Sustaining Lean: the determinants of a continuous improvement and learning culture

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Abstract
The aim of this study is to identify and propose the bundles of Lean practices that establish, embed, and sustain a continuous improvement (CI) culture. A conceptual framework, influenced by Knowledge-based view of the firm, was configured to assess the extent to which manufacturing companies are able to implement the selected Lean practices and to promote a sustainable CI culture. The findings (from 89 European manufacturing firms) reveal the significance of employee ambidexterity and cross-functional teaming on internal knowledge stock and sustaining a CI culture resulting from the implemented hard practices of Lean.

Keywords: Lean, Sustainability, Knowledge, Improvement

Introduction
Sustaining Lean initiatives beyond the initial performance improvements derived from the application of basic Lean tools is an articulated research gap (Bateman, 2005; Bortolotti et al., 2015). The majority of Lean literature suggests organizations struggle to sustain initial performance gains resulting in stalled or reverted change interventions which creates a negative memory (Netland et al., 2015) preventing the learning cycle that supports internal knowledge transfer and sustainability of improvement (Secchi and Camuffo, 2016). An embedded Lean learning process, where socio-technical elements of operations management (OM) enable improvements and embed a Continuous Improvement (CI) culture is a major challenge (Piercy and Rich, 2015). Further this improvement-based learning process must result in timely interventions to achieve the *to be* state and competitive advantage via improved operational execution.

The Toyota Production System (TPS) has drawn wide spread attention yet few OM studies investigate Lean sustainability and the tools necessary to guarantee this improved state. This research seeks to close the literature gap generated by the poor definition of Lean sustainability and fragmented understanding of the Human Resource Management (HRM) role during the Lean implementation by OM researchers. Investigating Lean from HRM perspective, Sparrow and Otaye-Ebede (2014) questions whether the HR architecture needs to promote a particular set of skills in order to exert a strategic and

enduring influence over the execution of a Lean strategy. Embedding knowledge is ascribable as the ultimate objective of a Lean learning system and a new form of dynamic capability based on systematic problem-solving and continuous improvements in organizations to better serve customers (Shah and Ward, 2007; Anand et al., 2009). Secchi and Camuffo (2016) propose how within-organization processes of knowledge transfer and learning affects Lean implementation and this remains a significant area of contribution.

For this reason, the theoretical perspective of the knowledge-based view (KBV) of firms (Grant, 1996) was adopted and allowed a greater appreciation of the human resource role and the engagement of these organisational specialists to enable Lean sustainability. KBV advocates individual knowledge creation and the primary role of a company is the collection, codification and integration of the existing and new knowledge, which is either developed by existing employees or acquired from new recruits who bring new knowledge to the firm. The continual pursuit of lean efficiency gains through applied bundles (Shah and Ward, 2007) and kaizen project knowledge circulation with minimum delay promotes cross-functional learning across a firm. Indeed, Lean cross-functional teams, which integrate and relate employees with different backgrounds, skills, and know-how (Shah and Ward, 2003) is a core capability. To achieve such integrated knowledge transfer, Grant (1996) proposes a series of tools, such as rules and directives (impersonal and low-cost), sequencing, routines and, finally, group problem-solving and decision-making, which are embedded features of Lean strategy if applied in a right way within organization.

Thus, the aim of this paper is to unite the Operations and Human Resource Management views of high performance and to propose the bundles of Lean practices that establish, embed, and sustain a CI culture. To achieve this objective, a conceptual framework of practices and mechanisms enhancing the sustainability of the Lean journey was compiled and translated into a structural framework of variables to assess the extent to which companies are able to implement the selected practices in order to promote a sustainable CI culture. Secondly, the study investigates the moderating impacts of *soft lean practices* which support effective knowledge transfer and embedded learning to yield a sustainable CI culture and exploit the implementation of *hard lean practices*. Drawing on empirical cases of businesses that have embarked on a Lean journey this paper explores those working practices that support the sustainability of a Lean journey over time.

Conceptual framework and Hypotheses

Our research investigates how companies develop a Lean CI culture. In this regard, MacDuffie (1995) suggested three conditions to sustain high economic performance-integrating employee's skill, employee's knowledge, and consistency between HRM practices and overall strategy of the firm. It means that, in case a company is willing to implement a Lean manufacturing system, the HRM related choices must support and be aligned to OM decisions (Bortolotti et al., 2015; Piercy and Rich, 2015; Longoni and Cagliano, 2015). Therefore, we can conclude the implementation of Lean tools and techniques is not enough to ensure the success and sustainability of a CI culture in the long-term. We propose a conceptual framework, see figure 1, that integrates Lean tools and techniques with soft practices, practices that are aligned with KBV of the firm, and measure the moderating effect of the softer practices on sustainable CI culture when Lean tools and techniques are applied.

According to the proposed framework, the relation between *Lean tools and techniques* and *sustainable CI* is enhanced by the introduction of *soft practices*, specifically

employee ambidexterity and cross-functional teams, both contributing to the accumulation of internal knowledge stock (IKS). Specifically, Adler et al. (1999) analyze the process of internalizing knowledge in a Toyota case study, which means creating internal knowledge stock, arguing that organizational memory and knowledge is the result of workers' active involvement in defining and refining formalized procedures over time and capability to routinize the innovation process to some extent. Concerning the connection between internal knowledge-stock and the exchange of information and knowledge occurring within the company, Secchi and Camuffo (2016) highlight the importance of creating, disseminating and storing knowledge within and throughout the organization and conceive the Lean roll-out process itself as a process of continuous organizational learning based on company capability to create, share and internalize knowledge. The combined implementation of *Lean tools and techniques* and *Lean soft practices* to reach a *sustainable CI*, as represented in our framework, aims at describing the comprehensive mechanism underlying what we can call *Lean sustainability*.

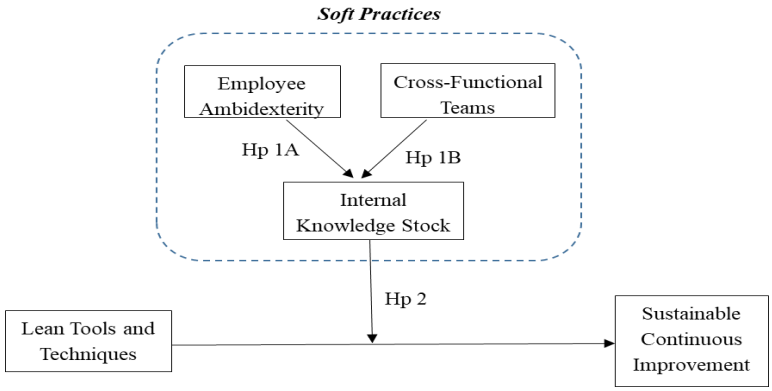

Figure 1 – Conceptual framework for Lean sustainability

The exploration of new alternatives reduces the speed with which existing skills are improved and improvements in existing procedures' competences make experimentation with others less attractive (March, 1991). The trade-off between exploration and exploitation involves conflicts between short-term and long-term concerns and between individual knowledge gains and collective knowledge. Developing ambidextrous capability means overcoming this trade-off so that organization store procedures, norms, rule and forms over time and learn from its members (March, 1991). Only exceptional firms can overcome this trade-off and adopt meta-routines, job enrichment, switching and partitioning. Meta-routines represent the workers' capability to systematize the creative process, that means transforming non-routine into more-routine tasks in order to change established procedures that have become obsolete and inventing new ones. Furthermore, Secchi and Camuffo (2016) observe that by building a set of processes that enable and encourage individuals to judge how to divide their time and responsibilities between conflicting demands of short and long-term objectives to develop contextual ambidexterity for their Lean journey. We hypothesize:

> ***Hypothesis 1A (Hp 1A):*** *developing individual ambidexterity at employee level positively contributes to the firm internal knowledge stock.*

Pagell and Le Pine (2002) argue teams are prescribed elements of Lean programs to ensure employees share their diverse knowledge, skills and experience with each other, then share knowledge across teams to promote learning/improvement for greater IKS. Lean team member cross-training and collaboration for improvements adds to individual and team knowledge to enhance output-based work (Longoni and Cagliano, 2015). Anand

et al. (2009) describe cross-functional teams (CFT) as having a precise role to capture explicit and tacit knowledge developed by their members and transform it for the team and the firm. We can conclude that cross-functional Lean teams are learning facilitators, which means source of sustainable competitive advantage. We hypothesize that:

Hypothesis 1B (Hp 1B): *organizing the work through cross-functional teams positively contributes to the firm internal knowledge stock.*

Sparrow and Otaye-Ebede (2014) investigate the capability of HR function within Lean Management and propose most Lean implementers facing sustainability problems. They find Lean practices are general and exportable but long-term success requires knowledge translation from people-centred approaches rather than processes. The HR function must support knowledge development within the organization to differentiate how value is created for competitive advantage. Anand et al. (2009) also support the positive correlation between the internal knowledge stock and success of a Six Sigma program. We hypothesize the IKS of a company plays a facilitating role in moving from the simple implementation of a Lean system to its sustainability over the long term. In light of these evidences, we hypothesize that:

Hypothesis 2*: developing the firm's internal knowledge stock positively contributes to a sustainable CI, when Lean tools and techniques are implemented.*

More details of items linked to each latent variable is included in the next section.

Research method

For the purpose of our analysis we refer to confirmatory (or theory testing or explanatory) survey research (Saunders et al., 2009). The confirmatory survey research takes place when knowledge of a phenomenon (in our case the achievement of Lean sustainability) has been articulated in a theoretical form, i.e. the conceptual framework, using well-defined propositions or hypothesis. In line with our objectives, confirmatory survey research allows to collect data to test the adequacy of the concepts developed in relation to the phenomenon under analysis, of the hypothesized linkages among the concepts, and of the validity boundary of the models (Forza, 2002).

The operationalization of the variable Lean tools and techniques (LTT), which is the independent variable designed to assess to what extent the manufacturing company is implementing the most cited and used LTT influenced by Shah and Ward (2007) Lean bundle study. Majority of the literature reporting hard Lean practices, i.e. tools and techniques, have developed their instrument based on Shah and Ward (2007) Lean bundles (Hadid and Mansouri, 2016; Bortolotti et al., 2015). Specifically, we considered six different categories of Lean techniques: TPM (Total Productive Maintenance, composed of four items, TQM (Total Quality Management, five items), Flow (three items), Pull (four items), Setup (three items) and SJIT (Supplier Just in Time, three items).

Literature does not provide a unique and commonly recognized measure of employee's ambidexterity (Adler et al., 1999; Bortolotti et al., 2015; Secchi and Camuffo 2016). Bortolotti et al. (2014) identified the aptitude to prefer exploitation over exploration, meaning that facts are preferred over intuition and creativity. The key items included to measure ambidexterity are (Adler et al., 1999; Martinez Jurado et al. 2013; Maalouf and Gammelgaard, 2016; Secchi and Camuffo, 2016): % of CI training over total training received by employees; % of non-routine tasks and responsibilities (e.g. identification of improvement opportunities, 5S, etc) added to routine tasks of employees; % time allocated by Lean experts/managers to the Lean roll-out across the plant; and % of daily time spent on CI activities by your direct reporting employees.

The best measure identified in literature that encapsulates the true meaning of role of CFT in Lean implementation and sustainability was provided by Bortolotti et al (2015):

employees receive training to perform multiple tasks; employees learn to perform a variety of tasks; the longer an employee has been in this organization the more tasks they learn to perform; employees are cross-trained to fill in for others if necessary; employees are arranged into CFT for CI programs.

Measures for IKS should be capable of integrating three aspects of knowledge: knowledge stored in databases, possessed by employees, and derived from interactions among employees. Subramaniam and Youndt (2005) and Lepak and Snell (2002) studies were used to identify appropriate measures for this study. The former reveal the intellectual capital, which is defined as the sum of all knowledge firms utilize for competitive advantage, is composed of three elements, which are the organizational capital (3 items), the human capital, and the social capital (4 items). Given this classification, we integrated Lepak and Snell (2002), as it provides a deeper understanding and analysis of the concept of human capital. They identify two dimensions of human capital: its value (5 items) and its uniqueness (3 items). Human capital value focuses on how individuals' knowledge create value for the company, while human capital uniqueness describes how such knowledge provide competitive advantage towards competitors, who cannot duplicate the abilities and skills of the employee. A total of 15 items across four categories of IKS were included for this study.

The outcome measure of the framework, sustaining CI, represent the ultimate objective of any Lean program. We have adopted four items from Subramaniam and Youndt (2005) and Bortolotti et al. (2015) study for operationalization CI, expressed as the ability of the firm to incrementally improve its performances by working on existing products, services and practices. All items were measured on 1-5 Likert scale, with 1 indicating strongly disagree to 5 indicating strongly agree with a statement.

The conceptual framework was converted into a structural model of measurable variables, administered through an online questionnaire submitted to European manufacturing companies. 89 valid responses from a sample size of 500 European companies were received (response rate of 17.8%). Each observation consists of 84 values (10 background questions and 74 items), each one assigned to a specific factor/variable. Automotive (28%) and Pharmaceutical industries (18%) were two key sectors responding to the instrument. Respondents typically held Lean Six Sigma Black Belt position (35%) or Head of CI (26%) positions in the company. The quality of the measurement model and the structural model were tested through statistical analysis. The analysis proves the designed questionnaire is a valid measurement instrument. For each hypothesis, we run the statistical analysis on R-Studio performing the following steps: Explanatory analysis to inspect data distribution, correlation among indicators and eventual inconsistencies; Partial Least Squares (PLS) Model to evaluate outer and inner model through confirmatory factory analysis and structural regression respectively; Post-Hoc analysis to test the goodness of the result of the PLS model through a re-sampling technique known as Bootstrap validation. Since this technique is not applicable to models with interactions terms, we applied it to the first group of hypotheses only (Hp 1A and Hp 1B).

Findings

Our first group of hypotheses focuses on how companies can manage employee ambidexterity (Hp 1A) and CFT (Hp 1B) to increase its IKS. Hp 1A indicate for positive relationship, i.e. developing employee ambidexterity would increase the amount of knowledge managed by the company. Similarly, Hp 1B measures positive relationship between organisation of work through CFT and IKS used by the firm to create value.

PLS represent a particular SEM model able to perform the confirmatory factor analysis and build the structural model at the same time. The measurement model of PLS addresses

the outer model of our framework consisting of the relationships between each latent factor and the indicators related. According to Nunnally (1978), Forza (2002) and Sanchez (2013), literature considers Cronbach's Alpha higher than 0.6 as acceptable. The unidimensionality indicator (i.e. Cronbach alpha value) are high for CFT (0.74) and IKS (0.90) and low for employee ambidexterity (0.495) after first round of PLS. Running PLS for two more rounds and dropping one item each from three latent constructs (AMB3 for ambidexterity, CFT3 for CFT and HCU2 for IKS) resulted in improved unidimensionality value (i.e. employee ambidexterity -0.617; CFT - 0.78; and IKS - 0.912). After assessing the quality of the measurement (outer) model, the next stage is to assess the structural part, that is the inner model of our framework. The path coefficient and the regression result for the two endogenous construct in presented in table 1.

Table 1 – Regression results for first set of hypotheses

	Estimate	**St. Error**	**P-value**
Employee Ambidexterity	0.3660	0.0840	***
Cross-Functional Teams	0.5240	0.0840	***
R^2	0.633		
Goodness of Fit (GoF)	0.617		
Total Effects			
	Direct	Indirect	Total
Employee Ambidexterity >>> CFT	0.000	0	0.000
Employee Ambidexterity >>> IKS	0.366	0	0.366
CFT >>> IKS	0.524	0	0.524
Bootstrap validation			
	Perc. 025	**Perc. 975**	
Employee Ambidexterity >>> IKS	0.2781025	0.503814	
CFT >>> IKS	0.3950771	0.6445805	

The path coefficient and p-value indicates positive correlation between predictor variables (ambidexterity and CFT) and dependant variable (IKS) and acceptance of alternate hypothesis Hp 1A and Hp 1B. The R-square value indicates strong explanatory power (R-square value > 0.6 is considered high) of the predictor variable to explain the variance in the dependant variable (Sanchez, 2013). The GoF value (value of 0.6 or higher considered acceptable) accounts for the good prediction capability of the structural model. We also measure the direct and indirect affects between latent constructs. As we can see, employee ambidexterity and CFT have a direct and positive effect on IKS. These effects are supported by significant p-values, leading to verification of Hp1A and Hp1B.

In order to obtain information about the variability of the parameter estimates we rely on a re-sampling procedure named *bootstrapping.* If the bootstrapping confidence interval does contain the zero, we may argue that the coefficients it refers to are not significant at a 5% confidence level. As we can see from table 1, no interval contains zero, leading us to confirm that the path coefficient estimated are significant at the chosen significance level.

Our second group of hypotheses focuses on the key role of IKS (as a facilitator of a sustainable Lean implementation, and therefore of sustainable CI. Hypothesis 2 assumes the facilitating role of IKS (divided into its four components: organizational capital, human capital value, human capital uniqueness and social capital) within the Lean sustainability framework. Thus, increasing the amount of knowledge stored and managed

by the firm should facilitate the achievement of sustainable CI when Lean tools and techniques are implemented.

Similar to first set of hypotheses tests, we perform similar analysis for second set of hypotheses and results are presented in table 2. The Cronbach's alpha value for all latent variables (lean tools and techniques- 0.90; organisational capital- 0.59; human capital value – 0.91; human capital uniqueness – 0.67; social capital – 0.85; and sustainable CI – 0.76) are close or higher than the threshold value 0.6, meaning the way we are computing each factor is correct, and the questions included in the questionnaire represent good indicators of the whole latent variable. After assessing the quality of the measurement (outer) model, we assess the structural (inner) model describing the relation among the latent variables Lean tools and techniques, IKS and sustainable CI.

Table 2– Regression results for the second hypothesis

	Estimate	**St. Error**	**P-value**
Lean Tools and Techniques	0.3669	0.154	*
Organizational Capital	0.1858	0.131	
Human Capital Uniqueness	0.1389	0.168	
Human Capital Value	0.2589	0.151	
Social Capital	-0.2905	0.137	*
R-square	0.409		
Goodness of Fit (GoF)	0.4296		
Moderating terms *(two stages regression result)*			
	Estimate	**St. Error**	**P-value**
Organizational Capital * Lean Tools and Techniques	-0.21531	0.16341	
Human Capital Uniqueness * Lean Tools and Techniques	0.63914	0.17126	***
Human Capital Value * Lean Tools and Techniques	-0.38826	0.15422	*
Social Capital * Lean Tools and Techniques	-0.09845	0.13242	
Organizational Capital	0.27526	0.12319	*
Human Capital Uniqueness	0.24722	0.17059	
Human Capital Value	0.25634	0.15362	
Social Capital	-0.34982	0.14836	*
Lean Tools and Techniques	0.46027	0.14685	**
Multiple R-square	0.5303		
Adjusted R-square	0.4534		

The regression result indicate social capital negatively contributes to the sustainable CI, while all the other IKS component and the variable Lean tools and techniques have a positive direct effect as shown in table 2. P-values are significant, tested at 5% significance level, only for the variables Lean tools and techniques and the fourth component of IKS, that is social capital. Before driving any conclusion from the hypothesis test, we measure the interactions between the variables to understand if some of them play a moderating role in defining the dependent variable sustainable CI. This is achieved by running a two-stage regression model.

The difference between multiple and adjusted R-square is not significantly big, leading us to believe that the added moderating terms increases the power of the whole model. Specifically, p-values show that the most significant role in predicting the value of sustainable continuous improvement is played by the variables Lean tools and techniques, human capital uniqueness*Lean tools and techniques, human capital value*Lean tools and techniques, organizational capital and social capital. A closer look at the results shows

that Lean tools and techniques and organizational capital are positively related to sustainable CI; and human capital uniqueness positively moderates the relation between Lean tools and techniques and sustainable CI, meaning that the interaction between these two independent variables positively contribute to the dependent one. However, we cannot state the same for the other two variables showing significance. The interaction between human capital value and Lean tools and techniques and social capital seem to negatively contribute to the sustainable CI.

Discussion and conclusion

The challenges underlying the sustainability of CI have led companies to search for ways to go beyond the short-term achievements and benefits coming from the initial application of the most known Lean practices (Bortolotti et al., 2015; Piercy and Rich, 2015; Bateman, 2005). However, many cases prove that companies become unable to further improve their performances and moving the company back to its original pre-improvement level. For this reason, self-sustaining improvement, and then Lean sustainability, requires to be constantly fuelled with energy by all the members of the company. Thus, this paper explores the meaning of Lean Sustainability for manufacturers and identifies how to realise sustainable gains through enhanced knowledge stocks to transition from initial implementation of tools to the establishment of a sustainable CI culture. To avoid the pitfalls of 'tool head' Lean application, this research supports a socio-technical system approach to improvement where human assets determine the effectiveness of learning and improvement processes.

We first discuss the key theoretical implications associated with our study. The *first implication* relates to the value and need for researchers to investigate the concept of a sustainable Lean strategy, which represents an area not yet deeply covered in the OM literature. The development of our theoretical framework, represented in figure 1, is the result of an accurate synthesis of literature within the OM and HRM fields. The whole framework was analysed using a knowledge-based perspective (Grant, 1996). Following MacDuffie (1995), who highlights the need of an alignment between operative and human resource strategy, our framework proposes a consistent system of manufacturing practices (hard practices) and HRM practices (soft practices), provides a picture of the mechanisms underlying the achievement of a CI culture in a long term, and providing meaningful definition to the term Lean sustainability. Specifically, according to our framework, to reach sustainable CI it is necessary to integrate the implementation of Lean tools and techniques with the moderator - internal knowledge stock. As Bateman and David (2002) and Bateman (2005) observe, sustainability requires the firm to go beyond the short-term process improvements focus where all employees should embrace a CI mind-set.

The *second implication* relates to the outcomes of the measurement model assessment for all our variables. Our questionnaire has shown good results in the confirmatory factor analysis performed as part of PLS analysis. Specifically, all the constructs represented in our framework shows acceptable values of the unidimensionality indicator, named Cronbach's alpha. Thus, our questionnaire represents a reliable measurement instrument, which can be used for further research and be used by managers to track their company's journey towards Lean sustainability.

The *third theoretical implication* refer to the outcome of the structural model analysis of our first group of hypotheses. More precisely, we have found statistical evidence of the positive relationship linking employee ambidexterity, CFT, and IKS. Both hypothesis tests (Hp 1A and Hp 1B) provide significant p-values and positive beta coefficients for the proposed structural model. This witnesses not only the reliability of the results obtained but also the existence of a positive relationship among the mentioned variables.

In conclusion, fostering employee ambidexterity does lead to an increase of the firm IKS and, similarly, organizing the work through CFT increment the IKS of the firm.

Finally, the *last theoretical implication* refers to the outcome of the structural model analysis of our hypothesis 2. We have found statistical evidence that two components of IKS, named human capital uniqueness and organizational capital, positively contribute to the achievement of sustainable CI. Human capital uniqueness is statistically significant when interacts with Lean tools and techniques and organizational capital is predictor of sustainable CI. Specifically, according to the results obtained, human capital uniqueness (Lepak and Snell, 2002) positively moderates (facilitates) the transit from a mere Lean implementation focused on the hard practices to a more comprehensive CI culture. Also, they show that the organization capital, representing the values and beliefs which characterises the firm culture, positively predict the achievement of the sustainable CI.

Our work influence managers to involve and promote employees as the source of energy for a self-sustaining improvement and our framework has been designed, and statistically tested, to depict a direction that firms should follow when implementing Lean. Our results show evidence that developing the IKS of the company facilitates the spread of a CI culture within the company and this should advise managers that besides accumulating expertise, it is important to effectively store and make it a valuable source accessible to all the employees (Secchi and Camuffo, 2016). By providing employees with unique tools and means, companies become able to develop a knowledge that is firm-specific, and then hardly replicable by competitors. For this reason, to develop human capital uniqueness, companies should adopt an employee-centred approach that is knowledge-based instead of job-based (Lepak and Snell, 2002). A knowledge-based approach is structured around employees' skills and competencies, rather than the execution of programmed tasks and job routines, as a job-based approach requires.

Promoting employee ambidexterity requires managers to provide employees with clear long-term directions as well as the space and time to explore new methods and ways to do things. Long-term directions should be shared rather than imposed, and ideally, in a continuous improvement environment, it should be the result of the contribution of each member of the firm. The other practice on which firms can rely on when willing to feed their knowledge stock, is the use of CFT. CFT should be the result of cross-functional training and more in general, the outcome of a company constant investment in people development. Promoting effective and productive multi-functional teams means providing people with the opportunity not only to share and integrate different kinds of knowledge, but also to promote the development of new ones (Longoni and Cagliano, 2015).

This research is ongoing with an attempt to collate more dataset for improving the validity of the findings. For 22 latent variables in the sample, we need at least minimum of 5 times to comment on the generalisability of the findings to wider manufacturing industry. A small dataset leads to a high variability of the values because uniqueness phenomena. A comparison between countries or continents would provide interesting perspectives on how Lean is implemented across the globe, especially regarding the soft practices, which are affected not only by the culture of the company itself but also by the culture of the country the company operates in. The companies which responded to our questionnaire have been implementing Lean for different numbers of years, meaning they belong to different stage of the Lean journey. With a larger dataset, it would worth exploring how results change if responses are grouped per the number of years the company has been implementing Lean. At each stage of the journey the managerial implication would differs and therefore would be possible to provide more precise

indications on how to interpret the model depending on how much Lean experience has been accumulated by the company.

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