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EXTENDING LEAN MANAGEMENT ALONG THE SUPPLY CHAIN: IMPACT ON EFFICIENCY

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1. Introduction

Lean Management (LM) has been adopted by firms in various economic sectors in recent decades and this has frequently enabled them to improve their competitiveness (Moyano-Fuentes and Sacristán-Díaz, 2012). Numerous researchers have detected a trend towards LM adoption that affects not only companies' internal organisation but also their external organisation (Shah and Ward, 2007). Indeed, it is widely recognised that LM is a systemic and integrated managerial approach primarily aimed at eliminating waste and inefficiencies in any process, which, to achieve the best possible performance, needs to be extended to all processes in the focal company and, if possible, across suppliers and customers (Danese et al., 2012; Danese et al., 2018). One major challenge that companies launching lean initiatives face is to identify LM practices that can be applied across the entire supply chain (SC), from order placement with suppliers to product distribution and delivery to the customer, to optimise all processes and activities from the final customer's point-of-view. This is known as Lean Supply Chain Management (LSCM) (Martínez-Jurado and Moyano-Fuentes, 2014; Swenseth and Olson, 2016). Therefore, LM can be implemented at two levels: at the internal level (focal firm) and the external level. External level LM entails interconnections between suppliers' and customers' internal LM implementations and the focal firm and the deployment of lean principles, practices and techniques across the supply chain.

Despite the paramount importance of jointly analysing and managing internal and external LM approaches, the literature has focused on these individually and the authors that analyse interrelationships do so using isolated LSCM components (Chávez et al., 2015; Bortolotti et al., 2016; Marodin et al., 2017; Vanichchinchai, 2020).

It is necessary to dig deeper into the way that the external and internal aspects of the supply chain align to impact or contribute to firm performance (Prajogo et al., 2016). So, the literature has focused on the impact of internal LM implementation on operational performance (e.g., Shah and Ward, 2003; Negrão et al., 2017; Marodin et al., 2019) but results have been inconclusive (e.g., Browning and Heath, 2009; Belekoukias et al., 2014; Zhu and Lin, 2018). At the external level, the literature analyses the impact on operating results of LM practices along the SC such as waiting time, inventory rotation and on-time delivery, also with mixed results (e.g., McIvor, 2001; Tortorella et al., 2018). It would, therefore, be interesting to use an integrated focus on LSCM and to examine the impact on other types of operating results, such as efficiency, which Shah and Ward (2003) state is one of the results that LM most impacts. The purpose of this study is to consider LM as a comprehensive strategy by studying the interrelationships between lean implementation at the internal (focal firm) and SC levels and the influence of both on efficiency, which could be considered one of the new frontiers of research in this field (e.g., Jasti and Kodali, 2015; Marodin et al., 2017; Danese et al., 2018). For this, the study has been based on the relational view of the Resource-Based Theory (RBT) (Arya and Lin, 2007) and integrated supply chain management (Lummus et al., 1998).

For their part, Hofer et al. (2012) and Qrunfleh and Tarafdar (2013) argue that several components of Supply Chain Management (SCM) mediate between internal LM and performance. LSCM may be the cause of this mediating effect, and so this paper examines LSCM's mediating effects on predicting the impact of LM's internal implementation on efficiency. To the authors' best knowledge, this is the first time that LSCM's mediating effect has been studied as a holistic strategy in the LM-performance relationship. Figure 1 synthesises the object of the study, differentiating between lean implementation at the internal and external levels and indicating the information and physical flows between the focal firm and the SC members along with the effects that will be investigated in this study.

The sample used to analyse these effects was composed of Spanish focal companies from industrial sectors in an intermediate position in the supply chain. Internal LM implementation in the focal firm has been identified from managers' perceptions of the overall level of internal

LM application in their plants compared to their competitors. This approach is in line with some previous literature (Bortolotti et al., 2015), as managers' perceptions of what implementing internal LM means can vary significantly. Besides, an LSCM measurement instrument has been used that was recently validated by a consensus among a panel of international researchers (Moyano-Fuentes et al., 2019) and constructed from managers' perceptions of aspects of the overall levels of LSC strategy implementation, and LSC planning.

This paper is organised as follows. The following section summarises the theoretical framework and describes in greater depth the arguments leading to the hypotheses. Section 3 describes the population, questionnaire, data gathering and variables. Section 4 contains an analysis of the results and empirical findings. Section 5 includes a discussion and implications for research and practice. The last section presents the most important conclusions, some directions for additional research and the study's limitations.

[Figure 1]

2. Theoretical framework

A Lean Supply Chain can be defined as a set of organisations directly linked by upstream and downstream flows of goods, services, finances and information that work together to reduce cost and waste by efficiently and effectively pulling what is required to meet the needs of individual customers (Lamming, 1996; Vitasek et al., 2005; Reichhart and Holweg, 2007). Thus, the key to adopting and implementing LSCM is that each SC member adopts LM internally and makes inroads into its implementation. These internal lean systems must be connected and work with each other to operate in a 'seamless' environment in which all flows are streamlined and synchronised. For this, SC members must deploy LM principles, practices and techniques to achieve lean goals at the SC level (Danese et al., 2012; Bortolotti et al., 2016). In this context, the present study examines the interrelationships between LM implementation at the internal (focal firm) and SC levels and the impact of both on efficiency. For this, we draw on the relational view of RBT. Below we explain the basis of RBT and develop three hypotheses concerning these interrelationships.

2.1. Resource-Based Theory: overview

RBT emerged from seminal studies (Penrose, 1959) that associated organisational resources with achieving competitive advantage (CA). The theory was developed from the concept of the Resource-Based View (RBV) in the 1980s and 90s (Wernerfelt, 1984; Barney, 1991; Grant, 1991). The RBV of the firm views organisations in terms of their available resources and the way that these resources can be combined to differentiate companies and enable them to achieve CA (Wernerfelt, 1984; Grant, 1991). RBV emphasises performance differences between organisations based on how they leverage unique, valuable, inimitable resources (Barney, 1991; Peteraf, 1993; Peteraf and Barney, 2003). Operationalising these resources jointly generates sustainable CA (e.g., Wernerfelt, 1984; Teece, 1988; Prahalad and Hamel, 1990). Resources can only be a source of CA when they are effectively leveraged to support or complement other organisational resources, capabilities or processes (Teece, 1988; Ray et al., 2004). These resources include not only tangible, but also intangible assets such as flexibility, agility, information, learning, human resources and commercial relationships, among others. As tangible resources can be imitated by competitors, they can provide temporary CA for firms, but intangible resources are more difficult to imitate as they are acquired through experience and so provide sustainable CA (Barney, 1991).

The term RBT has currently superseded RBV, which is a widely accepted explanatory theory of the relationships established between organisations seeking sustainable CA (Peteraf and Barney, 2003). The relational view of RBT is an extension of RBT that integrates the core tenets of RBT and relational network theory to explain how SC cooperation and collaboration can lead to sustainable CA (Prajogo et al., 2016). This framework has been used to explain the effect of resource complementarity in LM environments (Agyabeng-Mensah et al., 2020;

Kumar and Sanchez-Rodrigues, 2020), LM implementation at the internal level (Ghobakhloo and Hong, 2014; Ghobakhloo and Azar, 2018) and LM application at supply chain level (Iyer et al., 2019; Yildiz-Çankaya, 2020). In this sense, while LM provides productivity and cost advantages for focal firms, implementing this way of thinking across the supply chain is an extremely difficult and complex process in which RBT must underpin research into LSCM's effects on performance (Yildiz-Çankaya, 2020).

2.2. Effect of implementing internal lean management on implementing lean supply chain management

Empirical evidence supports a positive relationship between the implementation of internal LM practices and of external LM practices. For example, Furlan et al. (2011) suggest that LM internal human resource management practices may influence the successful implementation of LSCM practices, and Hofer et al. (2012) empirically support the tendency of firms with greater inventory leanness to more widely implement external LM practices. This can be explained by the implementation of internal and external LM practices providing greater performance benefits than implementing one LM approach alone (Hofer et al., 2012).

The Resource-Based Theory (RBT) suggests that every strategic decision made in every firm should be based on benefits to the SC instead of benefits to the individual firm. This goal cannot be achieved unless SC partners have strong and close relationships in which they can share their experience, knowledge and information to achieve CA (Manzouri and Rahman, 2013). In this sense, the impact of LM on performance at the focal firm internal level might be complemented by LM at the external level or by LSCM to improve performance. According to Teece (1986), complementarity refers to how one resource might influence another, and how this relationship affects a firm's competitive position or performance.

Previous research finds that internal LM implementation is considered a determinant driver or catalyst of LSCM (Rivera et al., 2007; Bortolotti et al., 2016). Thus, when a company in an SC has adopted and achieved a certain degree of internal leanness through its door-to-door value streams, the usual approach is for it to trigger and support the adoption of internal LM in its SC partners (Bortolotti et al., 2016). For example, lean buyers often promote and develop the lean capabilities of non-lean suppliers by deploying certain LSCM principles, practices and techniques, e.g., supplier development (Simpson and Power, 2005; Wee and Wu, 2009). Hubs or focal firms should not expect any SC members to adopt LM internally if they have not already done so themselves (Marksberry, 2012).

So, SC members should first adopt and enhance their levels of internal LM implementation and then gradually deploy LSCM principles, practices and techniques (Lamming, 1996; Towill, 1997). Consequently, internal LM must precede LSCM, since the lack of a high level of internal LM is one of the reasons why LSCM initiatives derail (Furlan et al., 2011). Similarly, many firms do not know the percentage of their suppliers that are using lean internally, suggesting that firms should extend their lean training and auditing to their suppliers (Cudney and Elrod, 2011).

Reconfiguring the SC structure in line with LM characteristics (e.g., supply base, supplier selection and evaluation, suppliers per item) and establishing a lean partnership model (e.g., long-term relationships based on mutual trust and commitment, frequent exchange of information, win-win relationship) with strategic SC partners (Lamming, 1996; Towill, 1997; Bortolotti et al., 2016; Ruiz-Benítez et al., 2018) are essential prerequisites for a lean focal firm to effectively deploy LSCM principles, practices and techniques. In this regard, Bortolotti et al. (2016) found that the choice of LSCM practices and their purpose and implementation mode are influenced not only by the state of the SC structure and its relationships, but also by the level of SC members' internal LM implementations. So, LSCM principles, practices, and techniques deployed by SC agents (owners) depend on their own internal LM implementation levels and those of SC members (recipients) (Bortolotti et al., 2016).

However, the approach to LSCM implementation taken in the literature is lean practices- and techniques-based alone. These include cooperation and partnerships (Moyano-Fuentes et al., 2012; Chávez et al., 2015), relationship building (Jayaram et al., 2008), information-sharing with suppliers and/or customers (Cagliano et al., 2006; So and Sun, 2010; Moyano-Fuentes et al., 2012), supplier and customer involvement (Shah and Ward, 2007), and Just-In-Time (JIT), information flow and customer relationship (Nimeh et al., 2018). This is why the interrelationships between lean implementation at the internal (focal firm) and external (suppliers, focal firm and customers) levels need to be examined. The following hypothesis is, therefore, formulated based on this theoretical reasoning:

H1. A higher level of internal LM implementation in the focal firm leads to a higher level of LSCM implementation.

2.3. Lean supply chain management-focal firm efficiency relationship

The relational view of the RBT suggests that firm performance is a result of both its internal resources and external SC resources (Arya and Lin, 2007). Furthermore, integrated SCM underlines the importance of inter-organisational cooperation to enhance customer satisfaction and operational efficiency (Chiksand et al., 2012). In this context, the purpose of LSCM is to improve operational performance and, specifically, product delivery results by integrating resources to share information and coordinate processes and activities along the SC, and implementing a continuous improvement process along the SC (Mollenkopf et al., 2010). Qi et al. (2017) found that an LSC strategy is appropriate for firms placing prioritising competition on cost compared to firms whose competitive priority is high flexibility, for which an agile SC is better choice.

Efficiency is a measure of firm operational performance that includes cost reduction, inventory turnover and cycle time (Danese and Romano, 2011; Danese et al., 2012). Many authors have analysed the impact of LM practices and techniques via the SC on different firm operational performance indicators and on how this relationship can be influenced by contextual factors (Marodin et al., 2016; Marodin et al., 2019).

Other researchers show that lean-based inter-firm process improvement is an important part of SC integration that has performance implications (Ahmed et al., 2017, Ahmed et al., 2019). So, for example, Heikkilä (2002) states that a good customer-supplier relationship contributes to reliable information flows, and reliable demand information flows contribute to high firm efficiency. According to the relational view of the RBT, when SC processes are highly integrated, the buyer firm's strategic resources are embedded with those of the supplier to develop processes, capabilities and relationships that are tacit and intangible and are typically valuable, thus representing a source of CA for firms (Prajogo et al., 2016). In this sense, Danese and Romano (2011) found that the impact on efficiency through customer integration occurs only under certain supplier integration conditions.

Apte and Goh (2004) highlighted that the reduction of variability through LSCM can increase efficiency by minimising cycle time. Simpson and Power (2005) and So and Sun (2010) found that supplier integration strategy reduces costs and improves global LSC results. Wee and Wu (2009) found that deploying VSM along the SC allows cost and lead time reductions. Azevedo et al. (2012) found that upstream LSCM practices reduce operational and inventory costs. Prajogo and Olhager (2012) stated that integrated logistics in LSC environments lead to reliable order cycles, inventory reduction and cost reduction, amongst other benefits. Finally, Ruiz-Benítez et al. (2019) recently found that eight of the LSCM practices reduce costs.

However, mixed results can be been found. According to the results in Danese et al. (2012), JIT production practices positively affect both efficiency and delivery. However, these authors also found that when efficiency is prioritised, companies should direct their efforts towards JIT production, whereas when their goal is to maximise delivery, they should invest in both JIT production and JIT supply. Qi et al. (2011) found that LSCM is more effective at improving business performance in a stable environment. Recently, Tortorella et al. (2018) found that LSCM practices related to customer-supplier relationship management (CSRM) indicate contradictory findings on delivery, costs and lead time.

These inconclusive findings can be explained by incomplete definitions of LSCM, different scales and constructs to measure LSCM and performance, a narrow focus on upstream SC levels and diverse contextual factors (McIvor, 2001; Simons and Taylor, 2007; Berger et al., 2018). Therefore, more empirical research is required to overcome prior weaknesses and shed light on the LSCM-efficiency relationship.

It must be taken into account that LSCM is not a set of isolated lean practices and techniques along the SC but a global strategy for SCM, and the extent to which this strategy is developed can greatly impact the efficiency of the focal firm.

The following hypothesis is, therefore, proposed, based on the above arguments:

H2: A higher level of LSCM implementation leads to a higher level of focal firm efficiency.

2.4. Mediating effect of lean supply chain management in the internal lean management implementation-focal firm efficiency relationship

Past research has found the potential existence of SCM-related mediation between internal LM implementation and performance (Hofer et al., 2012; Qrunfleh and Tarafdar, 2013) and LSCM may be the cause of this mediating effect. As stated above, internal LM implementation drives the spread of lean principles, practices and techniques along the SC (Rivera et al., 2007; Bortolotti et al., 2016). There is a temporal sequence in this process. First, both the focal company and SC members should adopt and enhance their internal LM implementation levels (Lamming, 1996; Towill, 1997; Bortolotti et al., 2016). Then, they should gradually but quickly deploy LSCM principles, practices and techniques along the SC (Bortolotti et al., 2016; Swenseth and Olson, 2016).

RBT points to each tier being able to gain a CA by using its SC's valuable, priceless and rare resources. According to this theory, SC is an inimitable competitive weapon which can provide the capability for product and process improvement (Ketchen and Hult, 2007). In this sense, success in managing an LSC strategy depends on accumulated valuable knowledge, competencies and cultural change linked to internal LM implementation (Furlan et al., 2011). In this context, the indirect impact of internal LM implementation on the performance of the focal firm would be expected to be greater via LSCM than its direct impact.

Therefore, the effect on efficiency of implementing LM as a comprehensive strategy, i.e., at the internal and external levels, should be investigated. The level of LM implementation would be expected to be surpassed by LSCM's greater impact on focal firm efficiency indicators such as unit cost of manufacturing, inventory turnover and cycle time (Danese et al., 2012).

At the LSCM operational level, the joint use of lean techniques and practices to eliminate waste and the reduction of sources of variability in the SC have a major added impact on these efficiency indicators in the focal firm (Danese et al., 2012). Unit cost of manufacturing decreases drastically when Value Stream Mapping (VSM) is used in LSC environments (Wee and Wu, 2009). Likewise, the use of Kanban cards and pull flow systems in a JIT SC reduces manufacturing costs (Rossini and Portioli-Staudacher, 2016). Also, generally-speaking, integrated inventory management reduces inventory-related costs (Hooshang, 2010) and, especially, the cost of preparing JIT purchase orders (Parveen and Rao, 2009; Hooshang, 2010), JIT distribution transport and delivery costs (Wang et al., 2004) and JIT delivery transport costs (Chen and Sarker, 2010), and achieves higher stock turnover while minimising inventory (Rossini and Portioli-Staudacher, 2016). Likewise, standardising techniques and practices for all SC members can reduce variability. For example, extending Vendor Management Inventory (VMI) to key suppliers has a strong impact on reducing unit manufacturing cost and high stock turnover and so increases focal firm efficiency (Yao et al., 2007). Also, use of LM techniques and practices along the SC and reduced variability can increase efficiency by minimising cycle time (Apte and Goh, 2004).

In addition, firm efficiency improvements at the LSCM planning level would come from long-term customer demand forecasting and only focusing on the current market segment, which would result in a lower per-unit manufacturing cost, high stock turnover (Qrunfleh and Tarafdar, 2013) and cycle time minimisation (Apte and Goh, 2004). Using queues as buffers to protect sub-processes along the SC so that they can be planned and balanced in advance improves efficiency by reducing customer demand and production lead-time uncertainty and variability (Aronsson et al., 2011). So, LSCM enables an optimal level of safety stock and its best location along the SC (Amirjabbari and Bhuiyan, 2014) and integrated inventory management (Parveen and Rao, 2009). Finally, frequent deliveries in small lots improve synchronisation and contribute to low inventory levels (Klug, 2016) while minimising the bullwhip effect (McCullen and Towill, 2001).

Thus, integrating both LSCM levels (operational and planning) would have a greater multiplier effect on focal firm efficiency than the impact of LM being internally implemented in the focal firm. LSCM implementation implies that SC members have internally implemented LM (Bortolotti et al., 2016; Swenseth and Olson, 2016). Thus, only when LM is implemented as a comprehensive strategy, i.e., at the internal and external levels, can LSCM take a prominent role in focal firm efficiency. In this case, the cumulative effect of SC members' contributions to efficiency and the complementary effects of the joint use of multiple LM techniques and practices would surpass the direct effect on efficiency of a company using LM internally (Hofer et al., 2012). So, LSCM may play a mediating role in the internal LM implementation focal firm efficiency relationship.

Taking all these arguments together, the following hypothesis can now be proposed:

H3: LSCM implementation has a mediating effect between internal LM implementation and focal firm efficiency.

3. Methodology

3.1. Population, questionnaire and data gathering

Data were collected via a questionnaire in a non English-speaking country, so the steps for back translation proposed by Brislin (1976, p. 221) were used. An English version of the questionnaire was developed, translated into Spanish and subsequently translated back into English, with translations done by professional translators specialising in management literature.

A draft version was tested with a panel of five internationally-recognised SCM researchers to guarantee content validity. A pilot study was then conducted with five heads of SCM to ensure that the item definitions in the sample were meaningful and comprehensive, thus minimising response bias and confirming the survey instrument's quality and validity (Saunders et al., 2009).

The questionnaire was divided into different areas depending on the key informant in order to leverage the most knowledgeable managers and minimise key-informant bias (Podsakoff et al., 2003). The questionnaire for the first area was directed at the head of SCM, logistics or operations management. Since high-ranking informants tend to be more reliable information sources than their low-ranking counterparts (Podsakoff et al., 2003), senior managers were targeted to ensure that respondents had sufficient knowledge of internal- and SC-level LM implementation and firm efficiency.

The study focuses on medium-sized enterprises in a single country. The literature recommends selecting a sample of firms located in a relatively homogeneous geographical, cultural, legal and political space to minimise the impact of other variables that cannot be controlled in empirical research (Rojo et al., 2016).

A population of 2,763 Spanish focal manufacturing companies with ≥ 50 employees was obtained from the SABI (Iberian Balance Sheet Analysis System) database and by consulting information available on company websites to confirm their sectors of activity to provide empirical evidence on the proposed research hypotheses. Companies were classified into sectors according to the CNAE (Standard Industrial Classification in Spain) catalogue and any industrial sectors not in an intermediate position in their SC were excluded (approach taken by van der Vaart et al., 2012).

Data were gathered by telephone survey using a computerised system (Computer Aided Telephone Interviewing, CATI). A web questionnaire was also designed by the mid-point of the expected fieldwork period to make it easier for any non-responding interviewees to respond. Fieldwork was from 30 January 2018 to 20 July 2018, with 113 firms identified as not forming part of the population as they had closed down, become insolvent or depended on other firms to adopt decisions on SCM. The final population was, therefore, 2,650 companies, of which 285 responded (10.8% response rate) and returned valid questionnaires. The sampling error was 5.49 per cent, with a confidence level of 95 per cent for $p = q = 0.5$. A similar or even smaller sample size has been used in several recent SCM studies (Qrunfleh and Tarafdar, 2013; Rojo et al., 2016). In summary, the sample size is appropriate and does not jeopardise the reliability of the results.

Table 1 shows firm distribution in the population and the sample according to the CNAE sector classification. A similar distribution of companies among the various sectors can be observed with no great differences in the size of the surveyed firms. The mean number of employees in the firms in the sample is 184.1, with a standard deviation of 327.5 and a median of 99 workers.

[Table 1]

No evidence of response bias was found in a comparison of respondents with non-respondents. So, no significant differences were found between the population and the sample for distribution by annual sales, number of employees and gross operating profit (for 2015 and 2016, taken from the SABI database). Phone calls were then made to a random selection of firms that did not respond to the questionnaire. No specific characteristics were observed in those that decided not to participate and no pattern in the reasons provided to justify their refusal to do so. In general, there does not seem to be any non-response bias in the sample.

Finally, the first forty and last forty responses were compared and no significant differences ($\alpha = 0.05$) were found for any of the variables in the questionnaire, confirming that there was no late response bias. In summary, the data and analysis confirm that the sample used was randomly obtained and statistically representative of the population.

3.2. Variables

Internal Lean Management Implementation. Respondents were asked to compare their firm's global internal LM implementation level with their competitors' on a five-point Likert scale (1 = poor, low; 3 = average or equal to the competition, 5 = superior) (measure used by Bortolotti et al., 2015). This variable was '0' when the firm had not implemented internal LM. The questionnaire also contained a question on the number of years that LM had been implemented internally in the company with the mean observed to be 5.7 years with a standard deviation of 0.47 years.

Lean Supply Chain Management. This is a reflective construct that relies on multiple-item scales based on a construct structure proposed and validated by Moyano-Fuentes et al. (2019) and composed of eight items derived from the literature (Vonderembse et al., 2006; Aronsson et al., 2011; Qi et al., 2011; Azevedo et al., 2012; Jasti and Kodali, 2015; Soni and Kodali, 2016; Tortorella et al., 2017). LSCM is measured according to three dimensions: (i) tools to eliminate waste in the SC; (ii) LSC operationalisation, and (iii) LSC planning. Informants were asked to indicate their level of agreement with a series of statements on LSCM on a five-point Likert scale (1 = totally disagree; 3 = neither agree nor disagree; 5 = totally agree).

Efficiency. This is a measure related to firm operational performance: unit cost of manufacturing, inventory turnover and cycle time (from raw materials to delivery) (Danese et al., 2012; Danese and Romano, 2013). Following several authors, we decided to focus on perceptual and relative performance measures by asking respondents to compare their firm's efficiency with competitors on a five-point Likert scale (1 = poor, low; 3 = average or equal; 5 = much better than average) (Liu et al., 2009; Danese et al., 2012). Given that perceptual measures can be subject to bias, in line with other studies (Danese and Kalchschmidt, 2011) we collected objective data on firm performance and verified the existence of a significant correlation between perceptual measures and objective data (standardised by industry). For example, we found that unit cost of manufacturing correlated with operating costs. In line with other studies (Bortolotti et al., 2015), we decided to use perceptual scales as they are more robust than objective scales for comparing firms operating in different competitive contexts (e.g., sector, firm size, product complexity, etc.).

Survey items and instructions to respondents are presented in the appendix.

4. Analysis and results

4.1. Measurement Model

Content validity was ensured by the questionnaire pre-test. Scale unidimensionality was assessed by exploratory factor analysis, giving eigenvalues higher than the unit, standardised factor loads greater than 0.5, significant explained variance for each extracted factor and high values for chi-squared/degrees of freedom in Bartlett's sphericity test ($p < 0.05$). One second-order factor was used to measure LSCM. Exploratory factor analysis results and a description of observable variables are given in Table 2. Items indicated with an asterisk (*) were discarded after exploratory factor analysis and reliability analysis. Reliability was tested using Cronbach's alpha. Scores of 0.7 or higher were considered acceptable and 0.6 adequate as high coefficient alpha does not always mean high internal consistency, since alpha is also affected by the length of the test or number of items per construct (Nunnally, 1978; Merschmann and Thonemann, 2011). Hence, we considered a 0.6 limit to be reasonable, which is broadly accepted in the literature (Nunnally and Bernstein, 1994).

Divergent validity, or the ability of the scales to discriminate between the different constructs being measured, was confirmed by two tests (Flynn et al., 1999; Anand and Ward, 2004). First, in Tables 2 and 3, the Cronbach's alpha coefficients for the scales were greater than their correlations with other scales. Second, the average item-to-total correlations with items not in the scales were substantially lower than the average item-to-total correlations with items in the respective scales.

[Table 2]

[Table 3]

Finally, confirmatory factor analysis (CFA) was performed using EQS 6.1 software to confirm the scales' dimensionality and test convergent validity. Data exploration was first carried out by the normalised estimation of Mardia's test, which confirmed multivariate non-normality of data. In such situations, the Robust Maximum Likelihood method is more appropriate as it improves standard error estimates and scales the model test statistics as per the Satorra and Bentler theory, which takes into account the degree of non-normality (Satorra, 1993; Bentler, 2006). Final CFA fit was highly satisfactory. Standardised factor loads and R^2 for the variables are given in Table 4.

[Table 4]

4.2. Structural equation model and mediating effects

A Structural Equation Model (SEM) was developed to test the hypotheses (Figure 2). Covariance-Based SEM (CBSEM) was chosen over Partial Least Squares (PLS) and Variance-Based SEM. CBSEM outperforms PLS in terms of parameter accuracy provided that the sample exceeds a threshold of 250 observations (our sample = 285 observations) (Reinartz et al., 2009).

The baseline model in Figure 2 was run first. This model included the effects of LM's internal implementation on LSCM and the LSCM-firm efficiency relationship and yielded an overall good fit (Satorra-Bentler's scaled χ^2 = 51.94; df = 26; χ^2/df = 1.997; RMSEA: 0.060; CFI: 0.946; IFI: 0.948; MFI: 0.954). The relationships in H1 and H2 ($p < 0.05$) were shown to be significant.

[Figure 2]

The baseline model was modified to measure the mediating effect considered in H3 (LSCM implementation mediates the internal LM implementation-efficiency relationship) with the addition of a direct path from internal LM implementation to efficiency (Model 1, Figure 3). CBSEM analysis results showed that Model 1 did not provide an adequate fit with the data (Satorra-Bentler's scaled χ^2 = 83.41; df = 29; χ^2/df = 2.876; RMSEA: 0.083; CFI: 0.886; IFI: 0.890; MFI: 0.905). The significant path coefficients remained the same as in the baseline model with no significant coefficient for the new path between internal LM implementation and firm efficiency (see Figure 3). The χ^2 difference test was not significant for Model 1 vs. the baseline model ($\Delta\chi^2(3df)$ = 31.47, $p > 0.05$), indicating that the latter would be a better explanation of the data than Model 1.

In Model 1, the fit did not improve when the direct (non-mediating) effect was included. H3 is supported due to a significant effect in the baseline model and a lack of improvement in fit in Model 1, which considers the direct internal LM implementation-firm efficiency relationship (see Bruque-Cámara et al., 2015 for a similar methodology).

[Figure 3]

5. Discussion and implications

5.1. Discussion

The empirical research highlights that the principal focus is still on an internal approach in most companies that have embraced LM (Reichhart and Holweg, 2007; Martínez-Jurado and

Moyano-Fuentes, 2014; Danese et al., 2018). However, previous studies indicate that implementing LM at both the internal and external levels results in better performance than only one LM approach (Hofer et al., 2012). Given this background and what can be observed in Figure 1, this study considers LM to be a comprehensive strategy and investigates the interrelationship between internal and external lean implementation and how this improves focal firm efficiency. So, for the first time, a validated construct has been used on LSCM to enable the study of its overall mediating role in the focal firm's internal LM implementation-efficiency relationship.

This study has several outcomes with interesting academic and managerial implications.

5.2. Implications for academic research

The following academic implications have been derived from the obtained results.

a) Effect of internal LM implementation on LSCM implementation

Our findings indicate that internal LM implementation is a driver of LSCM implementation, which underlies the complementarity aspect of the RBT, i.e., the proposed complementary effect between internal level LM and LSCM implementation. This means that LM is a global strategy that should be implemented sequentially. This implies that LM should first be implemented at the internal level in a large number of the firms in the supply chain to later enable the implementation of LSCM in a group of firms. This can be explained in the RBT context as internal level LM being a resource that numerous firms have successfully deployed, enabling firms to learn and obtain deep knowledge of the principles, practices and typical LM tools over time. Any prior experience and knowledge that firms possess would enable these individual resources to become embedded and their complementarity would allow the firms to forge ahead with implementing a new, more complex and more powerful resource such as LSCM (Kumar and Sanchez-Rodrigues, 2017). Also, as every supply chain is different, the LSCM resource is currently very specific to each case and the supply chain members involved are usually the focal firm's strategic suppliers. These findings are related to recent contributions to the literature that determine that a learning orientation and establishing strategic relationships with suppliers are antecedents to LSCM implementation (Iyer et al., 2019; Yildiz-Çankaya, 2020).

b) Lean supply chain management-focal firm efficiency relationships

The results indicate that focal firm efficiency improves when LM extends throughout the SC. This is in line with the relational view of the RBT and integrated SCM, which underline that cooperation and collaboration in the SC can lead to sustainable competitive performance (Arya and Lin, 2007; Danese and Romano, 2011; Azadegan et al., 2013). Implementing LSCM is extremely difficult and complex (Yildiz-Çankaya, 2020), which means that it is currently a very specific, difficult-to-imitate resource and, therefore, according to the RBT, a generator of CA (Yildiz-Çankaya, 2020). Recent studies support this idea (Iyer et al., 2019) as they find that implementing LSCM depends on the specificity and complementarity of other resources that enable collaboration in the SC and that our findings show lead to better operating results. So, the indication is that firms must work with SC partners to reduce or minimise waste and achieve better performance.

c) Mediating effect of LSCM in the internal LM implementation-focal firm efficiency relationship

This study demonstrates that internal level and external level LM make different contributions to improving focal firm efficiency. Our results indicate that senior managers perceive that internal LM implementation alone is not enough to achieve the breakthrough improvements that LM offers, and that for this LM principles, practices and techniques must be extended across the SC. This deduction is based on the surveyed managers' knowledge and interpretations of the connection between internal level and external level LM and the impacts of both on focal firm efficiency.

In this sense, LSCM is confirmed to exert a mediating effect on the impact of LM internal implementation on focal firm efficiency and it may also be useful for explaining the mixed findings on the internal LM-performance relationship detected in the literature. In other words, internal level LM has a positive and significant effect on focal firm efficiency only when it contributes to a higher level of LSCM implementation. These results can be explained by the RBT. LM has spread across sectors and countries since first emerging in 1990 (Womack et al., 1990). Over time, internal level LM has stopped being a unique, difficult-to-imitate resource that leads to CA. However, LM learning and knowledge gained over several decades have resulted in a new resource -LSCM- that has been created out of the aggregation of complementary LM resources at the internal level of firms in the supply chain and that is difficult to imitate. Therefore, a firm's CA (via better operating results) is not only dependent on its own internal resources (internal LM), but also on its external resources (LSCM), which is how internal resources extend beyond a firm's boundaries and are embedded in its SC. This explanation is backed up by recent findings (Iyer et al., 2019) highlighting that relational partnership resources are critical as they determine collaboration capability as a mechanism to facilitate building LSCM for CA.

This finding confirms the above-mentioned indication that LM strategy must be implemented sequentially, especially if a firm wants to achieve the results expected from its implementation. Therefore, this study's results indicate that a broader approach is needed to investigate LM's impact on performance to provide a sustainable advantage. The study demonstrates that focal firm internal level LM should be complemented with SC level LM to provide a better understanding of the drivers of CA. To improve SC effectiveness through better efficiency outcomes, LM implementation needs to be the goal of all SC members.

5.3. Managerial implications

From a practical perspective, our findings indicate that LM at the internal level alone does not provide any benefits and that benefits are only obtained when LSCM is implemented. Managers should, therefore, be aware of the major role played by LSCM implementation and prioritise their efforts to minimise the use of resources and improve efficiency by adopting an external approach to their LM implementations. To achieve the best operational performance from LM, managers should pay attention to the transfer of knowledge, competencies and cultural change linked to LM implementation on the internal level to their SC members, and the joint implementation of LSC principles, practices and techniques. Thus, implementation at the internal level would be the indispensable first step towards other tiers of the SC implementing lean on the internal level and, ultimately, to achieving interconnected internal lean systems and having everything in place for LM to translate into improvements to efficiency.

So, managers should be aware that lean implementation at the internal level in their companies and, therefore, the efficiency of the companies that they manage, are affected by the degree to which their customers and suppliers implement lean at the internal level. For example, high variability caused by customers and suppliers implementing lean can undermine the efficiency level obtained with internal lean implementation (e.g., demand and supply variability can desynchronise internal Just-in-Sequence flows and, subsequently, reduce internal efficiency levels).

In more general terms, this study provides a tool for managers to assess the operational aspects of LSC strategy implementation and LSC planning aspects and, consequently, to identify and address weaknesses that enable them to enhance LSCM implementation. Senior managers need to understand that this advance is a major competitive weapon, as LSCM's impact on efficiency can transform their lean supply chain strategy into a CA.

6. Conclusions, limitations and further research

This study seeks to contribute to the impact on performance of extending LM along the SC. To analyse this impact, we have investigated the interrelationships between internal and external level LM implementation and the influence of both on focal firm efficiency.

The findings highlight that external level LM implementation positively impacts focal firm efficiency. Moreover, LM implementation at the internal level exerts a positive impact on LM implementation at the external level, showing a complementary effect between LM implementation between these levels. On the other hand, LM at the internal level does not impact the efficiency of the focal firm on its own but requires LM to be implemented along the SC for focal firm efficiency to be improved. So, LSCM is a competitive weapon that provides better operational results for the focal firm.

6.1. Limitations and future research lines

Regarding the limitations of this study and future research lines, this work evaluates LSCM implementation from the perspective of the focal company, which may distort the analysis. So, further research on LSCM should consider the vision of the level of LSCM implementation from the perspective of a variety of upstream and downstream members. Also, this work focuses on focal firm efficiency and does not use an SC-level measure of efficiency. It would, therefore, be interesting to test for efficiency with a measure at SC level.

We use data from industrial sectors in an intermediate position in their SCs in Spain. So, it might be interesting to conduct a cross-country analysis to test this model for other countries and international SCs. While this limitation restricts the results geographically, it also increases the certainty that they apply to these sectors and to other countries with similar characteristics to Spain.

Another major limitation is the use of subjective measures of efficiency. In line with previous studies (Danese and Kalchschmidt, 2011; Bortolotti et al., 2015) and as discussed in section

3.2, we decided to use perceptual and relative measures of efficiency compared to competitors. Although our choice has some advantages, especially when measuring the efficiency of firms operating in different contexts, it can, nonetheless, cause some bias derived from managers' perceptions and because no change is observed in their firms' efficiency. Thus, further longitudinal studies would corroborate the found results by analysing how quantitative measures of focal firm efficiency change over time when lean management is extended along the SC.

Past empirical evidence points to an appropriate organisational culture and trust among SC agents being vital factors for sustaining LSCM (Jadhav et al., 2014). Another possible research line with both theoretical and practical implications would be to examine the link between these factors and LM implementation at the internal and external SC levels and the impact on efficiency. Measures could then be adopted to mitigate any potential problems associated with LM implementation along the SC and its impact on efficiency.

Some previous studies state that companies that implement LM principles, practices and techniques also need to implement a resilient approach to overcome the increasing vulnerability of their SCs and achieve adequate performance (Ruiz-Benítez et al., 2018). Future studies should examine the interrelationships between LSC, resilient SC and efficiency.

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Appendix.

Survey

1. Please score on a scale of 1-5 your firm's overall level of internal lean management implementation compared to competitors. 1 = poor, low; 2 = below average; 3 = average or equal to the competition; 4 = above average; 5 = superior to the competition:________________

2. Please indicate the number of years that lean management has been implemented internally in your firm:_____________ years

3. Please score on a scale of 1-5 the degree to which you agree with the following statements related to lean at the supply chain management level. 1= totally disagree; 2 = disagree; 3 = neither agree nor disagree; 4 = agree; 5 = totally agree:

Statement	**1**	**2**	**3**	**4**	**5**
Value stream mapping is used to identify and eliminate waste throughout our supply chain					
Our supply chain uses lean manufacturing techniques (such as pull flow, Kanban systems, and setup time reduction)					
Our supply chain generates high stock turnover and minimises inventory					
Process and product standardisation are common practices in our supply chain					
Our supply chain delivers in small lot sizes					
Our supply chain does long-term forecasting of customer demands and only focuses on current market segments					
In our supply chain, the strategy for handling uncertainty consists of using queues and buffers to protect sub-processes					
Our supply chain structure seldom changes					

4. Please, indicate on a scale of 1-5 your firm's position in the following efficiency indicators compared to competitors. 1 = poor, low; 2 = below average; 3 = average or the same as the competition; 4 = above average; 5 = much better than average:

Item	**1**	**2**	**3**	**4**	**5**
Unit cost of manufacturing					
Inventory turnover					
Cycle time					

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

SECTOR	Number and percentage of companies in population		Number and percentage of companies in sample		Response Rate
Food products and tobacco	543	20.49%	52	18.25%	9.57%
Chemicals and pharmaceutical products	422	15.92%	49	17.19%	11.61%
Manufacture of metals products	322	12.15%	45	15.79%	14.29%
Manufacture of machinery and equipment	275	10.38%	34	11.93%	12.36%
Motor vehicles	273	10.30%	24	8.42%	8.79%
Meat industry	158	5.96%	6	2.11%	3.80%
Electrical machinery and materials	141	5.32%	14	4.91%	9.93%
Manufacture of beverages	106	4.00%	8	2.81%	7.55%
Furniture industry	82	3.09%	8	2.81%	9.76%
Informatics, Electronics and Optics	81	3.06%	13	4.56%	16.05%
Manufacture of another transport material	77	2.91%	12	4.21%	15.58%
Shoes and Leather	63	2.38%	5	1.75%	7.94%
Other manufacturing industries	60	2.26%	9	3.16%	15.00%
Fabrics and Textile	47	1.77%	6	2.11%	12.77%
Total	**2,650**	**100%**	**285**	**100%**	**10.79%**

Table 2. Exploratory factor analysis

Factor	Variable	Standardized factor loading	Cronbach's α	Bartlett test	% Explained variance
Lean Supply Chain Tooling	Value stream mapping is used to identify and eliminate waste throughout our supply chain (LCS_1)	0.886	0.69	χ^2= 270.415	72.466
	Our supply chain uses lean manufacturing techniques (such as pull flow, Kanban systems, and setup time reduction) (LCS_2)	0.839		df= 15	
Lean Supply Chain Operationalization	Our supply chain generates high stock turnover and minimizes inventory (LCS_3)	0.821		Sig.= 0.000	
	Process and product standardization is a common practice in our supply chain (LCS_4)	0.768			
	Our supply chain delivers in small lot sizes* (LCS_5)				
Lean Supply Chain Planning	Our supply chain does long term forecasting of customer demands and only focuses on the current market segments (LCS_6)	0.684			
	In our supply chain, the strategy for handling uncertainty consists of using queues and buffers to protect sub-processes (LCS_7)	0.881			
	Our supply chain structure seldom changes* (LCS_8)				
Efficiency	Unit cost of manufacturing (EFF1)	0.690	0.63	χ^2= 102.183	57.205
	Inventory turnover (EFF2)	0.817		df= 3	
	Cycle time (from raw materials to delivery) (EFF3)	0.757		Sig.= 0.000	

Table 3. Correlations between scale items

	LSC_1	LSC_2	LSC_3	LSC_4	LSC_6	LSC_7	EFF1	EFF2	EFF3
LSC_1									
LSC_2	,543**								
LSC_3	,145*	,245**							
LSC_4	,173**	,204**	,366**						
LSC_6	,164**	,226**	,264**	,336**					
LSC_7	,193**	,267**	,140*	,172**	,351**				
EFF1	0,042	0,064	0,049	0,102	0,044	0,043			
EFF2	0,038	0,073	,320**	,199**	,167**	0,071	,348**		
EFF3	-0,077	-0,002	,175**	0,075	0,111	0,005	,304**	,435**	
LII	,350**	,611**	,153*	,130*	,156**	0,078	-0,046	0,009	0,064

Note: *p<0.01; ***p<0.05*

Table 4. Confirmatory factor analysis

Factor	Variable	Standardized factor loading	R^2
Lean Supply Chain Tooling	LSC_1	0.65*	0.422
	LSC_2	0.86*	0.737
Lean Supply Chain Operationalization	LSC_3	0.58*	0.334
	LSC_4	0.65*	0.425
Lean Supply Chain Planning	LSC_6	0.70*	0.489
	LSC_7	0.51*	0.256
Efficiency	EFF1	0.46*	0.214
	EFF2	0.79*	0.617
	EFF3	0.56*	0.318

Note: *p<0.01

Figure 1. Object of the study

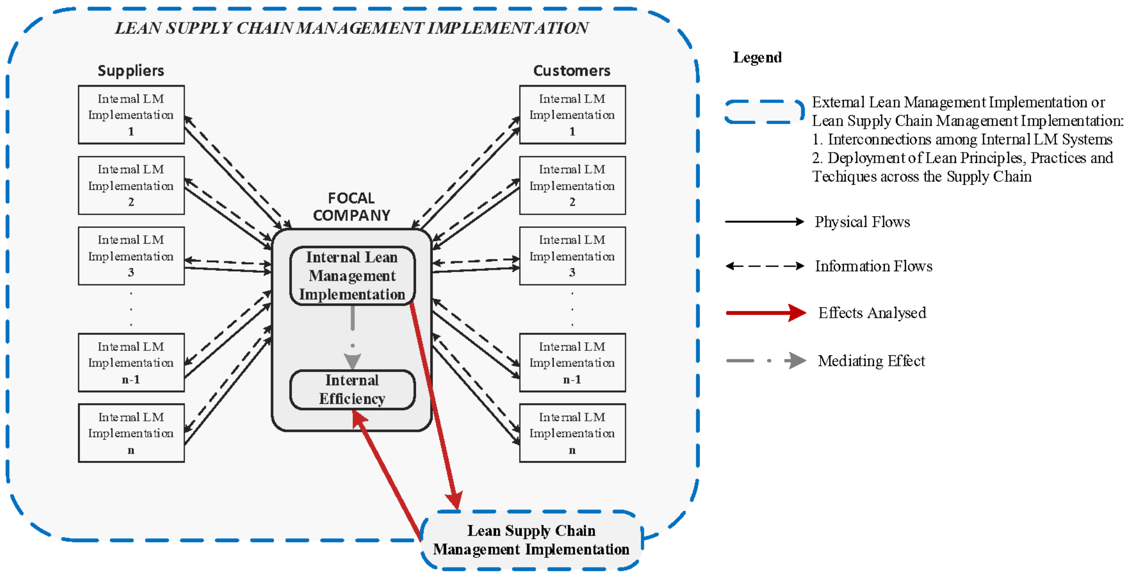


Figure 2. Baseline and measurement model

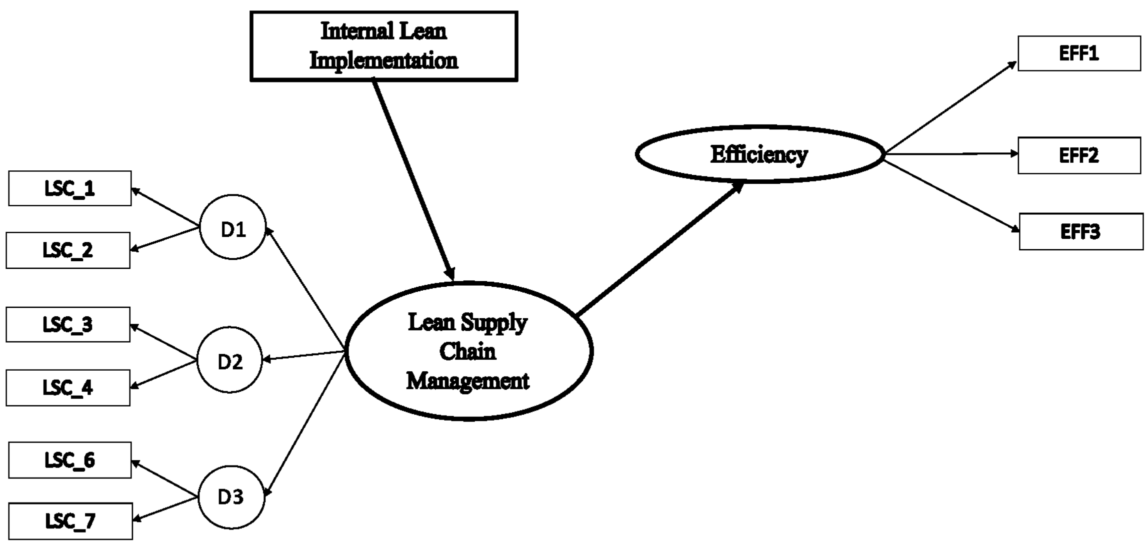
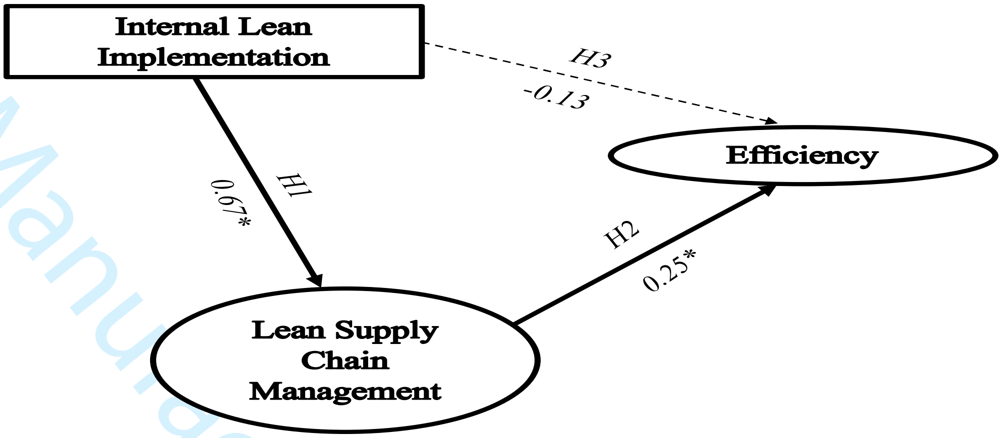


Figure 3. Model 1: Structural baseline equation model and model to highlight mediating effects



Note: $*p < 0.05$

Model	χ^2	df	$S-B\ \chi^2/df$	RMSEA	CFI	IFI	MFI	RHO	$\Delta\chi^2$
Baseline	51.94	26	1.997	0.060	0.946	0.948	0.954	0.756	n/a
Model 1	83.41	29	2.876	0.083	0.886	0.890	0.905	0.761	31.47