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Impact of the Supply Chain on Sustainable and Business Performance During the COVID-19 Pandemic

Impacto de la cadena de suministro en el desempeño empresarial y sostenible durante la pandemia de COVID-19

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ABSTRACT

The main objective of this empirical study is to provide empirical evidence that allows quantifying the impact of the supply chain on sustainable and firm performance during the COVID-19 pandemic. An electronic survey was applied to collect information on 65 manufacturing firms selected through simple random sampling, using the statistical technique of Partial Least Squares Structural Equation Modeling (PLS-SEM) to analyze the data obtained using the SmartPLS 4.0 software. Furthermore, the analysis carried out in this study identifies a need for more theoretical and, above all, empirical evidence in this area, which prevents the generalization of the results obtained. Likewise, the results suggest that during the COVID-19 pandemic, the supply chain positively impacted sustainable performance. However, an adverse effect was also detected on firm performance, so it is possible to conclude that the COVID-19 pandemic substantially improved the sustainable performance of manufacturing companies. However, it also generated a decrease in their level of firm performance.

Keywords: Supply chain; COVID-19 pandemic; sustainable performance; firm performance.

JEL code: M21



RESUMEN

Este estudio empírico tiene como principal objetivo aportar evidencia empírica que permita cuantificar los efectos de la cadena de suministro en los rendimientos sustentable y empresarial durante de la pandemia del COVID-19. Se aplicó una encuesta electrónica para recolectar información de 65 empresas manufactureras seleccionadas mediante un muestreo aleatorio simple, utilizando la técnica estadística del Partial Least Squares Structural Equation Modelin (PLS-SEM) para el análisis de los datos obtenidos, mediante el uso del software SmartPLS 4.0. Además, el análisis realizado en este estudio identifica una falta de evidencia teórica y, sobre todo, empírica en esta área lo cual impide la generalización de los resultados obtenidos. Asimismo, los resultados obtenidos sugieren que durante la Pandemia del COVID-19 la cadena de suministro generó un impacto positivo en el rendimiento sustentable, pero también se detectó un impacto negativo en el rendimiento empresarial, por lo cual es posible concluir que durante la pandemia del COVID-19 se generó una mejora sustancial en el rendimiento sustentable de las empresas manufactureras, sin embargo, también generó una disminución en su nivel de rendimiento empresarial.

- 4 Palabras clave: Cadena de suministro; pandemia del COVID-19; rendimiento sustentable; rendimiento empresarial.

Código JEL: M21.

INTRODUCTION

During the COVID-19 pandemic, various adverse effects were generated in the global economy (Haraguchi *et al.*, 2023), particularly in the entire supply chain of manufacturing companies of all sizes and sectors (Ivanov & Dolgui, 2020b; Butt, 2021). However, the pandemic also helped manufacturing firms improve their skills and capabilities to mitigate risks in the supply chain (Haraguchi *et al.*, 2023). However, it is still not clear in the scientific, academic, and business communities how practical the response of manufacturing companies to quickly adapt to the changes generated during the COVID-19 pandemic (Renn *et al.*, 2022), which is why researchers and academics need to focus their studies on providing empirical evidence on the effects generated. During the COVID-19 pandemic, the supply chain and manufacturing companies' performance levels were high (Haraguchi *et al.*, 2023).

In this context, the disruption of the supply chain caused during the COVID-19 pandemic in manufacturing firms and its effects on firm performance has been little explored in the literature; the few studies have focused on the United States, China, Japan, and Thailand (Haraguchi *et al.*, 2023). Furthermore, published studies that have analyzed the breakdown of the supply chain in manufacturing firms during the COVID-19 pandemic have focused on a variety of sectors, for example, automotive and aeronautics (Belhadi *et al.*, 2020), fashion industry (McMaster *et al.*, 2020), and medical industry (Belhouideg, 2020). However, only some studies have addressed how supply chain disruption was used to manage risks during the COVID-19 pandemic (Chang *et al.*, 2022) and improve firm performance (Ivanov, 2020a).

5

During the COVID-19 pandemic, several negative impacts were generated on both businesses and supply chain, including a significant reduction in their efficiency and firm performance (Ivanov, 2020a; Guan *et al.*, 2020), as well as a disruption among companies participating in the supply chain, which generates adverse effects on sustainable and firm performance (Ivanov, 2020b; Ivanov & Dolgui, 2020a). In this sense, during the COVID-19 pandemic, diversified and dynamic negative impacts were generated on the entire global economy (Koonin, 2020; Haren & Simchi-Levi, 2020).

Proof of this is that the COVID-19 pandemic, according to the report published by Fortune Magazine in February 2020, long before the World Health Organization declared COVID-19 a global pandemic (March 21, 2020), had negatively impacted 94% of the 1,000 largest companies in the world, generating severe disruption in the management of their supply chains (Fortune, 2020).

Impact of the Supply Chain on Sustainable and Business Performance During the COVID-19 Pandemic

Furthermore, the COVID-19 pandemic has negatively impacted both the sustainability of the supply chain and the companies that participate in the supply chain of most of the world's manufacturing industries, including the automotive sector (Gunessee & Subramanian, 2020; Paul & Chowdhury, 2020), which is causing an interruption in the flow and raw materials from the primary production and distribution centers to the production centers (Chowdhury *et al.*, 2021). In addition to the multidimensional negative impacts generated in the supply chain, the COVID-19 pandemic is also negatively affecting the level of business performance and global trade (Donoth *et al.*, 2020); proof of this is that international trade is reduced by around 32% in 2020, derived from the economic crisis generated by COVID-19 pandemic (WTO, 2020).

Additionally, derived from the negative impacts of the COVID-19 pandemic on the supply chain of manufacturing firms, researchers, academics, and industry professionals consider that more empirical evidence should be provided on this topic (Chowdhury *et al.*, 2021) since the studies published in the current literature are scarce and the secondary effects generated by COVID-19 pandemic in the supply chain must be delved deeper (Chowdhury & Paul, 2020; Iyengar *et al.*, 2020). Thus, to provide empirical evidence, this study has as its research question: *What are the effects of the supply chain on the sustainable and firm performance of manufacturing firms in the automotive industry in Mexico during the COVID-19 pandemic?*

6

LITERATURE REVIEW

During the COVID-19 pandemic, various changes were generated in local and global supply chains, affecting their level of sustainable and firm performance, which caused companies to explore the adoption of more effective strategies to mitigate risks and improve their results (Aljuneidi *et al.*, 2023). Furthermore, during the COVID-19 pandemic, the supply chain was affected in different ways (Aljuneidi *et al.*, 2023), one of the main effects being the demand for essential products such as masks and disinfectants, which caused a shortage in the market for these products, as well as an increase in the costs of transporting the products (Mbah & Wasum, 2022), thereby generating an increase in sustainable performance and a decrease in firm performance (Ivanov, 2020a).

The attention paid to the effects of the COVID-19 pandemic on the supply chain of manufacturing companies is similar among researchers and industry professionals (e.g., Business Insider, 2020; Deloitte, 2020; Fortune, 2020), mainly because various reports indicate that a significant percentage of companies have had problems in their supply chain during the COVID-19 pandemic (Fortune, 2020). This unprecedented situation has caused a re-evaluation of the supply chain activities of manufacturing companies and the exploration

of innovative solutions to address the challenges (Aljuneidi *et al.*, 2023), as well as to improve sustainable and firm performance (Ivanov, 2020b; Ivanov & Dolgui, 2020b).

In this context, numerous studies have proposed different strategies to deal with the effects generated during the COVID-19 pandemic in manufacturing companies, including increasing production capacity, optimizing supply chain infrastructure, and exploring sustainable supply chain systems (e.g., Naz *et al.*, 2021; Nordhagen *et al.*, 2021; Paul & Chowdhury, 2021). However, in a recent study, Aljuneidi *et al.* (2023), through an extensive literature review, identified that of 393 papers found in the WoS and Scopus databases, only 52 (13%) analyzed the effects of the supply chain on sustainability during and after the pandemic, 40 used mathematical models, 12 were focused on the electronics and automotive industry. Five were carried out in Basil, the only country in Latin America.

SUPPLY CHAIN AND SUSTAINABLE PERFORMANCE DURING COVID-19 PANDEMIC

An essential characteristic of the COVID-19 pandemic is having plunged the supply chain into a crisis in the last five years, which was characterized by a transformation of production systems from insourcing to outsourcing, from local to global, and certainty to uncertainty in business (Ivanov, 2024). Furthermore, during the COVID-19 pandemic, supply chain management and its effects on business results were challenged, moving from order to chaos, from controllable or uncontrollable activities, from the rigid and fluid to the flexible and adaptable, and from the certain to the uncertain (Ivanov, 2024). Thus, during the COVID-19 pandemic, the supply chain of manufacturing companies was affected globally, thereby generating concern for researchers, academics, and professionals to know the extent of its effects on business results (Reza *et al.*, 2023).

7

In this sense, Sarkis (2020) found that even though manufacturing companies faced a shock during the COVID-19 pandemic, improving supply chain sustainability allowed organizations to overcome the economic crisis, which enables us to establish that the COVID-19 pandemic presents a broad opportunity for companies to generate and apply new ideas in the supply chain that significantly improve their sustainable performance (Nandi *et al.*, 2021). Furthermore, the need for society to preserve, regenerate, and restore natural resources (e.g., reforestation, water, recreation parks, climate, and air quality) are substantial elements that strongly impact the sustainable performance of manufacturing companies (Liu *et al.*, 2020).

Regarding the effects of the supply chain on the automotive industry during the COVID-19 pandemic, Chervenkova and Ivanov (2023) found that the pandemic drastically transformed

Impact of the Supply Chain on Sustainable and Business Performance During the COVID-19 Pandemic

the automotive industry, negatively affecting its global networks in terms of severity, complexity, scale, and duration of the impact, but also allowed an improvement in its level of sustainable performance. Karamoozian *et al.* (2024) found that during the COVID-19 pandemic, the global automotive industry suffered severe disruptions that generated a domino effect, making it difficult to predict business results. However, companies developed contingency plans that effectively addressed the risks, allowing them to improve their sustainable performance.

Additionally, Mishrif and Khan (2023) found that the digitalization of the supply chain during the COVID-19 pandemic was what allowed for improving the sustainability of companies, while Marco-Ferreira *et al.* (2023) found that to mitigate the effects of the COVID-19 pandemic on the supply chain of manufacturing firms, organizations had to be more resilient and use a more sustainable business model. This is why manufacturing firms that have adopted and implemented sustainability activities in their supply chains not only did they significantly reduce the risks (Reza *et al.*, 2020; Choi, 2020) but also increase their level of sustainable performance by a high percentage (Ivanov, 2020b; Ivanov & Dolgui, 2020b).

8 Furthermore, theoretical and empirical evidence has been provided in the supply chain literature, establishing that sustainability not only improves supply chain activities but also significantly improves the sustainability of manufacturing firms (Kouhizadeh *et al.*, 2021). Likewise, recently, various sustainability activities have gained the attention of researchers, academics, and industry professionals, primarily when they are directly related to the supply chain of manufacturing firms since they are considered an essential element to improve innovation and avoid the breakdown of the supply chain in times of crisis generated by COVID-19 pandemic (Treiblmaier & Beck, 2020) since generally its attributes not only encourage the exchange of information and negotiation mechanisms but also improve firm sustainability performance (Saber *et al.*, 2019). Thus, considering the information presented, it is possible to propose the following research hypothesis:

H1: The supply chain has positive effects on sustainable performance level

Supply Chain and Firm Performance during COVID-19 Pandemic

Most of the papers published in the literature that analyze the effects generated during the COVID-19 pandemic on the supply chain have used various methodologies, including surveys (e.g., Nikookar & Yanadori, 2022; Spieske *et al.*, 2022), secondary data (e.g. Mariappan *et al.*, 2022), and case studies (e.g. Acar *et al.*, 2022), and have generally focused on supply chain resilience and disruption (Guest Editorial, 2022). Few studies have analyzed the effects of the supply chain on firm performance (Ivanov, 2024). A possible cause of this phenomenon is that in most product purchases, consumers prefer to make them online and

through traditional distribution channels (Ivanov & Das, 2020), significantly reducing the supply chain and business performance (Siche, 2020).

In this sense, Reza *et al.* (2023) analyzed the effects during the CIVOD-19 pandemic on the prices of products that were purchased in person and online, finding a drop in personal purchases and a substantial increase in online purchases, thereby collapsing the supply chain, and reducing the level of firm performance. For their part, Seif *et al.* (2023) demonstrated that during the COVID-19 pandemic, the supply chains of food and essential personal hygiene products collapsed, which generated severe economic problems in manufacturing companies that manufactured non-basic products. A possible cause of this phenomenon is the panic generated among consumers due to the shortage of this type of product in conventional stores and traditional distribution channels globally (Hobbs, 2020; Richards & Rickard, 2020).

Likewise, non-essential products have significantly reduced their demand, mainly due to decreased consumer income, who prefer to save some economic resources to alleviate an uncertain future (Chiaramonti & Maniatis, 2020; Abhishek *et al.*, 2020). This decrease in purchasing levels is generating severe economic problems in various industries, including tourism, aerospace, and automotive, which are facing a severe crisis in their financial and firm performance (Majumdar *et al.*, 2020). Therefore, their billing levels create ambiguity and uncertainty in their supply chains, affecting decision-making (Gunessee & Subramanian, 2020) and increasing the prices of non-essential products (Fariás & Araújo, 2020).

In a recent study, Sun *et al.* (2022) found that during the COVID-19 pandemic, a contraction was generated in the supply chain of electric vehicles, which caused a reduction in the level of firm performance, while Rajak *et al.* (2022) found that during the COVID-19 pandemic, the entire vehicle supply chain was severely affected, which generated a substantial decrease in sales and, as a consequence, a reduction in firm performance. Similar results were found by Spieske *et al.* (2022), who suggest that automotive industry companies should collaborate in exchanging knowledge, information, and learning to improve not only the entire supply chain but also the level of firm performance.

Additionally, the COVID-19 pandemic is causing a significant reduction in the production processes of manufacturing firms (Richards & Rickard, 2020), which is why the production capacity of companies has been dramatically reduced, also caused by the political decisions to reduce working hours so that employees maintain social distancing, and stagger workers' working days to prevent the spread of COVID-19 pandemic (Leite *et al.*, 2020). Likewise, social distancing and safety measures are decreasing production levels in manufacturing firms (Trautrimis *et al.*, 2020), as well as limiting supply chain operations for all types of goods, resulting in both the obsolescence of machinery and equipment and the reduction in

Impact of the Supply Chain on Sustainable and Business Performance During the COVID-19 Pandemic

firm performance (Dente & Hashimoto, 2020). Thus, considering the information presented, it is possible to propose the following research hypothesis:

H2: The supply chain has adverse effects on firm performance level

METHODOLOGY

To answer the research questions proposed in this paper, an empirical study was carried out in the manufacturing firms of the automotive industry in Mexico, using the business directory of the automotive industry in Mexico, which had a record of 900 companies as of May 30, 2020, these companies belonging to various business chambers and local, regional, and national organizations, which is why the empirical study did not focus on a particular business association. Likewise, an electronic survey was applied to collect information on 65 manufacturing firms selected through simple random sampling. This survey was applied during June and July 2020 by a private company dedicated to the investigation of markets.

Likewise, to measure the supply chain, an adaptation was made to the scale proposed by Marshall *et al.* (2014), who considered that the supply chain can be measured through 8 items. To measure sustainable performance, an adaptation was made to the scale proposed by Bansal (2005) and Chan (2005), who considered that sustainable performance could be measured through 6 items. An adaptation was made to the scale that Bag (2014) proposed, who thought this construct could be measured through 6 items to measure firm performance. Likewise, all items on the scales were measured through a five-point Likert-type scale, with 1 = Completely disagree to 5 = Completely agree as limits, since generally, these types of scales provide a balance appropriate between the complexity of the respondents and the ease of analysis of the information (Forza, 2016; Hair *et al.*, 2016).

In addition, the reliability and validity of the scales of the supply chain, sustainability, and business performances were measured through Cronbach's Alpha, Composite Reliability Index (CRI), and Extracted Variance Index (EVI), respectively, to assess its internal consistency (Hair *et al.*, 2019). Furthermore, the literature also establishes that the use of scales with various items can generate problems with content validity (Rossier, 2002) since they can artificially increase the correlations of the error terms (Drolet & Morrison, 2001; Hayduk & Littvay, 2012), which is why the use of measurement scales with few items is recommended. Table 1 shows the specific items used for each construct.

Table 1. Measurement Model Assessment

Indicators	Constructs	Factor loads (p-value)	Q ²
Supply Chain Composite Type A (SSC)			
Cronbach's alpha: 0.926; Dijkstra-Henseler's rho: 0.942; CRI: 0.939; EVI: 0.660			
SSC1	It constantly monitors its suppliers to ensure they comply with safety and hygiene requirements.	0.724 (0.000)	0.082
SSC2	Periodically apply questionnaires or surveys to your suppliers to monitor their correct application.	0.735 (0.000)	0.091
SSC3	Constantly monitors the commitment that its suppliers have in safety and hygiene, as a process to improve its goals.	0.861 (0.000)	0.101
SSC4	It constantly carries out safety and hygiene audits on its workers to eliminate items that are abandoned or that are not in the right places.	0.876 (0.000)	0.125
SSC5	You have a system to balance the work/family of your employees with the employees of your suppliers throughout the supply chain.	0.825 (0.000)	0.122
SSC6	It has an audit system to verify compliance with the safety and hygiene standards of the employees of its main suppliers.	0.931 (0.000)	0.108
SSC7	It constantly supports its main suppliers to obtain some certification in safety and hygiene standards.	0.790 (0.000)	0.097
SSC8	It has a code of conduct system of ethics with its main suppliers so that they remove damaged or quality-defective products from the company.	0.732 (0.000)	0.074
Sustainable Performance Type A (SDP)			
Cronbach's alpha: 0.918; Dijkstra-Henseler's rho: 0.928; CRI:0.934; EVI: 0.671			
SDP1	It has among its objectives the care of the environment	0.775 (0.000)	0.127
SDP2	Makes great efforts to promote environmental care	0.706 (0.000)	0.124
SDP3	It has a great commitment to investing in projects that protect the environment	0.859 (0.000)	0.123
SDP4	Frequently discusses the results of environmental care performance within the organization.	0.888 (0.000)	0.135
SDP5	They have excellent performance in protecting the environment compared to other companies in the same industry or sector.	0.876 (0.000)	0.808
SDP6	They are recognized by society for their effectiveness in protecting the environment.	0.810 (0.000)	0.086
Business Performance Type A (ORP)			
Cronbach's alpha: 0.899; Dijkstra-Henseler's rho: 0.933; CRI: 0.922; EVI: 0.665			
ORP1	Economic benefits have been reduced	0.810 (0.000)	0.110
ORP2	The profit margin has been reduced	0.762 (0.000)	0.103
ORP3	Return on assets has decreased	0.799 (0.000)	0.107
ORP4	Return on investment has been reduced	0.830 (0.000)	0.109
ORP5	Sales volume has been reduced	0.787 (0.000)	0.097
ORP6	Sales performance has decreased	0.893 (0.000)	0.093
ORP7	Cash flow has been reduced	0.844 (0.000)	0.089

Notes: CRI: Composite Reliability Index; EVI: Extracted Variance Index; Q²: Cross-validated redundancies Stone-Geisser Q² index
 Source: Own elaboration.

Table 1 shows the results obtained and indicates that the factor loadings of all the items are significant, varying between 0.706 and 0.931, exceeding the minimum recommended level of 0.7. Furthermore, all the constructs are characterized by having a Cronbach's Alpha value greater than 0.8, indicating their level is satisfactory (Hair *et al.*, 2019). Likewise, CRI and Dijkstra-Henseler's rho levels are also above the recommended limit of 0.7. CRI varies between 0.922 and 0.939, while Dijkstra-Henseler's rho is in the range of 0.928 and 0.942, all above the recommended value (Bagozzi *et al.*, 1991; Hair *et al.*, 2011). Finally, the EVI values are at levels that exceed the 0.5 limits proposed by the literature (Fornell & Larcker, 1981; Bagozzi *et al.*, 1991).

Impact of the Supply Chain on Sustainable and Business Performance During the COVID-19 Pandemic

Likewise, evaluating the scales requires discriminant validity, which can be measured through the Fornell and Larcker criterion, cross-loadings, and correlations' Heterotrait-Monotrait ratio (HTMT) (Hair *et al.*, 2019). Furthermore, discriminant validity indicates the degree to which a construct is different from the other constructs of a theoretical model (Hair *et al.*, 2019), which is why the most effective measure for its measurement is the HTMT (Henseler *et al.*, 2015) since HTMT is technically an estimate of what the actual correlation between two constructs would be if they were measured perfectly, which is why an HTMT value of less than 0.85 is recommended (Henseler *et al.*, 2015). Table 2 shows the discriminant validity values more clearly.

Table 2 shows the results obtained, and according to the Fornell and Larcker criterion (Panel A), the variance shared between each pair of constructs is less than the variance extracted for each construct, which is feasible to establish the existence of discriminant validity between the scales. Furthermore, the most effective measure for discriminant validity is HTMT (Henseler *et al.*, 2015), and Table 2 shows that the values of the HTMT ratio vary between 0.366 and 0.676, which are very satisfactory. They are far from the maximum recommended value of 0.8 by Henseler *et al.* (2015). Finally, concerning the cross-loadings (Panel B), Table 2 shows that the values of the cross-loadings of each construct are higher than the values of the other scales, which makes it possible to establish the existence of discriminant validity between the three measurement scales.

12

Table 2. Measurement Model Discriminant Validity

PANEL A Fornell-Larcker Criterion				Heterotrait-Monotrait Ratio (HTMT)			
	1	2	3	1	2	3	
1 Supply Chain	0.812						
2 Sustainability Performance	0.362	0.819		0.366			
3 Business Performance	0.466	0.627	0.816	0.465	0.676		
PANEL B Cross-loadings							
	SSC	SDP	ORP		SSC	SDP	ORP
SSC1	0.724	0.289	0.888	SDP4	0.396	0.153	0.574
SSC2	0.735	0.222	0.876	SDP5	0.436	0.268	0.541
SSC3	0.861	0.349	0.810	SDP6	0.267	0.350	0.463
SSC4	0.876	0.478	0.504	ORP1	0.256	0.257	0.810
SSC5	0.825	0.354	0.561	ORP2	0.283	0.283	0.762
SSC6	0.931	0.456	0.592	ORP3	0.376	0.282	0.799
SSC7	0.790	0.323	0.464	OPR4	0.271	0.415	0.830
SSC8	0.732	0.432	0.451	OPR5	0.244	0.153	0.787
SDP1	0.304	0.775	0.526	ORP6	0.331	0.463	0.893
SDP2	0.269	0.666	0.455	ORP7	0.272	0.437	0.844
SDP3	0.505	0.859				0.558	

Notes: SSC: Supply Chain; SDP: Sustainable Performance; ORP: Business Performance. **PANEL A:** Fornell-Larcker Criterion: Diagonal elements (bold) are the square root of the variance shared between the constructs and their measures (EVI). For discriminant validity, diagonal elements should be more significant than off-diagonal elements. **PANEL B:** Cross-loadings of the items for all the constructs.

Source: Own elaboration.

RESULTS

To respond to the two research hypotheses raised in this empirical study, PLS-SEM was used with the support of SmartPLS 3.3 software (Hair *et al.*, 2019) since this statistical modeling technique is the most recommended for the type of data available (Chin, 2010; Hair *et al.*, 2011; Henseler *et al.*, 2012), and its application is essentially recommended in those situations in which the theory is less developed (Hair *et al.*, 2012), the objective pursued when applying structural equation modeling is the prediction and explanation of critical constructs (Rigdon, 2012), the small sample size and the non-normality of the data derived from the measurement scales may be present (Henseler *et al.*, 2009; Hair *et al.*, 2012; Goodhue *et al.*, 2012). Table 3 shows more precisely the results obtained from the PLS-SEM application.

The results obtained from the application of PLS-SEM (Table 3) show that the adjusted R² value is more significant than 0.10, while f² values are positive (Hair *et al.*, 2019), and the SRMR value is below 0.08 (Hu & Bentler, 1998). Furthermore, the geodesic discrepancy (dG) and the unweighted least squares discrepancy (dULS) are below the HI99 values, thereby verifying the significance of the supply chain model (Dijkstra & Henseler, 2015). Finally, the results obtained verify that the supply chain of manufacturing firms in the automotive industry favors sustainable performance but not the level of firm performance, which is why the coefficient linked to the relationship between the supply chain and the sustainable and firm performance levels are 0.466 and 0.362, both being significant with p-values of 0.000.

Table 3. Structural Model

Paths	Path (t-value; p-value)	95% confidence interval	f ²	Support
SSC → SDP	0.466 [5.292; 0.000]	[0.263-0.605]	0.370	Yes
SSC → ORP	0.362 [4.004; 0.000]	[0.148-0.491]	0.225	Yes
Endogenous variable	Adjusted R ²	Model Fit	Value	HI99
SDP	0.248	SRMR	0.101	0.162
ORP	0.163	dULS	3.535	6.071
		dG	2.071	2.229

Notes: SSC: Supply Chain; SDP: Sustainable Performance; ORP: Firm Performance. One-tailed t-values and p-values in parentheses; bootstrapping 95% confidence intervals (based on n = 5000 subsamples) SRMR: standardized root mean squared residual; dULS: unweighted least squares discrepancy; dG: geodesic discrepancy; HI99: bootstrap-based 99% percentiles.

Source: Own elaboration.

In this sense, the supply chain significantly improves the level of performance of manufacturing firms in the automotive industry, only from the sustainability perspective but not from the economic perspective. Likewise, the coefficient linked to the relationship between the supply chain and the level of sustainable performance is positive and significant

Impact of the Supply Chain on Sustainable and Business Performance During the COVID-19 Pandemic

at 0.466 (p-value 0.000), which shows empirical evidence in favor of hypothesis H1 and coincides with the results obtained by Nandi *et al.* (2021). Finally, the results reveal the existence of a significant negative effect of the supply chain and the level of firm performance at 0.362 (p-value 0.000), which indicates that the supply chain is constraining the firm performance of manufacturing firms in the automotive industry, which is in line with the results obtained by Ranney *et al.* (2020).

Additionally, the results obtained in this empirical study also have different implications for managers and organizations, the first of which is related to the data derived from the application of the 65 surveys to the same number of companies, which allowed a general analysis of the existing relationship between the supply chain and the level of both sustainable and firm performance in a strategic sector of the Mexican economy, which is why in future studies it would be pertinent to analyze these same variables in longitudinal studies or successful case studies, to corroborate whether the supply chain is indeed one of the determinants of increased sustainable performance, but at the same time the effect during the COVID-19 pandemic on the supply chain also negatively affects the level of firm performance.

14

A second implication derived from the results obtained is that not only is a significant change taking place in the supply chain of manufacturing firms worldwide, since, in essence, the supply chain systems have adapted to the conditions of the market caused during the COVID-19 pandemic, by bringing as quickly as possible not only food and medical products to customers' homes, but also all types of products, including vehicles, which means that companies have to improve and make its supply chain management system more efficient, to significantly reduce product delivery times and conditions through a series of nodes and stages that allow products to reach the final consumer in the required conditions and time. Otherwise, supply chain inefficiency will lead to higher costs and market loss (Gligor *et al.*, 2019).

In this sense, the agility of the supply chain of manufacturing firms is presented as a third implication since agility contributes not only to the increase of competitive advantages but also to the improvement of the sustainable performance of companies (Gligor *et al.*, 2019). Thus, supply chain agility generally facilitates the delivery of all types of products to end consumers quickly and efficiently. However, the COVID-19 pandemic is putting increasing pressure on manufacturing firms to streamline their supply chain, not only due to unusual consumer purchasing behavior (Donthu & Gustafsson, 2020) but also to improve their sustainable performance, even though this does not allow them to increase their firm performance.

Under this threshold, despite the complexity that the supply chain represents, the managers of manufacturing firms in the automotive industry in Mexico that have among their goals the promotion of sustainability activities inside and outside the organizations, to future they will be able to obtain a more significant effect on firm performance (Nandi *et al.*, 2021). Therefore, this empirical evidence indicates that managers could increase their firm performance through a holistic strategy that includes the entire supply chain since the COVID-19 pandemic is forcing companies to produce, supply, order, and deliver the products required by end consumers through digital platforms (Ting *et al.*, 2020), which will impact the sustainability of companies.

Furthermore, the results obtained also have implications for the public administration of the three levels of government since government support and legislation are being used more intensely, derived from the pressure exerted by society as a whole (Wesseling *et al.*, 2015), as well as the so-called “new normal” resulting during the COVID-19 pandemic, which is making more evident the need to increase visibility over the supply chain, increase its flexibility and risk management. Therefore, the COVID-19 pandemic is forcing manufacturing firms, including the automotive industry, to prepare to better face future crises and pandemics through changing traditional supply chain systems (Sarkis *et al.*, 2020; Queiroz *et al.*, 2020).

Likewise, this study has several limitations, some of which may become future lines of research. Firstly, the sample only collects information from manufacturing firms in the automotive industry in Mexico, so the results could not be generalized to other sectors or other countries, and it would be interesting to apply more studies of this type in different sectors or countries to verify the results obtained. Secondly, only one study has been carried out considering cross-sectional data, so temporal effects have yet to be analyzed in the proposed model, hence the importance of researchers, academics, and industry professionals carrying out longitudinal studies. Thirdly, a survey was applied only to company managers. In future studies, it would be essential to analyze the effects of the COVID-19 pandemic on workers' health and validate the information with data from subsequent companies to the COVID-19 pandemic.

Thirdly, the information was obtained only from 65 surveys that collected the opinions of company managers. Therefore, using quantitative data from other sources or the opinions of employees and suppliers could reinforce the results obtained in this study (Afsar *et al.*, 2020). However, it is essential to highlight that the level of formal information in Mexico through statistics needs to be revised. Furthermore, this study opens future lines of research that can contribute to strengthening the literature on sustainability and supply chain in the automotive industry since some of these future studies can be oriented towards the analysis of the mediating effect of some particular characteristics of managers of manufacturing firms such

Impact of the Supply Chain on Sustainable and Business Performance During the COVID-19 Pandemic

as level of education, gender, experience, etc., or contingent factors such as the level of growth of the companies, their level of dynamism, competitiveness, etc.

CONCLUSIONS

The results obtained in this study allow us to generate various conclusions, among which the following stand out. The first conclusion is that the model of the relationship between the supply chain, sustainable performance, and firm performance has internal solid consistency, obtaining a high correlation between the three constructs, which allowed the acceptance of the two proposed hypotheses. A second conclusion is that the supply chain can be considered an effective business strategy since it generates various benefits not only to final consumers but also to manufacturing firms that make up the Mexican automotive industry, as it is considered an alternative for reducing the adverse effects caused during the COVID-19 pandemic, not only in Mexico but also globally.

A third conclusion is that this study focuses on how the supply chain contributes to increasing sustainable performance and decreasing firm performance in the context of the Mexican automotive industry through the analysis of an empirical study on a sample of 65 manufacturing firms. Thus, the relationship between these three constructs is a topic that is still open to discussion in the current literature (Mena & Schoenherr, 2020), with the literature establishing the need for researchers, academics, and industry professionals to guide their studies in the empirical contrast in different contexts (Nandi *et al.*, 2021).

A fourth conclusion is that the results obtained have shown that supply chain activities strongly influence the sustainable performance of manufacturing firms in the automotive industry in Mexico since these effects are not only direct and cheerful but also significant adverse indirect effects are identified that allow us to establish the existence of a reduction in the level of firm performance. In this sense, the sustainable performance of the manufacturing firms analyzed benefits from the good practices implemented through supply chain activities, even when they are also reducing the level of firm performance.

Finally, the supply chain is strongly associated with increasing sustainable performance (Hazarika *et al.*, 2019; Lin *et al.*, 2020) and decreasing firm performance (Ivanov & Das, 2020; Chowdhury *et al.*, 2021). Therefore, this empirical study contributes to previous literature by enriching the analysis and discussion on sustainability and providing theoretical and empirical evidence that determines the importance of the relationship between the supply chain and sustainable performance and the level of firm performance. This is especially important since, due to the level of complexity and global expansion of the automotive

industry supply chain, manufacturing firms face various internal changes to adequately and efficiently manage the adverse effects of the COVID-19 pandemic (Nandi *et al.*, 2021).

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Impact of the Supply Chain on Sustainable and Business Performance During the COVID-19 Pandemic

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