The impact of operational intellectual capital on lean practices

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Abstract

The purpose of this study is to investigate how synergies between operational intellectual capital (OIC) and lean practices emerge. In particular, the authors explore three knowledge based resource dimensions: human capital (HUC), structural capital (STC) and social capital (SOC). This study aims to examine a research framework relating knowledge-based resources, lean practices and operational performance. Our findings highlight the importance of leveraging a system of complementary knowledge based resource dimensions and addresses the need for the reformulation of lean implementation theory in terms of the emergent knowledge-based view of the firm.

Keywords

Operational intellectual capital, Lean practices and Resource based theory

Introduction

In the quest of helping companies succeed, researchers looked at world known companies and studied their actions in order to find the winning formula. Success stories include Toyota, Mercedes, Caterpillar, Bosch, Siemens and Volvo (Clegg et al., 2013), Boing (Chavez et al., 2015) and many smaller and less known companies (Boscari et al., 2016, Jayaram et al., 2008, Shook, 2008) who implemented lean and in that way exhibited competitive advantage. Uncertainties and rapid changes in the operating environments have challenged managers to seek further sources that can support them in achieving competitive advantage.

Lean management has been implemented by companies worldwide and a large number of publications examined the relationship between lean manufacturing adoption and organisational performance (Negrão et al., 2016, Jasti and Kodali, 2015). The core idea of lean manufacturing is to maximize customer value while minimizing waste. The ultimate goal of implementing lean production in an operation is to increase productivity, enhance quality, shorten lead times, and reduce cost (Wahab et al., 2013). Most of the studies showed a positive relationship between the implementation of lean practices and performance (Bortolotti et al., 2015, Boscari et al., 2016, Chavez et al., 2015, Fullerton et al., 2014, Jayaram et al., 2008). However, some authors pointed out to a negative relationship or no relationship between lean practices and some performance measures (Bortolotti et al., 2013, Chen and Hua Tan, 2013, Fullerton et al., 2003). Negrão et al. (2016) highlights that most of the research focused on the lean technical aspects (i.e. practice implementation and its effect on performance), rather than the “people” related issues. More recently, researchers shifted towards “why” lean works (or not), bringing more focus to the human resource management (HRM) bundles. For example, Bonavia and Marin-Garcia (2011) assert that the majority of research concentrated on examining the HRM practices needed to maintain lean implementation over time, but little is known on how the HR function can have a more strategic impact on lean practices. Sparrow and Otaye-Ebede (2014) reported that in order to achieve sustainable lean implementation, companies need to focus on building dedicated and specialised knowledge into people management and create a broader structural grouping of intellectual capital. Similarly, Durst and Runar Edvardsson (2012) stated that knowledge and the management of intellectual capital had become a key factor of growth and sustainability in firms, allowing them to become more adaptable and responsive.

Building on these theoretical arguments, our study examines the influence of OIC on the efficacy of lean practices. In line with Menor et al. (2007) and other arguments offered by Zhang et al. (2015), Matthews and Marzec (2012), Li et al. (2014), we posit that the OIC represents a strategic knowledge based resource, that is valuable, hard to imitate or substitute and when leveraged effectively it generates superior operational and competitive advantage. Consistent with Subramaniam and Youndt (2005), we define the OIC as the aggregation of all knowledge embedded in the company's operating resources – structural, human and social. In order to consider the effects of these forms of embeddedness, our study will examine the following research question:

How does human, structural and social capital contribute to the efficacy of lean practices?

In answering this question, we make three key contributions to operations management literature. First, we extend the application of intellectual capital theory in operations management research, by recognising the structural, relational and knowledge aspects of embeddedness (Lee et al., 2011). Second, we build on lean literature to argue that the operational intellectual capital contributes to the efficacy of lean practices (Sparrow and Otaye-Ebede, 2014). Third and last, our research offers practitioners insights into the advantages of managing knowledge assets for improved operational performance, as well as highlighting how the OIC can be leveraged to enhance and sustain the competitive advantage generated though lean practices (Wang et al., 2014).

The remainder of the paper is organised as follows: the literature review related to lean practices and operational intellectual capital is reviewed and the hypotheses are developed; then the research methodology and data analysis is outlined, followed by the discussion of the results and conclusion.

Literature review

Theoretical background

The study of lean manufacturing has advanced considerably over the past two decades. Lean management is a holistic business strategy that requires a change in mind set that extend beyond operations. Lean thinking emphasizes excellence through the elimination of waste and a focus on continuo us improvement (Fullerton et al., 2014). Most of the studies investigated the efforts related to the adoption of lean practices and their relationship to performance by industry (Negrão et al., 2016), however recent studies highlighted the need to investigate how "people" resource can enhance the effect of lean on operational performance (Bonavia and Marin-Garcia, 2011, Bortolotti et al., 2015, Jayaram et al., 2008). According to proponents of knowledge based perspective (KBV) (Grant, 1996, Hörisch et al., 2015, Nickerson and Zenger, 2004) and resource based perspective (RBV) (Hitt et al., 2016, Barney, 1996), knowledge is the most important strategic resource of the firm. In order to maintain their competitive advantage, companies need to "manage the system of complementary resources that constitutes its knowledge base" (Menor et al., 2007: p.561). The effect of lean practices on operational performance has been studied and majority of researchers suggest positive impacts (Negrão et al., 2016, Jasti and Kodali, 2015). Consequently, this study will not focus on the impact of lean practices on performance, but rather how their impact can be enhanced. Although research showed that intellectual capital leads to better organisational performance (Wang et al., 2014, Lu et al., 2014, Hsu and Wang, 2012, Menor et al., 2007), no study looked at how intellectual capital influence the implementation of lean practices. Moreover, how specific elements of IC influence the efficacy of lean practices has not been studied. Therefore, this study makes important contributions to theory and practice within the OM and IC research streams.

Lean practices and OIC

Sparrow and Otaye-Ebede (2014) assert that the interactions between operations management and HRM practices represent a lean philosophy and these have a synergistic effect on the operational performance. "People" resource has been identified as key to the successful implementation of lean projects and recent studies suggest that operational intellectual capital plays a critical role in sustainable competitive advantage (Bonavia and Marin-Garcia, 2011, Clegg et al., 2013). According to Ling (2013) intellectual capital has many potentials yet to be explored. For instance, Wang et al. (2015) state that IC has a much bigger influence on employees than previously expected and that is also very important considering that lean implementation depends on employees willingness to adopt lean practices. In order to improve performance, an organization needs to continuously improve its effectiveness as well as efficiency. This is possible only through a continuous development of organizational competencies. The capabilities are rooted in the organizational knowledge assets which build the OIC of the organizations (Schiuma and Lerro, 2008, Menor et al., 2007). In a lean implementation, we argue that three dimensions of OIC: human, structural and social capital, will enhance lean implementation performance. Given that organisations accumulate expertise in multiple cycles of knowledge processing (Lee et al., 2011), this research posits that companies in order to enhance the lean practices implementation need to understand how to leverage different forms of knowledge resources (i.e. OIC dimensions). Figure 1 depicts the proposed research framework based on the theoretical advancements that follow.

According to Teece (2014), knowledge based resources both explicit and tacit, form competitive advantage. These knowledge-based resources are typically stored in personnel, organizational routines, manufacturing processes and relationships across the supply chain. Menor et al. (2007) cite Eisenhardt and Santos (2003) who claim that these knowledge based resources create competitive advantage because they are rare, valuable and difficult to substitute or imitate, in line with RBV, and they termed them operational intellectual capital (OIC). Similarly to Menor et al. (2007), we use the OIC components defined by Subramaniam and Youndt (2005): human, social and structural capital.

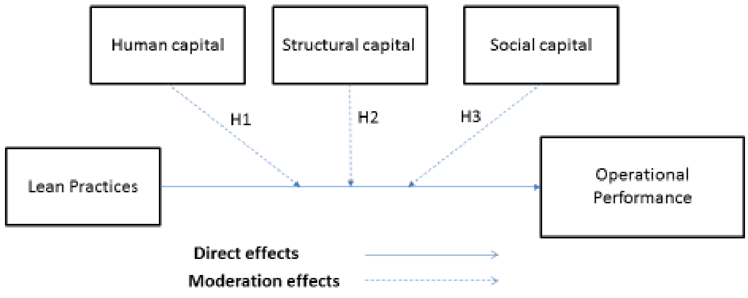

Figure 1. Research framework

Human capital (HUC) is the knowledge, experience and professional skills and abilities in employees (Subramaniam and Youndt, 2005). If organizations invest in educating and training their employees, their professional skills and competence would increase, resulting in better individual and organizational performance. Snell and Dean (1992) have highlighted the role of human capital, specifically skilled human resources, in implementation of new manufacturing practices such as advanced manufacturing techniques, just-in-time, and total quality management. Such programmes are quite complex to enact within an organisation, and require knowledgeable employees. Lee et al. (2011) examined the role of intellectual capital in implementing manufacturing process innovations (MPI). Initial findings suggested that HUC did not affect MPI, however when looking at the type of MPI (incremental versus radical) the results suggested that the greater HUC the higher technical performance of radical MPI projects. Their assertions concur with Subramaniam and Youndt (2005), who found that HUC had no direct impact on incremental innovation capability, while it had a significant impact on radical innovation capability. Thus, we hypothesise that the possession of knowledge, experience and professional skills and abilities in employees enables lean practices to achieve higher levels of operational performance.

H1: Manufacturing plants that are characterised by high levels of HUC gain higher operational performance benefits from investments in lean practices, as compared to plants with low levels of HUC

Structural capital (STC) involves "the institutionalized knowledge and codified experience residing within and utilized through database, patents, manuals, structures, systems and processes, which can be conceptualized in terms of organizational processes and information systems" (Subramaniam and Youndt, 2005: p.451). According to Guerrero-Baena et al. (2015), structural capital is the frame and the glue of an organization because it provides the tools and architecture for retaining, packaging and moving knowledge along the value chain (Cabrita and Bontis, 2008). Sharing information is key to developing a learning culture, where workers can access cross-departmental knowledge. In order to facilitate this, knowledge must be deemed valuable and companies must focus on the quality of the information shared, rather than quantity. Ferdows (2006) highlighted the need for proper codification of information in order to facilitate its movement between organisational units. Tu et al. (2006) and Huang et al. (2008) empirically showed that information sharing and internal learning have a positive impact on successful implementation of manufacturing practices. Therefore, STC enables workers to access valuable complementary expertise thereby leading to a more successful implementation of lean practices. Thus, we propose the following hypothesis:

H2: Manufacturing plants that are characterised by high levels of STC gain higher operational performance benefits from investments in lean practices, as compared to plants with low levels of STC

Social capital (SOC) is defined as "the knowledge embedded within, available through and utilised by interactions among individuals and their networks of interrelationships" (Subramaniam and Youndt, 2005: p.451). In comparison to structural capital, which requires a formal process and procedures, social capital does not need any predetermined rules (Lee et al., 2011). Ayas (1997) referred to social capital as the "relational network density", degree of informality, openness of communication within and outside the organisation. Matthews and Marzec (2012) in their study presented empirical evidence of social capital having positive impacts in quality management, project management, new product development and supply chain management. Similarly, Yuan et al. (2009) found that investments in social capital, was an important precondition that enhanced the group learning and performance. When implementing lean a key element is employee involvement. People like to express their opinion and feel safe to discuss issues that can lead to improvements. Having a strong collaborative culture can lead to successful implementation of lean (Bortolotti et al., 2015). Thus, we posit:

H3: Manufacturing plants that are characterised by high levels of SOC gain higher operational performance benefits from investments in lean practices, as compared to plants with low levels of SOC

Methodology

Data collection

Data were collected as part of the Global Manufacturing Research Group (GMRG), a multinational group of OM researchers. Standardised survey instruments have been developed over a number of years and administered by GMRG members in their respective country. The data used in this paper, is part of the fifth round. The unit of analysis for the survey is the manufacturing site or plant, and all data were collected from plant managers as key informants within that site, who often consult others in their firm. Over 900 responses have been collected, representing 13 countries.

Measures

Lean practices, operational performance and operational intellectual capital are all constructed variables and had to be tested using confirmatory factor analysis. All analyses were performed using AMOS and SPSS 22. Lean practices were measured by considering the plant's level of investments of financial and human resources in the previous two years (see Appendix A). Operational performance is a second order construct that measures operational capabilities compared to major competitor(s) on the 7 point Likert scale (1- far worse to 7- far better) (see Appendix A). The third constructed variable is operational intellectual capital consisting social, structural and human capital (see Appendix A). Composite reliability statistics indicated strong construct reliability in each case; all values are well above 0.7 (Fornell and Larcker, 1981). The results established convergent validity and unidimensionality for each construct, as all item loadings (lambdas) are highly significant (all t-values are >2.0). The results also indicated acceptable discriminant validity for the measures at both the construct and item levels. We interpret these results as strong, especially given the multi-country, multi-industry and highly varying size of the organizations and plants represented in this data set. All AVE (convergent validity) are greater >0.5 in line with (Hair et al., 2013).

Control variables and sample

Size is used as a control variable because it is believed that large organizations can potentially have more resources (Hemphälä and Magnusson, 2012). Industry was used as a control variable through a proxy of complexity of the product, because the literature explicitly states that some industries (like electronics) have higher number of innovations than for example the oil or food industry. This was checked by a complexity variable calculated by number of parts in the product ranging from 1 for simple products to 7 for more than 1000 parts in the product. Additionally, we tested whether there is difference in developed and developing countries as some studies showed that technology investment yield positive results in developed but not in developing countries (Zhou et al., 2009). The sample consists 987 manufacturing companies from 13 countries, out of which 19.5% are small companies up to 50 employees, 41.8% of companies are middle sized companies (50 to 250 employees) and 32.1% of companies are large with over 250 employees.

Results

To test our hypotheses we used three OLS regression analyses (Wiengarten et al., 2013). The analysis was conducted in three separate models reflecting the three interaction terms (level of lean investment and social capital; level of lean investment and human capital and level of lean investment and structural capital). In the first step of the OLS analysis, the control variables stage of development of the country, complexity of the produced product (proxy for industry) and firm size were introduced, in the second step level of lean investment (Model I) social capital (Model II) human capital and (Model III) structural capital were introduced. In the third step the interaction terms were introduced. Linearity and multicollinearity were checked before OLS analysis (Kennedy, 2003). Firstly, the variance inflation factors (VIFs) were calculated and listed below. The resulting VIFs indicate that multicollinearity is not apparent.

Table 1: OLS analysis for moderation effects

	Model 1 Social capital interaction on performance	**Model 2 Human capital interaction on performance**	**Model 3 Structural capital interaction on performance**
Variable			
Step 1. Control variables			
Country stage	0,068 (0,041)	0,068(0,041)	0,068(0,041)
Complexity	0,048 (0,152)	0,048 (0,152)	0,048 (0,152)
No of employees	0,054 (0,112)	0,054 (0,112)	0,054 (0,112)
Step 2. Independent variables			
Lean investment	0,513 (0,000)	0,534 (0,000)	0,535 (0,000)
Moderators			
SOC	0,237 (0,000)		
HUC		0,230 (0,000)	
STRUCT			0,187 (0,000)
Step 3. Interaction			
Lean* SOC	0,063 (0,015)		
Lean*HUC		0,029 (0,259)	
Lean*STRUCT			0,054 (0,043)
Step 1 Rsquare Change/Sig.	0,010 (0,026)	0,010 (0,026)	0,010 (0,026)
Step 2 Rsquare Change/Sig.	0,392 (0,000)	0,391 (0,000)	0,374 (0,000)
Step 3 Rsquare Change/Sig.	0,004 (0,015)	0,001 (0,259)	0,003 (0,043)
Max VIF	1,192	1,134	1,176
R	0,637	0,635	0,622
Adjusted R2	0,402	0,399	0,383
Sig	0,000	0,000	0,000
Outcome	**H1 Supported**	**H2 not supported**	**H3 Supported**

Two out the three hypotheses are confirmed as we found significant moderating effects. Even though literature review showed mixed results of lean management implementation on operational performance, we found that lean practices have a significant and positive impact on operational performance. Results presented in Table 1 indicate that, as expected, investments in lean management such as Quality management programs (e.g., TQM, Six-Sigma), Cost reduction programs (e.g., Target Costing), Manufacturing lead time reduction programs, Planning/scheduling processes and methods, Processing technologies (e.g., FMS, automation), Flexible workforce, Supplier development, Workforce training and development, Integrating manufacturing and design processes, Plant information flows automation, Customer service, Customer process integration, Supplier process integration do significantly improve operational performance (B = 0.593; $p < 0.001$).

According to Menor et al. (2007), investments into OIC should augment operational performance. Accordingly, we found support that all three dimensions of OIC have a positive impact on operational performance. Our hypotheses proposed that investments in lean practices have a stronger positive impact on operational performance when combined with high levels of investments in social, human and structural capital. To analyse the synergetic effects, interaction terms were calculated by adding the two-way interaction term to the OLS Model I, II and III. In model I this contributed to a significant change in the variance explained ($R2$ adj. = 0.402, $p = 0.000$), and the interaction term was significant (B = 0.063, $p < 0.015$). For model II testing the synergic effects of lean and human capital the variance explained is ($R2$ adj. = 0.399, $p = 0.000$), the interaction term was not significant (B = 0.029, $p < 0.259$). The OLS Model III contributed to a significant change in the variance explained ($R2$ adj. = 0.383, $p = 0.000$), and the interaction term was significant (B = 0.054, $p < 0.043$). According to Aguinis et al. (2005), the magnitude of interaction effects are considered strong in all three cases, even though for Model II (for human capital, the interaction term is not significant).

Discussion and contributions

Companies in order to gain competitive advantage attempt to introduce innovative practices and technology. It is paramount that the operational intellectual capital, which represents the organisational learning capability, is used to enhance maximal benefits from this change. This study, using a multidimensional view of OIC, tested this proposition. Our findings of moderation effects (for all three OIC dimensions) reinforces the role of OIC as a mechanism that enhances performance in lean implementation. In line with Lee et al. (2011), our results suggest that human capital did not moderate the lean implementation. This can be explained by the fact that lean implementation results in incremental innovation capability, which "build on and reinforce the applicability of existing knowledge base" (Abernathy and Clark, 1985: p.5). When companies select, recruit, train and reward employees, they should focus not only on their individual skills or functional expertise, but also on their ability to share it with other team members, in order to create a collaborative culture. Acceptance of knowledge from others is another important aspect of change implementation (Beer and Eisenstat, 2000). Companies need to design proper channels of knowledge collection and dissemination (Ferdows, 2006). This is where structural capital plays an important role in enhancing lean implementation. Our results corroborate with Tu et al. (2006), and highlight the need for firms to develop an open learning culture, where workers can access cross-departmental knowledge. This type of structural embeddedness leads to better coordination and implementation of lean practices across departments. Sawhney et al. (2010) state that the reason why not all companies experience improved operational performance from lean implementation, is that they do not focus on sustainability aspect of change. Managers tend to focus on targets and improvements, and forget to recognise the progress achieved by the workers. Social capital has a crucial role in the implementation of lean. Managers need to encourage "socialisation" as a form of sharing knowledge and organise events where people can discuss their experiences. These can act as generative means of interrelationships and contribute to successful lean implementation.

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Appendix A

Construct	Items	Related literature
Leanness **Lean implementation areas in terms of investment of financial and human resources** scale (1- not at all to 7- to a great extent).	1. Quality management programs (e.g., TQM, Six-S...)	(Shah and Ward, 2007)
	2. Cost reduction programs (e.g., Target Costing)	
	3. Manufacturing lead time reduction programs	
	4. Planning/scheduling processes and methods	
	5. Processing technologies (e.g., FMS, automation)	
	6. Flexible workforce	
	7. Supplier development	
	8. Workforce training and development	
	10. Integrating manufacturing and design processes	
	11. Plant information flows automation	
	13. Customer service	
	14. Customer process integration	
	15. Supplier process integration	
Performance **Performance construct compared to major competitor(s)** on the 7 point Likert scale (1- far worse to 7- far better).	1. Labor unit costs	(Schoenherr and Narasimhan, 2012)
	2. Total product unit costs	
	3. Raw material unit costs	
	4. Product performance	
	5. Product conformance to customer specifications	
	6. Pre-sales service and after sales service	
	7. Delivery speed	
	8. Delivery reliability	
	9. Response to changes in delivery due dates	
	10. Production volume flexibility (increase/decrease volume)	
Operational Intellectual Capital		
Social capital scale (1- not at all to 7- to a great extent).	SOC This plant and its major external partners have common	(Lee et al., 2011, Menor et al., 2007, Subramaniam and Youndt, 2005)
	SOC This plant and its major external partners have similar	
	SOC This plant and its major external partners have common	
	SOC This plant and major external partners share common	
	SOC This plant and its major external partners have shared	
	SOC This plant and its major external partners have common	
	SOC We are able to discuss problems and tough issues openly.	
	SOC People are quite accessible to each other in the plant.	
Structural capital scale (1- not at all to 7- to a great extent).	STC Processes in our plant are well defined.	
	STC We usually follow the sequence of written procedures and	
	STC Much of this plant's knowledge is contained in manuals,	
	STC Standard operating procedures are in place.	
Human capital scale (1- not at all to 7- to a great extent).	HUC Every employee in this plant has useful experience.	
	HUC Employees in this plant are experts in their particular jobs	
	HUC Employees in this plant are considered among the best	
	HUC Employees in this plant are highly skilled in their	