

UNRAVELING THE BLACK BOX OF SUPPLY CHAIN FLEXIBILITY IN LEAN PRODUCTION ENVIRONMENTS

Abstract

Purpose – This research further examines the full mediating role of Supply Chain Flexibility (SCF) between Lean Production (LP) and business results (BP) found in the previous literature. This effect negates the direct LP-BP effect (the so-called “total eclipse effect”). We analyze the individual contributions that the different SCF dimensions (sourcing flexibility; operating system flexibility; distribution flexibility, and information system flexibility) make to the “total eclipse effect” between LP and BP produced by SCF. The Relational Resources-Based View and Resource Orchestration Theory are used to support the theoretical framework.

Design/methodology/approach – Covariance-based Structural Equations Modeling (CB-SEM) is used to test the SCF LP-BP total eclipse hypothesis and four additional mediation hypotheses, one for each of the SCF dimensions. Data obtained via a questionnaire given to 260 companies are analyzed with CB-SEM, and SPSS Process is used to evaluate the mediation effect.

Findings – Research results indicate that only one of the dimensions (operating system flexibility) has a full mediation effect between LP and BP and is, therefore, the main contributor to the eclipse effect. Two other dimensions (sourcing flexibility and distribution flexibility) have partial mediation effects, so they also contribute to developing the eclipse effect, although to a lesser extent. Lastly, information system flexibility is neither a full nor a partial mediation factor and does not contribute to the eclipse effect.

Originality/value – These findings have some important implications. For academia, they generate new knowledge of the role that each of the SCF dimensions or components plays in the LP-BP relationship. For company management, the findings offer supply chain managers specific information on the individual effects that the different types of SCF flexibility have between LP and BP. This will allow companies to target their efforts to develop certain types of flexibility in LP contexts depending on the outcomes that senior managers want to achieve with their SCs.

Keywords: Lean Production, Supply Chain Flexibility, Supply Chain Flexibility dimensions, Business Performance, Mediation.

1. INTRODUCTION

Supply Chain Flexibility (SCF) is defined as the capability of a company network composed of a focal company and its suppliers and customers to adapt to fluctuations in the chain and changes in the environment (Tiwari *et al.*, 2015). Companies currently operate in an extremely complex and highly changing environment and competition is based on their supply chains (SC) rather than on the companies themselves (Gilchrist, 2016; Ghobakhloo *et al.*, 2018).

In this context, SCF takes on great importance as SCs must be very flexible (Malhotra and Mackelprang, 2012; Luo and Yu, 2016; Enrique *et al.*, 2022) to continually adapt to a highly changing environment (Tiwari *et al.*, 2015; Enrique *et al.*, 2022). In addition, major changes in the environment caused by the Covid-19 pandemic and the Russia-Ukraine war have led to considerable transformations in SCs (Kazancoglu *et al.*, 2022; Ali *et al.*, 2023), and only SCs that have developed a high level of flexibility have been able to adapt to all these changes (Chenarides *et al.*, 2020; Kazancoglu *et al.*, 2022) and survive.

In other respects, since the end of the 1990s, companies have been using the Lean system to eliminate wastage, become more efficient, and reduce variability by eliminating everything that does not add value from the customer perspective (Moyano-Fuentes and Sacristán-Díaz, 2012). Companies initially implemented Lean internally, especially in the production area (Lean Production, LP) (Warnecke and Hüser, 1995; Jasti and Kodali, 2015), and its use led to improvements in both their economic (Dieste *et al.*, 2021) and operational (Wee and Wu, 2009; Wiengarten *et al.*, 2013; Marodin *et al.*, 2016) business performance (BP) (Losonci and Demeter, 2013; Luo and Yu, 2016; Abreu-Ledón *et al.*, 2018). Extending Lean practices to the SC (Lamming, 1996) multiplies its beneficial effects for the companies in the chain (Wee and Wu, 2009; Moyano-Fuentes *et al.*, 2019; 2021) including, especially, more flexible SCs (Qamar *et al.*, 2018; Maqueira *et al.*, 2021; Moyano-Fuentes *et al.*, 2021) and a more powerful effect on BP (Moyano-Fuentes *et al.*, 2021). However, the literature states that a deeper understanding is needed of the way that internal and external aspects of SCs align to contribute to improving BP (Prajogo *et al.*, 2016).

Hofer *et al.* (2012), Qrunfleh and Tarafdar (2013), and Moyano-Fuentes *et al.* (2021) state that some SC components mediate the internal implementation of Lean and BP. In this line, recent findings in the literature show that SCF plays a mediating role between LP and BP and produces what has been called a "total eclipse" (Maqueira *et al.*, 2021). This term refers to the effect noted in the prior literature of SCF nullifying the direct positive relationship between LP and BP (Wee and Wu, 2009; Losonci and Demeter, 2013; Marodin *et al.*, 2016) found when SCF is not present (Maqueira *et al.*, 2021). Maqueira *et al.*, 2021 explain the "total eclipse" effect that SCF has between LP and BP as follows: firms begin to use Lean (LP) internally to improve BP and achieve this goal. However, as time passes, the LP practices spread among the various agents in the SC and they also become very flexible. When this occurs, SCF has a multiplier effect on BP that renders the earlier direct effect between LP and BP negligible (Maqueira *et al.*, 2021). SCF is an

extremely complex concept composed of several dimensions that the prior literature has sought to analyze (see literature review by Tiwari *et al.*, 2015; Manders *et al.*, 2017). One widely used taxonomy (Swafford *et al.*, 2006; Moon *et al.*, 2012; Rojo *et al.*, 2016, 2018, 2020) distinguishes the following dimensions as the main components of SCF: (1) sourcing flexibility; (2) operating system flexibility; (3) distribution flexibility, and (4) information system flexibility. Although the prior literature recognizes that SCF is a multidimensional concept (see Stevenson and Spring, 2007 for a broad review of the topic), most of the empirical studies analyzed in a literature review by Liu *et al.* (2019) consider SCF as a single unit and ignore the fact that the antecedents and consequences of each of the SCF components are different (Tachizawa and Gimenez, 2009; Rojo-Gallego-Burín *et al.*, 2020) and that managers make separate decisions on SCF for each of the specific parties involved (suppliers, distributors, information system, etc.) (Choi and Krause, 2006; Gligor *et al.*, 2020; Um and Han, 2021). It is extremely useful for academia and firms to know about the individual mechanisms that underlie this "eclipse total" effect so that they can achieve the multiplier effect of SCF on BP in LP contexts. Knowledge of these mechanisms will enable more judicious decision-making that acts on each of the SCF components to drive up BP in LP contexts.

The relevance of SCF for company survival in today's complex environments (Chenarides *et al.*, 2020; Kazancoglu *et al.*, 2022; Ali *et al.*, 2023) and the importance that SCF can have in LP environments due to its multiplier effect on BP (total eclipse effect) (Maqueira *et al.*, 2021) demand further exploration of the role that SCF's full mediation plays in the LP-BP relationship found in the prior literature (Maqueira *et al.*, 2021). This is especially true given that managers do not make decisions on SCF holistically but individually on each of the SCF dimensions (Choi and Krause, 2006; Gligor *et al.*, 2020; Um and Han, 2021). It is important to identify whether all the SCF components contribute to the "eclipse effect" or whether it is produced by only one or several of the SCF components (Maqueira *et al.*, 2021).

This is, therefore, the purpose of this research, which is supported by two explanatory theories: The Relational Resources-Based View (Lavie, 2006) and the Resource Orchestration Theory (Sirmon *et al.*, 2011). Derived from the resources and capabilities theories, these two theories provide a theoretical base that conforms with the above arguments as, on the one hand, the resources are shared and mobilized in company networks and, on the other, they highlight the major role of senior management in identifying, combining, implementing, and leveraging these resources in company networks to generate new capabilities. The theoretical framework

developed in this work enables contributions to be made to both of these theories. This work's main contribution to the RRBV is to highlight the importance of sharing and exploiting resources in a company network to achieve flexibility (in this case, SCF). The resources that are freed up by extending LP practices along the SC and eliminating wastage allow new investments to be made into the new resources that SCF enables. Also, the results of this work allow the areas of SC to be identified in which these new resources should be put into operation to improve BP. This work contributes to ROT in LP contexts by defining a hierarchy of areas that need to be prioritized and that managers should address sequentially through the identification, combination, leveraging, and implementation of their own resources and those of the company network to improve BP via SCF (see theoretical implications and discussion section).

As far as the authors know, this analysis is original, and the results are interesting for both academia and company management. This work's main contributions to the literature are that (i) new academic knowledge is generated on the individual roles that the SCF dimensions or components play in the LP-BP relationship, given that SCF's role is considered to be highly relevant in the LP context (Hallavo, 2015; Qamar *et al.*, 2018; Moyano-Fuentes *et al.*, 2021), and (ii) the results inform SC managers about the specific individual effects that different types of SCF flexibility have on the LP-BP relationship. This knowledge will enable company managers to pursue the development of certain types of flexibility in LP contexts and prioritize some types over others when they wish to use their SCs to trigger some specific desired effects on performance.

This paper has been organized as follows. The following section briefly describes the theoretical background. The third section details the arguments that generate the hypotheses. The fourth section includes a description of the sample and methods used in the empirical analysis. The fifth section analyzes the results. The last two sections include a discussion, the main conclusions, research directions, and limitations.

2. THEORETICAL BACKGROUND

2.1. Relational Resource-Based View and Resource Orchestration Theory

The Relational Resource-Based View (RRBV) (Dyer and Sing, 1998; Lavie, 2006; Prajogo *et al.*, 2016), alternatively called the Extended Resource-Based View (Lewis *et al.*, 2010) is an extension of the Resources Based View (RBV) (Barney, 2001) that integrates the basic principles of the RBV theory and network theory. RRBV analyzes inter-organizational

relationships to explain how cooperation and collaboration between network members enable firms to obtain a competitive advantage through resource sharing (Dyer and Sing, 1998). According to the RBV, the resources that generate competitive advantage are valuable, rare, scarce, and difficult to imitate (Barney, 2001), so, shared resources in a company network are even rarer and more valuable (Lavie, 2006; Lewis *et al.*, 2010). Relationships of this type are also extremely difficult to imitate and constitute a competitive advantage (Lewis *et al.*, 2010; Prajogo *et al.*, 2016). This theoretical focus has previously been used to successfully explain the resource complementarity effect in LP (Agyabeng-Mensah *et al.*, 2020; Kumar and Sanchez-Rodrigues, 2020) and SC environments (Xu *et al.*, 2014; Yang *et al.*, 2019; Patrucco *et al.*, 2022).

Resource Orchestration Theory (ROT) is a theoretical lens that combines RBV and the dynamic capabilities theory and extends them to overcome the limitations of both (Sirmon *et al.*, 2011). As neither of these theoretical frameworks identifies how resources and capabilities can be developed in firms, ROT covers the gap by emphasizing the key character of managers as "orchestra conductors" who identify, bundle, and leverage resources to build new resources. As these new resources do not create a competitive advantage *per se* (Helfat *et al.*, 2007; Sirmon *et al.*, 2007), they are integrated into bundles to form capabilities, which are then leveraged to achieve a competitive advantage for the firm (Sirmon *et al.*, 2011). Although resources and capabilities are already difficult to imitate on their own, it is even more difficult to imitate the way that they are coordinated and synchronized (Hitt *et al.*, 2016), and this theoretical focus has recently been used for SCF (Rojo *et al.*, 2018; 2020; Benzidia and Makaoui, 2020; Jafari *et al.*, 2022a).

2.2 Lean Production, Supply Chain Flexibility, and the Business Performance relationship

The internal LP-BP relationship has been widely analyzed in the literature (see literature review by Negrão *et al.*, 2017) and, since the pioneering use of LP in the Toyota Corporation (Womack *et al.*, 1990), many companies have used LP to improve their results (Wee and Wu, 2009; Marodin *et al.*, 2016). As this improvement has also transferred to their financial performance (Dieste *et al.*, 2021), there is a broad level of consensus in the literature that a direct positive relationship exists between LP and BP (Negrão *et al.*, 2017). In addition, some works have found that internal LP use in companies is an antecedent of its extension to the SC (Lean Supply Chain, LSC) (Wee and Wu, 2009; Moyano-Fuentes *et al.*, 2021). In this line, research by Moyano-Fuentes *et al.* (2021) finds a positive and direct relationship between the use of lean internally and the extension of lean to the supply chain (LSC), and that LSC has a mediating effect

between the focal firm's internal use of lean and its operational performance. However, analysis **in the literature** of LSC's relationship with performance has been limited (see literature review by García-Buendía *et al.*, 2021).

In other respects, various works can be found in the literature that associates the concept of LP with flexibility (Boyle and Scherrer-Rathje, 2009; Lucherini and Rapaccini, 2017) and find that companies that implement LP increase their internal flexibility significantly. For example, Boyle and Scherrer-Rathje (2009) find that applying best practices that reduce sources of variability in manufacturing (such as LP practices: work cells, Single Minute Exchange Die (SMED), Just In Time (JIT), Total Quality Management (TQM)) enables greater flexibility in the area, and Lucherini and Rapaccini (2017) find that using LP practices (Cellular Manufacturing, JIT, SMED) produces manufacturing flexibility. LSC implementation is also associated with higher levels of SCF (Moyano-Fuentes *et al.*, 2019; Núñez-Merino *et al.*, 2020; Moyano-Fuentes *et al.*, 2021). Specifically, in a Systematic Literature Review on the effect that Industry 4.0 Information Technologies have on LSC, Núñez-Merino *et al.* (2020) find that these technologies generate SCF in this context. Qamar *et al.* (2018, 2020) find evidence in the automotive sector that both LP and Agile Production are related to SCF. Therefore, as LP is an antecedent of LSC (Moyano-Fuentes *et al.*, 2021), it is also an antecedent of SCF (Qamar *et al.*, 2018). Recent findings have revealed that the SC flexibility produced by the focal firm's internal use of LP has such a powerful effect on BP that it makes the direct effect of LP on performance so negligible that it is completely eclipsed. More precisely, despite the scarcity of contributions to the literature that analyze the relationship between LP and SCF, Maqueira *et al.* (2021) discovered this curious effect of SCF, which acts as a total mediation variable in the LP-BP relationship. Said authors explained that LP produces this total eclipse effect via the SCF-BP pathway and that it is so powerful that it renders the direct LP-BP effect negligible. However, as the literature shows, SCF is a very complex construct that comprises various dimensions (see literature review by Tiwari *et al.*, 2015; Manders *et al.*, 2017). Thus, further investigation is required into how this eclipse effect is produced with an analysis of the roles played by the different SCF dimensions in the LP-BP relationship. Maqueira *et al.* (2021) expressly state this as a future research line.

3. RESEARCH HYPOTHESES

3.1 Supply Chain Flexibility's "total eclipse" effect between Lean Production and Business Performance

Since the launch of the Toyota Production System (Womack *et al.*, 1990), there have been many successful internal implementations of LP in companies that have had positive economic (Dieste *et al.*, 2021) and operational (Wee and Wu, 2009; Marodin *et al.*, 2016) effects on BP (Losonci and Demeter, 2013; Luo and Yu, 2016; Abreu-Ledón *et al.*, 2018). Thus, there is a wide consensus in the scientific community on the effect between LP implementation and improvements to BP (Negrão *et al.*, 2017). For example, the flexibility provided by some specific Lean practices such as the "U-shape" plant configuration with flexible manufacturing cells enables production in small lot sizes, which involves suppliers (upstream SC) and optimizes operator movements. Thus, there is a reduction in cycle time and consequent improvements to some specific operating results (Aprile *et al.*, 2006; Moyano-Fuentes, Martínez-Jurado *et al.*, 2012). In addition, Lean practices, in general, also reduce wastage, which lowers costs and generates better BP (Lage-Junior and Godinho-Filho, 2010).

RRBV and ROT give support to the above. Senior managers in the production area detect, combine, and deploy new resources in their SCs which, when implemented, help to improve performance. For example, when companies use an information system to manage an electronic kanban (e-kanban) system to extend LP in their SC company network, they turn kanban into a resource shared by multiple companies; a resource that is rare, scarce, and difficult to imitate. Also, e-kanbans in the SC eliminate distribution and delivery errors and improve quality, which reduces non-quality costs and improves financial performance (Aprile *et al.*, 2006; Lage-Junior and Godinho-Filho, 2010). These arguments allow us to formulate the following hypothesis:

HYPOTHESIS H1a: There is a direct positive relationship between LP and Business Performance.

As previously stated, Maqueira *et al.* (2021) indicate that focal companies that implement LP internally achieve better BP. They also state that, over time, LP raises the level of SCF significantly and, when this happens, SCF's effect on performance is so powerful that the direct effect of LP on BP becomes negligible. So, SCF fully mediates LP-BP (Maqueira *et al.*, 2021). The findings of Moyano-Fuentes *et al.* (2021) are comparable, with LP found to be an antecedent to extending Lean to the SC, and a full indirect mediation effect found to exist between LSC and the operating results. So, there is a certain similarity between the concepts of LSC and SCF (Maqueira *et al.*, 2021; Moyano-Fuentes *et al.*, 2021). These findings can be explained by the RRBV and ROT. When Lean is extended to the SC, it is no longer only the focal firm's resources that are deployed but also the resources of a large number of agents in the chain. As a result, many

more resources are in operation and working hard to improve the efficiency of all the SC agents, which greatly impacts the focal firm's performance. The task assigned to the senior SC managers is to identify, select, implement, and orchestrate combinations of these resources as leveraging the resources associated with the Lean practices that have been extended along the SC has a significant impact on BP. We can, therefore, formulate the following hypothesis based on the above findings and arguments:

HYPOTHESIS H1b: Supply Chain Flexibility has a total mediation effect between LP and Business Performance.

For the SCF "total eclipse" effect to exist, the isolated effect of LP on BP needs to be positive and significant. In this sense, as has been shown and argued in hypothesis H1a, abundant previous research has generated a broad knowledge base that demonstrates that this individual effect exists (Negrão *et al.*, 2017). This leads us to formulate the following hypothesis as an extension of H1a and H1b.

HYPOTHESIS H1c: In isolation, LP has a direct positive effect on Business Performance.

Figure 1 shows the hypothesized models of the total eclipse effect; the Baseline Model (SCF total mediation) and Model 1 (direct effect on LP-BP in the absence of SCF).

Insert Figure 1 here:

Theoretical, hypothesized models:

Baseline Model (SCF total mediation) and Model 1 (isolated effect on LP-BP)

3.2 Individual mediation effects of Supply Chain Flexibility Dimensions between Lean Production and Business Performance

3.2.1 Mediation of Supply Chain Sourcing Flexibility

The main purpose of LP is to eliminate wastage and minimize internal and external variability as far as is possible (Naylor *et al.*, 1999; Purvis *et al.*, 2014; Qamar *et al.*, 2018; Moyano-Fuentes *et al.*, 2019). As a result, LP puts great emphasis on the resources that enable wastage to be eliminated and on the capabilities that enable high efficiency levels to be obtained (Shah and Ward, 2003; Qamar *et al.*, 2018). Whilst internal variability implies scrutiny of the

company's internal behavior, external variability implies extending the analysis to the SC level and suppliers and customers. Several authors state that applying LP internally enables practices to be implemented at the SC level, which improves chain flexibility (related to external variability), and that this, in turn, contributes to improving BP (Wu, 2003; Moyano-Fuentes *et al.*, 2021).

Applying LP involves implementing a series of management practices, some of which are closely linked to the relationship that firms have with their suppliers (Lamming, 1996; Wu, 2003; Moyano-Fuentes *et al.*, 2019). Companies that implement LP normally operate under stable demand conditions (Purvis *et al.*, 2014; Jha *et al.*, 2022), so, *inter alia*, they need to cement long-term relationships with some strategic suppliers based on trust and mutual commitment. These strategic suppliers should be assessed on their resources and capabilities, the added value that they provide, delivery fulfillment, and product quality, among other things (Wu, 2003; Purvis *et al.*, 2014; Qamar *et al.*, 2018; Moyano-Fuentes *et al.*, 2019). A long-term relationship with strategic suppliers is one of the practices that help to reduce external SC variability.

According to the RRBV, these associations with long-term strategic suppliers involve a combination of resources and capabilities that are valuable, unique, and difficult to imitate (Lavie, 2006; Lewis *et al.*, 2010; Ko *et al.*, 2018). They can become a strategic tool that allows to achieve a competitive advantage and, therefore, better performance (Lewis *et al.*, 2010; Omar *et al.*, 2012; Prajogo *et al.*, 2016; Moyano-Fuentes *et al.*, 2021). This is confirmed by prior studies that have found that companies with close relationships with their suppliers achieve better results (Dwyer *et al.*, 1987; Lambert and Knemeyer, 2004; Fynes *et al.*, 2005). So, in the current competitive environment characterized by high levels of uncertainty, the resources and capabilities provided by different suppliers can create more flexible SCs (SC sourcing flexibility), which positively impacts performance (Swaminathan, 2001). In LP contexts, companies seeking greater flexibility are paying greater attention to their SC partners (Purvis *et al.*, 2014), which implies constantly considering the possibility of reconfiguring the chain (Duclos *et al.*, 2003; Lummus *et al.* 2003; Moon *et al.*, 2012; Purvis *et al.*, 2014) rapidly and at a low cost (Tachizawa and Thomsen, 2007; Purvis *et al.*, 2014) in order to achieve the desired flexibility and, in turn, improve performance.

In this line, authors such as Duclos *et al.* (2003), Gosain *et al.* (2005), and Stevenson and Spring (2007) consider SC sourcing flexibility to be the SC coordinator's skill at reconfiguring an SC network by identifying, selecting, evaluating, incorporating, and replacing suppliers as and when required to adapt to changes in demand (Swafford *et al.*, 2006). This might entail the need

to expand the supplier base to obtain alternative supply sources (all good suppliers with long-term contracts) in order to give the SC the greater flexibility (Narasimhan and Das, 2000; Christopher *et al.*, 2005; Moon *et al.*, 2012; Purvis *et al.*, 2014) that it requires to respond to changes in demand (Jafari *et al.*, 2022b). Following Krajewski *et al.* (2005), one important aspect that should be taken into account is the type of components that are acquired. According to these authors, fixed-term contracts are more appropriate in the case of strategic components (highly complex and high value) as they reduce supplier uncertainty.

So, as Stevenson and Spring (2007) indicate, to increase SC sourcing flexibility, SC coordinators should be able to (i) constantly reconfigure their SCs to easily make adjustments when there are changes in the environment or when some specific needs arise (Gosain *et al.*, 2005), and (ii) easily and rapidly expand or swap suppliers in and out of this broader good supplier base (Swafford *et al.*, 2006; Moon *et al.*, 2012). These last authors also state that companies with a broader and more varied supplier base where suppliers can be easily swapped in and out at will could be more competent at ensuring the flow of materials and components needed for everyday operations (Moon *et al.*, 2012), thus minimizing any possible supplier uncertainty. The aim would be to achieve flexibility by establishing long-term contracts with a wide range of suppliers, which does not contradict LP practices. In this sense, the ability to establish partnerships and perform data analytics is extremely important and both capabilities have a positive effect on SCF that is moderated by the dynamic environment (Bag and Rahman, 2023). In this line, based on their study of the automotive industry in the Midlands (UK), Qamar *et al.* (2018) state that the company that coordinates the SC (which in their case has implemented LP) could focus on efficiency and use supplier management to achieve the required high levels of flexibility. In this sense, Ko *et al.* (2018) state that focal companies should focus on creating and maintaining supplier relationships that enable them to generate flexibility in their SCs as this has a positive impact on BP (in this specific case, through improving product innovation). In addition, having a broad supplier base that makes it easy to change how orders are allocated to suppliers is frequently cited in the literature on risk mitigation strategies (Piprani *et al.*, 2022).

Through the RRBV and ROT optic, the focal company's skill at identifying, grouping, combining, and coordinating/orchestrating the resources and capabilities of this broad supplier base as required in LP contexts (Christopher *et al.*, 2005; Helfat *et al.*, 2007; Sirmon *et al.*, 2011) is much more difficult to imitate and, thus, is a strategic tool for competing and improving BP (Hitt *et al.*, 2016).

Based on the foregoing arguments, SC sourcing flexibility can be anticipated to generate an indirect impact of LP implementation on BP, whereby we now formulate the following hypothesis:

HYPOTHESIS H2: Sourcing Flexibility in the Supply Chain has an individual mediation effect between LP and Business Performance.

3.2.2 Mediation of Supply Chain Operating System Flexibility

The ROT theoretical framework enables to visualize the implementation of LP practices as a bundle or portfolio of complementary practices or as the orchestration of a series of company-level resources and processes. ROT states that it is the managers' responsibility to detect, develop, and leverage bundles of practices, resources, and capabilities that act in synergy to obtain a sustained competitive advantage and, therefore, improve BP (Helfat *et al.*, 2007; Sirmon *et al.*, 2011). However, according to Baert *et al.* (2016), whether managers can generate synergy depends on the potential for resource and practice complementarity, among other things. Nawanir *et al.* (2020) empirically demonstrate that LP practices can have a greater effect when they are applied in combinations, as some complement and feed back into others, which transforms them into a portfolio that is likely to produce a competitive advantage through the development of operating system flexibility in the SC. This synergetic and multiplier effect can also be explained by the RRBV as contributions made by a variety of organizations in the SC network.

It must be taken into account that SC operating system flexibility is complex and its development requires the implementation of a set of appropriately combined practices (Mishra, 2016). Boyle and Scherrer-Rathje (2009) surveyed 168 North American manufacturing managers to identify the practices, tools, and techniques that they implement to improve flexibility in SC operations. The LP practices that they mentioned included work cells, SMED, JIT, TQM, and Total Productive Management (TPM) (as modified processes, design innovation, defect prevention...). Moreover, except for overcapacity, all of the top five best practices identified by manufacturing managers (multifunctional employees, focused factory, reduced setup time, kanban, and overcapacity) are considered to form part of LP. Similarly, the literature review by Nurdiani *et al.* (2018) concluded that implementing LP practices contributes to operating system flexibility (a finding attributed to software development). Further, Lucherini and Rapaccini (2017) used the case method to analyze improvements in operating system flexibility obtained through the implementation of LP practices (cellular manufacturing, JIT, and SMED) and

concluded that these contribute to the development of product mix flexibility and volume flexibility, which are both key flexibility drivers of SC operating system flexibility (Metternich *et al.*, 2013). Also, Nawanir *et al.* (2020) empirically demonstrated that this bundle of LP practices enhances SC operating system flexibility and reduces lead time, which improves BP. So, for example, the typical cellular-manufacturing LP plant layout enables the production flow to be instantly modified in the case of a machine breaking down. Likewise, TQM ensures that products are manufactured with the quality and variability that customers demand (Mishra, 2016; Nawanir *et al.*, 2020) and JIT provides flexibility by ensuring that products are available when and as they are required (Mishra, 2016). All these practices could be sources of the SCF that improves BP.

One of the basic principles of LP is that its implementation should reduce waste and, therefore, costs, which would improve BP (Moyano-Fuentes and Sacristán Diaz, 2012; Santos *et al.*, 2023). However, not all the works that analyze LP implementation find that this effect is produced automatically (Lin and Hui, 1999; Lewis, 2000). These diverging results in the prior literature can be explained by ROT, according to which the positive effect of LP on BP depends on whether different LP practices have been suitably orchestrated or combined to produce this synergistic or multiplier effect capable of developing SC operating system flexibility. In turn, SC operative system flexibility enables companies to offer products with a wide range of features, achieve economies of scale and scope (Stump and Badurdeen, 2012), standardize their processes to adapt as efficiently as possible to changes in the environment (Maqueira *et al.*, 2021) and, ultimately, improve BP.

Based on all the preceding arguments, LP implementation should be expected to have an indirect impact on BP through SC operating system flexibility, whereby we formulate the following hypothesis:

HYPOTHESIS H3: Operating System Flexibility in the Supply Chain has an individual mediation effect between LP and Business Performance.

3.2.3 Mediation of Supply Chain Distribution Flexibility

With instant response becoming the norm nowadays, the capability to make a product widely available and easily accessible is critical. As a result, companies are adopting decisions that would seem to be counterintuitive. For example, Amazon, which specializes in global sales, continues to open new physical distribution centers and delivery lockers in convenience stores near customers for on-time delivery, fast delivery, and customer convenience (Min *et al.*, 2019).

Previous works indicate that internal Lean use (such as LP) not only improves company-level performance but also facilitates the implementation of practices at the SC level (Wu, 2003; Moyano-Fuentes *et al.*, 2021).

According to the RRBV, the SC is a competitive weapon that is difficult to imitate and can improve focal company efficiency by enhancing the operational processes capability (Ketchen and Hult, 2007; Moyano-Fuentes *et al.*, 2021). Some works state that LP practices and SCF complement each other to ensure appropriate distribution and delivery performance (Christiansen *et al.*, 2003). In this context, distribution flexibility, which is connected to the capabilities of adapting to global requirements, meeting different customers' needs, modifying warehouse space, modifying transportation carriers, and incorporating product postponement (Lummus *et al.*, 2003; Moon *et al.*, 2012), is a high-customer-impact feature of SCF that requires SC members' collaboration in sharing logistics resources.

The process standardization and integration advocated by Lean (Tsai and Lasminar, 2021) needs to be complemented by SC delivery flexibility to improve BP. Shipment sizes tend to be smaller but more frequent in LP environments, which requires the capability to control and effectively respond through the transportation process (Wu, 2003). The use of standardized containers in transportation simplifies material distribution flows and helps reduce inventory (Nicholas, 1998; Wu, 2003), and this affords greater flexibility and helps improve results (Marley *et al.*, 2014). Similarly, suppliers in LP contexts are perfectly positioned to make frequent deliveries and facilitate transportation to support production through minimum plant inventory levels and a practically invisible transportation system (Wu, 2003). Suppliers can reduce expedited outbound shipments, achieve logistics advantages, and obtain superior load results by using side-loading trucks/trailers and having additional trucks/trailers standing by at the bay (Wu, 2003) as this provides the greater distribution and delivery flexibility that enables performance improvements. However, more recent studies indicate that minimizing inventory and JIT deliveries increases the frequency of replenishment cycles and, therefore, increases the total distance covered (Jakhar *et al.*, 2018) with a consequent rise in costs. Therefore, the capability to swap in or swap out carriers or other distributors is essential. This capability brings distribution and delivery flexibility, which enables relationships with a variety of carriers and the selection of the most suitable carrier for each delivery mode. Product delivery is, therefore, not affected by the main carrier being unable to comply with the delivery requirements (Moon *et al.*, 2012), and, ultimately, BP is not impacted.

In other respects, the reduction of delivery transport costs in JIT contexts requires integrated inventory and warehouse space management along the SC (Chen and Sarker, 2010). Srinivasan and Swink (2018) find that in today's changing contexts, companies must have a high degree of operating flexibility to develop lateral relationships with customers and suppliers to reduce operating costs and improve delivery performance. Warehouse space limitations are restrictions that are taken into consideration when lot sizes are reduced and optimized to control and manage inventory costs in integrated SCs (Shekarabi *et al.*, 2019). So, the LP practice of small lot manufacturing must be complemented with the capability to change warehouse space as, in conjunction, they offer distribution flexibility and enable to achieve better performance. In addition, distribution flexibility enables to control material and information flows to ensure that delivery programming adapts to customer orders (Lopes de Sousa Jabbour *et al.*, 2020), which would also have a positive effect on results.

Taking all these arguments together, an indirect impact of LP implementation on performance should be expected via SC distribution and delivery flexibility. This enables the following hypothesis to be formulated:

HYPOTHESIS H4: Distribution Flexibility in the Supply Chain has an individual mediation effect between LP and Business Results

3.2.4 Mediation of Supply Chain Information System Flexibility

Although LP can be implemented by introducing simple practices that do not need the support of an Information System (IS), this is the perfect tool for developing new capabilities in the SC that have a direct bearing on obtaining better BP (Moyano-Fuentes *et al.*, 2012). So, over time companies that implement LP adopt an IS that operates both internally in companies and externally (connecting the company with its suppliers and customers) to increase the effects of LP and achieve better performance (Moyano-Fuentes *et al.*, 2012). Adopting an IS also enables companies that configure SCs to develop internal capabilities that provide flexibility (Jin *et al.*, 2014; Qrunfleh and Tarafdar, 2014; Delic and Evers, 2020). For example, Jin *et al.* (2014) find that the information-sharing capability enabled by IS generates SCF, which enables a company to obtain a competitive advantage; Delic and Evers (2020) find that using additive manufacturing/3D printing has a direct positive relationship with SCF (IS use enables SCF) and this, in turn, has a positive impact on results. Finally, Qrunfleh and Tarafdar (2014) find a relationship between Lean strategy, IS strategy, SC, and BP. Several SC capabilities enabled by

IS contribute to increasing SCF in an LP environment (Gosain *et al.*, 2005; Kumar *et al.*, 2006; Srinivasan and Swink, 2018; Tsai and Lasminar, 2021) and thus improve the focal company's performance more than when SCF is not developed (Qrunfleh and Tarafdar, 2014). In LP contexts, the capabilities that generate SCF emerge when IS is applied to external logistics (Novais *et al.*, 2020), internal logistics (Jin *et al.*, 2014), or other business functions (Qrunfleh and Tarafdar, 2014). In this line, Novais *et al.* (2020) find that the use in LP environments of new technologies such as Cloud Computing applied to logistics develops high SC integration (a capability that generates SCF) and the indirect effect of LP on BP via cloud-supported logistics and SC integration is much stronger than its direct effect.

RRBV and ROT explain that IS is a tool or resource shared by the different companies in the SC and operationalizing this resource develops new capabilities in the agents that use the resources provided by SCF, which enables companies to obtain better results. In addition, it is the SC managers who use this shared resource and combine it with other resources that generate the new capabilities that impact both SCF and, even more powerfully, performance.

The above arguments allow us to formulate the following hypothesis:

HYPOTHESIS H5: Information System Flexibility in the Supply Chain has an individual mediation effect between LP and Business Results.

Figure 2 shows the theoretical model with the individual mediation effects of the SCF components (Models 2, 3, 4, and 5).

Insert Figure 2 here:

Theoretical, hypothesized Models 2, 3, 4, and 5: individual mediation effects of SCF components

4. METHOD

4.1 Population, questionnaire, and data gathering

A population of 1,717 companies taken from the Iberian Balance Sheet Analysis System (SABI) was used to test the research hypotheses. This population was identified based on some specific inclusion criteria: Spanish companies with more than 50 employees and in an

intermediate position in the supply chain. Businesses close to customers or raw material sources were excluded, as were industries or sectors strictly related to extractive activities or raw materials and their transformation (according to the National Classification of Economic Activities). The fieldwork to select the sample units was conducted with random sampling from November 13, 2017, to February 5, 2018, and yielded a final sample of 260 companies (15.1% percent of the response rate).

A questionnaire was prepared with items taken from the literature to capture key research themes. Four internationally recognized researchers in the area of SC Management specifically related to this study pre-reviewed the questionnaire used in the interviews. Following the researchers' recommendations, several questionnaire items were reformulated to better align them with the research objectives and modified so that they would be easily understood by companies. A pilot test was then conducted to determine companies' level of understanding of the questionnaire. During this test, the paper's authors held telephone interviews with 15 companies randomly taken from the SABI database. The questionnaire was then modified and adapted in line with the companies' suggestions to produce the final version used in the subsequent fieldwork stage. The pilot test results were not included in the subsequent analysis. The questionnaire contained questions related to LP implementation, SCF, and BP and was administered to the heads of SC Management, Logistics, and Operations Management.

Data collection was carried out by telephone survey using a Computer-Aided Telephone Interviewing (CATI) method. This methodology is often used in studies in the SC field (Rojo *et al.*, 2018; Novais *et al.*, 2020; Fernandez-Giordano *et al.*, 2022). The CATI method gives interviewers access to an information system that randomly displays the contact details of potential respondents and allows a computer to manage the entire process. CATI enables appointments to be made with respondents to facilitate interviewee responses, which are saved in real time (Novais *et al.*, 2020). The interviewers received specific training for this research and a supervisor was always on hand to control the quality of the interviews by randomly listening to surveys. The supervisor could thus give more precise instructions if any problems were detected with the interviewees' understanding of the questions. Furthermore, on the first day, the authors personally supervised the interviewers' work. The data were collected by four interviewers who worked simultaneously for four hours a day throughout the fieldwork period. The respondents were asked to give responses on behalf of their organizations/SCs rather than on a personal level, and the anonymity and confidentiality of their responses were guaranteed to reduce social

desirability bias (Podsakoff *et al.*, 2003; Nath and Agrawal, 2020). In addition, a web-based version of the questionnaire was sent to companies that had not filled out the entire questionnaire or had not had time to attend to the interviewers and, thus, allow any nonrespondents to answer.

A comparison of surveyed and nonsurveyed companies indicated no evidence of response bias. Similarly, no specific characteristics or patterns were found in the reasons that companies gave to justify their non-participation in the study. Early and late responses were compared and no significant differences were found in any of the variables included in the study. Finally, the sample and population distribution patterns were examined for similarities, with the results confirming that the study sample pattern was random and representative of the population (Table 1).

Lastly, Harman's single-factor test (Podsakoff *et al.*, 2003) was applied to check for any possible common method bias. The test results showed that the majority of the variance in our model could not be explained by any single factor (one of the factors explained 29.37 % of the total variance). This result indicates that common method bias was not a major issue in this study.

Insert Table 1 here:

Sample, population distribution, and response rate by industry

4.2. Variables

This section describes the variables considered in the measurement model in this research. Appendix A presents the questions in the questionnaire. Respondents were asked to evaluate the questionnaire statements for each factor on a 7-point Likert Scale (1="totally disagree" to 7="totally agree"). Appendix A also presents the authors that have previously used and validated this measurement instrument, the items that form each of the factors (item code), and the factors that were omitted after the exploratory factor analysis and reliability analysis. The variables marked with an asterisk in Appendix A and their corresponding items were removed after the exploratory factor analysis and reliability analysis (see measurement model details in the analysis and results section). This work does not consider any control variables in the theoretical models as its ultimate goal is to isolate and analyze the effects of the different SCF components or dimensions in the full mediation of the LP-BP relationship. Other works with a similar objective

and methodology have used the same focus that does not consider any control variables in the theoretical models (Gligor *et al.*, 2020).

Lean Production implementation: Reflexive second-order construct composed of two dimensions (first-order constructs): (1) Cellular manufacturing with three items (LP1, LP2, LP3), which is the physical distribution and production plant layout with the typical LP manufacturing cells; (2) Lean practices with five items (LP4, LP5, LP6, LP7, LP8), which is the implementation of some well-known LP practices: TQM, TPM, SMED, JIT, and kanban systems (Moyano-Fuentes *et al.*, 2012). Other researchers (Moyano-Fuentes *et al.*, 2012; Uhrin *et al.*, 2017) have previously validated and used the same measurement instrument as used here for this construct.

Supply Chain Flexibility: Second-order reflexive construct composed of four dimensions (first-order constructs): (1) SC sourcing flexibility; (2) SC operating system flexibility; (3) SC distribution flexibility; (4) SC information system flexibility. The measurement instrument for this construct was taken from previous research (Swafford *et al.*, 2006; Moon *et al.*, 2012; Rojo *et al.*, 2018). As it is useful for this research, each of the four first-order dimensions or factors that compose SCF are described below (Swafford *et al.*, 2006; Moon *et al.*, 2012).

Supply Chain Sourcing Flexibility: Reflexive first-order construct with three items (SCF1, SCF2, SCF3); the flexibility of the key supplier identification, selection, and replacement process followed to meet variations in demand (Martínez and Pérez, 2005; Kumar *et al.*, 2006; Candace *et al.*, 2011; Moon *et al.*, 2012). Also called SC suppliers' flexibility (Jin *et al.*, 2014).

Supply Chain Operating System Flexibility: Reflexive first-order construct with four items (SCF4, SCF5, SCF6, SCF7); the flexibility of volume and production structure adjustment to facilitate processes and the launch of new products and services on the market (Moon *et al.*, 2012). Also called SC manufacturing flexibility in the literature (Jin *et al.*, 2014).

Supply Chain Distribution Flexibility: Reflexive first-order construct with four items (SCF8, SCF9, SFC10, SCF11); the flexibility to modify warehouse structure and distribution models (Martínez and Pérez, 2005; Kumar *et al.*, 2006). Also called SC logistics flexibility in the literature (Naim *et al.*, 2010).

Supply Chain Information System Flexibility: Reflexive first-order construct with three items (SCF12, SCF13, SCF14); IS's flexibility to support SC members' needs by supporting transportation, distribution, and warehouse management, or by extending its use to multiple functions and departments (Moon *et al.*, 2012).

Business Performance: Reflexive second-order construct composed of two dimensions (first-order constructs): (1) Operational performance, with seven items (OP1, OP2, OP3, OP4, OP5, OP6, OP7), is the company's flexibility and delivery performance results (Flynn *et al.*, 2010; Bruque *et al.*, 2015, 2016); (2) Financial performance, with six items (FP1, FP2, FP3, FP4, FP5, FP6), consists of the value-creating capacity of for-profit organizations and represents growth and return on sales and profits (Flynn *et al.*, 2010; Yu *et al.*, 2013). Both of these dimensions have been measured in a similar way in the previous literature (Flynn *et al.*, 2010; Yu *et al.*, 2013; Bruque *et al.*, 2015, 2016).

4.3 Data analysis: Covariance-based Structural Equations Model

The CB-SEM measurement model (Kaplan, 2000) was constructed with the variables described in the previous section. Figure 3 presents the measurement model for each of the factors included in this research. Note that, depending on the model being analyzed, either the measure of SCF as a second-order construct or the individual measures of the first-order factors that it comprises are used. Six structural models are individually tested in this research: two models to explore the SCF construct's eclipse effect (Baseline Model: H1a, H1b, and Model 1: H1c) (see Figure 4) and four models to identify the isolated effects of each of the SCF dimensions (Model 2: H2; Model 3: H3; Model 4: H4, and Model 5: H5) (see Figure 5).

Insert Figure 3 here:
Measurement model in CB-SEM

5. ANALYSIS AND RESULTS

5.1 Measurement model

We used measurement models validated and used in previous research to ensure construct content validity. The measurement model's content validity also was assured through an analysis of the questionnaire conducted by four internationally recognized researchers in the area of SC management.

Scale unidimensionality was assessed with Exploratory Factor Analysis (EFA) using SPSS software v24. In an initial EFA, several items showed standardized load values below .5 and were duly removed. Specifically (see Appendix A), item LP7 was omitted from the LP

implementation construct; item SCF1 was omitted from SC sourcing flexibility; items SCF4 and SCF6 were also omitted from SC operating system flexibility; item SCF12 was omitted from SC information system flexibility, and item FP6 was omitted from the financial performance construct. A subsequent EFA (after the indicated items had been removed) was performed with Bartlett's test and a Kaiser-Meyer-Olkin (KMO) test. Varimax rotation with Kaiser was used for second-order factors. For first- and second-order factors, the results gave eigenvalues higher than the unit, standardized factor loads above .5, significant explained variance for each extracted factor, high values for Chi-Squared/degrees of freedom in Bartlett's sphericity test ($p < .05$), and adequate values for KMO ($> .6$), thus confirming unidimensionality of the scales. The EFA results are given in Table 2.

A measurement model was subsequently designed in CB-SEM with the 28 observed variables. Confirmatory Factor Analysis (CFA) was performed using CB-SEM with EQS 6.4 software to confirm the measurement model and construct multidimensionality. As a preliminary step, data exploration had been performed using Mardia's normalized estimation. This confirmed the multivariate non-normality of data, thus allowing the Robust Maximum Likelihood method to be applied in a CB-SEM analysis. The final fit of the CFA for all factors was satisfactory (Satorra-Bentler's scaled $\chi^2=664.636$; $df=331$; $\chi^2/df = 2.01$; RMSEA=.06; NFI=.778; NNFI=.854; CFI=.873; IFI=.875; MFI=.526).

Table 3 gives the CFA results, standardized factor loads, R^2 of the variables and Cronbach's alpha, Composite Reliability (CR), and Average Variance Extracted (AVE) of the first- and second-order factors. Cronbach's alpha and CR were assessed to assure the reliability of the scales (see Table 3). The Cronbach's alpha values for all the factors (first- and second-order) were above the accepted value of .7 (Bagozzi and Yi, 1988; Nunnally, 1994). Similarly, the CR values for all the variables presented acceptable levels that exceeded the .7 threshold recommended by Nunnally (1994). This confirmed the measurement instrument's reliability (see Table 3).

Construct convergent validity was demonstrated using the standardized loads of the observable variables in each factor, which were equal to or above .5 (Fornell and Larcker, 1981). Also, the AVE value was computed for each first- and second-order factor and in all cases presented values approaching 50% (Fornell and Larcker, 1981). These values provided evidence of adequate convergent validity (see Table 3).

Finally, the Fornell and Larcker (1981) procedure was also followed to evaluate construct discriminant validity by comparing the construct correlations and the AVE square root. Construct correlations were below the AVE square root in all cases (see Table 4), which confirmed discriminant validity. Table 4 shows the nonparametric correlations (Spearman) of the Baseline Model and Model 1, and the Model 2, 3, 4, and 5 constructs; the diagonal indicates the AVE square root values with correlations between constructs in the lower half.

Insert Table 2 here:

Exploratory Factor Analysis

Insert Table 3 here:

Confirmatory Factor Analysis

Insert Table 4 here:

Correlations between factors and AVE square roots

5.2 Structural models

CB-SEM with EQS 6.4 and the Robust Maximum Likelihood Method were chosen as the most accurate techniques for non-normal settings (e.g., Satorra, 1993; Bentler and Wu, 2002).

First, Model 1 and the baseline structural model were used to analyze SCF's "eclipse effect" between LP and BP. Model 1 considered that SCF was not present and found a significant positive relationship between LP and BP (H1c; .76; $p < .05$). Model 1 yielded an overall good fit (Satorra-Bentler's scaled $X^2=214.859$; $df=124$; $X^2/df = 1.733$, RMSEA=.053; NFI=.883; NNFI=.933; CFI=.946; IFI=.947; MFI=.840), so, hypothesis H1c is supported. The Baseline Model also presented an overall good fit (Satorra-Bentler's scaled $X^2=369.789$; $df=328$; $X^2/df = 1.127$, RMSEA=.022; NFI=.877; NNFI=.982; CFI=.984; IFI=.984; MFI=.923) but found no significant relationship between LP and BP and a significant positive relationship between LP and SCF (.67; $p < .05$) and SCF and BP (.98; $p < .05$). The Baseline Model's fit was also better than

Model 1's, so it is the most explanatory model. The analyses of the Baseline Model and Model 1, therefore, confirm the full measurement relationship (H1b). The results of these two models (see Figure 4) confirm SCF's "total eclipse effect" between LP and BP. Consequently, hypotheses H1b and H1c are accepted.

Insert Figure 4 here:

Structural Baseline Model and Model 1 results

Second, Structural Models 2, 3, 4, and 5 analyze the mediation effect by considering the isolated mediation effects of the four SCF dimensions between LP and BP. The results of this analysis are given in Figure 5. All the models presented good goodness of fit (see Figure 5). In Models 2, 3, and 4, the relationships between LP and the SCF dimension considered in each model were positive and significant, as were the relationships between each SCF dimension and BP. However, one of these relationships was not positive and significant in Model 5. Likewise, the relationship between LP and BP in Model 3 was not significant, whereas in Models 2, 4, and 5 it was. Therefore, the results obtained for the mediating relationships of sourcing flexibility (H2, Model 2), operating system flexibility (H3, Model 3), and distribution flexibility (H4, Model 4) lent support to these hypotheses, which are accepted. Notwithstanding, the results also indicated that mediation could be partial in Model 2 (H2) and Model 4 (H4), whereas it could be full in Model 3 (H3). No empirical support was given to the mediation of information system flexibility between LP and BP (H5, Model 5), so hypothesis H5 is rejected. In short, the structural models show the existence of individual mediation effects of the SC sourcing flexibility, SC operating system flexibility, and SC distribution flexibility dimensions between LP and BP, although no mediation effect of the SC information system flexibility dimension is found. Table 5 summarizes the hypotheses that are supported or rejected in light of the CB-SEM analyses.

Insert Figure 5 here:

Structural Models 2, 3, 4, and 5 results

Insert Table 5 here:

Summarized results of hypothesis testing with CB-SEM analysis

5.3 Analysis of type of mediation

We followed the Preacher and Hayes (2008) procedure using the IBM-SPSS PROCESS macro (v.4.0) to test the mediation effects of the Baseline Model and Models 2, 3, and 4. Mediation analysis was conducted by applying the bootstrapping method with 10,000 resamples and 95% bias-corrected confidence intervals (CIs). When zero is not present in either the upper or lower levels of a confidence interval, the mediation effect is significant (Hayes, 2013).

First, SCF's mediation effect in the LP-BP relationship (Baseline Model) was tested. Table 6 presents the results with the indirect effect of LP on BP shown to be significant ($p < .05$). In addition, the confidence interval does not include zero, indicating that SCF significantly mediates the relationship between LP and BP. Since the direct relationship between LP and BP is not significant, it is concluded that mediation is full. These results confirm SCF's eclipse effect (full mediation) (Maqueira *et al.*, 2021) of the LP-BP relationship, and acceptance of H1b and H1c is confirmed with a full SCF mediation effect (H1b).

Second, similar analyses of Models 2, 3, and 4 (see Table 6) confirmed support for hypotheses H2, H3, and H4. So, H2 and H4 are confirmed with partial mediation effects of SC sourcing flexibility (H2) and SC distribution flexibility (H4), and H3 with a full mediation effect of SC operating system flexibility. H5 is not empirically supported because LP has no indirect effect on BP via SC information system flexibility.

Table 6 gives the analysis results.

Insert Table 6 here:

Mediation effects analysis with PROCESS IBM-SPSS

6. THEORETICAL IMPLICATIONS AND DISCUSSION

This work's first contribution to theory is the identification of the individual roles played by the 4 SCF dimensions in SCF's full mediation effect between LP and BP, which are explained through the optics of RRBV and ROT.

First, SC operating system flexibility is found to have the greatest mediation effect as its mediation is full. This means that a focal company's operating system flexibility impacts the SC and is the SCF component that makes the largest contribution to BP. This is explained from the optic of RRBV and ROT as the contribution made by all the supply chain agents' resources being essential for achieving the multiplier effect of LP practices on BP via SCF. So, SC operating system flexibility is a capability that firms develop not only with the company's internal resources but also the resources of the various companies in the SC. The combined use of all these resources then enables the focal company, which is connected to its suppliers and customers, to develop operating flexibility, which is shared by the other companies along the SC. Moreover, this type of flexibility strongly impacts performance. To develop operating system flexibility, SC managers must identify, combine, deploy, and leverage their own resources and those of their supply chain agents. These findings are in line with previous works that find that the coordination and collaboration of all the agents are required to obtain good operations results (Lewis *et al.*, 2010; Omar *et al.*, 2012; Prajogo *et al.*, 2016).

Second, the SC sourcing flexibility and SC distribution flexibility dimensions also contribute to the "eclipse effect" but their mediation is partial. This means that an effective process is required to identify good suppliers and their resources along with the ability to rapidly negotiate and sign long-term contracts with them so that suppliers and their resources can be easily swapped in and out to meet customers' needs. SC managers can use suppliers as an aggregated top-level resource that they can orchestrate in the SC when required. Once again, the SC is a set of resources implemented in a company network. Notwithstanding its importance, this type of SCF does not have a strong effect on results, and shuffling suppliers and swapping them in and out does not trigger any spectacular increases in the results obtained with one supplier or another (they are all good suppliers with good resources). These results highlight the importance of having a large pool of good suppliers for SCF and are in line with previous works (Duclos *et al.*, 2003; Gosain *et al.*, 2005; Stevenson and Spring, 2007; Ko *et al.*, 2018; Qamar *et al.*, 2018). Something similar occurs with distribution and deliveries. Efficient (i.e., LP) companies need to single out the best logistics operators and the best alternative distribution companies as business partners with which to establish collaboration agreements as this generates SC distribution flexibility. Being able to change the carrier and delivery method when required provides SCF but these changes do not have a strong multiplier effect on results, either, as all the logistics suppliers and their resources are good. Some previous studies present similar related findings that highlight the importance of using the best distribution companies for SCF (Moon *et al.*, 2012; Wu, 2003).

Third, the SC IS flexibility dimension is found not to have any mediation effect in the LP-BP relationship. LP is found to influence the development of SCF associated with IS but the effect of the SC Information System does not impact BP, whereas LP does impact BP. This finding was unexpected as several investigations (Bruque *et al.*, 2015, 2016; Núñez-Merino *et al.*, 2020; Rojo *et al.*, 2020) show that Information Technologies develop many SCF-associated capabilities that impact BP. In this line, some recent works (Enrique *et al.*, 2022) demonstrate digitalization's importance for achieving SCF and obtaining a competitive advantage in turbulent environments. One explanation for the counterintuitive result found in our work may well lie in the measurement instrument since the instrument used to measure SC information system flexibility (Swafford *et al.*, 2006; Moon *et al.*, 2012; Rojo *et al.*, 2018, 2020) captures observable IT use variables. However, as Powell and Dent-Micallef (1997) indicate, it is not IT use *per se* that impacts BP and generates a competitive advantage but rather IT must be used in combination with other company resources and capabilities to generate business benefits.

At the academic level, this work's second major contribution to theory is that it detects the need to devise a measure of SC IS flexibility based on the identification of supply chain capabilities enabled by IT rather than the mere measurement of IT use in different functional areas. Previous investigations have highlighted that IT develops resource-sharing capabilities associated with SCF and that these, in turn, generate a competitive advantage (Jin *et al.*, 2014; Qrunfleh and Tarafdar, 2014).

Lastly, this work's third contribution to theory is that it joins other research in supporting the ability of the RRBV and ROT to explain SCM phenomena, in general (RRBV) (Lavie, 2006; Lewis *et al.*, 2010; Xu *et al.*, 2014; Yang *et al.*, 2019) and SCF, in particular (ROT) (Rojo *et al.*, 2018, 2020; Benzidia and Makaoui, 2020).

Thus, from the perspective of the RRVB, this work builds on the previous literature that has shown how leveraging complementary resources from different firms explains SC-level phenomena that improve firm performance (Lavie, 2006; Lewis *et al.*, 2010; Xu *et al.*, 2014, Yang *et al.*, 2019). More specifically from the RRVB perspective, this paper helps to explain that when a focal firm uses LP (internal resources and capabilities), it frees up resources previously devoted to issues that do not add value from the customer perspective. Over time, LP practices are extended to SC agents and this frees up resources on a large scale, with the significant reduction in costs and the improvement in productivity that this entails. This then enables the economic resources freed up by cost reduction to be allocated to the implementation of new resources that

generate SCF. Thus, SCF can be achieved by implementing LP in the focal company and subsequently extending it to the other agents in its SC. More explicitly, from the optic of the RRBV, these results are in line with the findings of Lewis *et al.* (2010), who highlight the importance of competing in company networks based on operations management (operations flexibility is the SCF dimension that has the greatest impact on the total eclipse effect). Also from the optic of the RRBV, the results of this work are in line with the findings of Malhotra and MacKelprang (2012) and Xu *et al.* (2014) as they highlight the complementarity that exists between a focal firm's intra-organizational resources (such as the focal firm-level resources linked to operations processes) and the resources of other SC agents for the generation of new capabilities (resources linked to operations processes and the levels of the different SC agents for the generation of SCF capabilities). The results are also consistent with those obtained by Moyano *et al.*, (2021), who found that when LP is extended along the supply chain (LSCM), LSCM has a total mediation effect between LP and the operating results.

From the perspective of ROT, this work's theoretical contribution to SCF is to highlight the important role that SC managers play in achieving SCF in LP environments via their actions on resources for processes associated with the four SCF dimensions: SC sourcing, SC operating system, SC distribution, and SC information system. Furthermore, the results of this work allow SC managers seeking to drive up BP by increasing SCF to establish a hierarchy of actions on the resources associated with each of these individual elements. To achieve their objective, SC managers must initially focus their actions on their internal production processes (in line with the findings of Lewis *et al.*, 2010 and Xu *et al.*, 2014) to identify their own and other agents' resources and combine these in innovative ways to achieve SCF and multiply their results. From the optic of ROT, this priority is supported by previous works such as Rojo *et al.* (2018, 2020), whose results highlight the importance of a focal company's operating resources for achieving SCF. As Bag and Rahman (2023) point out, for this it is essential to develop both the capability to establish strategic alliances with suppliers and customers that lead to greater internal efficiency (for example, by deepening JIT relationships) and the data analytics capability that allows effective control of the entire process in complex environments. Subsequently, in the second phase, efforts to build capabilities based on the coordination of resources should focus, with equal priority, on supplier management and distribution management; in this phase, SC managers should identify and combine internal, supplier, and customer resources to develop capabilities to respond to changing customer needs. This is consistent with the recent findings of Jafari *et al.* (2022b), who state that SCF is positively and directly related to customer responsiveness and that this

relationship is moderated by innovation orientation. Again, this innovation orientation will be critical for SC managers to combine and coordinate resources to achieve SCF.

Managers will be able to multiply BP by deploying resources according to the above-mentioned priorities one and two. In the context of ROT, SCF's multiplier effect on all BP types (operational, financial, etc.) has previously been identified by Benzidia and Makaoui (2020).

With regard to IS, we find a paradox in the present work: even though the flexibility that it generates has been shown to have no direct relationship with BP, it is still extremely important to take action on IS and this is far from the lowest priority in the hierarchy of actions; in fact, the opposite is true. IS is an essential resource without which the other SCF dimensions' objectives could not be achieved. It is, therefore, a cross-cutting resource that SC managers should apply to their internal processes and managing sourcing and distribution processes by combining it with other internal and external resources to achieve the ultimate goal of multiplying BP by increasing SCF. This is in line with Bag and Rahman's (2023) contribution that data analytics is a capability that increases SCF. In addition, these findings are more generally in line with those of Powel & Dent-Micallef (1997), who maintain that IS is a tool that must be combined with other business resources and capabilities to impact results. Furthermore, it has been clearly demonstrated in the literature that IS has a paradoxical relationship with business results (Brynjolfsson, 1993).

This hierarchy identifies the chronological order in which resources should be used to develop each of the four SCF dimensions in order to multiply BP by increasing SCF and can be explained by ROT. As mentioned, operating system flexibility capitalizes all the LP effects, while sourcing flexibility and distribution flexibility partially capitalize LP effects and information system flexibility does not capitalize LP at all. ROT emphasizes the role of managers in developing capabilities through the identification and synergistic combination of complementarities between different practices. Hence, as there is more experience and knowledge available on the intra-organizational effects of LP (Losonci and Demeter, 2013; Luo and Yu, 2016; Abreu-Ledón *et al.*, 2018) than on its inter-organizational effects, managers may find it easier and simpler to develop operating system flexibility through LP as it is a type of flexibility that is primarily internal to the focal firm (although it also has strong external implications for suppliers) rather than to develop LP distribution flexibility and sourcing flexibility. In fact, the finding that LP's strongest effect is on intra-organizational processes is in the same line as the results of Moyano-Fuentes *et al.* (2021), who found that when a firm implements LP, the strongest effect occurs in its-door-to-door processes, including its distributors' and providers' processes.

7. CONCLUSIONS

First, this work confirms SCF's "total eclipse" effect between LP and BP (Maqueira *et al.*, 2021), which is the result of SCF having a full mediation effect in the LP-BP relationship. Second, we explore the individual role that each SCF dimension plays in the LP-BP relationship or, in other words, in the "eclipse effect". The results show that the SC operating system dimension has the greatest influence on the "eclipse effect" as it fully mediates the relationship. The SC sourcing flexibility and SC distribution flexibility dimensions also contribute to the "eclipse effect", albeit to a lesser extent, as their mediation effects are partial. Lastly, the SC IS flexibility dimension is found to have no mediation effect. These findings have major implications for academia and company management. As far as the authors know, this is the first work to analyze the individual roles of the four SCF dimensions in mediation between LP and BP.

LP, BP, the SCF dimensions, and their interrelationships have been interpreted through the theoretical lens of ROT thanks to the integrative and cohesive theoretical framework that was developed for this study.

Thus, our model has a greater explanatory power of the relationship between LP, BP, and SCF than previous research (Maqueira *et al.* 2021). It enables us to test and verify whether the effect of an antecedent variable (LP) on a consequent variable (BP) operates through multiple SC mechanisms (operating system flexibility, distribution flexibility, sourcing flexibility, and information system flexibility) that act simultaneously, whereas the previous work that had analyzed this relationship (Maqueira *et al.*, 2021) did not consider the possibility of multiple simultaneous processes. This means that, in contrast to previous models that have only taken one relationship or mechanism into account (Maqueira *et al.* 2021), our study is closer to business reality as most business effects and phenomena operate through multiple mechanisms at once (Hayes, 2013). Future researchers interested in the LP-BP relationship will, therefore, be able to refer to this work to gain a more finely detailed or fuller picture when they need to consider the different factors that govern this relationship, such as the four SCF dimensions, for example. Besides, the gold standard for research states that known confounders should be included in future investigations (van Raaj, 2018).

7.1 Managerial implications

In the area of business management, the results of this work offer SC managers precise information about the specific individual effects that the four types of SCF flexibility have in the

LP-BP relationship. This knowledge will allow said managers to drive and prioritize the development of some specific types of flexibility in LP contexts depending on the end effects on SC performance that they wish to achieve. It is important to highlight this study's significant contribution at the practical level, as it provides recipes or indications for SC management at a level of detail that is consistent with business decision-making; managers do not make decisions on SCF at the global level but locally, and to different extents on the various components of SCF (Mediation effect; Choi and Krause, 2006; Gligor *et al.*, 2020). Heads of production and SC must be aware of the leading role that the responsibility for identifying, selecting, combining, and implementing their own resources and those of their suppliers confers upon them. Their role as the orchestra conductor deploying new resources is essential for achieving SCF, and this research identifies the specific baton movements that SC managers must make or orchestrate depending on the outcomes that they are seeking (or the melody that they wish to be played). It is especially important for companies that use LP to deploy new resources and capabilities that connect their productive systems with those of their suppliers as SC operating system flexibility is the capability that will have the greatest impact on their performance. Nevertheless, they should not neglect to identify good suppliers and good distributors with good resources with whom they should forge long-term associations to build a broad base of top-class suppliers and distributors with known resources that can be used flexibly as and when required. Managers must also recognize that IT is only a tool and that, in LP contexts, the mere availability of IT in the SC is not enough to improve performance; for this to materialize, new SCF-related capabilities must be developed and enabled by IT use.

7.2 Limitations and future directions

This work is not without its limitations. The population and sample correspond to a single country. However, this is a minor limitation as major differences also exist between companies in very different socioeconomic contexts. In addition, the considered theoretical models do not take into account any control variables, which is a minor limitation as the ultimate goal of this work is to analyze the isolated effects of the SCF components in the total mediation effect in the LP-BP relationship. Likewise, the use of a Likert scale to measure variables is not without its limitations as continuous quantitative variables are captured through only a single set of possible responses. This generates results with a given degree of granularity and with the possibility of incurring certain biases such as the central tendency bias or the bias associated with respondents' psychological characteristics that influence their perception (indulgence, severity, etc.). However,

this is also a minor limitation as the Likert scale is widely used in management research and a 7-point scale has been used in this study rather than the traditional 5-point scale, in order to mitigate granularity limitations. Also, the analysis was performed at a specific time, providing a snapshot of information related to that particular moment alone. Another limitation is related to the SCF measures used as they do not consider any other possible dimensions. Notwithstanding, this measure has been widely used and is complete, with 4 dimensions and 14 observable variables considered.

Future works could analyze the "eclipse effect" by considering both SCF at the aggregate level and the individual effects of its components on samples from different countries. Longitudinal studies could be used to consider company evolution between two points in time. Alternative measures to SCF could be used to analyze the effect. Future studies could also analyze SCF's eclipse effect by considering separate measures of operational performance and financial performance to identify whether the effect is produced in both or only one of these. Future studies should turn their focus to the IS flexibility paradox in SCF to corroborate that, even though IS flexibility does not affect the business results, it does directly affect all the other SCF components. Lastly, future works could develop a measure of SC IS flexibility based on capabilities enabled by IT rather than the mere use of IT.

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Figure 1. Theoretical, hypothesized models: baseline model (SCF total mediation) and model 1 (isolated LP-Business Performance effect)

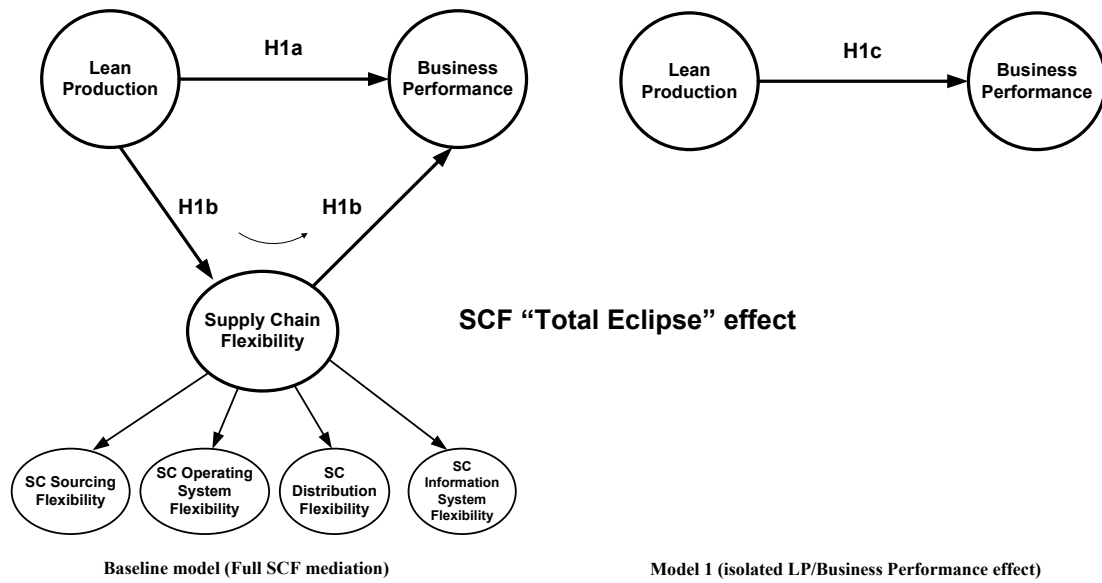
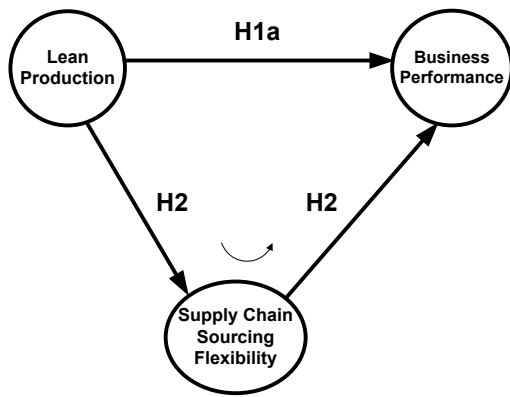
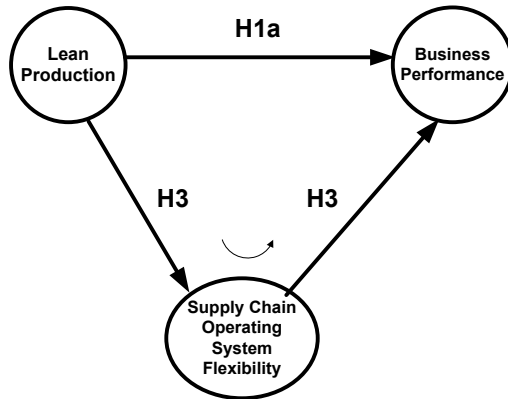


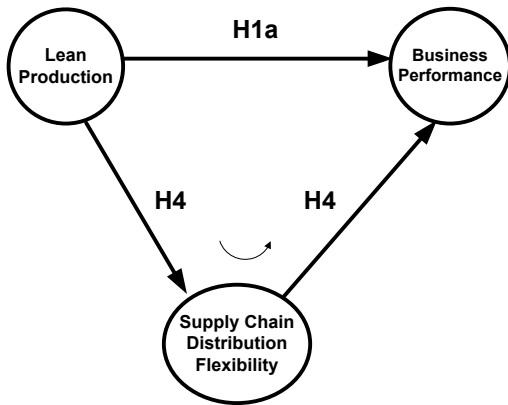
Figure 2. Theoretical, hypothesized models: individual mediation effects of Supply Chain Flexibility components



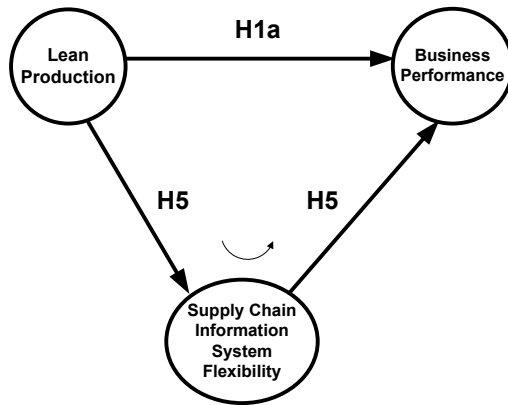
Model 2: SC Sourcing Flexibility mediation



Model 3: SC Operating System Flexibility mediation



Model 4: SC Distribution Flexibility mediation



Model 5: SC Information System Flexibility mediation

Individual mediation effects of Supply Chain Flexibility components

Figure 3. CB-SEM measurement model

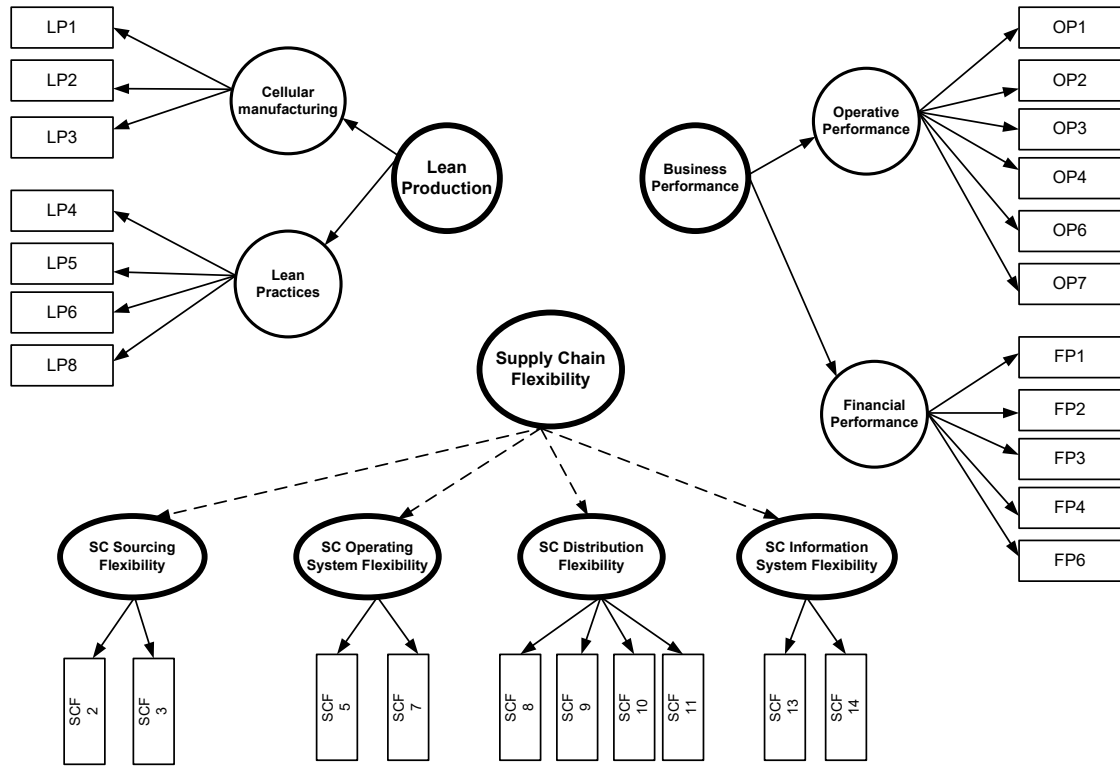


Figure 4. Structural baseline model and model 1: results

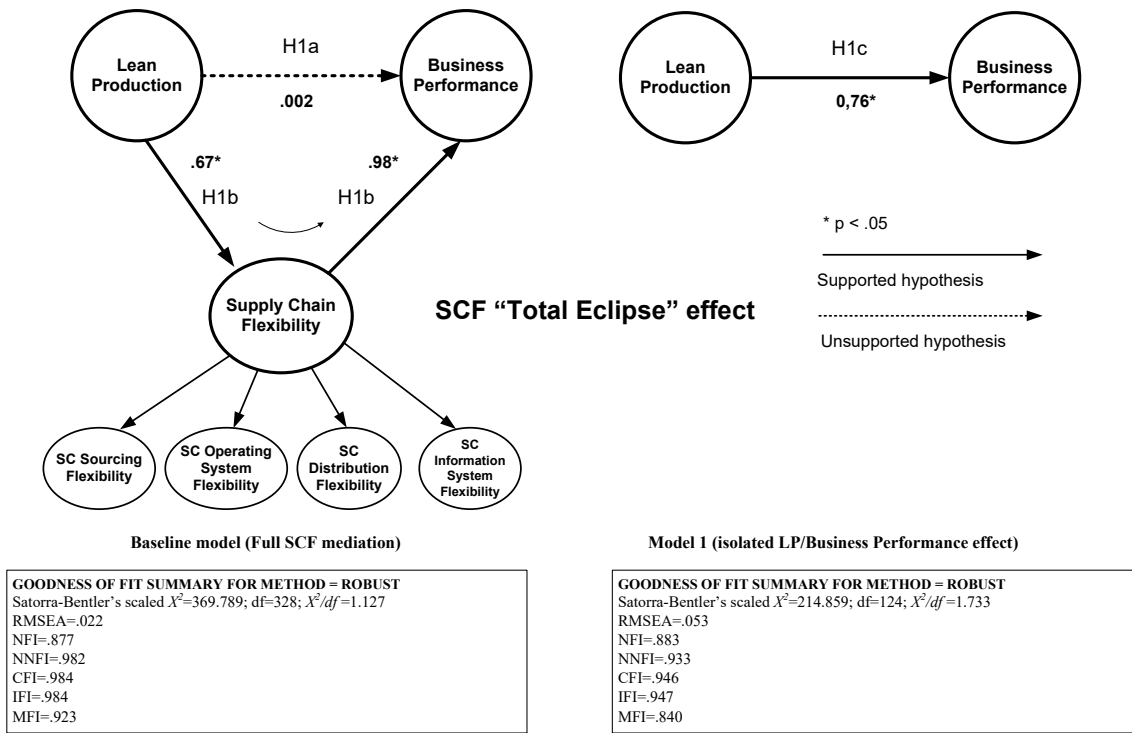
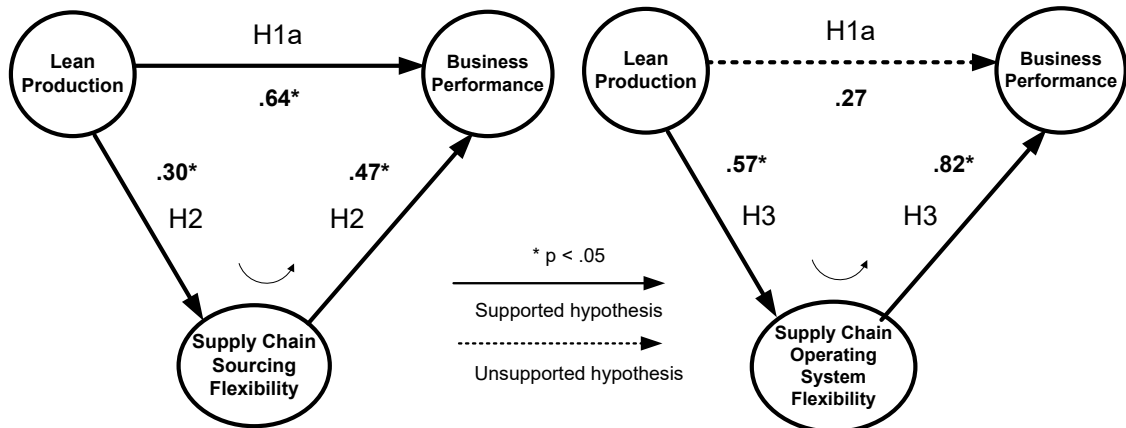


Figure 5. Structural models (models 2, 3, 4, and 5): results

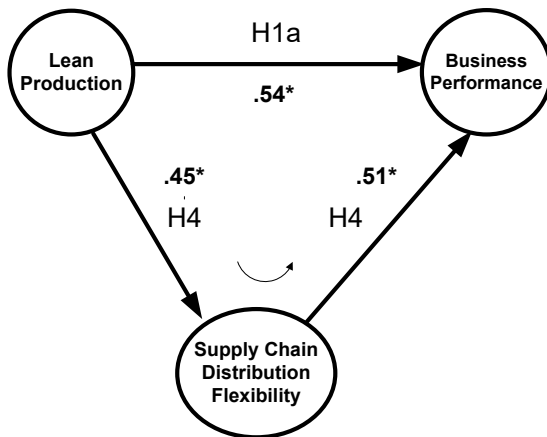


Model 2: SC Sourcing Flexibility mediation

GOODNESS OF FIT
 Satorra-Bentler's scaled $\chi^2=219.965$; $df=156$.
 $\chi^2/df=1.41$
 RMSEA=.040
 NFI=.894; NNFI=.959; CFI=.966; FI=.967; MFI=.884

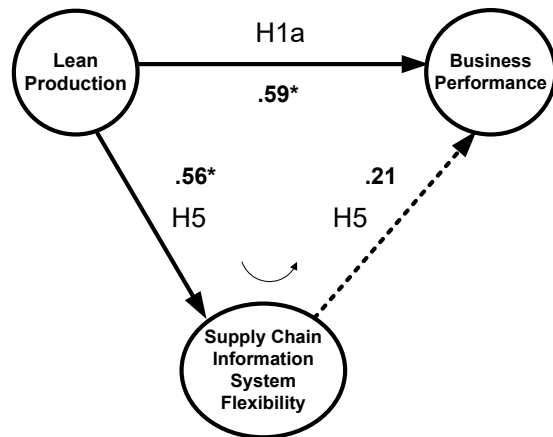
Model 3: SC Operating System Flexibility mediation

GOODNESS OF FIT
 Satorra-Bentler's scaled $\chi^2=236.935$; $df=156$.
 $\chi^2/df=1.52$
 RMSEA=.045
 NFI=.882; NNFI=.947; CFI=.956; FI=.956; MFI=.856



Model 4: SC Distribution Flexibility mediation

GOODNESS OF FIT
 Satorra-Bentler's scaled $\chi^2=335.688$; $df=195$.
 $\chi^2/df=1.72$
 RMSEA=.053
 NFI=.857; NNFI=.921; CFI=.934; FI=.935; MFI=.763



Model 5: SC Information System Flexibility mediation

GOODNESS OF FIT
 Satorra-Bentler's scaled $\chi^2=160.362$; $df=156$.
 $\chi^2/df=1.03$
 RMSEA=.010
 NFI=.920; NNFI=.977; CFI=.998; FI=.998; MFI=.992

Table 1. Sample, population distribution, and response rate by industry

Sector	No. of companies in population		No. of companies in sample		Response rate
	No.	%	No.	%	
Food products	629	36.6%	108	41.5%	17.2%
Tobacco and related products	7	0.4%	1	0.4%	14.6%
Beverages	89	5.2%	13	5.0%	14.6%
Fabrics and textile	86	5.0%	11	4.2%	12.8%
Leather and shoes	75	4.4%	8	3.1%	10.7%
Chemicals	251	14.6%	41	15.8%	16.3%
Pharmaceuticals	85	5.0%	15	5.8%	17.6%
Informatics, electronics, and optical	91	5.3%	13	5.0%	14.3%
Electrical machinery and equipment	97	5.7%	11	4.2%	11.3%
Motor vehicles	192	11.2%	32	12.3%	16.7%
Furniture	115	6.7%	7	2.7%	6.1%
Total	1717	100%	260	100%	15.1%

Table 2. Exploratory Factor Analysis

Construct		Observable variable code	Standardized factor loading	Bartlett test		KMO		% Explained variance					
Second-order	First-order												
Lean Production implementation	Production plant layout	LP1	.845	$\chi^2 = 178.521$ df = 3 sig. = .00	$\chi^2 = 499.796$ df = 21 sig. = .00	.677	.802	66.224%	62.445%				
		LP2	.820										
		LP3	.775										
	Lean practices	LP4	.735	$\chi^2 = 241.074$ df = 6 sig. = .00		.766		58.084%					
		LP5	.810										
		LP6	.794										
		LP8	.704										
Supply Chain Flexibility	SC Sourcing flexibility	SCF2	.913	$\chi^2 = 152.685$ df = 1 sig. = .00	$\chi^2 = 870.317$ df = 45 sig. = .00	.500	.747	83.441%	73.064%				
		SCF3	.913										
	SC Operating system flexibility	SCF5	.866	$\chi^2 = 74.431$ df = 1 sig. = .00		.500		75.051%					
		SCF7	.866										
	SC Distribution flexibility	SCF8	.689	$\chi^2 = 292.703$ df = 6 sig. = .00		.716		59.281%					
		SCF9	.732										
		SCF10	.865										
		SCF11	.783										
	SC Information system flexibility	SCF13	.911	$\chi^2 = 193.657$ df = 3 sig. = .00		.500		82.990%					
		SCF14	.911										
	Business Performance	Operational performance	OP1	.758		$\chi^2 = 916.147$ df = 21 sig. = .00		$\chi^2 = 2771.679$ df = 91 sig. = .00		.847	.866	55.768%	65.199%
			OP2	.798									
			OP3	.815									
OP4			.809										
OP5			.577										
OP6			.707										
OP7			.736										
Financial performance		FP1	.853	$\chi^2 = 1175.646$ df = 10 sig. = .00	.864	78.785%							
		FP2	.916										
		FP3	.947										
		FP4	.898										
		FP6	.818										

Table 3. Confirmatory Factor Analysis

Construct		Observable variable code	Cronbach's α		Composite Reliability		Standardized factor loading		R2		% Average Variance Explained				
Second-order	First-order														
Lean Production implementation	Production plant layout	LP1	.74	.79	.74	.82	.69	.69	.571	.476	49.85%	46.84%			
		LP2							.486						
		LP3							.439						
	Lean practices	LP4	.75	.76	.81	.81	.81	.81	.656	.390	.656		44.60%		
		LP5								.497					
		LP6								.531					
		LP7								.531					
		LP8								.365					
Supply Chain Flexibility	SC Sourcing flexibility	SCF2	.80	.81	.81	.88	.65	.65	.470	.422	71.05%				
		SCF3							.951						
	SC Operating system flexibility	SCF5	.67		.67		.79	.79	.79	.79	.624	.500	.624	50.10%	
		SCF7										.502			
	SC Distribution flexibility	SCF8	.77		.78		.79	.79	.79	.79	.624	.306	.624	47.66%	
		SCF9										.371			
		SCF10										.693			
		SCF11										.535			
	SC Information system flexibility	SCF13	.78		.79		.79	.79	.39	.39	.152	.435	.152	71.75%	
		SCF14										1.00			
	Business Performance	Operational performance	OP1		.86		.88	.89	.93	.60	.60	.529	.360	52.53%	59.89%
			OP2									.683			
			OP3									.693			
			OP4									.687			
OP5*			n.a.												
OP6			.279												
OP7			.281												
Financial performance		FP_1	.93	.93	.93	.93		.59		.59	.348	.306	.348	68.72%	
		FP_2										.606			
		FP_3										.863			
		FP_4										.947			
		FP_5										.947			
		FP_6										.714			
		FP_7										.714			

* Items removed after confirmatory factor and reliability analyses.

Table 4. Correlations between factors and AVE square root

				Correlation matrix, baseline model, and model 1		
Research constructs	Mean	SD	AVE	1	2	3
1. Lean Production	2.92	.47	.47	.685		
2. Supply Chain Flexibility	2.57	.46	.58	.421**	.776	
3. Business Performance	3.63	.72	.60	.410**	.622**	.774

				Correlation matrix, models 2, 3, 4, and 5					
Research constructs	Mean	SD	AVE	1	2	3	4	5	6
1. Lean Production	2.92	.47	.47	.685					
2. SCF Sourcing	4.09	1.20	.71	.230**	.843				
3. SCF Operating System	3.88	.85	.50	.344**	.359**	.707			
4. SCF Distribution	3.31	.91	.48	.330**	.452**	.473**	.693		
5. SCF Information System	5.04	.91	.72	.359**	.172**	.286**	.225**	.848	
6. Business Performance	3.63	.72	.60	.410**	.416**	.541**	.479**	.316**	.774

** Correlation significant at .001 level; diagonal = AVE square root

Table 5. Results of hypothesis testing with CB-SEM

Hypothesis	Path	Result / Support
Baseline Model; Total eclipse		
H1a	Lean Production (LP) → Business Performance (BP)	NO
H1b	Total mediation LP → Supply Chain Flexibility (SCF) → BP	YES
Model 1: isolated effect LP-BP		
H1c	LP → BP	YES
Mediation; Models 2, 3, 4, and 5		
H2	LP → SCF Sourcing → BP (Model 2)	YES
H3	LP → SCF Operating System → BP (Model 3)	YES
H4	LP → SCF Distribution → BP (Model 4)	YES
H5:	LP → SCF Information System → BP (Model 5)	NO

Table 6. Analysis of mediation effects; IBM-SPSS PROCESS

IV	MV	DV	Effect of IV on MV	Effect of MV on DV	Direct effect	Indirect effect	Total effects	95% CI for mean indirect effect	Mediation type	Hypothesis support	
Total eclipse											
LP→	SCF→	BP	.424*	.578*	-----	.245*	.245*	.176 .316	Total	H1b YES	
Isolated mediation of SCF dimensions											
LP→	SCF Sourcing→	BP	.391*	.547*	.207*	.214*	.421*	.149 .284	Partial	H2 YES	
LP→	SCF Operating System→	BP	.426*	.586*	-----	.250*	.250*	.179 .321	Total	H3 YES	
LP→	SCF Distribution→	BP	.421*	.573*	.179*	.242*	.420*	.175 .309	Partial	H4 YES	
LP→	SCF Information System →	BP	.474*	-----	.180*	-----	.180*	-----	No	H5 NO	

Notes: IV= independent variable; MV= mediating variable; DV= dependent variable; CI= confidence interval;

*Significant p < .05