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An integrative view on Lean innovation management

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ABSTRACT

This study proposes the Lean philosophy, which integrates a firm's "hard" and "soft" processes, as a promising way to enhance firm innovativeness. Five Lean principles that are specific to the innovation management context, namely, coaching leadership, learning culture, employee appreciation, learning routines, and collaborative networks, are discussed. Based on survey data obtained from 243 Dutch firms, the impact of these five principles on firm innovativeness is investigated. The results indicate that the Lean philosophy can be considered an inter-related socio-technical system, where coaching leadership enables the correct functioning of the hard and soft factors needed to achieve higher innovativeness.

1. Introduction

The business survival game is straightforward: innovate or disappear (Goffin & Mitchell, 2016). Less straightforward is "how" innovation processes can be effectively managed. One possible solution is to increase investment in Research and Development (R&D). However, the results of a comparison between a survey carried out by BCG Global Innovators (Ringel, Taylor, & Zablit, 2015) and a survey conducted by Booz & Company (Jaruzelski, Loehr, & Holman, 2013) on innovators and R&D spenders indicate that the size of the R&D investment is not the only decisive factor in creating value from innovation.[1] This phenomenon is perhaps not surprising, as Burns and Stalker (1961) had already suggested the need not to overestimate the impact of R&D investment on innovation capability. The management of innovation calls for a broad range of qualities and capabilities, which go beyond R&D spending (Cooper & Edgett, 2008). Innovation management needs a vision and a strategy, appropriate processes to implement innovation, and organizational conditions and culture that facilitate the emergence of ideas and their implementation (Bel, 2010). Along with the increase in competition, the quest for the "right" blend of process-driven and people-oriented aspects of innovation management has become one of the firms' highest priorities (Trott, 2008).

An essential contribution to innovation management comes from Operations Management. In the late 1980s, a team from the Massachusetts Institute of Technology (MIT) led by James Womack published the results of their study on the Toyota Production System (TPS), in which they proposed a set of best practices that, all together, are called "Lean management" (Womack, Jones, & Roos, 1990). Lean has been considered the greatest innovation in operations management (Holweg, 2007), and its principles and practices have been used in various domains, including culture (Mann, 2014), project management (Ballard & Howell, 2003), organizational change (De Toni & Tonchia, 1996), marketing (Piercy & Rich, 2009), information management (Hicks, 2007), accounting (Maskell, Baggaley, & Grasso, 2011), and leadership (Mann, 2009).

At its core, Lean is concerned with the management of processes and operations and is uniquely combined with a focus on people, culture, and leadership (Adler, 1993; Mann, 2009; Morgan & Liker, 2006; Wincel & Kull, 2016). Some scholars studied the link between Lean and various sociotechnical systems (Hummels & De Leede, 2000; Niepce & Molleman, 1998). The duality expressed by an interrelated system of "soft" and "hard" practices (Shah & Ward, 2007) is congruent with the conception and definition of innovation management. Therefore, the Lean management of innovation can be considered a promising approach for managers responsible for New Product Development (NPD), innovation funneling, R&D, and business development (Gudem, Steinert, & Welo, 2014) "to do the right thing, do it right, and do it better all the time" (Sehested & Sonnenberg, 2011, p. 3).

The literature on Lean and innovation is substantial but extremely fragmented, with a prominent focus on NPD (Al-Ashaab et al., 2013; Cooper & Edgett, 2008; Cusumano & Nobeoka, 1998; Gudem et al., 2014; Haque & James-Moore, 2004; Hines, Francis, & Found, 2006; Hoppmann, Rebentisch, Dombrowski, & Zahn, 2011; Morgan & Liker, 2006; Nepal, Yadav, & Solanki, 2011; Tuli & Shankar, 2015; Ward &

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[1] The BCG report announces Apple as the most innovative company from 2005 to 2013 and positions Nokia at the bottom of the list, while Jaruzelski et al. (2013) reports Nokia in the top ten R&D spenders from 2005 to 2013, and in none of these years Apple appears among the top R&D spenders at all.

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Sobek II, 2014). Themes such as product launch (Bowersox, Stank, & Daugherty, 1999), process improvement (Angelis & Fernandes, 2012; Khan et al., 2013), radical innovation (Bicen & Johnson, 2015), and creativity (Helander, Bergqvist, Stetler, & Magnusson, 2015; Hoerl & Gardner, 2010) have been extensively addressed. A few studies with a broader scope have focused on the management of innovation (Boehm, 2012; Browning & Sanders, 2012; Carleysmith, Dufton, & Altria, 2009; Reinertsen & Shaeffer, 2005; Schuh, Lenders, & Bender, 2013; Sehested & Sonnenberg, 2011; Solaimani, van der Veen, Gülyaz, & Venugopal, 2019). However, despite the commonalities between Lean and innovation management, empirical research on the conjunction of these areas is relatively scarce.

Building upon the existing body of knowledge, this study conceptualizes an integrative framework for Lean innovation management and empirically examines its impact on firms' innovativeness. In doing so, this study contributes to both the Lean and innovation management fields by advancing the understanding of whether, and to what extent, Lean practices and principles can be the drivers of firm's innovativeness. As discussed later, this study's insights into Lean innovation management can help firms achieve a learning-driven culture, effective learning routines, collaborative networks, and coaching-oriented leadership.

The remainder of this study is organized as follows. Since no broadly accepted definition of Lean innovation exists, in Section 2, a conceptual approach to the topic is proposed, and the research hypotheses are formulated. Section 3 details the applied research method, and Section 4 discusses the study's findings. In the Conclusion section, the overall theoretical and practical impact of this study, along with its limitations and suggestions for future research, are discussed.

2. Background theory and hypotheses

The simultaneous attention for hard and soft factors is an essential feature of the Lean philosophy (Shah & Ward, 2007). Typically, hard factors are associated with design, processes, tools, and structures, while soft factors comprise culture, behavior, and social-relational aspects (Bortolotti, Boscari, & Danese, 2015; Calvo-Mora, Picón, Ruiz, & Cauzo, 2013).

2.1. Innovation management: front-end and back-end

Similar to Lean, innovation management involves several hard and soft processes, which Bel (2010) refers to as the "front-end" and the "back-end" management of innovation. Front-end management is associated with the sociocultural dimension of innovation and includes all policies, plans, and activities that firms carry out to stimulate innovative ideas, such as the figurative fertilization of the firm's innovation "soil" (sometimes labeled as the "soft" side). An example from the innovation management toolbox is Terwiesch and Ulrich's (2009) so-called "Darwinator," which helps determine which ideas are most valuable in the fuzzy front-end.

Back-end management is focused on the activities and processes that are implemented once an idea has emerged. These activities represent the first steps toward market industrialization and commercialization (Flynn, Dooley, O'sullivan, & Cormican, 2003). For instance, the broadly accepted Stage Gate model (Cooper, 1990) can be considered a back-end approach to guide the innovation process toward commercialization. Discipline and efficiency in time and resources are prerequisites for the management of back-end processes (Bel, 2010). Back-end activities include figurative sowing, pruning, and harvesting of innovative initiatives (sometimes labeled as the "hard" side).

Conceptually, innovativeness is simultaneously affected by both front-end and the back-end management processes. Moreover, the front-end and back-end management of innovation are interdependent. For instance, a front-end oriented leader, who does not assess the technical feasibility of a new product, is likely to face implementation issues, while a back-end oriented leader, who lacks strategic vision and objectivity, is likely to incur in a market failure (Bel, 2010). Progressive firms invest in both the soft and the hard side of innovation and integrate both aspects into a socio-technical system that helps implement a firm's innovation strategy (Adams, Bessant, & Phelps, 2006; Ahmed, 1998). In the conceptualization proposed by this study, the front-end and the back-end processes are inter-related.

In the Lean literature, at least two expressions of front-end management processes (employee appreciation and learning culture) and two expressions of back-end management processes (collaborative networks and learning routines) are argued, while coaching leadership is seen as the adhesive force that harmonizes and empowers the front-end and the back-end management processes. This study aims to conceptualize and validate a holistic view of Lean innovation management rather than provide an exhaustive list of all front-end and back-end management processes. The proposed view include each concept in an integrative model. Future research may consider additional dimensions or aspects alongside the proposed conceptualization.

The next subsections describe how employee appreciation, the learning culture, collaborative networks, learning routines, and coaching leadership directly and indirectly affect firms' innovativeness. To model an integrative view without the need to observe all the dimensions of all processes, a novel methodology is utilized, as shown in Fig. 1.

2.1.1. Learning culture

A vital front-end management process is the focus on the learning culture that helps firms boost their innovation capability (Sehested & Sonnenberg, 2011). Employees are encouraged to develop a proactive attitude toward continuous improvement (*Kaizen* in Lean terms) (e.g., Adler, 1993; Blank, 2013; Johnstone, Pairaudeau, & Pettersson, 2011). As "change agents," employees have a sense of "problem ownership" and act autonomously (Braczyk, 1996; Ota, Hazama, & Samson, 2013; Sewing, Winchester, Carnell, Hampton, & Keighley, 2008). Studies on the Lean learning culture emphasize that at firms where continuous learning is a collective norm, firm innovativeness is more actively nurtured (Everett & Sitterding, 2013; Johnstone et al., 2011). Knowledge is considered a "dynamic gain," interwoven with employees' interaction and relationships (Bicen & Johnson, 2015), which results from knowledge sharing, collaborative problem-solving (Tyagi, Cai, Yang, & Chambers, 2015; Ward & Sobek II, 2014), as well as sharing and pursuing an innovation agenda across the company and beyond (Byrne, Lubowe, & Blitz, 2007). This line of reasoning leads to the following hypothesis:

H1. Lean front-end processes, expressed by a greater extent of learning culture, positively affect firm innovativeness.

2.1.2. Employee appreciation

Employees' motivation is another critical factor in Lean front-end management (Fiume, 2004; MacDuffie, 1995), in the absence of which dysfunctional behavior such as absenteeism, high turnover, poor attention for quality, strikes, and even sabotage are to be expected (Adler, 1993, p. 98). There are several ways to distinguish between different types of motivation, but the most basic distinction is between *intrinsic*

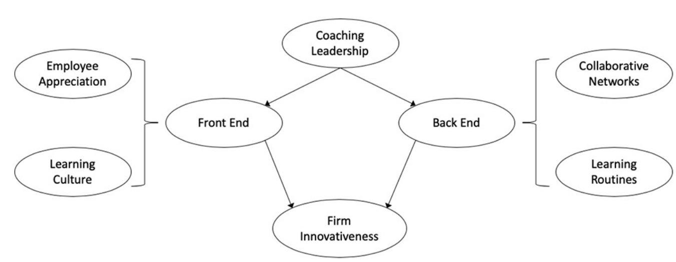

Fig. 1. Conceptualization of the Lean innovation management framework.

(i.e., doing something because it is inherently interesting or enjoyable) and *extrinsic* (i.e., doing something because it leads to a separable outcome, Ryan & Deci, 2000, p. 55). In particular, to boost the employees' intrinsic motivation to innovate, the Lean literature emphasizes the role of employees' appreciation (Adler, 1993; Holbeche & Mayo, 2009; Jeyaraman & Kee Teo, 2010; Netland, 2016). Employee appreciation is achieved in various nonfinancial ways, such as celebrating employees' achievements in factory "town hall" meetings (Netland, Schloetzer, & Ferdows, 2015; Sakai, Sugano, & Maeda, 2007), consciousness-raising sessions and trainings (Sakai et al., 2007), public recognition (Boehm, 2012; Carleysmith et al., 2009), peer admiration (Evans & Wolf, 2005), suggestion schemes (Adler, 1993; Delbridge, Lowe, & Oliver, 2000), and celebration of day-to-day inventions and success (Hines et al., 2006; Sewing et al., 2008). In line with this reasoning, the second research hypothesis is proposed:

H2. Lean front-end processes, expressed by a greater extent of employees' appreciation, positively affect firm innovativeness.

2.1.3. Learning routines

Lean's widespread popularity is largely due to its easy-to-understand and easy-to-use tools and techniques, such as the back-end processes (Standard & Davis, 2000). As discussed below, in the context of innovation management, the Lean focus is typically on processes that enable efficient and effective creation and appropriation of knowledge, also referred to as learning routines. While efficiency is about learning with the least possible resources, effectiveness refers to value-adding insights that fill specific knowledge gaps.

A key enabler of efficient learning processes is standardization (Morgan & Liker, 2006). Standardization helps minimize wasteful or non-value-adding (repetitive) processes, such as unnecessary reports and documentation and lengthy meetings, throughout innovation processes (Hines et al., 2006; Schuh et al., 2013). A "pull" approach complements standardization by prioritizing and acknowledging customer needs (instead of being overwhelmed by processes). As a result, more attention is devoted to value-adding activities that are vital for customers and end-users (Nepal et al., 2011; Reinertsen & Shaeffer, 2005).

Regarding the effectiveness of the learning process, in the Stage Gate model, which addresses various phases, from the ideation to the experimentation and evaluation (Cooper, 1990), a fact-based, hypothesis-driven, and problem-solving approach is advocated (Bicen & Johnson, 2015; Bieraugel, 2015; Nepal et al., 2011; Sewing et al., 2008). Typical tools are the Plan-Do-Check-Act, A3, Five-Whys, Fishbone diagrams, and trade-off curves (Carleysmith et al., 2009; Cooper & Edgett, 2008; Helander et al., 2015; Hoppmann et al., 2011; Khan et al., 2013; Nepal et al., 2011; Sewing et al., 2008). Careful management of the generated knowledge and insights (i.e., capturing, storing, structuring, and disseminating knowledge) is another key element of learning routines (Cusumano & Nobeoka, 1998; Hoppmann et al., 2011; Khan et al., 2013; Morgan & Liker, 2006). Accordingly, the following hypothesis is formulated:

H3. Lean back-end processes, expressed by a greater extent of learning routines, positively affect firm innovativeness.

2.1.4. Collaborative networks

Lean's aspiration for collaboration spans across organizational boundaries (Aoki & Lennerfors, 2013; Bidault, Despres, & Butler, 1998; Liker & Choi, 2004), but it is an often overlooked factor in the success of the TPS. Lean collaborative orientation involves customer centricity and supplier development. Schuh et al. (2013) posit that invention becomes innovation when it creates value for (or fulfills a need or desire of) customers. Case in point is that the TPS considered customers an integral part of its innovation process (Cooper & Edgett, 2008) and engaged them in carefully planned experiments with fast and frequent assumption-testing and feedback-loops (Bieraugel, 2015; Reinertsen & Shaeffer, 2005; Ries, 2011).

At the upstream, the TPS's early involvement and close relationship with suppliers in co-creation and collaborative innovation are exemplary (Aoki & Lennerfors, 2013; Bidault et al., 1998; Smith & Tranfield, 2005). Initiatives such as loyalty plans, educational programs, and traineeships involving supply chain partners, cross-company teams, consulting and problem-solving for suppliers, collaborative R&D activities, and multilateral agreements to centralize and exchange information and knowledge help stimulate supplier relationships (Bidault et al., 1998; Harkonen, Belt, Mottonen, Kess, & Haapasalo, 2009; Nepal et al., 2011; Smith & Tranfield, 2005; Tam, Chessum, & Leopold, 2012; Tan & Perrons, 2009; Tuli & Shankar, 2015; Wagner, 2006). In line with this argument, the following hypothesis is proposed:

H4. Lean back-end processes, expressed by a greater extent of collaborative networks, positively affect firm innovativeness.

2.1.5. Coaching leadership

The front-end and back-end management of innovation rely on innovation leadership, which enables, recognizes, and develops opportunities (Bel, 2010). In the Lean literature, the role of leadership is emphasized as a necessary link between the Lean tools and practices and higher-level Lean values and principles (Mann, 2009). Dombrowski and Mielke (2013, p. 570) define Lean leadership as: "*A methodical system for the sustainable implementation and continuous improvement of Lean Production Systems (LPS). It describes the cooperation of employees and leaders in their mutual striving for perfection. This includes the customer focus of all processes as well as the long-term development of employees and leaders.*" Besides continuous learning, customer focus, and process orientation (as previously discussed), this definition emphasizes people management, where employees are not just viewed as a "pair of hands" but as accumulators of knowledge (Takeuchi, Osono, & Shimizu, 2008).

Lean leaders express respect, recognition, and appreciation to workers for their effort (De Treville & Antonakis, 2006), respond in an emotionally positive manner, inject positive energy into the process, attempts to become part of the employees' work situation (Alpenberg & Scarbrough, 2016), empower workers to challenge the status quo (Takeuchi et al., 2008), facilitate them by providing the resources they need, and guide them in their problem-solving endeavors. For these reasons, in the Lean terminology, leaders are referred to as coaches (or *sensei*) and not as managers (Aoki & Lennerfors, 2013; Nahmens & Ikuma, 2011). Lean coaches' technical expertise typically helps them guide employees in effectively applying the learning routines while gaining employees' trust and confidence (Belt, Haapasalo, Harkonen, Mottonen, & Kess, 2009; Harkonen et al., 2009; Hoppmann et al., 2011; Nepal et al., 2011; Schuh, Lenders, & Hieber, 2011; Tyagi et al., 2015). These practices, in turn, break the vicious circle of managerial coercion and employee recalcitrance (Adler, 1993). Hence, the supportive role of coaching leadership is hypothesized as follows:

H5. The extent of a coaching leadership positively affects front-end and back-end innovation management processes.

2.2. Interrelationships between Lean innovation dimensions

As discussed earlier, Lean innovation is a systemic approach that is steered by and helps implement firms' innovation strategies.

First, a culture of continuous learning is typically associated with behaviors and routines based on which an organization learns from and supports innovation processes (Bessant & Caffyn, 1997) and behaviors such as collaborative learning and cross-functional teamwork (Bhuiyan & Baghel, 2005; Morgan & Liker, 2006) or systematic problem-solving routines inherent to Plan-Do-Check-Act (Ries, 2011). In turn, the learning routines depend on an open, collaborative, risk-taking organizational culture, without finger-pointing, and with minimum bureaucracy (Boyle, Scherrer-Rathje, & Stuart, 2011).

Second, the Lean philosophy emphasizes the appreciation of employees' efforts, which stimulates employees to more freely share information and insights and collaborate at various levels of the organizational hierarchy, thus leading them to be more comfortable in the contacts beyond the organizational boundaries, for instance, with suppliers, customers, and other network partners (Takeuchi et al., 2008). In addition, external exposure in terms of attending conferences, tour plants from other companies, and hosting external experts, is part of Lean organization responsibilities (Boyle et al., 2011). In turn, learning routines are essential elements of firms' outward orientation. As such, an in-depth understanding of customers' needs and desires calls for frequent iterative interaction, co-creation, and co-learning (Ries, 2011). Therefore, the following hypothesis is proposed:

H6. Front-end and back-end processes are positively correlated.

2.3. Environmental dynamism

As part of environmental uncertainty (Dess & Beard, 1984), dynamism seems to affect both Lean implementation and firms' innovativeness (Azadegan, Patel, Zangoueinezhad, & Linderman, 2013; Freel, 2005). Dynamism can be defined as the "rate and volume of change in the environment" (Azadegan et al., 2013; p. 194). On the one hand, greater variability in the external environment is likely to compel firms to introduce process and/or product innovation to maintain and boost their market position (Freel, 2005). On the other hand, in dynamic environments, assessing the changes, forecasting the effects, and developing operational responses is relatively more challenging (Azadegan et al., 2013). Firms performing in each of the various levels of environmental dynamism are likely affected by similar forces and adopt similar strategies. Thus, the relationship between firms' innovativeness and Lean implementation is contingent upon the level of environmental dynamism.

The effect of environmental dynamism needs to be accounted for in examining the impact of internal factors on firms' innovativeness. Without such refinement, the analysis is essentially limited to firms performing in a specific extent of environment dynamism, namely, the environment dynamism category with the largest number of observations. Hence, in this context, the generalizability of the findings is significantly hampered. Rather than measuring the impact of environmental dynamism on innovativeness, this study aims to refine the theoretical approach by accounting for the influence of the environment. Environmental dynamism is external to the firm. Hence, including it as a mediator (or an influencing factor) in a model of internal factors to the firm is not methodologically feasible. In the following sections, different levels of environmental dynamism are used to split the dataset and address innovativeness in each context.

3. Materials and methods

The Lean principles discussed so far are not independent of each other. To understand the Lean innovation system, the inter-relationships between its drivers need to be taken into account. In addition, Lean principles exert their influences simultaneously. The variation in the dependent variable is a result of the simultaneous impact of all the drivers. To attest the conceptualization of this inter-dependency and simultaneity, a sound methodological approach is necessary.

Ordinary-Least-Squares (OLS) estimation models are not suitable for examining inter-related explanatory variables as they require an orthogonal set of explanatory variables, while departing from this prerequisite introduces multicollinearity. Step-wise OLS models are also not appropriate for addressing simultaneous equations.

Structural Equation Modeling (SEM) is suitable for estimating the inter-relationships among non-orthogonal explanatory variables. The SEM approach consists of a series of simultaneous regression equations that simultaneously measure the individual and joint impacts of the explanatory constructs on the dependent variable (for instance, firms' innovativeness). Two types of SEM exist: Covariance-Based (CB) and Partial Least Squares (PLS) modeling. CB-SEM minimizes the difference between the observed and estimated covariance matrices, while PLS-SEM maximizes the explained variance of the endogenous constructs. Hence, CB-SEM can be applied to Confirmatory Factor Analysis (CFA), while PLS-SEM is more suitable for exploratory work (Hair, Ringle, & Sarstedt, 2011, 2013).

A comparative study of CB-SEM and PLS-SEM is carried out by Astrachan, Patel, and Wanzenried (2014). The study uses CB-SEM to determine whether an a priori model is valid (Gefen, Straub, & Boudreau, 2000). The characteristics of the SEM methodology match the objective of the present study, that is, the examination of the Lean principles and their impact on firms' innovativeness as an integrative system.

SEM allows addressing a set of latent constructs, which represent the conceptual model's building blocks, without the need for them to be directly observed. In SEM, two approaches exist for measuring latent constructs: the formative and the reflective methods. In the formative approach, the measurement items are described as an exhaustive list of attributes, which altogether constitute (form) a latent construct. In reflective measurement, the latent construct manifests (reflects) itself in several variables that are observed. Since these variables have a shared cause (i.e., the latent reflective construct), the reflective measurement items co-vary (see Fig. 2). Adding/discarding measurement items of a formative latent construct will change its essence since the formative construction is sensitive to the number and essence of its building blocks. In contrast, adding/discarding measurement items of a reflective latent construct will not change its essence, which is not sensitive to the choice of the number and the essence of the manifestation measurement items.

Since this study aims to examine the Lean principles as a system rather than (re)define those principles, a reflective measurement of the latent constructs is adopted. Hence, the proposed approach does not need to list and observe all attributes of each construct, and only some manifestations are observed to measure each latent construct.

SEM inter-relationships are solved numerically and simultaneously as one system. In SEM, the combined effect is measured without setting (or ignoring) the interplays of the explanatory constructs. As such, SEM utilizes the variance (in PLS)/covariance (in CB) matrix to account for the relationships between exogenous, endogenous, observed, and latent variables. Furthermore, SEM isolates the error term to neutralize the negative consequences of potential heteroscedasticity, autocorrelation, and endogeneity. Thus, CB-SEM with reflective measurement is used in this study.

3.1. Data

A total of 1250 questionnaires were sent to employees at various levels, companies, and industries in the Netherlands. A small portion of the respondents were (part-time) executive program students of Business Administration with a diverse professional background at Nyenrode Business University. These respondents filled out the questionnaire, disseminated it among their professional network, and requested their colleagues to fill out the questionnaire and spread it among their peers (snowball sampling).

Respondents were instructed to respond at the company level. Therefore, the survey reflects how Lean initiatives are implemented in

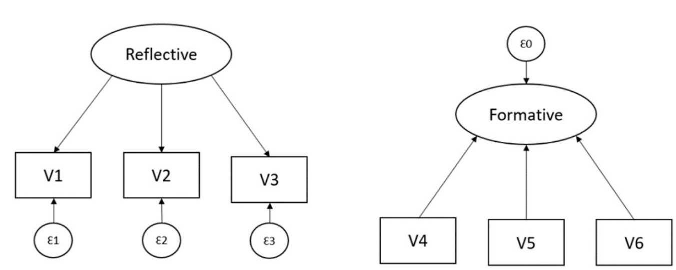

Fig. 2. Reflective vs. Formative measurement.

their companies. In this study, an online survey platform (Qualtrics) was used to collect responses to 61 items (55 for the five Lean concepts and six for firm innovativeness), five demographic questions, and six questions related to the competitiveness of the industry. In total, 358 surveys were received, corresponding to a response rate of 29%, which exceeds the common response rate in survey-based research in operations management and Lean, in particular. For instance, Shah and Ward (2007) used a sample of 280 surveys with a response rate of 13.5%, Nordin, Deros, and Wahab (2010) utilized 61 surveys, with a response rate of 24.4%, Kumar and Kumar (2014) used 47 surveys (28.8% response rate), and Hoppmann (2009) utilized 113 surveys, equal to a response rate of 14%. In this study, 100 surveys contained missing data, and additional 26 questionnaires were discarded as they were answered in less than seven minutes (a reasonable time needed to fill out the survey as appeared from pilot surveys that the authors conducted). Therefore, the final sample comprises 232 usable surveys.

On average, the respondents have almost six years of work experience, and most (14%) come from the Information and Communication Technologies industry, followed by Wholesale and Retail (11%), Banks (9%), Insurance and Health (9%), Education (8%), Construction and Real estate (5%), and 27% are listed as "Other." Gas, Water and Electricity, Chemicals and Materials, Machinery, Publishing Food, Beverage and Tobacco, Publishing, Transportation, Hotels and Restaurant, and Government altogether accounted for 17%. Most companies report annual sales over one billion Euros (30%), and companies spread out over the range (e.g., 10% with less than half a million, 15% between two and 10 million, and so on). These observations are matched by the number of employees, with a third of the respondents working in companies with more than five thousand employees, and the remainder spread out over the range (e.g., 10% with fewer than ten employees, and 14% with 250 to one thousand employees). Finally, the questions related to the industry's dynamism (e.g., "In our industry we are faced by a high rate of innovation") are rated on a five-point Likert scale (1 = never, 5 = always) and indicate an average of 3.18, with a standard deviation of 0.71. A complete overview of the demographics is available upon request.

Regarding the Lean items, some were slightly modified in terms of terminology or description for the sake of clarity. Furthermore, the order of the items was randomized to minimize respondent cognitive bias. However, several cross-loadings items were present in the factor analysis (as discussed in detail in Section 3.2). A total of 18 items were used for the analyses: three items for each of the five Lean constructs and firm innovativeness.

3.2. Operationalization

Reflective latent constructs were measured by questionnaire items for each Lean principle and the dependent construct, firm innovativeness. The items and their source in the literature are presented in Table 1.

The above list is a result of four steps. First, a pooled-sample CFA was performed on all the questionnaire items for the six articles mentioned above. The CFA model initially did not converge. This can be attributed to the fact that these constructs may lack the necessary compatibility. The overlap between the constructs can also contribute to the non-convergence. Since a reflective measurement was chosen, the next step aimed at extracting a compatible set of distinct constructs. Second, a Principal Component Analysis (PCA) was performed to examine the factor loadings of all questionnaire items. The items with a low factor loading were identified and eliminated in the next step (a total of 40 items). Third, in line with the results of the PCA, a CFA measurement model was hypothesized using the items with the highest factor loadings. Fourth, the CFA measurement model was tested regarding reliability, convergent validity, and discriminant validity. Moreover, model-to-data fit indices were examined to assure the plausibility of the hypothesized CFA measurement model.

3.3. Measurement model

The hypothesized CFA measurement model consists of 18 measurement items and six latent constructs. Each set of three measurement items (in the rectangles) is set to be a manifestation of the variation in each latent construct (in the ellipses). All latent constructs are set to covary. The error terms of all observed endogenous variables (i.e., questionnaire items) are isolated (in the circles). The complete measurement model is sketched in Fig. 3. The factor loadings are reported on the unidirectional straight causal paths from the latent constructs to each measurement item.

The covariance of the latent constructs is shown next to the bi-directional curved covariance arrows. Error terms are also reported. The mean of each measurement item is shown on the lower right corner of the rectangles. The variance of each latent construct is normalized to one and is reported in each ellipse.

Apart from the pre-requisite model convergence, the quality of the CFA model can be assessed using the model-to-data fit indices. CFA's goodness-of-fit complies with the widely accepted consensus-based cut-off points (based on Kenny, 2019). However, χ^2(the lower, the better) is sensitive to the sample size. To standardize the approach, this value is divided by the degrees of freedom. For the proposed CFA, χ^2/df is 1.98, which is smaller than the usual cutoff of 3. The root mean squared error of approximation (RMSEA), a measure of model-to-data error, is 0.064. A cut-off point of 0.050 (the lower, the better) is considered for excellent models, and RMSEA below 0.080 is considered acceptable. To statistically examine the magnitude of RMSEA, a one-sided one-sample *t*-test is performed (Pclose: 0.032, Probability RMSEA $\leq$ 0.05).

The Comparative Fit Index (CFI) is 0.945, which suggests an acceptable fit. The standardized root mean squared residual (SRMR) is 0.061, which is $<$ 0.080, generally considered the cut-off for a good fit (Hu & Bentler, 1999). The assessment suggests that the CFA model provides a good fit for the data.

To investigate the quality of the survey, a test for Common Method Bias (CMB) was performed. All observed variables (i.e., questionnaire items) in CFA were set to be affected by a latent variable, CMB, the bias which may arise from a single-informant questionnaire. This model did not converge. Alternatively, all the paths from the latent CMB variable to the measurement items were constrained to an arbitrary value of "*a*." This model did not converge either. These results suggest that common method bias is not likely to hamper the upcoming analyses.

The latent constructs were predicted using the measurement items in a CFA model. The predicted variables were subjected to three more quality tests, as reported in Table 2. Reliability of the constructs, tested by Cronbach's alpha and Composite Reliability measures, is confirmed as all values are $>$ 0.70. Convergent validity, measured by Average Variance Extracted (AVE), is also confirmed as all values are above 0.50 (it should be noted that the learning routine and learning culture constructs marginally passed this test). Discriminant validity was not found. All inter-construct correlations need to be smaller than the square root of AVE (bolded on the diagonal axis) to assure that the constructs share more variance within rather than between the other constructs. Two of the constructs, employee appreciation and learning culture, share more variance with the other construct than with themselves (Table 2). Matching the theory and hypothesis development, the constructs are not genuinely distinct concepts, but they act as proxies for a higher-level set of processes, that is, the front-end and back-end processes. The front-end and back-end latent constructs act as second-order latent variables that affect both the first order latent constructs (presented as examples or manifestations) and the firm's innovativeness.

3.4. Structural model

Based on the literature, a structural model is proposed: collaborative networks and learning routines are considered as proxies of the back-

Table 1
Operationalization of the constructs.

Construct	Items	Sources in literature
Firm innovativeness (FI)	**FI1** Our company is creative in its methods of operation **FI2** Our company seeks out new ways to do things **FI3** Our company frequently tries out new ideas	Calantone, Cavusgil, and Zhao (2002)
Collaborative networks (CN)	**CN1** Our customers are directly involved in current and future product/service **CN2** Our customers are actively involved in current and future product/service **CN3** We have corporate level communication on important issues with key suppliers	Shah and Ward (2007)
Learning routines (LR)	**LR1** We use signals or other technique(s) for control production or service processes **LR2** We conduct product or service capability studies before launch **LR3** We use statistical process control techniques or other advanced techniques to reduce process variance or deviations	Pakdil and Leonard (2014)
Employee appreciation (EA)	**EA1** We place great value on recognizing and rewarding employees' accomplishments **EA2** Taking time to celebrate employees' work achievements is valued in our company **EA3** We place great value on showing our appreciation for the efforts of each employee	Hogan and Coote (2014)
Learning culture (LC)	**LC1** A culture of continuous improvement is encouraged **LC2** Our company can be considered as a learning community **LC3** The management department is trained in teamwork and problem-solving skills	Oropesa Vento, Garcia Alcaraz, Maldonado Macias, and Martinez Loya (2016)
Coaching leadership (CL)	**CL1** My manager suggests ways to improve employees' performance **CL2** My manager helps employees focus on their goals **CL3** My manager supports employees' efforts	Arnold, Arad, Rhoades, and Drasgow (2000)

end processes; employee appreciation and learning culture as proxies of the front-end processes; coaching leadership is expected to affect the front-end and back-end processes, and, in turn, both have a significant impact on the outcome variable: firm's innovativeness. The front-end and back-end processes are expected to covary. The next section investigates the plausibility of the proposed structural model with respect to the data.

4. Results and discussion

Firm innovativeness, front-end processes, back-end processes, and coaching leadership are examined by taking into account the level of the environmental dynamism. Firms that operate in environments characterized by higher rates of innovation are likely to be more innovative (Li & Liu, 2014; Schindehutte & Morris, 2001), as shown in Fig. 4. To refine the calculation method and address the peculiarities of the different environments, the error terms are clustered around five levels of environmental dynamism (i.e., the rate of innovation). Accounting for the external effect of the environment, Lean front-end and back-end processes are shown to significantly affect the extent of firms' innovativeness, independently from the environment dynamism.

All hypothesized causal paths and covariance paths are significant at the 1% level. The results suggest that all five research hypotheses are supported by the data (the results are reported in the Appendix A). However, these results are not seen as a basis for prediction of output or allocation of resources as inputs. In contrast, the model as a whole is seen as a system of intertwined processes that altogether simultaneously enhance a firm's innovativeness. The reflective form of the proposed measurement leaves the model open for additions, and other examples of front-end and back-end processes can easily be integrated into the model. Other aspects of each process currently addressed can be integrated into the model. This integrative approach suggests that Lean innovation management drives firms' innovativeness through front-end and back-end processes, boosted by coaching leadership. This model explains a sizable amount of variation in each of its components as, overall, > 89% of the variation is explained. Finally, the equation-level extent of explanatory power is reported in Table 3, and the estimated structural model is shown in Fig. 5.

Before dealing with the estimated coefficients, the fit indices are discussed. These indices are shown in Table 4 and correspond to the basic model (without clustering). After clustering the error term, only the statistics regarding the residuals are available. SRMR is below 0.08; χ^2/df is below 3; RMSEA is close to 0.05 and below 0.08; CFI is close to 0.95 and above 0.90, which all suggest an acceptable model-to-data fit (based on Kenny, 2019).

Furthermore, Lean innovation processes are shown to have a significant impact on firms' innovativeness as a system. Specifically, back-end processes affect firm innovativeness with a standardized coefficient of 0.46. This impact is more than twice as large as the standardized impact of the front-end processes and might be due to the Dutch societal and organizational culture (as elaborated through comparison with other cultures by Hofstede, 2011). Dutch firms exhibit a common and homogeneous set of Lean front-end practices. Hence, less variation can be observed, thus resulting in a smaller standardized coefficients. The larger R^2, as presented in Table 3, for the front-end processes also hints at a lesser intra-firm variation of front-end compared to the back-end processes. These results imply that although synergistic, back-end processes are a more effective lever for Lean to increase firms' innovativeness. Without eliminating or undermining front-end processes, more attention to and investment in back-end processes can enhance firm's innovativeness.

Coaching leadership affects front-end and back-end processes by a coefficient of 0.85 and 0.52, respectively. The larger impact of coaching leadership on the soft processes is in line with Al-Najem, Dhakal, and Bennett (2012), who emphasize the interdependence of culture and leadership in the implementation of Lean systems. These results imply that coaching leadership, acting as a support to Lean front-end and back-end processes, plays a determining role in integrating the front-end and back-end processes, and enhancing both ends of Lean processes. Latent back-end processes load collaborative networks and learning routines with standardized coefficients of 0.81 and 0.66, respectively. Latent front-end processes load employee appreciation and learning culture with relatively sizable standardized coefficients of 0.88 and 0.98, respectively. These results support the conceptualization and model specification of Lean as a second-order integrative system. The coefficient on the covariance between front-end and back-end processes is 0.74 (all coefficients were significant at the 1% level). This significant and sizable covariance implies a synergistic interplay of front-end and back-end processes and directs firms to look at and plan for their Lean system as an integrated whole rather than a sum of isolated processes.

5. Conclusion

Previous studies evidenced that the Lean philosophy pursues a holistic approach in product development, with both culture/people and tools/techniques at its core (Hoppmann et al., 2011; Khan et al.,

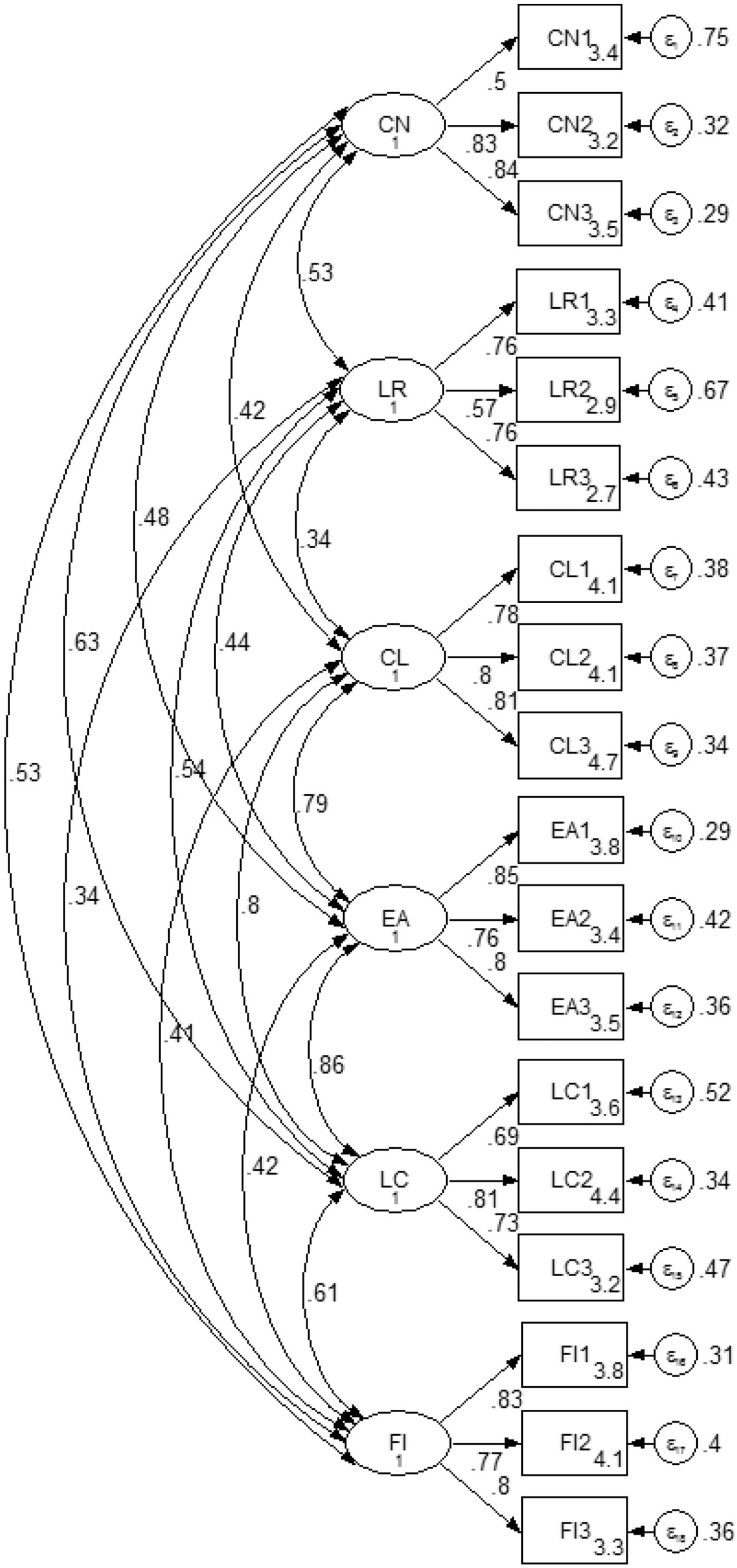

Fig. 3. CFA measurement model.

Table 2
Reliability, and convergent and discriminant validity of constructs.

Component	α[a]	CR[b]	AVE	FI	CN	LR	EA	LC	CL
FI	0.84	0.84	0.64	**0.80**[c]	0.61***	0.41***	0.48***	0.68***	0.47***
CN	0.74	0.78	0.55		**0.74**	0.63***	0.55***	0.71***	0.49***
LR	0.73	0.74	0.50			**0.71**	0.52***	0.63***	0.42***
EA	0.84	0.84	0.64				**0.80**	0.92***	0.87***
LC	0.78	0.79	0.51					**0.71**	0.87***
CL	0.84	0.83	0.64						**0.80**

*** $p \leq 0.01$.
[a] Cronbach's alpha.
[b] Composite Reliability.
[c] Diagonal cells in **bold** report the square root of AVE.

2013; Möldner, Garza-Reyes, & Kumar, 2018; Morgan, 2002). In the same vein, this study argues that firms' innovativeness can be fostered by an integrative Lean approach, which calls for a harmonious interplay between front-end and back-end management, that is, the management of the "soft" and "hard" processes (Bel, 2010). Although this study is preliminary, both hard and soft process management seems to reinforce the effect of one another in achieving the overall business objectives. Moreover, the Lean coaching leadership, marked by goal-orientation and supportive attitude toward employees, appears to boost the back-end processes and, even more, the front-end processes. It can be argued that coaching leadership serves as the adhesive force or source of alignment among all the soft and hard activities.

From a practical viewpoint and to the best of our knowledge, this research is the first integrative approach to understanding how Lean helps firms manage the innovation process and boost their innovativeness. Methodologically, SEM shows high efficacy in modeling the complex inter-relationships of Lean processes and firm innovativeness. The results of this study call for a holistic view of Lean implementation, which avoids an exclusive focus on the technical perspective of Lean (Jørgensen, Matthiesen, Nielsen, & Johansen, 2007), thus encouraging a shift of culture toward learning, employee appreciation, collaboration, and investing in coaching leadership without which culture, collaboration, and practices cannot effectively be enabled.

In practical terms, the Lean innovation management system proposed in this study provides guidelines on how an efficient and effective learning process at individual and collaborative levels can be achieved

Table 3
Equation-level goodness-of-fit.

Depvars	Fitted	Predicted	Residual	R-squared	mc	mc2
Front end	0.064	0.046	0.018	0.717	0.847	0.717
Back end	0.972	0.260	0.713	0.267	0.517	0.267
FI	1.394	0.564	0.831	0.404	0.636	0.404
LC	1.007	0.965	0.042	0.959	0.979	0.959
EA	1.282	0.983	0.299	0.767	0.876	0.767
CN	1.492	0.973	0.519	0.652	0.807	0.652
LR	1.135	0.488	0.647	0.430	0.656	0.430
Overall				0.895		

mc = correlation between depvar and its prediction.
mc2 = mc^2 is the Bentler-Raykov squared multiple correlation coefficient.

and describes how coaching leadership inspires, guides, and facilitates employees toward (and throughout) continuous and iterative cycles of learning. Lean innovation management is a socio-technical system that aims to promote an analytical mindset to stimulate continuous improvement, pursuing a systemic problem-solving approach to reach an efficient and effective learning process, ideally within a collaborative setting. The system altogether is encouraged and supported by a coaching leader.

This study suffered some limitations that can be overcome in future research. First, the dependent variable, firm innovativeness, is subjectively measured, which means that respondents are asked to score generalizable statements instead of measuring the "actual" firm

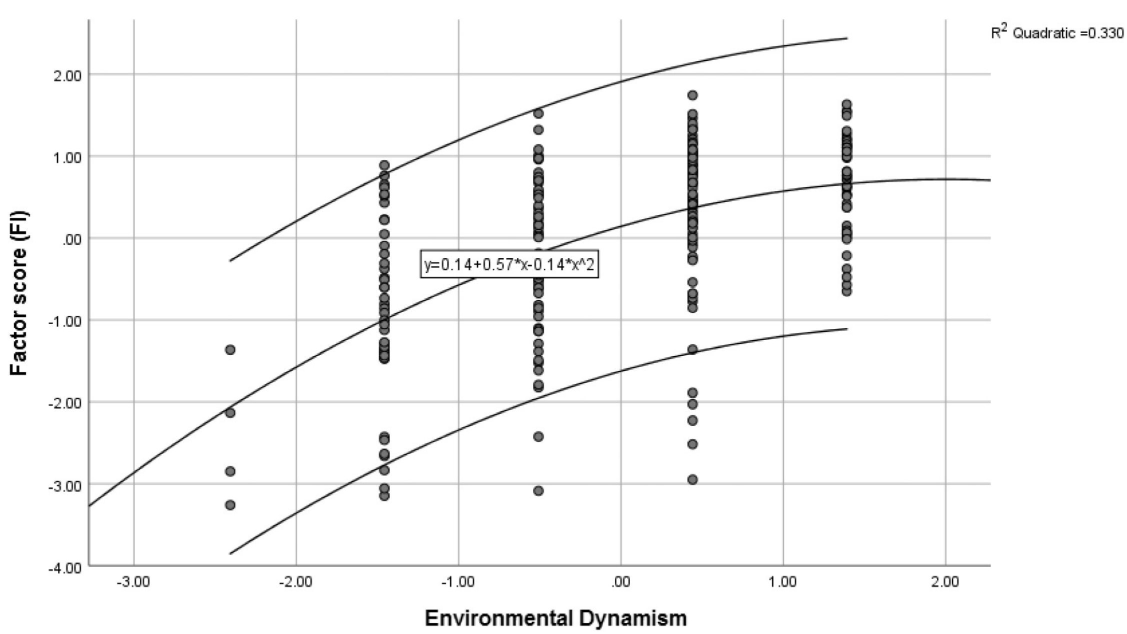

Fig. 4. Firms' innovativeness at various levels of environmental dynamism.

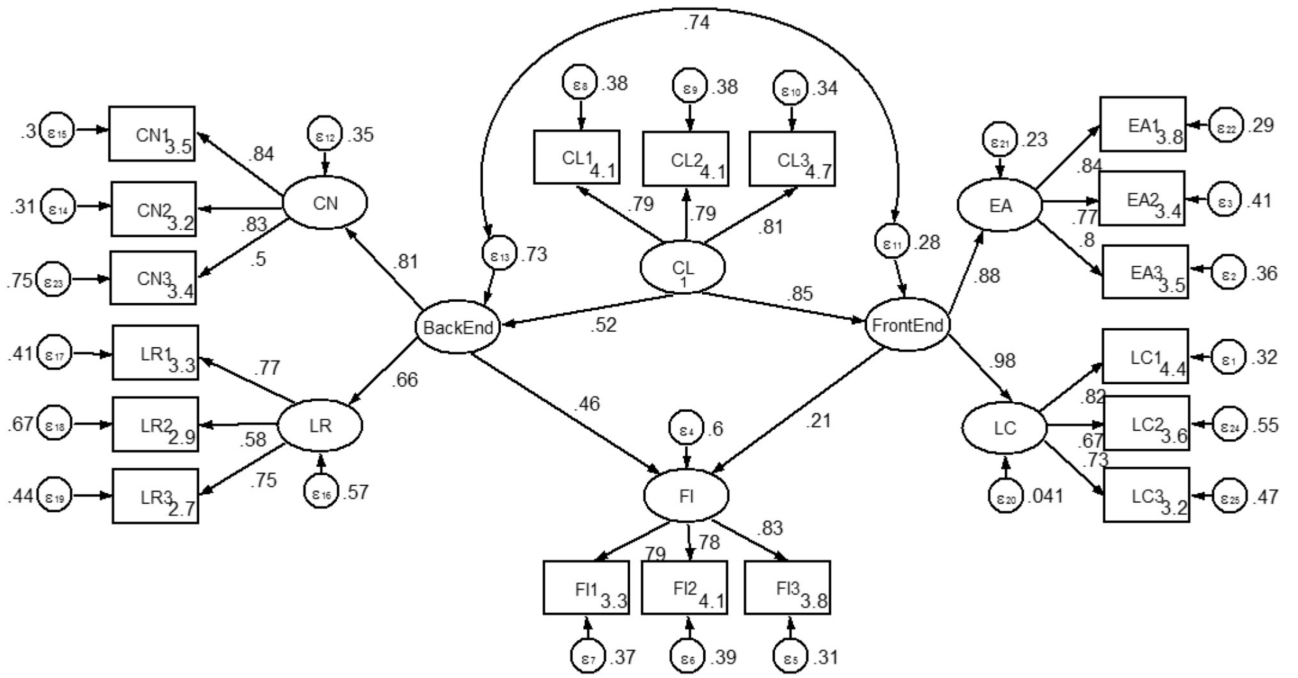

Fig. 5. Results of simultaneous equation estimation.

Table 4
Results of integrative SEM.

Model	Model$_1$ 2nd order
Test variable	β (S.E.)
Back-End → FI	**0.46***** (0.11)
Back-End → CN	**0.81***** (0.08)
Back-End → LR	**0.66***** (0.05)
Front-End → FI	**0.21***** (0.07)
Front-End → EA	**0.88***** (0.06)
Front-End → LC	**0.98***** (0.02)
CL → Front-End	**0.85***** (0.04)
CL → Back-End	**0.52***** (0.07)
Cov (FronEnd~BackEnd)	**0.74***** (0.19)
N	243
SRMR	0.06
Log pseudolikelihood	−6637.52
Model-to-data fit statistics (without clustering)	
χ^2/df	2.00
Root mean squared error of approximation RMSEA	0.06
Comparative fit index CFI	0.94

Dependent variable: Firm Innovativeness (FI).
βs are standardized coefficients. (S.E.) is standard error.
Standard errors are clustered around five Environmental Dynamism categories based on the rate of innovation.
*** $p \leq 0.01$.

innovativeness based on quantitative proxies, thus leading to the so-called "single informant bias" (Campbell & Fiske, 1959). All respondents are from the Netherlands; hence, plausible differences across geographies and cultures are not evaluated, which are proven to help understand Lean deployment (Netland, 2016), for instance, in health-care settings (Guimarães & Crespo de Carvalho, 2012). Future research can incorporate and evaluate the relevance of other Lean front-end and back-end principles and practices to either enhance the explanatory power of the presented model or to refute it by showing that an omitted Lean principle and/or practice can singularly explain more variation in firm's innovativeness than the presented integrative model does.

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Appendix A

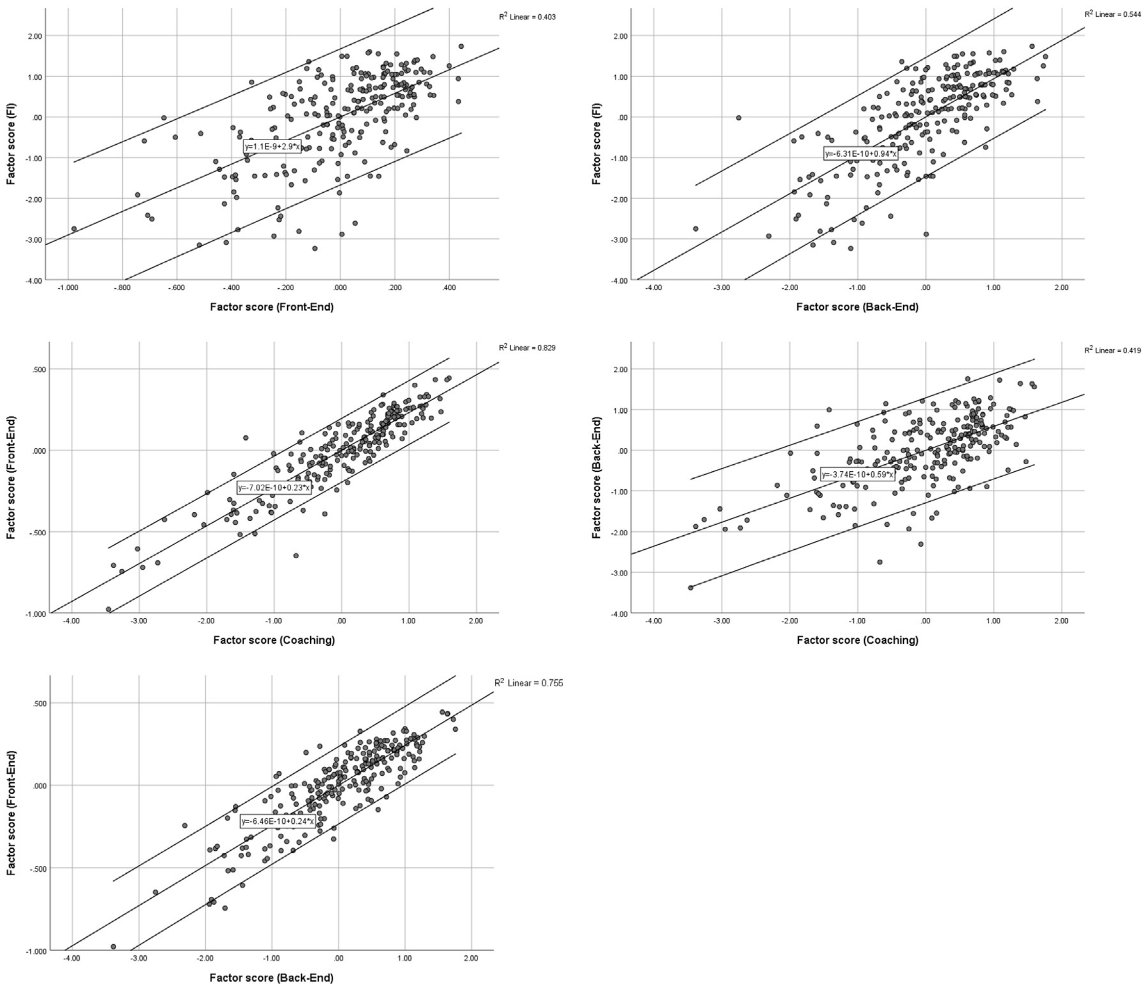

Fig. A1. Visualization of the results.

References

Adams, R., Bessant, J., & Phelps, R. (2006). Innovation management measurement: A review. *International Journal of Management Reviews, 8*(1), 21–47. https://doi.org/10.1111/j.1468-2370.2006.00119.x.

Adler, P. S. (1993). Time-and-motion regained. *Harvard Business Review, 71*(1), 97–108.

Ahmed, P. K. (1998). Culture and climate for innovation. *Eur Innov Manag, 1*(1), 30–43. https://doi.org/10.1108/14601069810199131.

Al-Ashaab, A., Golob, M., Attia, U. M., Khan, M., Parsons, J., Andino, A., ... Sopelana, A. (2013). The transformation of product development process into lean environment using set-based concurrent engineering: A case study from an aerospace industry. *Concurrent Engineering, 21*(4), 268–285. https://doi.org/10.1177/1063293X13495220.

Al-Najem, M., Dhakal, H., & Bennett, N. (2012). The role of culture and leadership in lean transformation: A review and assessment model. *Int J Lean Think, 3*(1), 119–138.

Alpenberg, J., & Scarbrough, D. P. (2016). Exploring communication practices in lean production. *Journal of Business Research, 69*(11), 4959–4963. https://doi.org/10.1016/j.jbusres.2016.04.059.

Angelis, J., & Fernandes, B. (2012). Innovative lean: Work practices and product and process improvements. *Int J Lean Six Sigma, 3*(1), 74–84. https://doi.org/10.1108/20401461211223740.

Aoki, K., & Lennerfors, T. T. (2013). The new, improved Keiretsu. *Harvard Business Review, 91*(9), 109–119.

Arnold, J. A., Arad, S., Rhoades, J. A., & Drasgow, F. (2000). The empowering leadership questionnaire: The construction and validation of a new scale for measuring leader behaviors. *Journal of Organizational Behavior, 21*(3), 249–269. https://doi.org/10.1002/(SICI)1099-1379(200005)21:3 < 249::AID-JOB10 > 3.0.CO;2-%23.

Astrachan, C.. B., Patel, V. K., & Wanzenried, G. (2014). A comparative study of CB-SEM and PLS-SEM for theory development in family firm research. *J Fam Bus Strategy, 5*(1), 116–128. https://doi.org/10.1016/j.jfbs.2013.12.002.

Azadegan, A., Patel, P. C., Zangoueinezhad, A., & Linderman, K. (2013). The effect of environmental complexity and environmental dynamism on lean practices. *Journal of Operations Management, 31*(4), 193–212. https://doi.org/10.1016/j.jom.2013.03.002.

Ballard, G., & Howell, G. (2003). Lean project management. *Building Research and Information, 31*(2), 119–133. https://doi.org/10.1080/09613210301997.

Bel, R. (2010). Leadership and innovation: Learning from the best. *Global Business and Organizational Excellence, 29*(2), 47–60. https://doi.org/10.1002/joe.20308.

Belt, P., Haapasalo, H., Harkonen, J., Mottonen, M., & Kess, P. (2009). Improving product development in different types of ICT companies. *Int J Innov Learn, 6*(6), 672–693. https://doi.org/10.1504/IJIL.2009.026651.

Bessant, J., & Caffyn, S. (1997). High-involvement innovation through continuous improvement. *International Journal of Technology Management, 14*(1), 7–28. https://doi.org/10.1504/IJTM.1997.001705.

Bhuiyan, N., & Baghel, A. (2005). An overview of continuous improvement: From the past to the present. *Management Decision, 43*(5), 761–771. https://doi.org/10.1108/00251740510597761.

Bicen, P., & Johnson, W. H. (2015). Radical innovation with limited resources in high-turbulent markets: The role of lean innovation capability. *Creativity and Innovation Management, 24*(2), 278–299. https://doi.org/10.1111/caim.12120.

Bidault, F., Despres, C., & Butler, C. (1998). The drivers of cooperation between buyers and suppliers for product innovation. *Research Policy, 26*(7), 719–732. https://doi.org/10.1016/S0048-7333(97)00034-6.

Bieraugel, M. (2015). Managing library innovation using the lean startup method. *Library Management, 36*(4/5), 351–361. https://doi.org/10.1108/LM-10-2014-0131.

Blank, S. (2013). Why the lean start-up changes everything? *Harvard Business Review, 91*(5), 63–72.

Boehm, E. (2012). Improving efficiency and effectiveness in an automotive R&D Organization: How a traditional R &D division reshaped itself into a high-performance organization. *Res-Technol Manag, 55*(2), 18–25. https://doi.org/10.5437/08956308X5502011.

Bortolotti, T., Boscari, S., & Danese, P. (2015). Successful lean implementation: Organizational culture and soft lean practices. *International Journal of Production*

Economics, 160, 182–201. https://doi.org/10.1016/j.ijpe.2014.10.013.

Bowersox, D. J., Stank, T. P., & Daugherty, P. J. (1999). Lean launch: Managing product introduction risk through response-based logistics. *J Prod Innov Manag: Int Publ Prod Dev Manag Ass, 16*(6), 557–568. https://doi.org/10.1111/1540-5885.1660030.

Boyle, T. A., Scherrer-Rathje, M., & Stuart, I. (2011). Learning to be lean: The influence of external information sources in lean improvements. *Journal of Manufacturing Technology Management, 22*(5), 58–603. https://doi.org/10.1108/17410381111134455.

Braczyk, H. J. (2013). Organisational restructuring as an innovation strategy Lean production in industry. *Interdiscip. Sci. Rev. 21*(4), 362–372.

Browning, T. R., & Sanders, N. R. (2012). Can innovation be lean? *Calif Manag Rev, 54*(4), 5–19. https://doi.org/10.1525/cmr.2012.54.4.5.

Burns, T. E., & Stalker, G. M. (1961). *The management of innovation.* London, UK: Tavistock Publications.

Byrne, G., Lubowe, D., & Blitz, A. (2007). Using a Lean Six Sigma approach to drive innovation. *Strategy Leadersh, 35*(2), 5–10. https://doi.org/10.1108/10878570710734480.

Calantone, R. J., Cavusgil, S. T., & Zhao, Y. (2002). Learning orientation, firm innovation capability, and firm performance. *Industrial Marketing Management, 31*(6), 515–524. https://doi.org/10.1016/S0019-8501(01)00203-6.

Calvo-Mora, A., Picón, A., Ruiz, C., & Cauzo, L. (2013). The relationships between soft-hard TQM factors and key business results. *International Journal of Operations & Production Management, 34*(1), 115–143. https://doi.org/10.1108/IJOPM-09-2012-0355.

Campbell, D. T., & Fiske, D. W. (1959). Convergent and discriminant validation by the multitrait-multimethod matrix. *Psychological Bulletin, 56*(2), 81–105. https://doi.org/10.1037/h0046016.

Carleysmith, S. W., Dufton, A. M., & Altria, K. D. (2009). Implementing Lean Sigma in pharmaceutical research and development: A review by practitioners. *R&D Management, 39*(1), 95–106. https://doi.org/10.1111/j.1467-9310.2008.00542.x.

Cooper, R. G. (1990). Stage-gate systems: A new tool for managing new products. *Bus Horizons, 33*(3), 44–54. https://doi.org/10.1016/0007-6813(90)90040-I.

Cooper, R. G., & Edgett, S. J. (2008). Maximizing productivity in product innovation. *Research-Technology Management, 51*(2), 47–58. https://doi.org/10.1080/08956308.2008.11657495.

Cusumano, M. A., & Nobeoka, K. (1998). *Thinking beyond lean: How multi-project management is transforming product development at Toyota and other companies.* New York, NY, USA: The Free Press.

De Toni, A., & Tonchia, S. (1996). Lean organization, management by process and performance measurement. *International Journal of Operations & Production Management, 16*(2), 221–236. https://doi.org/10.1108/01443579610109947.

De Treville, S., & Antonakis, J. (2006). Could lean production job design be intrinsically motivating? Contextual, configurational, and levels-of-analysis issues. *Journal of Operations Management, 24*(2), 99–123. https://doi.org/10.1016/j.jom.2005.04.001.

Delbridge, R., Lowe, J., & Oliver, N. (2000). Shopfloor responsibilities under lean teamworking. *Human Relations; Studies Towards the Integration of the Social Sciences, 53*(11), 1459–1479. https://doi.org/10.1177/00187267005311003.

Dess, G. G., & Beard, D. W. (1984). Dimensions of organizational task environments. *Administrative Science Quarterly, 29*(1), 52–73. https://doi.org/10.2307/2393080.

Dombrowski, U., & Mielke, T. (2013). Lean leadership–fundamental principles and their application. *Procedia CIRP, 7*, 569–574. https://doi.org/10.1016/j.procir.2013.06.034.

Evans, P., & Wolf, B. (2005). Collaboration rules. *IEEE Engineering Management Review, 33*(4), 50–57.

Everett, L. Q., & Sitterding, M. C. (2013). Building a culture of innovation by maximizing the role of the RN. *Nursing Administration Quarterly, 37*(3), 194–202. https://doi.org/10.1097/NAQ.0b013e318295ed7f.

Fiume, O. J. (2004). Lean at Wiremold: Beyond manufacturing, putting people front and center. *Journal of Organizational Excellence, 23*(3), 23–32. https://doi.org/10.1002/npr.20013.

Flynn, M., Dooley, L., O'sullivan, D., & Cormican, K. (2003). Idea management for organisational innovation. *International Journal of Innovation Management, 7*(04), 417–442. https://doi.org/10.1142/S1363919603000878.

Freel, M. S. (2005). Perceived environmental uncertainty and innovation in small firms. *Small Business Economics, 25*(1), 49–64. https://doi.org/10.1007/s11187-005-4257-9.

Gefen, D., Straub, D., & Boudreau, M. C. (2000). Structural equation modeling and regression: Guidelines for research practice. *Communications of the Association for Information Systems, 4*(1), 1–77. https://doi.org/10.17705/1CAIS.00407.

Goffin, K., & Mitchell, R. (2016). *Innovation management: Effective strategy and implementation.* Basingstoke, UK: Palgrave Macmillan.

Gudem, M., Steinert, M., & Welo, T. (2014). From lean product development to lean innovation: Searching for a more valid approach for promoting utilitarian and emotional value. *International Journal of Innovation and Technology Management, 11*(2), 1–20. https://doi.org/10.1142/S0219877014500084.

Guimarães, M., & Crespo de Carvalho, J. (2012). Lean healthcare across cultures: State-of-the-art. *American International Journal of Contemporary Research, 2*(6), 187–206. http://hdl.handle.net/10071/13972.

Hair, J. F., Ringle, C. M., & Sarstedt, M. (2011). PLSSEM: Indeed a silver bullet. *Journal of Marketing Theory and Practice, 18*(2), 139–152. https://doi.org/10.2753/MTP1069-6679190202.

Hair, J. F., Ringle, C. M., & Sarstedt, M. (2013). Partial least squares structural equation modeling: Rigorous applications, better results and higher acceptance. *Long Range Planning, 46*(1–2), 1–12. https://doi.org/10.1016/j.lrp.2013.08.016.

Haque, B., & James-Moore, M. (2004). Applying lean thinking to new product introduction. *Journal of Engineering Design, 15*(1), 1–31. https://doi.org/10.1080/0954482031000150125.

Harkonen, J., Belt, P., Mottonen, M., Kess, P., & Haapasalo, H. (2009). Analysing telecom companies using the Toyota NPD model. *International Journal of Mobile Communications, 7*(5), 544–561. https://doi.org/10.1504/IJMC.2009.024392.

Helander, M., Bergqvist, R., Stetler, K. L., & Magnusson, M. (2015). Applying lean in product development-enabler or inhibitor of creativity. *International Journal of Innovation and Technology Management, 68*(1–2), 49–69. https://doi.org/10.1504/IJTM.2015.068774.

Hicks, B. J. (2007). Lean information management: Understanding and eliminating waste. *International Journal of Information Management, 27*(4), 233–249. https://doi.org/10.1016/j.ijinfomgt.2006.12.001.

Hines, P., Francis, M., & Found, P. (2006). Towards lean product lifecycle management: A framework for new product development. *Journal of Manufacturing Technology Management, 17*(7), 866–887. https://doi.org/10.1108/17410380610688214.

Hoerl, R. W., & Gardner, M. M. (2010). Lean Six Sigma, creativity, and innovation. *Int J Lean Six Sigma, 1*(1), 30–38. https://doi.org/10.1108/20401461011033149.

Hofstede, G. (2011). Dimensionalizing cultures: The Hofstede model in context. *Online Read Psychol Cult, 2*(1), 3–26. https://doi.org/10.9707/2307-0919.1014.

Hogan, S. J., & Coote, L. V. (2014). Organizational culture, innovation, and performance: A test of Schein's model. *Journal of Business Research, 67*(8), 1609–1621. https://doi.org/10.1016/j.jbusres.2013.09.007.

Holbeche, L., & Mayo, A. (2009). *Motivating people in lean organizations.* London, UK: Routledge.

Holweg, M. (2007). The genealogy of lean production. *Journal of Operations Management, 25*(2), 420–437. https://doi.org/10.1016/j.jom.2006.04.001.

Hoppmann, J. (2009). *The lean innovation roadmap-a systematic approach to introducing lean in product development processes and establishing a learning organization* (Doctoral dissertation)Germany: Technical University of Braunschweig.

Hoppmann, J., Rebentisch, E., Dombrowski, U., & Zahn, T. (2011). A framework for organizing lean product development. *Engineering Management Journal, 23*(1), 3–15. https://doi.org/10.1080/10429247.2011.11431883.

Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling, 6*(1), 1–55. https://doi.org/10.1080/10705519909540118.

Hummels, H., & De Leede, J. (2000). Teamwork and morality: Comparing lean production and sociotechnology. *Journal of Business Ethics, 26*(1), 75–88. https://doi.org/10.1023/A:1006242516664.

Jaruzelski, B., Loehr, J., & Holman, R. (2013). The global innovation 1000: Navigating the digital future. *Strategy Bus Mag,* 73. Retrieved from: https://www.strategy-business.com/article/00221?gko=e5ecf, Accessed date: July 2019.

Jeyaraman, K., & Kee Teo, L. (2010). A conceptual framework for critical success factors of lean Six Sigma: Implementation on the performance of electronic manufacturing service industry. *Int J Lean Six Sigma, 1*(3), 191–215. https://doi.org/10.1108/20401461011075008.

Johnstone, C., Pairaudeau, G., & Pettersson, J. A. (2011). Creativity, innovation and lean sigma: A controversial combination? *Drug Discovery Today, 16*(1), 50–57. https://doi.org/10.1016/j.drudis.2010.11.005.

Jørgensen, F., Matthiesen, R., Nielsen, J., & Johansen, J. (2007). Lean maturity, lean sustainability. In I. Moon, G. M. Lee, J. Park, D. Kiritsis, & G. von Cieminski (Eds.). *Advances in production management systems* (pp. 371–378). Boston, MA, USA: Springer.

Kenny, D. A.. Measuring model fit. (2019). Retrieved from: http://davidakenny.net/cm/fit.htm (accessed on July 2019) .

Khan, M. S., Al-Ashaab, A., Shehab, E., Haque, B., Ewers, P., Sorli, M., & Sopelana, A. (2013). Towards lean product and process development. *International Journal of Computer Integrated Manufacturing, 26*(12), 1105–1116. https://doi.org/10.1080/0951192X.2011.608723.

Kumar, R., & Kumar, V. (2014). Barriers in implementation of lean manufacturing system in Indian industry: A survey. *Int J of Latest Trends Eng Technol, 4*(2), 243–251.

Li, D. Y., & Liu, J. (2014). Dynamic capabilities, environmental dynamism, and competitive advantage: Evidence from China. *Journal of Business Research, 67*(1), 2793–2799. https://doi.org/10.1016/j.jbusres.2012.08.007.

Liker, J. K., & Choi, T. Y. (2004). Building deep supplier relationships. *Harvard Business Review, 82*(12), 104–113.

MacDuffie, J. P. (1995). Human resource bundles and manufacturing performance: Organizational logic and flexible production systems in the world auto industry. *ILR Review, 48*(2), 197–221. https://doi.org/10.1177/001979399504800201.

Mann, D. (2009). The missing link: Lean leadership. *Frontiers of Health Services Management, 26*(1), 15–26. https://doi.org/10.1097/01974520-200907000-00003.

Mann, D. (2014). *Creating a lean culture: Tools to sustain lean conversions.* New York, NY, USA: Tayor Francishttps://doi.org/10.1201/b17563.

Maskell, B. H., Baggaley, B., & Grasso, L. (2011). *Practical lean accounting: A proven system for measuring and managing the lean enterprise.* New York, NY, USA: Tayor Francishttps://doi.org/10.1201/b11454.

Möldner, A. K., Garza-Reyes, J. A., & Kumar, V. (2018). Exploring lean manufacturing practices' influence on process innovation performance. *Journal of Business Research.* https://doi.org/10.1016/j.jbusres.2018.09.002 in press.

Morgan, J. M. (2002). *High performance product development: A systems approach to a lean product development process* (Doctoral dissertation)USA: University of Michigan.

Morgan, J. M., & Liker, J. K. (2006). *The Toyota product development system: Integrating people, process, and technology.* New York, NY, USA: Tayor Francis.

Nahmens, I., & Ikuma, L. H. (2011). Effects of lean construction on sustainability of modular homebuilding. *Journal of Architectural Engineering, 18*(2), 155–163. https://doi.org/10.1061/(ASCE)AE.1943-5568.0000054.

Nepal, B. P., Yadav, O. P., & Solanki, R. (2011). Improving the NPD process by applying lean principles: A case study. *Engineering Management Journal, 23*(3), 65–81. https://

doi.org/10.1080/10429247.2011.11431910.
Netland, T. H. (2016). Critical success factors for implementing lean production: The effect of contingencies. *International Journal of Production Research, 54*(8), 2433–2448. https://doi.org/10.1080/00207543.2015.1096976.
Netland, T. H., Schloetzer, J. D., & Ferdows, K. (2015). Implementing corporate lean programs: The effect of management control practices. *Journal of Operations Management, 36*, 90–102. https://doi.org/10.1016/j.jom.2015.03.005.
Niepce, W., & Molleman, E. (1998). Work design issues in lean production from a sociotechnical systems perspective: Neo-Taylorism or the next step in sociotechnical design? *Human Relations; Studies Towards the Integration of the Social Sciences, 51*(3), 259–287. https://doi.org/10.1023/A:1016992403973.
Nordin, N., Deros, B. M., & Wahab, D. A. (2010). A survey on lean manufacturing implementation in Malaysian automotive industry. *Int J Innov Manag Technol, 1*(4), 374–380.
Oropesa Vento, M., Garcia Alcaraz, J. L., Maldonado Macias, A. A., & Martinez Loya, V. (2016). The impact of managerial commitment and Kaizen benefits on companies. *Journal of Manufacturing Technology Management, 27*(5), 692–712. https://doi.org/10.1108/JMTM-02-2016-0021.
Ota, M., Hazama, Y., & Samson, D. (2013). Japanese innovation processes. *International Journal of Operations & Production Management, 33*(3), 275–295. https://doi.org/10.1108/01443571311300773.
Pakdil, F., & Leonard, K. M. (2014). Criteria for a lean organisation: Development of a lean assessment tool. *International Journal of Production Research, 52*(15), 4587–4607. https://doi.org/10.1080/00207543.2013.879614.
Piercy, N., & Rich, N. (2009). The implications of lean operations for sales strategy: From sales-force to marketing-force. *Journal of Strategic Marketing, 17*(3–4), 237–255. https://doi.org/10.1080/09652540903064738.
Reinertsen, D., & Shaeffer, L. (2005). Making R&D lean. *Res-Technol Manag, 48*(4), 51–57. https://doi.org/10.1080/08956308.2005.11657325.
Ries, E. (2011). *The lean startup: How today's entrepreneurs use continuous innovation to create radically successful businesses.* New York, NY, USA: Random House LLC.
Ringel, M., Taylor, A., & Zablit, H. (2015). The most innovative companies 2015. Retrieved from: https://www.bcg.com/publications/2015/growth-lean-manufacturing-innovation-in-2015.aspx/, Accessed date: July 2019.
Ryan, R. M., & Deci, E. L. (2000). Intrinsic and extrinsic motivations: Classic definitions and new directions. *Contemp Educational Psychol, 25*(1), 54–67.
Sakai, Y., Sugano, T., & Maeda, T. (2007). Introduction of Toyota production system to promote innovative manufacturing. *Fujitsu Scientific & Technical Journal, 43*(1), 14–22.
Schindehutte, M., & Morris, M. H. (2001). Understanding strategic adaptation in small firms. *Int J Entrepreneurial Behav Res, 7*(3), 84–107. https://doi.org/10.1108/EUM0000000005532.
Schuh, G., Lenders, M., & Bender, D. (2013). *Lean innovation.* Berlin, Germany: Springer Vieweg.
Schuh, G., Lenders, M., & Hieber, S. (2011). Lean innovation–introducing value systems to product development. *Int J Innov Tech Manag, 8*(1), 41–54. https://doi.org/10.1142/S0219877011002192.
Sehested, C., & Sonnenberg, H. (2011). *Lean innovation, a fast path from knowledge to value.* Berlin, Germany: Springer-Verlag.
Sewing, A., Winchester, T., Carnell, P., Hampton, D., & Keighley, W. (2008). Helping science to succeed: Improving processes in R&D. *Drug Discovery Today, 13*(5), 227–233. https://doi.org/10.1016/j.drudis.2007.11.011.
Shah, R., & Ward, P. T. (2007). Defining and developing measures of lean production. *Journal of Operations Management, 25*(4), 785–805. https://doi.org/10.1016/j.jom.2007.01.019.
Smith, D. J., & Tranfield, D. (2005). Talented suppliers? Strategic change and innovation in the UK aerospace industry. *R&D Management, 35*(1), 37–49. https://doi.org/10.1111/j.1467-9310.2005.00370.x.
Solaimani, S., van der Veen, J. A. A., Gülyaz, E., & Venugopal, V. (2019). On the application of Lean principles and practices to innovation management: A systematic review. *Total Quality Manag J (forthcoming)*.
Standard, C., & Davis, D. (2000). Lean thinking for competitive advantage. *Automot Manuf Prod, 12*(1), 1–3.
Takeuchi, H., Osono, E., & Shimizu, N. (2008). The contradictions that drive Toyota's success. *Harvard Business Review, 86*(6), 96–104.
Tam, D. A., Chessum, T., & Leopold, J. (2012). The challenge of innovation and the high-performance team. *Health Environ Re Des J, 5*(3), 66–73. https://doi.org/10.1177/193758671200500307.
Tan, K. H., & Perrons, R. K. (2009). Is globalisation an enabler of radical innovation in Toyota? *Int J Entrepreneursh Innov Manag, 9*(3), 285–298. https://doi.org/10.1504/IJEIM.2009.025144.
Terwiesch, C., & Ulrich, K. T. (2009). *Innovation tournaments: Creating and selecting exceptional opportunities.* Boston, MA, USA: Harvard Business Press.
Trott, P. (2008). *Innovation management and new product development.* Harlow: Financial Times Prentice Hall.
Tuli, P., & Shankar, R. (2015). Collaborative and lean new product development approach: A case study in the automotive product design. *International Journal of Production Research, 53*(8), 2457–2471. https://doi.org/10.1080/00207543.2014.974849.
Tyagi, S., Cai, X., Yang, K., & Chambers, T. (2015). Lean tools and methods to support efficient knowledge creation. *International Journal of Information Management, 35*(2), 204–214. https://doi.org/10.1016/j.ijinfomgt.2014.12.007.
Wagner, S. M. (2006). A firm's responses to deficient suppliers and competitive advantage. *Journal of Business Research, 59*(6), 686–695. https://doi.org/10.1016/j.jbusres.2006.01.006.
Ward, A. C., & Sobek, D. K., II (2014). *Lean product and process development.* Cambridge, MA, USA: Lean Enterprise Institute.
Wincel, J. P., & Kull, T. J. (2016). *People, process, and culture: Lean manufacturing in the real world.* New York, NY, USA: Productivity Presshttps://doi.org/10.4324/9781315300399.
Womack, J. P., Jones, D. T., & Roos, D. (1990). *The machine that changed the world.* New York, NY, USA: Rawson Associates.

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