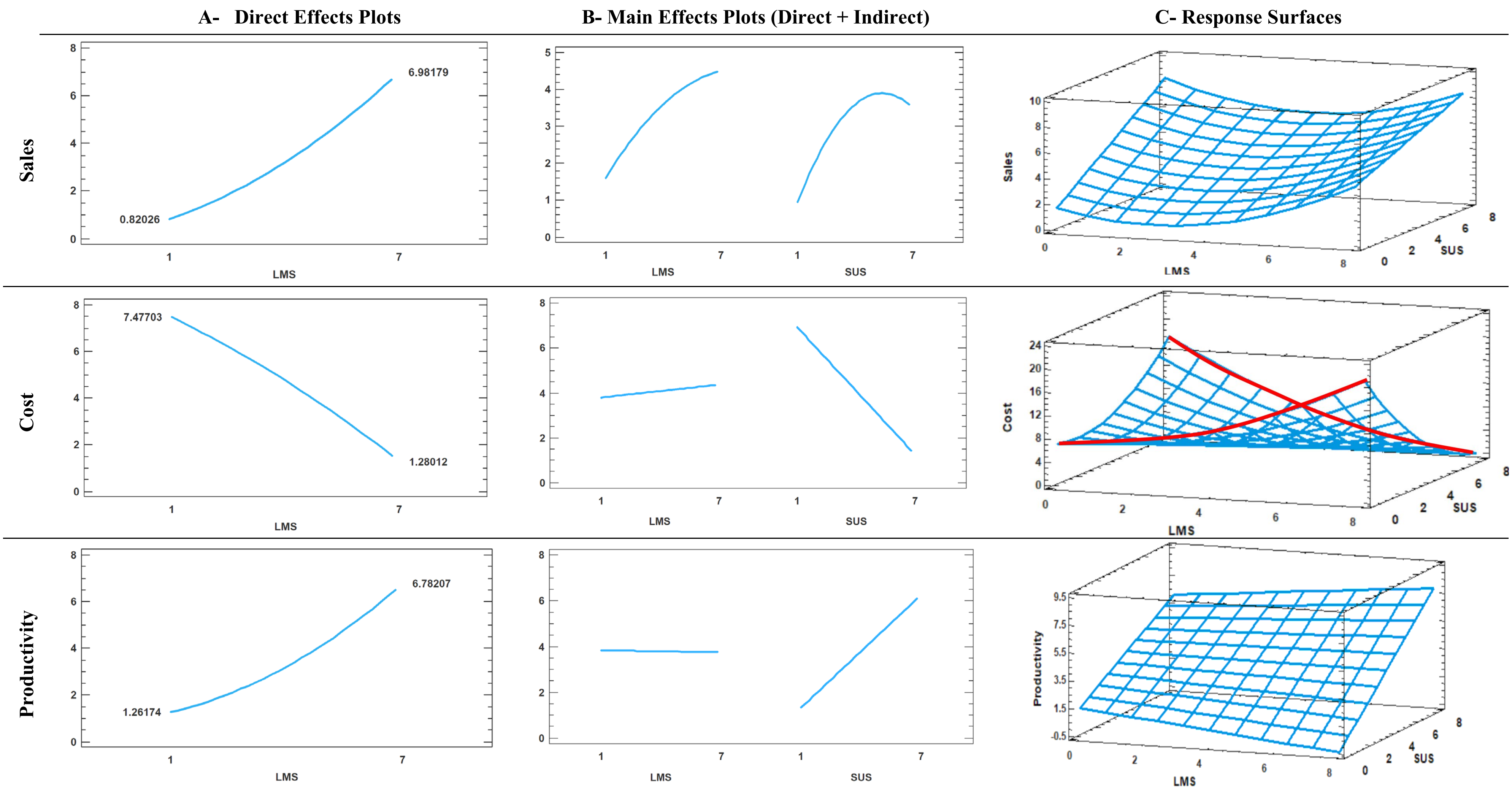

Figure 5. (A) Effect of LMS without the Sustainability Practices mediation parameter on sales, cost and productivity; (B) Effect of LMS with the SUS mediation parameter on the operations performance metrics; (C) 3-D Response surfaces showing the mediating effect.

On the other hand, sales showed different results. LMS has a significant effect on sales and that didn't change when applying the SUS practices (p-value <0.001) but the relative β coefficient decreased. This means that LMS and SUS together enhance the sales growth of the company. These findings present similarities with previous studies showing that lean and sustainability practices had a positive effect on sales growth (Green and Inman, 2007; Kannan and Tan, 2005; Molina-Azorin et al., 2009).

Accordingly, the hypotheses H4-a, b, c: "Sustainability practices mediate the relationship between lean manufacturing practices and sales, productivity and cost, respectively" are supported.

6. Conclusion

In this paper, empirical models were designed aiming at studying the relationship between lean manufacturing practices, sustainability practices, operational, strategic and tactical flexibility and OPMs (sales, cost, productivity). The questionnaire was validated and data was collected from textile industries. The results confirmed the theoretical hypotheses regarding (i) the mediating effect of LMS on the relationship between the flexibility dimensions and OPMs and (ii) the sustainability practices as mediator between LMS and OPMs. Textile industries would experience an increase in sales, productivity and a reduction of cost if they would implement, at a time, moderate to high levels of LMS, flexibility and sustainability practices.

6.1. Managerial implications

This study provides an in-depth understanding of how to improve the performance by including sustainability practices and LMS in association with FMS. The positive relationship between operational, tactical and strategic flexibility and LMS will encourage managers to implement both practices to improve the OPMs. Moreover, the empirical models developed in this study can be applied by any textile firm to optimize their performance by accurately defining their Flexibility, Lean and Sustainability strategies.

6.2. Limitations and future research

This study have some limitations and future research opportunities. The sample covered the textile industry. Therefore, the sample can be expanded for future research targeting other manufacturing sectors or increasing the sample size. In addition, it would be interesting to compare the implementation of LMS, SUS and FMS in firms from different emerging countries. Additionally, the study was limited to the sales, cost and productivity performance indicators; however further studies can be applied to analyze the mediating effect of SUS and LMS on other OPMs such as quality, employee's morale, safety, efficiency, etc.

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