Lean, sustainability and the triple bottom line performance: a systems perspective-based empirical examination

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Abstract

Purpose – This study draws on the systems perspective to study the individual and combined interaction effect of lean management (LM) and sustainability management (SM) on the organization's triple bottom line (TBL) performance.

Design/methodology/approach – The study employs structural equation modeling to test the proposed hypotheses using data from the sixth version of the International Manufacturing Strategy Survey (IMSS VI).

Findings – The study finds that LM is positively related to all dimensions of the TBL performance. In contrast, SM is positively related to social and environmental performance and negatively related to economic performance. Finally, by finding that the interaction between LM and (SM) is positive for social and environmental performance, this study not only confirms that LM is an enabler for sustainability, but it also supports that the two paradigms are mutually compatible and reinforcing.

Practical implications – The findings imply that practitioners pursuing both LM and SM should leverage their mutual positive effects and balance the unintended effects of implementing isolated bundles by implementing them together as a complete socio-technical system. Their combined impact on the TBL performance will outweigh the sum of their individual effects in the case of isolated implementations.

Originality/value – In contrast with the extant literature, this study proposes that LM and SM make parts of one system as opposed to one correlated with the other or having a positive causal effect on the other. Taking an integrated systems approach, the study empirically verifies the "mutual compatibility" of the lean and sustainability paradigms argument, with regard to their effect on the TBL performance.

Keywords Lean management, Sustainability management, Triple bottom line performance, Socio-technical systems

Paper type Research paper

1. Introduction

Increasing globalization and competition have force manufacturing firms to resort to becoming lean as well as sustainable (Kleindorfer *et al.*, 2005; Longoni and Cagliano, 2015; Piercy and Rich, 2015; Distelhorst *et al.*, 2016; Ciccullo *et al.*, 2018; Thanki and Thakkar, 2020). Thus, these firms need to employ organizational designs that fully exploit the simultaneous synergistic and overlapping aspects of the two paradigms while balancing the tradeoffs between them (Hamja *et al.*, 2021; Hoque *et al.*, 2020). For example, to enable environmental sustainability, Esquel (a Hong Kong-based leading producer of cotton shirts) introduced cotton farmers to newer productivity-enhancing harvesting techniques and diluted control in its relationship with the farmers (Lee, 2010). The former is synonymous with the "process improvement" facet (Bajjou and Chafi, 2021), whereas the latter relates to the "involvement of

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stakeholders" dimension of lean management (LM). Similarly, Nike's and its supplier Silver Star's successful implementation of LM and the resulting benefit of employee well-being and improved sustainability performance (Distelhorst *et al.*, 2016) also suggest that the benefits of LM in enabling the organizations to implement sustainability should be exploited by implementing the two paradigms together (Thanki and Thakkar, 2020).

In the academic world as well, the combination of LM and sustainability management (SM) has attracted significant attention (Hoque *et al.*, 2020; Sarkis and Zhu, 2018; Cherrafi *et al.*, 2016; Martínez-Jurado and Moyano-Fuentes, 2014). However, extant literature at the intersection of LM, SM and facets of the triple bottom line (TBL) performance is very segregated (Figure 1). Most of the studies are at the intersection of LM and environmental sustainability (Ali *et al.*, 2020; Thanki and Thakkar, 2020; Ugarte *et al.*, 2016; Wichaisri and Sopadang, 2017; Zhu and Sarkis, 2004), arguing that through waste minimization and "just in time (JIT)" production, lean is "inherently green" (Mollenkopf *et al.*, 2010; Zhu and Sarkis, 2004; Ali *et al.*, 2020). There is a need for studies on lean and other dimensions of sustainability (Luo and Bhattacharya, 2006; Kliendorfer *et al.*, 2005). Moreover, current literature at the intersection of lean and sustainability finds support for the causal (De Treville *et al.*, 2005; Taubitz, 2010) and the reverse causal relationship between them (Sroufe, 2003; Corbett and Klassen, 2006; Azevedo *et al.*, 2011). Proponents of the causal link argue that through dilution

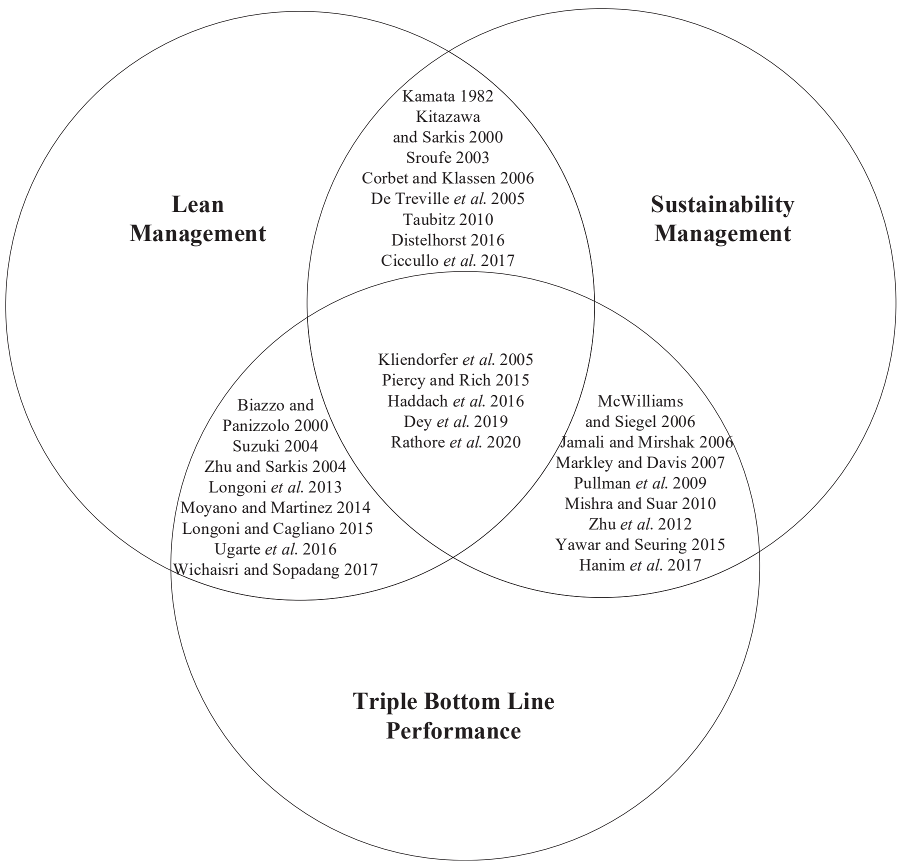

Figure 1.
Representative literature on interfaces of lean management, sustainability management and triple bottom line performance

of control and stakeholder involvement, LM aids in the implementation of sustainability program (Hamja *et al.*, 2021; Hoque *et al.*, 2020). Conversely, supporters of the reverse causal link hold that the implementation of environmental standards and accompanying move to full life cycle analysis results in better process and product design, eventually saving costs and aiding lean and improved operations (Sroufe, 2003; Corbett and Klassen, 2006).

There are only a few studies that focus on the three-way intersection of LM, SM and TBL performance (Kliendorfer *et al.*, 2005; Piery and Rich, 2015; Haddach *et al.*, 2016; Dey *et al.*, 2020; Rathore *et al.*, 2020). Kliendorfer *et al.* (2005) argued that firms must integrate environmental, health and safety metrics with other process metrics to reap benefits from the synergies between lean and green (Klassen, 2001; King and Lenox, 2001). Piercy and Rich (2015) also conferred that both lean and sustainability are mutually reinforcing and compatible. More recently, Haddach *et al.* (2016) used correlation analysis to propose that lean practices, when combined with environmental and social practices, have a more significant impact on the TBL performance than the isolated impact of either of these practices. Finally, Dey *et al.* (2020) and Rathore *et al.* (2020) argued and empirically tested various mediation links between LM practices and sustainable performance.

However, there are important issues in the literature that highlight the need for more research. Firstly, most of the extant literature on the enablers of sustainability implicitly assumes that the three dimensions of TBL are synergistic, which may or may not be the case. Secondly, the literature is unclear regarding the direction of causality between lean, sustainability and the TBL (Azevedo *et al.*, 2011) performance and the reason for the arguably positive correlation between the constructs (Haddach *et al.*, 2016). For example, the correlation could be because (1) one set of the practices leads to the other directly or via mediating variables (Dey *et al.*, 2020; Rathore *et al.*, 2020), and they are individually positively related to the TBL, (2) they both move in the same direction because of a third unknown variable that is positively related with them and the TBL or (3) the two are parts of one system.

Thirdly, the literature studies individual bundles of LM, with individual bundles of SM and dimensions of the TBL (Longoni and Cagliano, 2015; Distelhorst *et al.*, 2016). Isolating the impact of individual bundles of practices from a cluster gives an incomplete understanding if the bundles are interacting with other bundles within and outside the cluster. For example, when managers try to implement dilution of control (a factor in the lean cluster), they can neither hold workers' flexibility and autonomy constant (lean cluster) nor can they hold communication constant (the SM cluster). Therefore, any subsequent increase in the TBL performance cannot be attributed to the dilution of control alone. Selective implementation of some practices from an interdependent system also renders the potential of the holistic system to balance unintended trade-offs ineffective. For example, implementing JIT production in isolation may lead to the conclusion that the smaller and infrequent deliveries because of implementing "lean" decrease environmental performance (Venkat and Wakelant, 2006). Only when it is implemented with other aspects of lean, including continuous improvement, resource efficiency, added emphasis on process productivity and minimizing of wastages (Bajjou and Chafi, 2021), will the net effect of "lean" on environmental performance be captured.

Using the systems perspective, this study seeks to address the issues above by proposing that the underlying relationship is that of a complex interaction between the two paradigms that makes them parts of one system. It posits that the emergent behavior of lean and SM when the holistic system is put in place together is very different from the behavior when the two paradigms are adopted separately and sequentially. Therefore, optimizing such a holistic socio-technical system requires that the two paradigms be implemented together (Chaplin and O'Rourke, 2018) to exploit their positive externalities on one another and balance any unintended trade-offs of implementing isolated bundles. The study results confirm most of the hypotheses regarding the direct effects of lean and SM on the TBL performance. The positive interaction effect between the two paradigms is also supported for social and environmental performances, supporting the argument that the two paradigms are "mutually compatible." The benefits of co-implementation established in this study will encourage managers to overcome resistance, skepticism and trade-offs while implementing either of them, promoting the adoption of LM as an enabler for SM.

The rest of the article is organized as follows. The following section discusses the conceptual framework of the study. It is followed by a section on the literature review and hypotheses development. Section 4 presents the research methodology and results. Finally, Section 5 discusses the results and their theoretical and practical implications and concludes the paper.

2. Conceptual model

2.1 Theoretical underpinning: systems perspective and socio-technical theory

Systems perspective propagates that individual elements of a subsystem, which have external or interaction effects upon one another, should not be studied in isolation (Luhmann, 1995). Socio-technical systems theory builds on the systems perspective to study complex socio-technical systems, where complex technical infrastructure and humans interact. The theory posits that to optimize the socio-technical system as a whole, the social aspects comprisingpeople and society must be in balance and harmony with the technical aspects of structures and processes (Piercy and Rich, 2015). Manufacturing firms are complex socio-technical systems, requiring optimal management of both its processes, technology and tasks, as well as its people and the interrelationships between them (Saurin *et al.*, 2013). Both LM and SM paradigms provide concepts for realizing social and technical systems. Therefore, using the socio-technical systems lens, this study intends to investigate the individual and combined effect of sustainability and LM on the TBL performance (Figure 2).

This study puts forward that both LM and SM share common social elements, including more involvement by stakeholders, dilution of control and open communication in the workplace. Moreover, the dimensions that are unique to the constructs also positively reinforce one another**.** For example, implementing SM standards and training stakeholders for sustainability involves certain costs. Coupling the paradigm with the cost minimization benefits of lean entailed by process focus, continuous improvement and information integration balances the temporary increase in cost, enabling the adoption of SM.

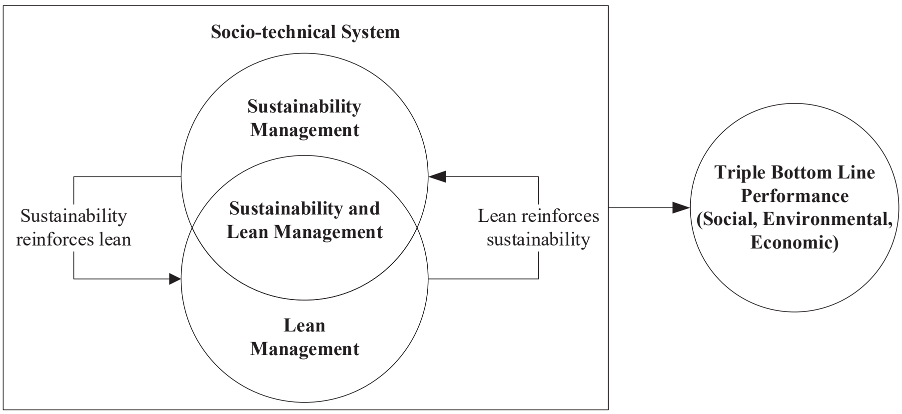

Figure 2.
Conceptual model

Likewise, lean implementation requires a social foundation. Sustainability provides that foundation by positively engaging and motivating the stakeholders through effective implementation of standards, taking care of their health and safety and engaging in their co-development. Furthermore, it fosters an open and involved organizational culture that is receptive to change, enabling the adoption of LM and reinforcing the effect of lean on the TBL (Dorval *et al.*, 2019).

To reiterate, each element of lean provides either the social or the technical foundation, equipping the firm with the capabilities that enable effective SM implementation, to improve the TBL. Similarly, each element of SM also provides the social foundation that LM requires to work efficiently (Dües *et al.*, 2013; Longoni and Cagliano, 2015).

3. Literature review and hypotheses development

3.1 Sustainability management and the TBL performance

Extant literature is inconsistent on the relationship between SM and dimensions of the TBL (Seuring and Muller, 2008; McWilliams and Seigel, 2000). While majority of the research finds a positive relationship between CSR and the three performance dimensions (Sroufe, 2003; Golicic and Smith, 2013; Orlitzky *et al.*, 2003), other studies find an insignificant (McWilliams and Seigel, 2000) or negative (Smith *et al.*, 2007) relationship between the two. The inconsistency is attributed to the many different definitions of SM and its manifestations, improper understanding of relatively less tangible social practices and social performance (Shafiq *et al.*, 2014) and the lack of inclusion of intervening (Galbreath and Shum, 2012) as well as contextual variables (Barnett, 2007).

This study takes the stakeholder perspective and maintains that firms employ their SM program to satisfy various internal and external stakeholders. It invokes the social exchange theory, precisely the principle of reciprocity (Cropanzano and Mitchell, 2005) to hypothesize the resulting positive impact on the TBL. For example, the employees and suppliers in manufacturing companies invest in hard work with the expectation of being fairly compensated. When the firm reciprocates and reinforces these expectations by investing in their health, safety and training, they want to put in more effort, hard work and quality (Sandhya and Sulphey, 2020). As a result, a dynamic, positive relationship will establish, with its foundations built on trust, loyalty and mutual commitment.

Similarly, a firm's customers expect it to comply with sustainability standards and provide them with reasonably priced products that conform to the quality and reliability standards (Flynn *et al.*, 1995). When the firm engages in SM practices, these expectations are also positively reinforced, increasing their satisfaction levels. Also, through engaging in SM, firms increase the self-worth and satisfaction of stakeholders who identify with it (Mishra and Suar, 2010), resulting in improved social performance of the firm.

SM also increases economic performance through several channels. Knowing that stakeholders hold positive evaluations of socially responsible behavior, firms use SM as a signaling mechanism to distinguish themselves as reliable and trustworthy and manifest their hidden good intentions. Signaling is especially relevant when there is information asymmetry (Boulding and Kirmani, 1993). The suppliers and employees reciprocate by providing better quality products, which is tied to improved economic performance (Yee *et al.*, 2008). The customers reciprocate by increasing their re-purchases and referrals and exhibiting loyalty to the firm (Mishra and Suar, 2010; Mittal and Kamakura, 2001). Through its signaling ability and generating goodwill, SM also enhances firm's reputation, further increasing economic performance.

Finally, greater stakeholder involvement, adoption of standards and sustainability communication all create a proactive environmental attitude in the workplace (Longoni and Cagliano, 2015). Moreover, developing suppliers to improve their sustainability performance and the resulting increased supplier integration have been proven to positively affect environmental performance directly too (Klassen, 2001). Information integration with all stakeholder groups results in clear communication of precise demands across the supply chain. The resulting reduction in bullwhip effect, unnecessary extra production, transportation and inventory stocking (Piercy and Rich, 2015; Kainuma and Tawara, 2006) has a myriad of beneficial environmental outcomes, including less energy consumption and pollution as waste production levels. Therefore, we hypothesize:

H1abc. The firm's engagement in sustainability management practices positively affects its TBL (a: social, b: environmental, c: economic) performance.

3.2 Lean and TBL performance

The relationship between lean and dimensions of the TBL performance has found positive (Distelhorst *et al.*, 2016; Longoni and Cagliano, 2015; Piercy and Rich., 2015) as well as negative support (Suzuki, 2004). This inconsistency can also be attributed to the lack of contextual variables and the different and contradictory definitions of lean in literature (Piercy and Rich, 2015). This study adopts Shah and Ward's (2007) comprehensive definition of lean, which takes into account the people (social) and the process (technical) components of lean on the one hand, and the external and internal (to the focal firm) stakeholders components on the other hand. Most of the literature taking the holistic construct of lean agrees that by aiming to produce the same output with fewer resources, reduced inventory, fewer reworks and production defects, "lean is inherently green" (Longoni and Cagliano, 2015; King and Lenox, 2001; Florida, 1996; Kitazawa and Sarkis, 2000).

Lean also entails information integration with and greater involvement of the stakeholders, which results in less unnecessary extra production and a more proactive environmental attitude across the entire supply chain, both of which increase environmental performance (Piercy and Rich, 2015; Kainuma and Tawara, 2006). In contrast, smaller and frequent deliveries resulting from JIT production have also been associated with more pollution (Venkat and Wakeland, 2006), but we hold that studying only JIT production is not reflective of the relationship between the higher-order construct of LM and environmental performance.

Similarly, our study agrees with literature that supports that by focusing on minimizing wastages and inventory, and aiming to produce the same output with fewer resources, lean is also inherently economically viable (Florida, 1996). Furthermore, the stakeholder involvement for quality and cost improvement as part of LM also improves economic performance (Longoni and Cagliano, 2015; Klassen, 2001). Other facets of LM, such as information integration with suppliers and customers, are proven to reduce the bullwhip effect and unnecessary extra production, transportation and inventory stocking (Hoque *et al.*, 2020; Piercy and Rich, 2015; Kainuma and Tawara, 2006), saving costs on multiple levels.

With regard to social performance, on the one hand, there is evidence that worker training, involvement, incentives and focus on quality positively affect employee motivation and well-being (Longoni and Cagliano, 2015; De Treville *et al.*, 2005; Paul Brunet and New, 2003). Literature also confers that through increased worker training, standardization of work and visual management, lean operations also deliver high levels of operational safety at the workplace (Hamja *et al.*, 2021; Hoque *et al.*, 2020; Taubitz, 2010). On the other hand, literature also warns us of the potential adverse effects of increased stress levels and injury resulting from increased workloads, work intensity and forced productivity enhancement that come with LM (Askenazy, 2001; Conti *et al.*, 2006; Distelhorst *et al.*, 2016).

This study confers that if lean is seen as a mere "waste reduction toolkit" or "JIT production" (Zhu and Sarkis, 2004; Kitazawa and Sarkis, 2000), the resulting pressure to be more productive is likely to increase the stress levels of the stakeholders and reduce social performance. However, when the holistic and dynamic system of lean is implemented, the emphasis on efficiency and productivity is balanced with dilution of control and stakeholder involvement and assuagement, resulting in a positive net effect on social performance. Thus, we hypothesize:

H2abc. The firm's engagement in lean management practices positively affects its TBL (a: social, b: environmental, c: economic) performance.

3.3 Interaction between lean and sustainability management for TBL performance

Extant literature lends three key reasons for the synergies between lean and sustainability. First, both are interlinked because they require similar capabilities and result from a common drive of innovation (Piercy and Rich, 2015; Florida, 1996). Secondly, companies that work toward implementing ISO 9000 for operational excellence often naturally move toward ISO 14000 for sustainability performance, and vice versa (Piercy and Rich, 2015; Kitazawa and Sarkis, 2000; Corbett and Klassen, 2006). Thirdly, Piercy and Rich (2015) use the systems perspective to explain that "lean provides social-foundation for sustainability and pairs it with a technical system to implement improvement while sustainability provides a social-foundation for lean but often lacks the technical system tool kit element to drive forward improvement."

This study also takes the systems perspective to convey that each element of lean provides either the social or the technical foundation that enables the effective implementation of SM practices to improve TBL performance, just as each element of SM provides a social foundation reinforcing the effect of LM on TBL (Dües *et al.*, 2013; Longoni and Cagliano, 2015). Elements of process focus such as reorganizing layouts for streamlining processes, reducing setup time, using Kanban systems and continuous improvement programs and total preventive maintenance provide a technical foundation for removing tangible (physical) hurdles and wastages. The result is increased overall visibility and transparency in the workplace which aids the monitoring and assessment facets of SM, whereas the direct reduction in physical hurdles and wastages helps with several operational and environmental agendas that enable SM adoption and make it more effective (Franchetti *et al.*, 2009).

Information integration, including improved forecasting, planning and cross-functional decision-making associated with technical lean practices, helps build both technical and eventually social foundation for SM. Clear and efficient communication helps in the integration of different stakeholders and in dilution of control across the organization. It removes intangible (mental) hurdles in implementing SM such as an organizational culture that can be rigid toward change (Dorval *et al.*, 2019). The coordination of precise demands across the entire supply chain also reduces the bullwhip effect and decreases unnecessary extra production, transportation and inventory stocking (Piercy and Rich, 2015; Kainuma and Tawara, 2006), reducing the tangible hurdles and clutter in the workplace. The former helps in the enabling of SM through working at the top management's mindset. In contrast, the latter directly results in less energy consumption, pollution and wastages, aiding the implementation of social responsibility standards.

Similarly, through engaging in altruism and caring for the stakeholders, SM motivates and involves them in the firm's affairs, helping in building a social foundation for LM that is based on an open and involved organizational culture that is receptive toward change (Dorval *et al.*, 2019). This foundation can be subsequently leveraged for making the adoption of other facets of LM such as information integration, process focus and continuous improvement easier, reinforcing the effect of LM on the TBL (Piercy and Rich, 2015). These complex intertwined interactions make up the socio-technical system, whose optimization requires the simultaneous adaptation and implementation of both lean and sustainable paradigms as a completely aligned system. Individual effects of both SM and LM on the TBL performance are hypothesized to be positive, but whenever one bundle is adopted in isolation, their positive external effects of enabling one another will not be realized, rendering the full potential of each bundle unexploited (Thanki and Thakkar, 2020). Therefore, we hypothesize that:

H3abc. Lean and sustainability management practices positively interact with one another to enhance the TBL (a: social, b: environmental, c: economic) performance.

4. Research methodology

4.1 Data collection and sample

This study uses the latest edition of the IMSS VI data. The data set comprises data from manufacturing firms from assembly manufacturing plants that have more than 50 employees. The IMSS VI questionnaire was first developed in English and then translated into other languages. It was extensively pre-tested and subsequently refined before the final launch. The key respondents included top-level operations managers/directors or equivalent position individuals who had knowledge about the firm's strategic and operational practices.

In total, 2,586 questionnaires were distributed across different countries. The final IMSS VI sample consisted of 931 companies from 22 countries situated in Europe, Asia and the Americas, giving a response rate of 36% (931/2586). The local research teams tested for nonrespondent and late-respondent biases by comparing the publicly available secondary information regarding size, industry, sales and proprietorship of the target companies with the received responses. In cases where such information was not available, survey responses were used to test the differences between early and late responses. However, significant evidence of late-response bias and nonresponse bias was not found in the data (Armstrong and Overton, 1977).

The survey followed the techniques described by Podsakoff *et al.* (2003) to minimize common method bias (CMB) proactively. First, items of constructs prone to CMB, such as predictor and criterion variables, were separated from each other in the questionnaire. Second, the survey employed different scale anchors/formats to measure independent and dependent variables. Third, the data collection process maintained the respondent's and firm's anonymity to reduce the social desirability need of the respondent. Finally, the survey employed objective concepts and explained items to reduce ambiguity. Missing data analyses revealed that the missing data were not systematically related to the observed data (MCAR: Little's t-test p-value > 0.10). Therefore, cases with more than 10% (5) missing values on the variables of interest were excluded from the analysis. The rest of the missing values were imputed using the series mean. The remaining sample used in the subsequent analysis consisted of 750 responses from manufacturing firms in 22 countries in Europe, North America, Asia and South America (Table 1).

4.2 Measures

We operationalized the TBL performance as first-order reflective constructs for each of the three performance dimensions. In contrast, SM and LM are operationalized as second-order reflective constructs (Jarvis *et al.*, 2003). SM has been operationalized as a multidimensional construct comprising internal social and environmental sustainability and external sustainability (Gimenez *et al.*, 2012) as its first-order reflective constructs. Items for all constructs (Table 2) are adapted from the supporting work of Kitazawa and Sarkis (2000) and Krause *et al.* (2000).

Firm size *(number of employees)*	Number	% of useable sample
Small *(less than 250)*	355	47.3
Medium *(251 to 500)*	122	16.3
Large *(more than 500)*	273	36.4
Industry		
ISIC 25 manufacture of fabricated metal products, except machinery and equipment	233	31.1
ISIC 26 manufacture of computer, electronic and optical products	103	13.7
ISIC 27 manufacture of electrical equipment	127	16.9
ISIC 28 manufacture of machinery and equipment not elsewhere classified	175	23.3
ISIC 29 manufacture of motor vehicles, trailers and semi-trailers	77	10.3
ISIC 30 manufacture of other transport equipment	35	4.7
Region and country (country sample size)		
Europe and North America	413	55.07
The Netherlands (36), Romania (39), Finland (28), Switzerland (18), Portugal (26), Spain (18), Italy (32), Belgium (20), Canada (21), Denmark (28), Germany (10), Hungary (40), Norway (24), Slovenia (17), Sweden (20), the United States of America (31)		
Asia and South America	337	44.93
India (89), China (107), Taiwan (24), Malaysia (12), Japan (79), Brazil (26)		

Note(s): Total useable sample size = 750; ISIC: International Standard Industrial Classification

Table 1.
Sample demographics

LM is operationalized as a second-order reflective construct comprisingthree first-order reflective constructs, namely, technical lean practices (TLP), internal social lean practices (SLP internal) and external social lean practices (SLP external) (Neely *et al.*, 2014). Individual items measuring the first-order constructs (Table 2) are adapted from literature (Demeter and Matyusz, 2011; Zhou and Benton, 2007; Ellinger *et al.*, 2000).

The TBL performance is measured as social, environmental and economic performance. All items (Table 2) are adapted from literature (Gimenez *et al.*, 2012; Rao, 2002; Zhu and Sarkis, 2004; Wagner, 2010). Finally, to contextualize the study in terms of firm size, firm age, level of investment in research and development, and strategic initiatives, we controlled for these variables.

4.3 Measurement model analysis

We followed the two-step procedure recommended by Anderson and Gerbing (1988), where the structural model testing follows confirmatory factor analysis (CFA). The CFA results are used to test the measurement model, including reliability, validity and unidimensionality of the constructs. Thus, all constructs were made subject to CFA using the AMOS modeling software (version 22). Overall, the values of fit indices are acceptable ($\chi^2_{624\ \mathrm{df.}} = 1844.266$, RMSEA = 0.051, GFI = 0.880, AGFI = 0.857, CFI = 0.919, TLI = 0.908, IFI = 0.919, NFI = 0.882) (Hu and Bentler, 1999). Table 2 shows the values of Cronbach's alpha, Joreskog ρ, comparative fit index (CFI), average variance extracted (AVE) and factor loadings with respective standard errors.

The standardized factor loadings and error estimates indicate that the scales exhibited satisfactory reliability. Also, almost all our measurement scales have Cronbach's alpha as well as Joreskog ρ coefficients greater than 0.8 (except the three performance constructs which have alphas close to 0.7, an expected and satisfactory result for the 2 item scales), with most being greater than 0.9 (Kline, 1998) (Table 2). Following (Hair, 2009), we assess the

Sustainability (second order construct) (Cronbach's alpha = 0.946, Joreskog ρ = 0.901, CFI = 0.917, AVE = 0.753)
Internal social sustainability *(SFL = 0.846, SE = 0.068)*
Internal environmental sustainability *(SFL = 0.922, SE = 0.059)*
External sustainability *(SFL = 0.833, SE = 0.058)*
Internal social sustainability (Cronbach's alpha = 0.819, Joreskog ρ = 0.848, CFI = 0.994, AVE = 0.585)
Social certifications *(SFL = 0.720, SE = 0.048)*
Formal sustainability oriented communication, training programs and involvement (S*FL = 0.851, SE = 0.039*)
Formal occupational health and safety management system (S*FL = 0.689, SE = 0.036*)
Work/life balance policies (S*FL = 0.789, SE = 0.035*)
Internal environmental sustainability (Cronbach's alpha = 0.790, Joreskog ρ = 0.813, CFI = 1.000, AVE = 0.596)
Environmental certifications (e.g. EMAS or ISO 14001) *(SFL = 0.629, SE = 0.055)*
Energy and water consumption reduction programs *(SFL = 0.825, SE = 0.039)*
Pollution emission reduction and waste recycling programs *(SFL = 0.843, SE = 0.051)*
External sustainability (Cronbach's alpha = 0.875, Joreskog ρ = 0.879, CFI = 1.000, AVE = 0.709)
Suppliers' sustainability performance assessment through formal evaluation, monitoring and auditing using established guidelines and procedures *(SFL = 0.781, S.E. = 0.033)*
Training/education in sustainability issues or suppliers' personnel *(SFL = 0.863, SE = 0.035)*
Joint efforts with suppliers to improve their sustainability performance (S*FL = 0.878, S.E. = 0.047*)
Lean management (second order construct) (Cronbach's alpha = 0.872, Joreskog ρ = 0.869, CFI = 0.930, AVE = 0.691)
Technical lean practices *(SFL = 0.958, SE = 0.121)*
Internal social lean practices *(SFL = 0.776, SE = 0.061)*
External social lean practices (S*FL = 0.750, SE = 0.064*)
Technical lean practices (Cronbach's alpha = 0.867, Joreskog ρ = 0.862, CFI = 0.859, AVE = 0.442)
Restructuring manufacturing processes and layout to obtain process focus and streamlining *(SFL = 0.468, S.E. = 0.059)*
Undertaking actions to implement pull production *(SFL = 0.636, SE = 0.063)*
Improving forecasting and planning accuracy *(SFL = 0.674, SE = 0.058)*
Increasing information integration *(SFL = 0.678, SE = 0.044)*
Engaging in product/part tracking and tracing programs *(SFL = 0.665, SE = 0.070)*
Quality improvement and control *(SFL = 0.699, SE = 0.064)*
Improving equipment availability *(SFL = 0.730, SE = 0.064)*
Benchmarking/self-assessment *(SFL = 0.733, SE = 0.072)*
Social lean practices (internal) (Cronbach's alpha = 0.837, Joreskog ρ = 0.838, CFI = 0.985, AVE = 0.463)
Delegation and knowledge of your workers (e.g. empowerment, training) *(SFL = 0.726, S.E. = 0.063)*
Open communication between workers and managers *(SFL = 0.670, S.E. = 0.062)*
Lean organization (e.g. few hierarchical levels and broad span of control) *(SFL = 0.660, SE = 0.057)*
Continuous improvement programs through systematic initiatives (e.g. kaizen, improvement teams, improvement incentives) *(SFL = 0.698, SE = 0.068)*
Autonomous teams (e.g. the team responsible for planning, execution and control . . .) *(SFL = 0.722, S.E. = 0.071)*
Workers flexibility (e.g. multi-tasking/skilling, job rotation) *(SFL = 0.600, SE = 0.060)*
Social lean practices (external) (Cronbach's alpha = 0.899, Joreskog ρ = 0.894, CFI = 0.848, AVE = 0.516)
Sharing information with key suppliers (about sales forecast, production plans, order tracking and tracing, delivery status, stock level) *(SFL = 0.626, S.E. = 0.056)*
Developing collaborative approaches with key suppliers (e.g. supplier development, risk/revenue sharing . . .) *(SFL = 0.676, SE = 0.047)*
Joint decision-making with key suppliers (about product/process design/modifications, quality improvement and cost control) *(SFL = 0.671, SE = 0.077)*
System coupling with key suppliers (e.g. vendor managed inventory, JIT, Kanban, continuous replenishment) *(SFL = 0.698, SE = 0.067)*
Sharing information with key customers *(SFL = 0.776, S.E. = 0.064)*
Developing collaborative approaches with key customers *(SFL = 0.764, SE = 0.067)*
System coupling with key customers *(SFL = 0.793, SE = 0.073)*
Joint decision-making with key customers *(SFL = 0.724, SE = 0.065)*

(*continued*)

Table 2.
Constructs reliability and validity analysis (n = 750)

Social Performance (Cronbach's alpha = 0.691, Joreskog ρ = 0.691, CFI = 1.000, AVE = 0.528)
Workers' motivation and satisfaction (*SFL = 0.733, SE = 0.022)*
Health and safety conditions *(SFL = 0.720, SE = 0.022)*
Environmental performance (Cronbach's alpha = 0.679, Joreskog ρ = 0.686, CFI = 1.000 AVE = 0.524)
Materials, water and/or energy consumption *(SFL = 0.771, SE = 0.021)*
Pollution emission and waste production levels *(SFL = 0.673, SE = 0.021)*
Economic performance (Cronbach's alpha = 0.679, Joreskog ρ = 0.678, CFI = 1.000 AVE = 0.513)
Sales *(SFL = 0.710, SE = 0.028)*
Return on sales *(SFL = 0.723, SE = 0.028)*

Note(s): CFI: comparative fit index, AVE = average variance extracted, SFL: standardized factor loading, SE = standard error

Table 2.

standardized factor loadings, the critical ratio and AVE to test convergent validities. Most standardized path loadings are greater than 0.70, with a few greater than 0.60 (Table 2). We retained the items with loadings greater than 0.60 except one item, that is, process focus (0.468). The item was retained despite the low standardized path loading to maintain content validity. All factor loadings are significant (p values < 0.01). Finally, the average variance extracted for most of the scales is greater than 0.5. The exceptions TLP (AVE = 0.442) and SLP internal too have AVEs close to 0.50, which signifies that most of the underlying variance in the model is being explained by the latent variables. Thus, the results (Table 2) suggest that convergent validity is not a concern for the measurement scales.

By comparing the chi-square of alternate models, where the correlation between various constructs was fixed to 1, we found that the chi-square value increased significantly (p-value < 0.01) in the constrained compared to the unconstrained model, demonstrating that our constructs exhibit sufficient discriminant validity (Segars and Grover, 1993). In addition, squared inter-construct correlation values between all (except between LM and SM) pairs of constructs are less than the AVE values of the individual constructs in each pair, thus providing evidence for satisfactory discriminant validities (Table 3) (Segars and Grover, 1993). The higher correlation between SM and LM is expected because the two constructs have overlapping elements, with the unique ones positively reinforcing one another. They are proposed to be elements of a holistic socio-technical system that should be implemented together to exploit the potential synergies.

The confirmatory single-factor test suggested by Podsakoff *et al.* (2003) was used to examine CMB. A significant increase (p-value < 0.05) in the value of chi-square ($\chi^2_{629\ \mathrm{d.f}} = 1844.572$ to $\chi^2_{665\ \mathrm{d.f}} = 5360.036$), when comparing a single-factor model to one in which items are loaded onto their respective constructs, provides evidence that CMB is not a significant problem in this research (Podsakoff *et al.*, 2003). All values of CFI are greater than or close to 0.90, thus satisfying the condition of unidimensionality.

The constructs of sustainability and LM were operationalized as second-order constructs; hence, additional measurement analysis was carried out to justify the choice (Jarvis *et al.*, 2003). First, the second-order factor loadings provided in Table 2 are all greater than 0.70 and

Construct	Sustainability management	Lean management	Social performance	Environmental performance
Lean mgmt	0.773			
Social performance	0.602	0.620		
Environmental performance	0.440	0.403	0.640	
Economic performance	0.187	0.386	0.385	0.330

Table 3. Correlations among constructs

significant at $p < 0.01$. Secondly, the value of R^2 when the second-order constructs of SM and LM are regressed on their respective first-order constructs is 1.000 for both of them, providing evidence that the first-order constructs explain sufficient variance in the second-order constructs. Thirdly, the value of chi-square of first-order single-factor model for SM (728.586 at d.f = 36) is significantly (p-level < 0.01) greater than the value of chi-square of three first-order correlated factors model (411.220 at d.f = 32). Similarly, for LM, the chi-square of first-order single-factor model (2624.578 at d.f = 210) is also significantly (p-level < 0.01) greater than the chi-squared of three first-order correlated factors model (777.497 at d.f = 201). Therefore, the findings support second-order operationalization of the constructs of SM and LM (Marsh and Hocevar, 1985).

4.4 Structural model analysis

The structural model (Figure 3) was tested using the AMOS version 22. The fit indices of our model are better than generally accepted threshold values ($\chi^2_{\ 2\ d.f} = 70.684$, RMSEA = 0.214, GFI = 0.971, AGFI = 0.694, CFI = 0.960, TLI = 0.702, IFI = 0.961, NFI = 0.959) (Hu and Bentler, 1999).

All control variables had insignificant effects on social, environmental and economic performance. In addition, the statistical significance of our hypothesized relationships did not change with the inclusion of the control variables. Therefore, maintaining the reasoning that "the inclusion of unnecessary controls is undesirable as it reduces the statistical power, and distorts relationships between the main study variables," the rest of the analyses report SEM results without the inclusion of control variables (p. 16, Chun *et al.*, 2013; Spector and Brannick, 2011).

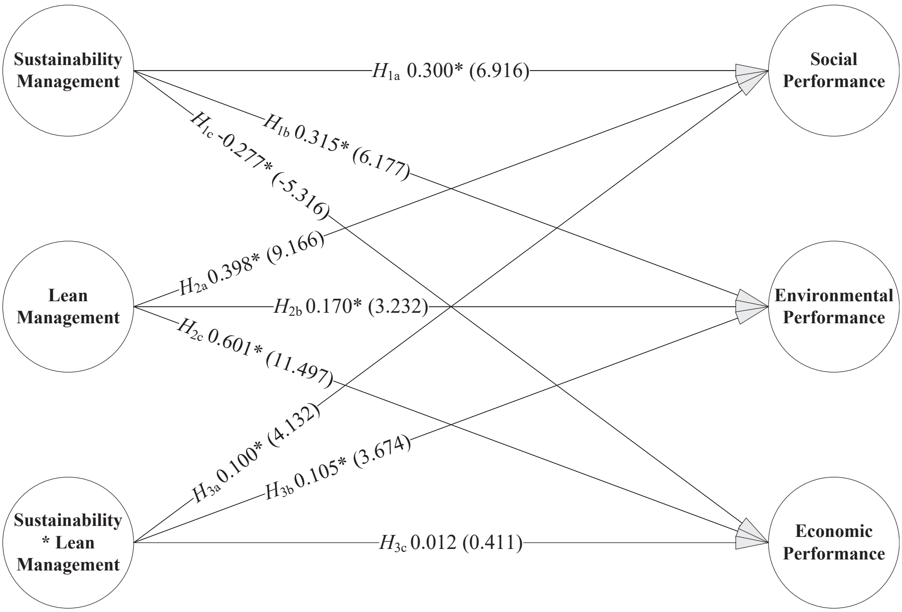

Figure 3.
Results with path coefficients for direct hypotheses testing

Note(s): * = significance < 0.01. Values in parenthesis are t-values. Direction of arrows indicates direction of positive relationship

The results of the structural model testing indicate that the relationship between SM and social performance is positive and significant (β = 0.300 and p-value < 0.01), as is the relationship between SM and environmental performance (β = 0.315 and p-value < 0.01), thus supporting hypotheses H1a and H1b, respectively. However, the results failed to support hypothesis H1c (β = –0.277 and p-value < 0.01) regarding SM and economic performance.

H2a regarding the relationship between LM and social performance (β = 0.398 and p value < 0.01), H2b proposing that LM practices increase environmental performance (β = 0.170 and p-value <0.01) and H2c hypothesizing that LM positively impacts economic performance (β = 0.601 and p value < 0.01) are all supported.

Finally, our results support H3a, suggesting that LM and SM positively interact for a more pronounced positive effect on the social performance (β = 0.100 and p-value < 0.01), as well as H3b (β = 0.105 and p-value < 0.10), suggesting a positive interaction effect between lean and sustainability with respect to environmental performance. However, the results fail to support H3c (β = 0.012 and p-value > 0.10), which suggested positive interaction between LM and SM regarding their effect on economic performance.

5. Discussion

5.1 Discussion of results

Results of the empirical analysis support most of the proposed hypotheses. First, pertaining to SM and the three performance dimensions, the findings support that SM has a positive and significant effect on social and environmental performance (Ali *et al.*, 2020). This finding is not only empirically supported (Gimenez *et al.*, 2012) but it is also consistent with our theorization that once the firm engages in socially responsible behavior toward its key stakeholders and the environment, their motivation, well-being and satisfaction are bound to get better, reciprocally. The results, however, fail to support that SM positively affects economic performance, whereas a positive relationship between the two is largely supported in extant literature (Ameer and Othman, 2012; Golicic and Smith, 2013). However, the finding is neither implausible nor unprecedented (Smith *et al.*, 2007). Investing in sustainability is costly, especially in the short run when returns in the form of improved operational and subsequently economic performance have not been realized. Another plausible explanation in literature is that there could be diminishing returns to social responsibility or a curvilinear relationship (inverted U-shaped) between sustainability and economic performance (Bernal-Conesa *et al.*, 2016). It may be so, that manufacturing firms in our sample and therefore population are mature in terms of adopting socially responsible practices, to an extent that they have already exhausted most gains from it.

Second, agreeing with the majority of precedent literature (Florida, 1996; Klassen, 2001; Longoni and Cagliano, 2015; King and Lenox, 2001; Kitazawa and Sarkis, 2000; De Treville *et al.*, 2005; Paul Brunet and New, 2003), hypotheses H2a, H2b and H2c proposing a positive relationship between LM practices and each of the three performance dimensions of TBL are all supported, supporting that LM enables all dimensions of sustainability performance. Support for H2a suggesting a positive relationship between LM and social performance is contrary to some of the precedent studies, which warn us of the potential adverse effects of increased stress levels and injury that result from an overemphasis on productivity and performance in the lean program (Askenazy, 2001; Conti *et al.*, 2006). Results of the study, however, confirm that when that emphasis is coupled with worker training, involvement and incentives, as well as the dilution of control elements of lean (Hamja *et al.*, 2021; Hoque *et al.*, 2020; Longoni and Cagliano, 2015; De Treville *et al.*, 2005; Paul Brunet and New, 2003), the resulting holistic system of lean increases rather than decreases social performance.

H2b is supported in accordance with most of the extant literature, maintaining that through its effect on waste minimization, JIT production and producing of more output using less of the inputs, "lean is inherently green" (Corbett and Klassen, 2006; Florida, 1996; Zhu and Sarkis, 2004). However, Venkat and Wakeland (2006) have pointed that the smaller and frequent deliveries as a result of JIT might result in more pollution and increase direct and external costs of production. Where it might be true in contexts looking at the single element of JIT, the study results confirm that when the entire system of practices in the bundle of lean is implemented, environmental performance increases. Similarly, by committing to produce products efficiently, that is, more output with fewer resources, and minimizing inventories and excess production, support for H2c (LM → economic performance) is also very intuitively appealing.

Third and most interestingly, empirical validation of positive interaction between sustainability and LM for an enhanced effect on the organization's TBL is a novel and major contribution of this study. The study supports H3a and H3b, supporting the "mutual compatibility" of the paradigms' argument for both social and environmental performance. The finding also attracts our attention to the fact that most of the commonalities between the two paradigms are social/people-oriented, including stakeholder involvement, dilution of control and open communication with the stakeholders (Hoque *et al.*, 2020). These elements are expected to increase economic performance in turn, but the relationship might not be a direct one. More research needs to be done in different contexts and over time to explore the sequential channel of relationships between individual dimensions of the TBL that follow after implementing the sustainability and LM program.

Finally, the results failed to support H3c, proposing a positive interaction effect between the two paradigms for economic performance. As the interaction between lean and sustainability has not been empirically tested before, there is not enough literature to support the validation of the hypothesis (for social and environmental performance) and the lack of it thereof (for economic performance). One reason for the lack of support for H3c might be that the negative and significant coefficient on SM and economic performance balances the positive and significant coefficient on LM and economic performance, rendering the interaction insignificant. Another reason is found in the expected multicollinearity between the constructs of SM and LM. Multicollinearity inflates error variances of the estimated coefficients, but the problem is exacerbated for interaction terms, so much so that it renders significant coefficients insignificant (Aiken *et al.*, 1991). Solutions to the problem include either augmenting the construct or dropping the correlated items, leading to multicollinearity (Aiken *et al.*, 1991). Unfortunately, we cannot implement either of the solutions without losing the constructs' essence and our theoretical argument grounded in the systems perspective. Sharing so many common dimensions, with the uncommon ones positively relating to and enabling one another, multicollinearity is an unintended but expected empirical consequence of the very definitions and theoretical rationale behind the constructs in the study. Future researchers can adopt different measurement scales to explore potential reasons for the lack of support of H3c.

5.2 Theoretical implications

This study rests at the intersection of LM and the three pillars of sustainability together. Extant literature has studied various resource-based (including sustainability related knowledge and learning), institution-based (including CSR as a mode of governance, and top management support for sustainability) and capability-based (absorptive capacity) enablers of SM and sustainable performance (Soundararajan and Brammer, 2018; Riikkinen *et al.*, 2017; Meinlschmidt *et al.*, 2016; Brammer *et al.*, 2012). This paper studies LM as a capability-based enabler of sustainability, which not only directly affects the TBL positively but also lays the foundation for easing the implementation of SM, making its effect on the TBL more pronounced.

This study acknowledges the links made between lean and environmental sustainability in the extant literature and extends it by proposing that the benefits of lean can be extended to social and economic sustainability as well (Hamja *et al.*, 2021; Hoque *et al.*, 2020; Piercy and Rich, 2015; King and Lenox, 2001). The study simultaneously agrees with the logic and rationale provided by researchers, arguing for both the causal (De Treville *et al.*, 2005; Taubitz, 2010) and the reverse causal (Sroufe, 2003; Corbett and Klassen, 2006) relationship between lean and sustainability. It employs the system perspective approach to propose that the two paradigms should be studied together as a holistic socio-technical system.

The socio-technical theory and systems perspective allow us to visualize how lean reinforces and enables sustainability and makes its adoption cost-effective by diluting control and minimizing wastages in the workplace. It also helps us acknowledge how SM aids the adoption of LM by working on stakeholder engagement and motivation and contributing to an open and involved culture that is more receptive to change. While studying the combined interaction effect of lean and sustainability, this study takes the TBL as its dependent variable. In contrast, most existing studies on sustainability focus on one or two of the three dimensions, implicitly assuming that the three are synergistic (Linton *et al.*, 2007), which may or may not be the case in practice. By separately accounting for the direct and interaction effects on each of the performance dimensions from the TBL, the study implicitly allows the effect of firm's multidimensional sustainability initiatives to vary across the three pillars of sustainability.

Finally, to the best of our knowledge, this study presents an initial attempt to empirically test the synergistic relationship between the two paradigms regarding their impact on the TBL performance. The field is still in its infancy, and most of the extant research on lean and SM is theoretical, with only a few empirical case studies. The conceptual studies of Piercy and Rich (2015), and Longoni and Cagliano (2015) talk about the "mutual compatibility" of lean and social responsibility with regard to performance outcomes. This study, however, goes a step further to empirically test its propositions regarding the individual and combined effect of lean and SM on the TBL using a large-scale multi-industry and global data set.

While the focus of this paper has been more toward theory testing rather than theory building, application and empirical validation of the systems perspective on lean and sustainability sets a stepping-stone toward a better understanding of reconciling multiple paradigms. It can serve as a useful example for interdisciplinary research, exploring the synergies, complementarities and trade-offs between alternate paradigms and the reconciling organizational systems that engender as a result of balancing them.

5.3 Managerial implications

Managers and practitioners in today's world are increasingly concerned about balancing multiple and seemingly contradictory operational objectives to pursue organizational ambidexterity. Viewing in isolation, academicians, as well as practitioners, mostly agree that being socially responsible as well as being lean is beneficial for the focal firm. The benefits of improved social, environmental and economic performance may not be immediately realizable, making investing in lean and sustainability programs risky. However, it is important to realize the synergies between the two programs and that investing in one can have positive external benefits in terms of enabling implementation and improving the effectiveness of the other. The finding is especially insightful to convince reluctant shareholders that view the two as substitute and mutually exclusive alternative paradigms that they can invest in.

Similar to the examples of Esquel, Nike and Silver Star that motivated this study, this paper provides evidence to say that much is to be gained from leveraging the positive externalities of the LM and SM programs on one another. Therefore, firm owners and managers must implement the two together as a holistic socio-technical organizational system to exploit the system's full potential and balance any unfavorable and unintended trade-offs of implementing either of the programs individually (Chaplin and O'Rourke, 2018). Selective and sequential implementation of similar and co-dependent practices also results in duplication of efforts, resulting in suboptimal usage of the firm's scarce resources. The confirmation that lean is a capability-based enabler of sustainability, along with the realization that combined rather than the sequential implementation of both paradigms is critical for practitioners in today's competitive world (where the implementation of both has become more of a necessity than a choice) so they can optimally allocate their scare resources in co-implementation, taking full advantage of the synergies and positive external benefits of the paradigms on one another.

5.4 Limitations and future research

This study has few limitations providing directions for future research. Firstly, as is the case with any study that uses cross-sectional survey data, the causality of our findings is not very definitive. There is a need for longitudinal studies to investigate the relationship between sustainability and TBL performance. The implementation of SM is considered a cost center in the short run, and cross-sectional data may reveal its long-term benefits on economic performance. Longitudinal studies can also help further investigate the curvilinear relationship between SM and economic performance suggested by Bernal-Conesa *et al.* (2016). Similarly, some other moderating variables can be researched (Barnett, 2007), such as organizational culture, institutional pressures or organizational commitment, that may significantly influence the success and the long-term impact of SM on performance.

Secondly, our measure for SM aggregates internal (social and environmental) and external dimensions (first-order constructs) of sustainability at the second-order level. Also for LM, the social (internal and external) and technical lean practices are aggregated at the second-order level. Future studies can replicate the analysis by separating LM and SM constructs into subdimensions and analyzing the interrelationships between the subdimensions in more detail. Finally, the data set employed in the paper is large and includes developed and developing countries together. This increases the generalizability of our results, but it also leads to aggregation-led masking. Although measurement invariance tests revealed that the regression weights are robust and invariant across the two groups. Still, future researchers can replicate this study in other settings by controlling for the degree of development of countries.

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