International Journal of Knowledge Management
Volume 17 • Issue 2 • April-June 2021

Knowledge-Based Assessment Applied to Lean Brazilian Toyota Plants:
Employees' Perceptions

Jorge Muniz Jr., Universidade Estadual Paulista (UNESP-FEG), Brazil
https://orcid.org/0000-0003-3496-0256

Vagner Batista Ribeiro, Universidade Estadual Paulista (UNESP-FEG), Brazil

Ninad Pradhan, University of Tennessee, Knoxville, USA

ABSTRACT

This paper proposes knowledge-based assessment applied to Brazilian Toyota plants which practice lean manufacturing to evaluate work, production, and knowledge factors based on the perspective of blue-collar workers and managers. The two researched plants were selected based on be pure Toyota DNA representatives, and belong to two Toyota auto parts makers ('polar' cases), in which TPS is "transparently observable." The results evidence that employees judge factors related to people as important and considered the relationship between knowledge and lean in the plants are aligned. The data indicates that the Brazilian culture does not influence changes in the Toyota work context and DNA. The contribution of this study is to provide an assessment instrument that integrates the production, knowledge, and work context for a lean system, understanding blue-collar manufacturing employees and front-line supervisors are therefore essential to the success of a Lean implementation. Finally, the paper offers a guideline to assess and develop a favorable context to encourage knowledge sharing.

KEYWORDS

Assessment, Brazilian Toyota Plants, Knowledge Management, Knowledge Sharing, Lean Manufacturing, Workers

INTRODUCTION

This paper proposes knowledge-based assessment applied to Brazilian Toyota plants which practice Lean Manufacturing to evaluate work, production, and knowledge factors based on the perspective of blue-collar workers.

Chen and Holsapple (2009) provide initial insights related to integration of Knowledge Management (KM) and Lean Manufacturing (LM), highlighting the benefits of knowledge sharing in the context of waste reduction. The KM-LM relationship has been explored for knowledge sharing in shop floor environments (Yang & Cai, 2009; Muniz Jr., Batista Jr. & Loureiro, 2010),

DOI: 10.4018/IJKM.2021040101

application to Six Sigma projects (Baral, Kifor & Bondrea, 2014), Supply Chain Management (Liu, Leat, Moizer, Megicks & Kasturiratne, 2013), outsourcing (Gong & Blijleven, 2017), information systems (Buřita, Hrušecká, Pivnička & Rosman, 2018; Fiechter, Marjanovic, Boppert & Kern, 2011), and in the service sector services (Zhao, Rasovska & Rose, 2016). However, integration of KM and LM in Manufacturing has only been explored in a limited sense in academic literature, which has highlighted the need for such studies, especially in the context of different industry sectors or types of production systems (Gong & Blijleven, 2017; Shadi, 2017; Gowen III, Stock & McFadden, 2008), and KM-LM assessment.

KM-Lean assessment has been shown to be important for organizational competitiveness (Shirouyehzad, Rafiee & Berjis, 2017; Wang, Ding, Liu & Li, 2015). Related studies expand upon the need for KM in organizations (Buyukozkan, Parlak & Tolga, 2016; Dehghani & Ramsin, 2015; Reed et al., 2011) and on the development of performance evaluation models to assess KM systems and correct deleterious effects as appropriate (Shirouyehzad, Rafiee & Berjis, 2017; Wang, Ding, Liu & Li, 2015; Lin, Chang & Lin, 2011). KM performance evaluation models must support the organization's KM strategy and verify whether KM is able to achieve organizational objectives in the current environment (Chen & Fong, 2015). Such models must also consider organizational characteristics such as capacity, reliability, and performance (Chen & Fong, 2015; Hesamamiri, Mahdavi Mazdeh, Jafari & Shahanaghi, 2015). The dynamic nature of KM makes the development of a precise evaluation model as challenging as it is important (Wang, Ding, Liu & Li, 2015). Finally, evaluation methods for a well-integrated KM-Lean system must also include LM aspects such as people and LM tools (Shadi, 2017; Zhao, Rasovska & Rose, 2016). Blue-collar workers and front-line supervisor perspectives are important to LM implementation (Delbridge, 2003; Manville, Greatbanks, Krishnasamy & Parker, 2012; Bhamu & Sangwan, 2014).

The opportunities for KM-Lean assessment exist in the areas of human factors, methodology, learning, Toyota Production System (TPS) assessment, and interaction with other management approaches (Psomas & Antony, 2019). This study focuses on the following research questions:

- What are the key KM-Lean factors related Brazilian Toyota culture?
- What are the differences in blue-collar worker and manager perspectives about TPS?
- Is KM relevant to Brazilian Toyota plants?

The growth in application of TPS principles in Brazil raises issues about their applicability within a distinctive cultural context that is very different from Japan. The success in sustaining LM is determined to a large extent by the hybridization of where it is being implemented (Liker, Fruin & Adler, 1999). In other words, the implementation of LM may require different strategies, which to some extent adapt to the local culture of the host country. This is observed by undesirable results in some cases, such as loss of focus, redundancies, interdepartmental conflicts, waste of resources (time, financial and personnel) and even layoffs. This contributed to not creating a favorable context for production and people.

The automotive industry is ideal for studying the transferability of LM in the context of KM, since it is considered a "microcosm", where the characteristics of the Organization of Production and Work Organization in general are "crystallized" and can be observed (Biazzo & Panizzollo, 2000). Automotive companies have revolutionized the supplier relationship culture, product development methods, and have introduced the Toyota Production System to the productive process. This has a strong influence on other sectors.

Based on the research context grounded by organizational interests and academic research gaps, the authors applied Action-Research (AR) data collection procedures (Coughlan & Coughlan, 2002) to capture worker perception from two Brazilian Toyota Plants about LM (Problem solving methodology, Standard Operating Procedure, 5S, Quick Change Over, Poka-yoke), and KM factors (Training, Communication, Reward and Recognition, Socialization, Internalization, Externalization).

The contribution of this study is to provide an assessment instrument that integrates the Production, Knowledge and Work (P, K, W) context for a LM system. The implementation of this assessment provides a blue-collar perspective of the Toyota DNA implemented in Brazil and provides a basis for improvement actions. In doing so, this paper contributes towards understanding the acceptance of the Toyota DNA in a different culture. This has positive consequences for managers who must understand the worker perspective in achieving successful practical implementations. Finally, the paper offers a pragmatic guideline on how to assess and develop a favorable context to encourage knowledge conversion processes and its sharing in the organization. These contributions are aligned with research opportunities indicated in previous research (Erden, von Krogh & Nonaka, 2008; Nonaka, Von Krogh & Voelpel, 2006; Nakano, Muniz Jr., & Batista Jr., 2013).

Context of Study

The automotive industry is considered a "microcosm", where the characteristics of the Organization of Production and Work Organization in general are "crystallized" and can be observed (Biazzo & Panizzollo, 2000).

The major global automotive brands are located in Southeastern Brazil, including Ford, GM, VW, Toyota, Hyundai, Fiat, Land Rover, Nissan, PSA Citroen (including Peugeot), Cherry, Honda, Scania, MAN and Mercedes Benz), and South (VW Audi, Renault, Nissan, BMW, Volvo, Agrale). More recently, plants have also been set up in the Northeast by companies such as Ford, Jeep, JAC, and Troller. The Brazilian automotive industry has undergone a significant transformation in supplier relations, relocating production activities, engineering and product development, work and production organization in recent years. There is evidence that firms are beginning to implement some of the Toyota production system principles, with varying success (Wintersberger & Muniz Jr., 2017).

The growth of Toyota Production System principles in Brazil raises issues about their applicability within a distinctive cultural context that is very different to Japan. Success in sustaining LM is determined to a large extent by the hybridization (Liker, Fruin & Adler, 1999) of where it is being implemented. In other words, the implementation of LM may require different strategies which to some extent adapt to the local culture of the host country. This is evidenced by undesirable results in some cases, such as loss of focus, redundancies, interdepartmental conflicts, waste of resources (time, financial and personnel) and even layoffs, not contributing to the creation of a favorable context for production and people.

The structure of this work presents a theoretical background relating KM and LM, assessment of LM implementation, learning, workers and Human Resources development. The applied Methodology is presented in the sequence. Finally, the findings based on blue-collar workers perspective is discussed, supporting the conclusions and the indications for future potential researches.

THEORETICAL BACKGROUND

The Relationship Between Knowledge Management and Lean Manufacturing

Organizations are continually shaped by the global competitive landscape. This requires organizations to aggressively search for robust strategies for excellence and continuous improvement. Two of the prominent strategies towards these goals are Knowledge Management (KM) and Lean Manufacturing (LM), both of which have a strong influence on the industrial sector.

KM has steadily emerged as an impactful approach for improving organizational performance by mapping, managing, and consolidating the intellectual assets (Baral, Kifor & Bondrea, 2014; Shadi, 2017). The activities comprising KM are knowledge acquisition, knowledge generation, knowledge selection, knowledge assimilation, and knowledge emission (Chen & Holsapple, 2009). These knowledge generation activities span multiple production dimensions, including strategic, structural, procedural, individual, and information technology (Shadi, 2017; Chen & Holsapple, 2009; Yang & Cai, 2009).

LM is an established support for business strategy and problem-solving across industrial sectors. LM enables organizations to meet and exceed customer expectations and to increase process performance (Andersson, Hilletofth, Manfredsson & Hilmola, 2014; Antony, Snee & Hoerl, 2017). LM tools such as SMED, TPM, Poka Yoke, and 5S, rely on access to information and organizational expertise to achieve continuous improvement (Gowen III, Stock & McFadden, 2008; Beckett, Wainwright & Bance, 2000).

The insight towards the synergy of KM and LM is that these areas can complement each other. KM based on tacit - explicit knowledge conversion, which support Lean Six Sigma breakthroughs and improve organizational performance (Chen & Holsapple, 2009; Baral, Kifor & Bondrea, 2014). KM supports LM decision systems, such as Kaizen events, by providing information acquisition and dissemination (Gowen III, Stock & McFadden, 2008). Knowledge sharing is also important in transitory periods, for example, to sustain worker knowledge through termination and recruitment. KM-based tools are a strategic component of LM implementations (Buřita, Hrušecká, Pivnička & Rosman, 2018; Shadi, 2017).

Conversely, Lean Six Sigma principles can be applied to enhance the process performance of KM and to continuously improve KM systems (Lin, Chen, Wan, Chen & Kuriger, 2013). Junker et al. (2011) and Barber, Munive-Hernandez and Keane (2006) find that KM practices in production environments stand to benefit from the inclusion of LM implementation factors including culture, leadership, measurement, education, reward and incentive systems, organizational adaptability, values and norms, and supporting technology.

Knowledge-Based Integrated Production Management

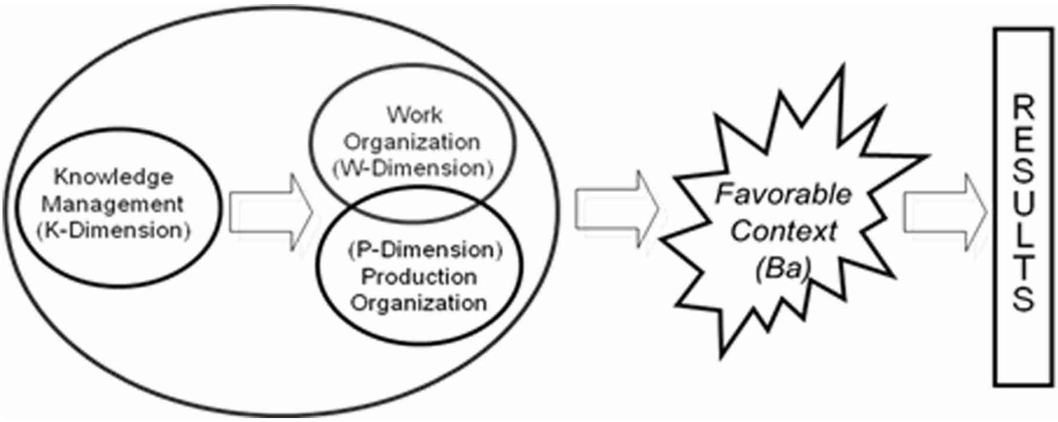
Muniz Jr., Batista Jr. and Loureiro (2010) detailed that production management models have two dimensions, a human or social dimension represented by the work organization called the “W-dimension” and a technical dimension represented based on LM tools used by workers to control the production, which is the “P-dimension”. The P and W-dimensions essentially capture the explicit structure and the behavior of the production management system. Such a system has also a tacit structure that is progressively converted into explicit, as it is better understood.

Knowledge has been acknowledged to be an important component of production management systems. However, there has been a perception that only explicit knowledge can be effectively managed, captured and kept updated (Nonaka & von Krogh, 2009). There is an understanding that tacit knowledge exists, is important, and needs to be formally included in a model of production management system, especially to model shop floor environments. The study by Nonaka and von Krogh (2009) shows that better results are achieved by actions that are focused on tacit knowledge sharing and people integration.

The ideal context which stimulates and realizes these actions has been called the *‘Ba’* context (Nonaka, 1994). The Ba context provides the motivation for traditional production models to add a third dimension – the Knowledge or “K dimension” – which permits tacit and explicit knowledge to be formally integrated into the extant P-W context. This objective is illustrated in Figure 1.

The Knowledge-based Integrated Production Management (K-PMM) Model (Muniz Jr., Batista Jr. & Loureiro, 2010) is a theoretical model, which is visually depicted in Figure 2. The K-PMM model promotes the integration of P, K, W dimensions because it is formally concerned with the conversion from tacit to explicit knowledge. It formalizes this conceptual insight by developing appropriate procedures and assessing their use in the shop floor knowledge identification and sharing activities. The star involving Production Organization and Work Organization represents the set of defined, controlled and integrated factors for carrying out production management in a way that creates the *‘Ba’*. As in the Taylorist and Socio-technical models, the dashed line represents the permeability of

Figure 1. Dimensions for promoting the 'Ba' (Muniz Jr., Batista Jr. & Loureiro, 2010)



the production operations shop floor environment to external factors, such as market, strategic and technological aspects reflected in production processes.

K-factors are based on a "knowledge conversion" process typically used in KM to acknowledge the importance of tacit knowledge and focus on the conversion of knowledge from explicit to tacit and vice-versa (Table 1). The four basic patterns of knowledge conversion, called SECI process, are: Socialization (experiences exchange between people), Externalization (registration and formal availability of knowledge for other people), Combination (content explicitly available generating new knowledge) and Internalization (acquisition of knowledge by means already formalized and recorded). The inclusion of the SECI (Socialization, Externalization, Combination and Internalization) conversion process and the knowledge spiral (Nonaka, 1994) formalizes the integration of P, K, W factors. This offers a complete version of KM which can be integrated into traditional production management models. The measures and procedures related to KM factors allow factors and results to be studied as a dynamic, causal relationship.

P-factors promote the use of worker knowledge and involvement. These factors focus on tools which contribute toward the control and improvement of the daily activities of production workers, for example: Problem Solving Methods (Garvin, 1993); Standard Operating Procedure (Ohno, 1988); 5S

Figure 2. Knowledge-based integrated production management model (K-PMM) with dimensions and factors (Muniz Jr., Batista Jr. & Loureiro, 2010)

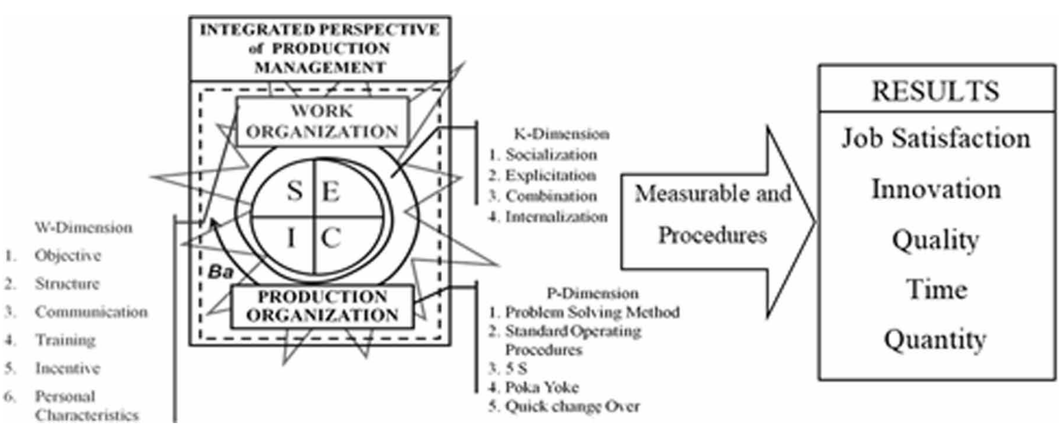


Table 1. Knowledge conversion process – SECI (Adapted from Nonaka, 1994)

To From	Tacit	Explicit
Tacit	Socialization (Dialogue)	Externalization (Write)
Explicit	Internalization (Study/Read)	Combination (Summarize)

(Ohno, 1988); Poka Yoke (Ohno, 1988) and Quick Changeover (Shingo, 1989). The use of P-factors enhances operators learning by systematically seeking improvement in the production environment. In this work, LM and mass production considerations were central in the selection of factors.

W-factors include items such as: objectives (Smith, 2001), structure, communication (Worley & Doolen, 2006), training (Nonaka, 1994; Darrah, 1995), incentives (Smith, 2001). The W-factors relevant to supporting KM must consider the interaction between the operators and the organization, sharing of measurable objectives, work and communication structure, and training and incentives. Two work organization models were considered in selecting these factors: the semi-autonomous models and the enriched model. The selected factors must enhance people's involvement in achieving organization objectives by the creation, retrieval, share, and use of knowledge. The selected factors cover various aspects in production: "who can help to do what?", material and time resources availability, communication among group members and between the group and the other people in the organization, required training by the various activities, and by the operation of the production machinery and incentives.

The K-PMM model thus defines P, K, W factors and motivates their integration. Muniz Jr., Batista Jr. and Loureiro (2010) conclude that the K-PMM model influences the realization of *'Ba'*, because it satisfies the following objectives: 1. Support socially-built knowledge; 2. Stimulate the cooperation and teamwork; 3. Emphasize the importance of sharing and transforming knowledge from personal to organizational and from tacit to explicit; 4. Stimulate interactive work on problems (try and error) as a learning process; 5. Suggest that a production management model for promoting the *'Ba'* in shop floor workers should have the three P, K, W integrated dimensions.

The social or sociocultural aspect existent in organizations with knowledge-based contexts is also strongly studied, not only considering KM as a process of generation and share of information, but also as a social process of learning as observed in the Toyota Production System (Spear & Bowen, 1999). Personal involvement in a knowledge-based culture is stimulated by the social engagement of individuals, since socialization allows openness to learning through continuous interaction that promotes experiences share with others and the direct observation of practices and skills of the experts in the group. This social influence has a direct impact on the development of a communication system, on the behavior and on the individual learning intention, providing a sharing and acquisition of tacit knowledge (Cleveland, 2016; Cleveland & Ellis, 2015; Ingvaldsen, 2015; Reed et al., 2011). Patton (2001) used the KM evaluation process to identify internal lessons learned and best practices.

In summary, KM and LM literature was surveyed, leading to several observations which define the methods used in this work. KM assessment has been carried out using specific and mixed methods. The use of the Likert scale method – common during data collection – is found to be amenable to KM assessment. It captures the dimensions of interviewee perception about KM factors, which are precursors to KM performance (Armaghan & Renaud, 2017; Chawla & Saxena, 2016; Chen & Fong, 2015; Dukić, Kozina & Milković, 2015). Fuzzy methods have also been used in KM assessments, usually in factor validation, decision making processes, and performance improvement (Hesamamiri, Mahdavi Mazdeh, Jafari & Shahanaghi, 2015; Wang, Ding, Liu & Li, 2015; Lin, Chang & Lin, 2011).

Assessment of Lean Manufacturing Implementations

Leanness assessment is defined as a procedure to estimate the level of leanness attained (Narayanamurthy & Gurumurthy, 2016), either qualitatively or quantitatively or both. The basic qualities of a LM assessment are (Hallam, 2003): 1. Must be measurable and in-line with the strategic objectives of the company and customer value, 2. Must enable control and evaluation of performance, and 3. Must aid in the understanding of current scenario and help in identifying opportunities for improvement. Narayanamurthy and Gurumurthy (2016) present the insight that outcomes of LM implementation must be assessed in the context of organization-specific variables and must include behavioral aspects of its employees. Moreover, LM assessment methods must capture the entire LM journey of an organization. It is within this context that the authors frame research questions for Leanness assessment: 1. What are the different types of qualitative and quantitative methodologies adopted to assess the leanness level of an organization? 2. How are these assessment methodologies validated and what is the outcome of these assessment methodologies? 3. What are the research objectives/issues addressed by studies in the domain of leanness assessment and how has this research topic evolved over the years? 4. What are the potential future research directions for researchers in the domain of leanness assessment? This paper presents an exploration of the second question for Leanness assessment for the Brazilian automotive sector.

Lean Learning

A factor that affects the quality of LM implementation is the environment provided to enable Lean learning, which express the learning curve of LM by the organization. The study by Psomas and Antony (2019) surveys the barriers to Lean learning in organizations and its impacts on LM implementation. The authors cite the influence of the influence of contextual variables on the creation of learning organizations (Tortorella, Marodin, Miorando & Seidel, 2015). The identification of variables and mechanism is essential for aligning learning and performance to enhance operational performance, organizational knowledge, and organizational performance (Alagaraja, 2014). Psomas and Antony (2019) reinforce studies on Lean learning, in respect to the within-organization processes of knowledge transfer and learning (Secchi & Camuffo, 2016), Hoshin Kanri (Nicholas, 2016), the context of the automotive industry (Marodin, Frank, Tortorella & Saurin, 2016). Understanding the role of organizations in Lean learning is especially critical because of the established role of organization culture as the basis and enabler of all organization-wide activities such as LM implementations (Liker, 2004; Hines, Martins & Beale, 2008; Bhamu & Sangwan, 2014).

The Perspectives of Management and Line Workers

The lessons from Lean learning and implementation have been primarily surveyed at the level of management or supervisors. But the worker plays a critical role in LM implementations. For example, it is important to involve production team members in checking, reporting, and correcting hidden minor failures and stoppages. These activities boost employee confidence to face future challenges, strengthen an employee's ability to work in teams, provide opportunities to display leadership skills and to solve problems logically. However, this process is only successful when line workers and supervisors have a clear communication about goals and decisions (Bhamu & Sangwan, 2014).

This relationship between the "navigators" and "doers" of LM implementation and the knowledge derived from their LM experiences has been addressed only to a limited extent in literature (Psomas & Antony, 2019). Papadopoulou and Ozbayrak (2005) and Losonci, Demeter and Jenei (2011) study how worker management evolves in the LM context, after LM has been implemented. Losonci, Demeter and Jenei (2011) further explore employee and managerial perceptions about the implementation. Wickramasinghe and Wickramasinghe (2011) investigate a broad range of related topics. They study the role of employee attitudes and beliefs on LM implementations, participative decision making from the perspective of both managers and workers, implications for human resources, and the effect of pay on employees. Angelis, Conti, Cooper and Gill (2011) explore the role of specific work practices in a LM system and their impact on worker commitment. Stone (2012), AL-Najem, Dhakal, Labib and Bennett (2013) and Taylor, Taylor and McSweeney (2013) assess the roles of the people involved in LM whereas Marodin and Saurin (2015) focus on the role of manager support and its measurement.

Lean Manufacturing Implementations and Human Resource Development

LM implementations are therefore clearly impacted by issues originating from the dynamics between workers and management (Alagaraja, 2014). Therefore, organizations must consider the question of effectiveness of LM implementations as an issue related to leveraging human resource development. In other words, how can HRD expertise be integrated to enhance learning and performance in organizations implementing LM? This argument is further solidified by works which relate factors related to human resources to their role in implementing Lean. Topics covered in literature include broad discussions on LM ideas such as 5S, kaizen, and culture (Antony, Snee & Hoerl, 2017; Gupta & Jain, 2013; Baral, Kifor & Bondrea, 2014) and HRD considerations such as diffusing knowledge into decision making, performance feedback, roles and responsibilities, and knowledge propagation (Bhamu & Sangwan, 2014; Andersson, Hilletofth, Manfredsson & Hilmola, 2014). Alagaraja (2014) discusses the relationship between reduced set up times, training, internal partnerships and communication.

Though most of the research has been from engineering and operations management, there has been a recent increase of interest from disciplines associated with human resource and organizational development (Stone, 2012; Antony, Snee & Hoerl, 2017). Notable contributions include studies on planned organizational change and HRD interventions (Hummels & De Leede, 2000), human performance (Genaidy & Karwowski, 2003), and motivating job characteristics (Treville & Antonakis, 2006). Despite these efforts, extant LM literature appears to still have under-explored the importance of HRD.

There is also an opportunity to theorize and validate the role of HRD in facilitating Lean learning and performance improvement (Alagaraja, 2014). Further, there is a potential to increase the collaboration between practitioners and scholars in HRD and LM, for example (Mann, 2005; Liker, 2007; Liker & Hoseus, 2008; Harris & Harris, 2007).

KM – Lean Manufacturing Research Gap

The KM-Lean collaboration has been explored in various application domains. Recent research has explored the relation in the context of Supply Chain Management (Liu, Leat, Moizer, Megicks & Kasturiratne, 2013), outsourcing (Gong & Blijleven, 2017), and the service sector (Zhao, Rasovska & Rose, 2016). Industry initiatives such as the Toyota A3 approach, also establish the importance of KM on Lean knowledge-based enterprises, in encouraging the knowledge capture and sharing in shop floor contexts (Yang & Cai, 2009).

This paper seeks to leverage the research opportunity to create a synergistic framework to study KM and LM in the context of manufacturing organizations. There are limited efforts that explore this opportunity for convergence. Chen and Holsapple (2009) provide initial insight about the integration of KM activities with LM programs to gain the power of shared knowledge. Buřita, Hrušecká, Pivnička and Rosman (2018) and Fiechter, Marjanovic, Boppert and Kern (2011) highlight the symbiotic roles of enterprise information systems – an outcome of KM practices – and improved efficiencies and waste elimination strategies – an area within LM management, towards gaining competitive advantage.

This paper also seeks to capture worker perceptions about the integrated use of LM tools using KM, similar to Baral, Kifor and Bondrea (2014). This will enhance the understanding the experiences of, and differences between, blue-collar manufacturing employees and front-line supervisors are therefore essential to the success of a LM implementation (Delbridge, 2003; Manville, Greatbanks, Krishnasamy & Parker, 2012; Bhamu & Sangwan, 2014).

Table 2. Profile of the Toyota plants researched

Plant	T1	T2
Inauguration year	1997	2002
Industrial Customer	4	1
Direct labor [people]	105	24
Indirect labor [people]	27	30
Assembly lines	10	12
Product	Plastic Parts	Indicators sets
Interviewees	55	22

METHODOLOGY

The fieldwork prepared for this study follows six steps:

1. Comprehensive literature review related terms as KM and LM raised on Web of Science (2000-2018) to map relevant factors, which are assessed in this paper;
2. Comprehensive contextual learning of the practice of TPS, based on internship in Toyota plants, similar to Muniz Jr. et al. (2013);
3. Instrument design and validation, in which the research instrument collects worker judgments about: (i) "importance" given to each mapped factor and (ii) "attention given by the plant" to each factor. The questions use 4-point scale with a score of (0 - zero) for "Not important", (1)"Slightly important", (2) "Important", and (3) "Very important";
4. Pre-test application, in which the instrument is applied to a small sample of workers in the plant and revised leading to the final version;
5. Data collection and analysis based on plant-wide research instrument application, and data treatment is based on descriptive statistics;
6. Discussions, in which meetings were conducted to discuss results with workers, area leaders, and Human Resources representatives.

Sample Characterization

Brazil was chosen for the study because it belongs to the group of emerging economies (Ramamurti & Singh, 2009) and is one of the 10 largest car manufacturers in the world, with some 2.9 million vehicles produced in 2019 (OICA, 2020). Brazilian automotive plants have followed TPS principles with success (Wintersberger & Muniz Jr., 2017).

Two plants were selected out of the Toyota auto parts makers in Brazil (representative cases, also known as 'polar' cases). TPS is "transparently observable" (Eisenhardt, 1989) in these plants. The researched plants, referred to as "Toyota 1" (T1) and "Toyota 2" (T2) are described in Table 2.

The research was conducted considering the entire workforce from the plant, including all job categories and tenures (Table 3). The interviewees' sample was not probabilistic and based on convenience. The T1 group comprised operators (61.8%), senior operators (10.9%), assemblers (21.8%) and leaders (5.5%), and the T2 group comprised operators (68.2%), senior operators (13.6%) and assemblers (18.2%). The majority of employees in T1 (69.1%) and a significant percentage in T2 (40.9%) had completed high school and had their first industrial experience with Toyota.

Table 3. Employees profile (n = 55)

Profile		T1 (%)		T2 (%)	
Number of employees per work shift	Morning	21	(38.2)	22	(100.0)
	Afternoon	21	(38.2)	0	(0.0)
	Night	13	(23.6)	0	(0.0)
Employees function	Operator	34	(61.8)	15	(68.2)
	Senior Operator	6	(10.9)	3	(13.6)
	Assembler	12	(21.8)	4	(18.2)
	Leader	3	(5.5)	0	(0.0)
Employees educational level	Incomplete high school	5	(9.1)	3	(13.6)
	Complete high school	38	(69.1)	9	(40.9)
	Technical level	6	(10.9)	8	(36.4)
	Higher education level	6	(10.9)	2	(9.1)
Employees age	Until 25 years old	26	(47.3)	9	(40.9)
	26 to 30 years old	16	(29.1)	6	(27.3)
	More than 30 years old	13	(23.6)	7	(31.8)
Employee period of work in the sector	Less than 1 year	23	(41.8)	6	(27.3)
	1 to 3 years	21	(38.2)	14	(63.6)
	More than 3 years	11	(20.0)	2	(9.1)
Employee period of work in the company	Less than 1 year	19	(34.5)	4	(18.2)
	1 to 3 years	21	(38.2)	15	(68.2)
	More than 3 years	15	(27.3)	3	(13.6)

Development of Measurement Instrument

The research instrument was designed to assess factors related to Knowledge, which included socialization (dialogue/talk based on standard operating procedures - SOPs), externalization (writing of SOPs), and internalization (studying/reading of SOPs). Twelve additional factors were included,

Figure 3. Research instrument model - training questions

Work Factor	Factor level of importance (1 = Not important / 2 = Little important / 3 = Important / 4 = Very important)					Perception regarding the company attention to the factor (4 = Very attention / 3 = Reasonable attention / 2 = Little attention / 1 = Any attention)				
Training	For the production, I think the requirement of a training program is:	1	2	3	4	4	3	2	1	As regards the training, I realize that the company gives:

Table 4. Research Instrument validation

Research Instrument Validation	Interviewees	
	T1 (%)	T2 (%)
Considered the questions easy to understand	98.2	90.9
Considered the questions easy to answer	98.2	77.3

seven of which were related to people and five to worker process control tools (see details in Tables 5, 6 and 7).

The research instrument collected worker judgement about (i) "importance" given to each factor and (ii) "attention given by the company" to each factor, using a 4-point scale (see Figure 3).

Data Collection and Analysis Procedure

The researchers started every data collection session with information about the data collection procedure and its confidentiality. All interviewees responded using a paper copy of the research instrument (questionnaire) and filled the questionnaire within an hour.

The results are presented in Data Discussion (Section 4), which includes a discussion of the workers' responses and interviews sessions to provide feedback from workers across job categories and tenures. The validation of the research instrument by workers was completed using two questions as shown in Table 4.

RESULTS AND DISCUSSION

Brazilian Culture and Lean Manufacturing Implementation

Results show that interviewees consider Work factors – related to people – as either "Very important" or "Important". This is particularly relevant in the success of implementing LM philosophy in an organization, evidenced by recent literature that reinforces the connection between the understanding of human resource factors and LM implementation (Antony, Snee & Hoerl, 2017; Baral, Kifor & Bondrea, 2014; Andersson, Hilletofth, Manfredsson & Hilmola, 2014; Alagaraja, 2014). It is also relevant in synergizing the efforts of people with different backgrounds, insights, and skills towards common organizational goals (Gong and Blijleven, 2017).

The employees interviewed for this study also judge that their companies regularly give attention to Work factors and offer supporting production control actions to achieve quality and productivity. Losonci, Demeter and Jenei (2011) emphasize that worker perceptions regarding the success of LM environments depend highly on their commitment and beliefs, and the proper communication and changes to work environments.

These perspectives from the Toyota plants in Brazil provide insights into the influence of Brazilian culture on LM implementations. Previous work has already shown that Brazilian Toyota plants are aligned with TPS DNA (Towill, 2007; Black, 2007; Liker, 2004; Dyer & Nobeoka, 2000; Spear & Bowen, 1999). However, understanding the effect of Brazilian culture on organizational culture is relevant since most workers at these plants are immersed and educated in Brazilian culture. The fact that workers consider Work factors to be important and find the incumbent Toyota culture supportive of these factors indicates that ***Brazilian culture is compatible with the organizational culture in Toyota plants***. This result is critical since organizational culture is the base for all involvement activities in LM, and has been shown to be both a result and enabler of sustainable and successful LM operations (Gelei, Losonci & Matyusz, 2015; Bhamu & Sangwan, 2014; Hines, Martins & Beale, 2008).

The organizational work system was positively evaluated, but some points of difference between employee and organizational perception were identified. In T2, employees rated the communication between production line personnel and production support personnel (e.g. maintenance, tooling, quality, PCP) to be either Very Important or Important for production performance. However, employees did not unanimously perceive these factors being 'High Attention' areas for the company. Only 50% of employees considered that the company gives "High Attention" or "Reasonable Attention" to this factor, whereas 50% consider that the attention is either low or absent. In other words, there is a disconnect between the importance given by the company to this area of communication and the level of importance accorded by employees to the same issue. ***Analysis and improvement of communication process therefore demands in-depth analysis and action***. The communication process is vital to the success of production. A practice considered important by workers but not perceived thus by management can negatively affect employee motivation and performance. Modes of communication involving production team members present a challenge in developing LM in knowledge-based environments. Clear communication can improve employee involvement in planning their work, strengthen the ability to work in teams, provide opportunities to display leadership skills, and empower them to solve problems logically (Antony, Snee & Hoerl, 2017; Bhamu & Sangwan, 2014; Alagaraja, 2014).

The attention given to personal relationships and trust transmitted by individuals was also evaluated differently between employees and organizations. Most employees in T2 (81.8%) considered these factors to be "Very Important". However, only 50% perceived that the company gives attention to this factor and 50% consider that attention is not appropriately given. ***The development of healthy interpersonal relationships in the production division is therefore a recommended point of action***. The integration of managers into the operations is important and can influence the relationship with subordinates (Narayanamurthy & Gurumurthy, 2016). Efficient and intensive communication between all departments involved is important (Buřita, Hrušecká, Pivnička & Rosman, 2018).

Other human resources factors connected to LM implementation have minor differences in their perceived importance and the perception of attention devoted to them by the company. Moreover, there were minor differences in their scores at T1 and T2. 'Resource' (time availability), 'Incentive' and 'Personal Characteristics' were more strongly identified as important in T1, but equally satisfactory perceived in both companies. 'Roles and Responsibilities' (leader) and 'Resources' (materials and equipment) were more strongly identified as important in T2, but also equally satisfactory perceived in both companies. A complete overview of the results, including the attributed level of importance and perceptions regarding the work organization is presented in Table 5. These human resources factors have also been highlighted and studied in literature because of their relevance in LM implementation in an organization, for example, Time Availability (Cleveland & Ellis, 2015), Incentive (Nakano, Muniz Jr., & Batista Jr., 2013), Roles and Responsibilities (Bhamu & Sangwan, 2014).

LM factors related to the management of physical resources used in production, which result in services and goods, are aligned in companies T1 and T2. Employees perceive these LM practices as "Very Important" or "Important" and the factors are perceived similarly by the companies. An overview of the results for production organization is presented in Table 6. Some LM production practices, such as 'Quick Changeover' (SMED) and 'Poka-yoke' were more strongly identified as important in T2, but equally satisfactory perceived in both companies (Poka-yoke also more strongly perceived in T2). The practice related to 'Standard Operation Procedures' was more strongly identified as important in T1, while the practice related to "Problems Solution Method' was more strongly perceived in T1. The results reinforce the existence of strong support given by the companies to Lean knowledge sharing, which creates a favorable environment for propagating TPS culture. There is considerable scope to generate and disseminate knowledge when executing Lean Six Sigma breakthroughs (Chen & Holsapple, 2009; Baral, Kifor & Bondrea, 2014). This knowledge can be considered as a key resource for organizations to improve their organizational performance. Conversely, the process performance of KM can be improved, and the continuous improvement of KM systems can be achieved using Lean Six Sigma (Lin, Chen, Wan, Chen & Kuriger, 2013).

Table 5. Question results for Work Organization promoting factors

Work Factor	Level of importance attributed							Perception regarding the company attention						
	Question	Results (%)						Results (%)						Question
			NA	NI	SI	I	VI	HA	RA	SA	MA	NA		
Goals (Int)	For the production work team, in my work shift, I think that to be all people involved in the process of goals achievement is:	T1	0.0	0.0	0.0	20.0	80.0	36.4	50.9	12.7	0.0	0.0	T1	As regards the involvement of the team people in the process of goals achievement, I realize that the company gives:
		T2	0.0	0.0	4.5	18.2	77.3	22.7	50.0	22.7	4.5	0.0	T2	
Goals (Ext)	For me, to know the production goals to be achieved is:	T1	0.0	0.0	1.8	21.8	76.4	74.5	18.2	7.3	0.0	0.0	T1	As regards the training, I realize that the company gives:
		T2	0.0	0.0	0.0	18.2	81.8	86.4	9.1	4.5	0.0	0.0	T2	
Roles and responsibilities (Leader)	For my work shift, in the production, I consider that to know the functions that the leader must perform, as well as the limits of the leader's responsibility, including what he should do and what he should not do is:	T1	0.0	0.0	1.8	41.8	56.4	50.9	38.2	10.9	0.0	0.0	T1	As regards to define the roles and responsibilities of the leader, I realize that the company gives:
		T2	0.0	0.0	4.5	31.8	63.6	36.4	54.5	9.1	0.0	0.0	T2	
Roles and responsibilities (Senior Operator)	For the production, I consider that to know the functions that the Senior Operator must perform, as well as the limits of his responsibility, including what he should do and what he should not do is:	T1	0.0	0.0	1.8	41.8	56.4	45.5	41.8	10.9	1.8	0.0	T1	As regards to define the functions and responsibilities of the Senior Operator, I realize that the company gives:
		T2	0.0	0.0	0.0	50.0	50.0	36.4	45.5	18.2	0.0	0.0	T2	
Roles and responsibilities (Operator/ Assembler)	For the production, I consider that to know the functions that the Operator/Assembler must perform, as well as the limits of the Operator/Assembler responsibilities, including what they should do and what they should not do is:	T1	0.0	0.0	0.0	21.8	78.2	52.7	41.8	3.6	0.0	1.8	T1	As regards to define the functions and responsibilities of the Operator/Assembler, I realize that the company gives:
		T2	0.0	0.0	0.0	18.2	81.8	63.6	27.3	4.5	4.5	0.0	T2	
Resources (materials and equipment)	For the production, I think that to have the devices and equipments well adjusted, with up-to-date maintenance and without stopgaps or troubleshooters is:	T1	0.0	0.0	0.0	12.7	87.3	47.3	38.2	14.5	0.0	0.0	T1	As regards the use of poka yoke devices to prevent the occurrence of errors, I realize that the company gives:
		T2	0.0	0.0	0.0	0.0	100.0	54.5	36.4	4.5	4.5	0.0	T2	
Resources (time availability)	For the production, I think that having time to exchange experiences about the production problems, in other words, time to share and receive tips about the production is:	T1	3.6	0.0	1.8	32.7	61.8	18.2	47.3	27.3	5.5	1.8	T1	As regards to have an specific time to exchange experiences, I realize that the company gives:
		T2	0.0	0.0	0.0	40.9	59.1	13.6	40.9	31.8	13.6	0.0	T2	
Communication (problems solution)	During the solution process of a production problem, the communication between the professionals who are solving this problem is:	T1	1.8	0.0	0.0	32.7	65.5	45.5	49.1	1.8	1.8	1.8	T1	As regards the communication between professionals who are solving a production problem, I realize that the company gives:
		T2	0.0	0.0	4.5	31.8	63.6	31.8	50.0	13.6	4.5	0.0	T2	
Communication (work shift / line)	For the production, I think that the communication between the professionals of a work shift with others is:	T1	1.8	0.0	3.6	34.5	60.0	25.5	38.2	30.9	3.6	1.8	T1	As regards the communication between professionals of a work shift with others, I realize that the company gives:
	For the production, I think that the communication between the professionals of a production line with others is:	T2	0.0	0.0	22.7	36.4	40.9	13.6	36.4	36.4	13.6	0.0	T2	As regards the communication between professionals of a production line with others, I realize that the company gives:

continued on following page

Table 5. Continued

Work Factor	Level of importance attributed								Perception regarding the company attention						
	Question	Results (%)						Results (%)						Question
			NA	NI	SI	I	VI	HA	RA	SA	MA	NA		
Communication (factory)	For the production, I think that the communication between the professionals inside the factory (Operator, Senior Operator, Assembler and Leader) is:	T1	0.0	0.0	1.8	25.5	72.7	29.1	41.8	27.3	0.0	1.8	T1	As regards the use of poka yoke devices, which could be able to prevent the occurrence of errors, I realize that the company gives:
		T2	0.0	0.0	0.0	27.3	72.7	18.2	59.1	22.7	0.0	0.0	T2	
Communication (support)	For the production, I think that the communication between the production professionals and those people in the support areas (Maintenance, Tooling, Quality, PCP) is:	T1	1.8	0.0	5.5	25.5	67.3	40.0	29.1	27.3	0.0	3.6	T1	As regards the communication between the production professionals and those people in the support areas (Maintenance, Tooling, Quality, PCP), I realize that the company gives:
		T2	0.0	4.5	4.5	45.5	45.5	18.2	31.8	31.8	18.2	0.0	T2	
Training	For the production, I think the requirement of a training program is:	T1	0.0	0.0	0.0	16.4	83.6	54.5	36.4	9.1	0.0	0.0	T1	As regards the training, I realize that the company gives:
		T2	0.0	0.0	0.0	9.1	90.9	50.0	36.4	13.6	0.0	0.0	T2	
Incentive	For the production, I think that the existence of recognition by suggestion and implementation of improvements is:	T1	1.8	0.0	0.0	32.7	65.5	23.6	36.4	30.9	7.3	1.8	T1	As regards recognition, I realize that the company gives:
		T2	0.0	0.0	0.0	50.0	50.0	13.6	40.9	27.3	18.2	0.0	T2	
Personal characteristics	For the production, I think that the characteristics of each person, in other words, if a person is dynamic, has initiative, shows interest or not, is:	T1	1.8	0.0	1.8	27.3	69.1	23.6	47.3	21.8	5.5	1.8	T1	As regards the personal characteristics, I realize that the company gives:
		T2	0.0	0.0	0.0	36.4	63.6	18.2	40.9	27.3	13.6	0.0	T2	
Personal Relationship	For the production, I think that a person's relationship with other members of the team, in other words, the trust that this person transmit to the others is:	T1	3.6	0.0	0.0	29.1	67.3	23.6	52.7	21.8	0.0	1.8	T1	As regards the relationship between the production professionals, I realize that the company gives:
		T2	0.0	0.0	0.0	18.2	81.8	9.1	40.9	27.3	22.7	0.0	T2	
NA = Not answered / NI = Not important / SI = Slightly important / I = Important / VI = Very important / HA = High attention / RA = Reasonable attention / SI = Some attention / MA = Minimal attention / T1 = Toyota 1 / T2 = Toyota 2														

The ***practices related to the four patterns of knowledge conversion*** (SECI) were judged as either "Very Important" or "Important" in both companies, presenting the existence of a favorable context to promote knowledge sharing in the shop floor environment. The difference was that T1 employees rated 'Externalization' and 'Internalization' highly, while the T2 employees defined the 'Socialization' factor as more relevant and the 'Combination' factor as the more strongly perceived in. The complete results for the KM factors are presented in Table 7.

PRACTICAL IMPLICATIONS

The assessment method supports the efforts of managers to analyze and implement actions which maintain and improve the KM.

Figure 4 illustrates the four possible scenarios observed on the shop floor and LM activities. Depending on the scenario, a corrective action may be needed. Scenarios and their appropriate responses are indicated as follows:

Table 6. Question results for Production Organization promoting factors

Production Factor	Level of importance attributed							Perception regarding the company attention						
	Question	Results (%)						Results (%)						Question
			NA	NI	SI	I	VI	HA	RA	SA	MA	NA		
Problems Solution Method	When common problems occur in production, I think that to solve these problems, the existence of a written procedure is:	T1	0.0	1.8	3.6	45.5	49.1	69.1	27.3	3.6	0.0	0.0	T1	As regards to create a written procedure for solving common production problems, I realize that the company gives:
		T2	0.0	4.5	9.1	59.1	27.3	54.5	40.9	4.5	0.0	0.0	T2	
Standard Operation Procedure	For the production, I think that the existence of a written procedure (work instruction), indicating how to do common daily activities is:	T1	0.0	0.0	0.0	20.0	80.0	78.2	18.2	3.6	0.0	0.0	T1	As regards to the use of work instructions for the common daily activities, I realize that the company gives:
		T2	0.0	0.0	13.6	50.0	36.4	68.2	27.3	4.5	0.0	0.0	T2	
5S Culture	For the production, I think that cleanliness and organization in the workplace (5S) are:	T1	0.0	0.0	0.0	20.0	80.0	67.3	21.8	10.9	0.0	0.0	T1	As regards to the cleanliness and organization in the workplace (5S), I realize that the company gives:
		T2	0.0	0.0	0.0	31.8	68.2	90.9	0.0	4.5	4.5	0.0	T2	
Quick Changeover (SMED)	For the production, I think that a procedure for setup processes (Quick Changeover), aiming its time reduction and a more secure line is:	T1	1.8	0.0	0.0	50.9	47.3	36.4	50.9	9.1	1.8	1.8	T1	As regards to create a procedure for setup processes (Quick Changeover), aiming its time reduction and a more secure line, I realize that the company gives:
		T2	0.0	0.0	0.0	27.3	72.7	45.5	36.4	18.2	0.0	0.0	T2	
Poka-yoke (Zero defect)	For the productive process, I think that the use of poka yoke devices in the prevention of setup errors is:	T1	0.0	0.0	3.6	43.6	52.7	61.8	30.9	7.3	0.0	0.0	T1	As regards to use poka yoke devices in the prevention of setup errors, I realize that the company gives:
		T2	0.0	0.0	0.0	4.5	95.5	81.8	18.2	0.0	0.0	0.0	T2	

NA = Not answered / NI = Not important / SI = Slightly important / I = Important / VI = Very important / HA = High attention / RA = Reasonable attention / SI = Some attention / MA = Minimal attention / T1 = Toyota 1 / T2 = Toyota 2

As indicated in submission system, Figure 4 is placed on before Table 6

Scenario A - suggests that manager REQUIRES special attention to align expectations between Worker and Manager. Both stakeholders consider this to be an important factor, but DO NOT both "perceive attention" related this factor by the company;

Scenario B - suggests that manager may not give attention to a specific factor because worker and manager DO NOT consider this factor important, and both "perceive attention" of the company regarding this factor;

Scenario C - suggests little need of manager attention because Worker and Manager consider this factor as important and perceive that the company has paid attention; or both DO NOT consider the factor as important and DO NOT realize the company's attention;

Scenario D - expands the alternatives possible of misalignment between Worker - Managers perspectives, therefore this scenario needs management attention.

The observed results indicate a positive relation between the worker and the company, in the context of the importance given by workers to the LM, Knowledge and Work factors and the perception of the factor in the companies. The evidence from collected data for the companies evaluated in this study is that Scenario "C" (Figure 4) is realized, that is, little management attention is needed. This reinforces the successful assimilation of the Toyota DNA, evidencing that Brazilian culture does not interfere with TPS implementation. The positive relation shows that People, Processes, and Knowledge are well integrated in the LM production environment studied in Brazil.

Table 7. Question results for KM promoting factors

KM Factor	Level of importance attributed							Perception regarding the company attention						
	Question	Results (%)						Results (%)						Question
			NA	NI	SI	I	VI	HA	RA	SA	MA	NA		
Socialization	For the production, I think that to exchange experiences on the production with the other workmates, in other words, passing and receiving tips is:	T1	0.0	0.0	0.0	32.7	67.3	29.1	43.6	25.5	1.8	0.0	T1	As regards to the exchange of experience about the production among professionals, I realize that the company gives:
		T2	0.0	0.0	0.0	27.3	72.7	9.1	45.5	36.4	9.1	0.0	T2	
Externalization	For the production, I think that to do the review of the work instruction, after analyzing a problem is:	T1	0.0	0.0	1.8	21.8	76.4	67.3	25.5	5.5	1.8	0.0	T1	As regards to the review of work instructions, after analyzing a problem, I realize that the company gives:
		T2	0.0	0.0	9.1	36.4	54.5	63.6	31.8	4.5	0.0	0.0	T2	
Combination	For the production, I think that summarizing and illustrating (including photos and drawings) the work instruction is:	T1	1.8	0.0	1.8	36.4	60.0	72.7	23.6	1.8	0.0	1.8	T1	As regards to summarize and illustrate the work instructions, I realize that the company gives:
		T2	0.0	0.0	4.5	31.8	63.6	81.8	18.2	0.0	0.0	0.0	T2	
Internalization	For the production, I think that the reading of the working instruction is:	T1	0.0	0.0	0.0	18.2	81.8	61.8	34.5	3.6	0.0	0.0	T1	As regards to the reading of the working instruction, I realize that the company gives:
		T2	0.0	0.0	0.0	36.4	63.6	59.1	36.4	4.5	0.0	0.0	T2	
NA = Not answered / NI = Not important / SI = Slightly important / I = Important / VI = Very important / HA = High attention / RA = Reasonable attention / SI = Some attention / MA = Minimal attention / T1 = Toyota 1 / T2 = Toyota 2														

CONCLUSION AND FUTURE WORK

Based on a comprehensive literature review about Lean Manufacturing (LM) and Knowledge Management (KM), this article demonstrated a valuable instrument in the assessment of knowledge-based systems. The instrument, as well as the applied methodology was delineated considering the premises of the Knowledge-based Integrated Production Management Model. The aim of the research was to assess LM (production), Knowledge, and Work (people) organization at two Brazilian workplaces which follow LM implementation since they are Toyota production plants. The assessment provided insights into the relation between Knowledge sharing among employees (blue-collar workers) and performance on the shop floor.

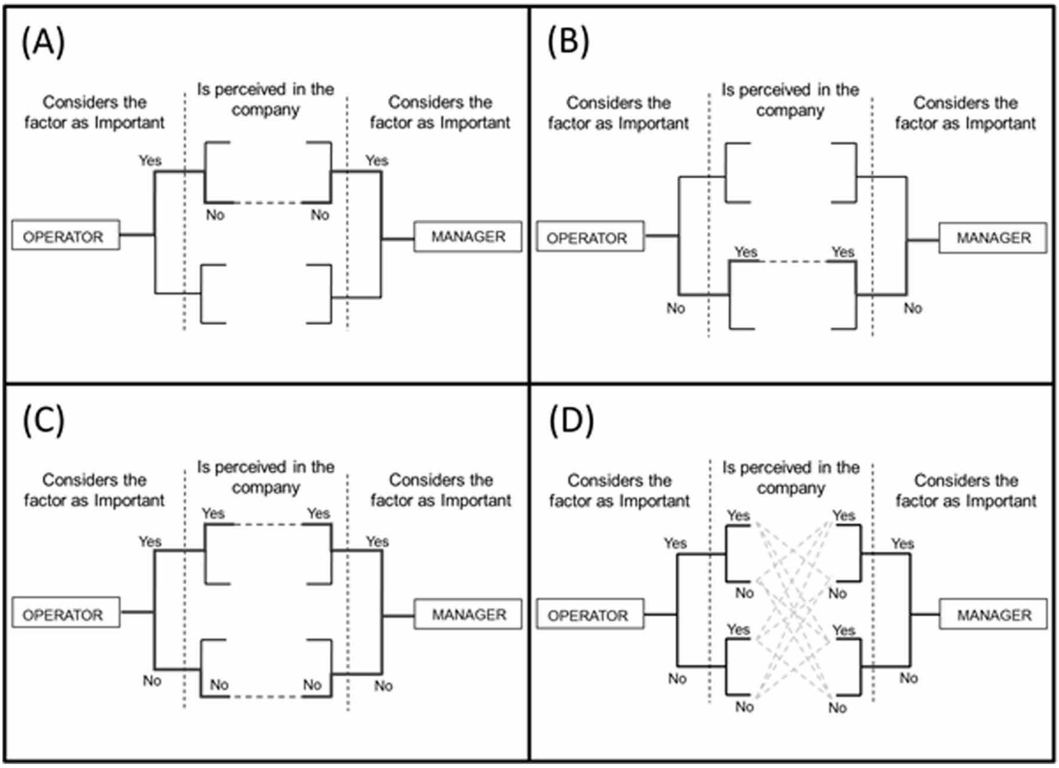
An identification of factors that integrate LM, Knowledge, and Work in the production environment can be observed in this paper. Relevant factors are identified using the literature review and the application results from this work. Employee perceptions as well as the observed performance of companies support the ability of the studied factors (appropriately listed in Tables 5, 6 and 7) to integrate LM, Knowledge, and Work.

A robust view of KM companies' performance was also obtained, supporting the assessment method conducted in this work as an appropriate way to assess such LM, Knowledge, and Work factors.

The results evince that employees judge the factors related to people (Work Factors) as important. They also considered the relationship between Knowledge and LM techniques and judged that the plants are aligned with this relationship. This contributes to understanding the importance given by its managers to the LM, Knowledge, and Work factors. The data suggests that the Brazilian culture does not influence changes in the Toyota work context and the results also provide an overview of the Toyota DNA implemented in Brazil, which supports the improvement actions. We also specifically conclude that:

- the assessment tool can evaluate factors related to LM, Knowledge, and Work from the worker/manager perspective (Figure 4);

Figure 4. The K-IAM possible scenarios (Muniz Jr., Nakano & Batista Jr., 2012)



- the two Brazilian Toyota plants researched have similar results indicating similarity with the Toyota literature (Tables 5, 6 and 7);
- the positive judgment about factors is evidenced independent of the job tenure, shift and function of the interviewees (judgment of importance about the factors and Brazilian Toyota plants reality); and
- worker Knowledge (tacit knowledge) is relevant to the Brazilian Toyota plants activities.

This study was limited to assess Production, Knowledge and Work organization in the shop floor context and involving the blue-collar workers perception of two Brazilian plants from the Toyota group. The assessment can be applied in other departments or organizations, considering different cultures, worker groups, or production sectors. There is a potential for similar work to be applied at other automotive plants and use the outcomes presented as DNA Toyota.

REFERENCES

AL-Najem, M., Dhakal, H., Labib, A., & Bennett, N. (2013). Lean readiness level within Kuwaiti manufacturing industries. *International Journal of Lean Six Sigma*, *4*(3), 280–320. doi:10.1108/IJLSS-05-2013-0027

Alagaraja, M. (2014). A conceptual model of organizations as learning-performance systems: Integrative review of lean implementation literature. *Human Resource Development Review*, *13*(2), 207–233. doi:10.1177/1534484313495852

Andersson, R., Hilletofth, P., Manfredsson, P., & Hilmola, O. P. (2014). Lean six sigma strategy in telecom manufacturing. *Industrial Management & Data Systems*, *114*(6), 904–921. doi:10.1108/IMDS-02-2014-0069

Angelis, J., Conti, R., Cooper, C., & Gill, C. (2011). Building a high-commitment lean culture. *Journal of Manufacturing Technology Management*, *22*(5), 569–586. doi:10.1108/17410381111134446

Antony, J., Snee, R., & Hoerl, R. (2017). Lean six sigma: Yesterday, today and tomorrow. *International Journal of Quality & Reliability Management*, *34*(7), 1073–1093. doi:10.1108/IJQRM-03-2016-0035

Armaghan, N., & Renaud, J. (2017). Evaluation of knowledge management in an organisation. *Journal of Information & Knowledge Management*, *16*(1), 1750006. doi:10.1142/S021964921750006X

Baral, L. M., Kifor, C. V., & Bondrea, I. (2014). Assessing the impact of DMAIC-knowledge management methodology on six sigma projects: an evaluation through participant's perception. In *International Conference on Knowledge Science, Engineering and Management, KSEM 2014, Sibiu, Romania*. Springer. doi:10.1007/978-3-319-12096-6_31

Barber, K. D., Munive-Hernandez, J. E., & Keane, J. P. (2006). Process-based knowledge management system for continuous improvement. *International Journal of Quality & Reliability Management*, *23*(8), 1002–1018. doi:10.1108/02656710610688185

Beckett, A. J., Wainwright, C. E. R., & Bance, D. (2000). Implementing an industrial continuous improvement system: A knowledge management case study. *Industrial Management & Data Systems*, *100*(7), 330–338. doi:10.1108/02635570010349113

Bhamu, J., & Sangwan, K. S. (2014). Lean manufacturing: Literature review and research issues. *International Journal of Operations & Production Management*, *34*(7), 876–940. doi:10.1108/IJOPM-08-2012-0315

Biazzo, S., & Panizzolo, R. (2000). The assessment of work organization in lean production: The relevance of the worker's perspective. *Integrated Manufacturing Systems*, *11*(1), 6–15. doi:10.1108/09576060010303622

Black, J. T. (2007). Design rules for implementing the Toyota Production System. *International Journal of Production Research*, *45*(16), 3639–3664. doi:10.1080/00207540701223469

Buřita, L., Hrušecká, D., Pivnička, M., & Rosman, P. (2018). The use of knowledge management systems and Event-B modelling in a lean enterprise. *Journal of Competitiveness*, *10*(1), 40–53. doi:10.7441/joc.2018.01.03

Buyukozkan, G., Parlak, I. B., & Tolga, A. C. (2016). Evaluation of knowledge management tools by using an interval type-2 Fuzzy TOPSIS method. *International Journal of Computational Intelligence Systems*, *9*(5), 812–826. doi:10.1080/18756891.2016.1237182

Chawla, A., & Saxena, S. (2016). A confirmatory factor analysis of knowledge management assessment instrument in Indian higher educational institutions. *International Journal of Quality & Reliability Management*, *33*(7), 1019–1029. doi:10.1108/IJQRM-07-2014-0097

Chen, D. C., & Holsapple, C. W. (2009). Knowledge shared is power: Utilizing knowledge management activities to replicate lean sigma best practices. *Knowledge Management & E-Learning: An International Journal*, *1*(2), 90–102.

Chen, L., & Fong, P. S. W. (2015). Evaluation of knowledge management performance: An organic approach. *Information & Management*, *52*(4), 431–453. doi:10.1016/j.im.2015.01.005

Cleveland, S. (2016). Social media systems in the workplace: Toward understanding employee knowledge creation via microblogging within shared knowledge domains. *MDPI-Informatics, 3*(11), 1-14.

Cleveland, S., & Ellis, T. J. (2015). Rethinking knowledge sharing barriers: A content analysis of 103 studies. *International Journal of Knowledge Management*, *11*(1), 28–51. doi:10.4018/IJKM.2015010102

Coughlan, P., & Coghlan, D. (2002). Action research for operations management. *International Journal of Operations & Production Management*, *22*(2), 220–240. doi:10.1108/01443570210417515

Darrah, C. N. (1995). Workplace training, workplace learning: A case study. *Human Organization*, *54*(1), 31–41. doi:10.17730/humo.54.1.b157846883363978

Dehghani, R., & Ramsin, R. (2015). Methodologies for developing knowledge management systems: An evaluation framework. *Journal of Knowledge Management*, *19*(4), 682–710. doi:10.1108/JKM-10-2014-0438

Delbridge, R. (2003). *Life on the Line in Contemporary Manufacturing*. Oxford University Press.

Dukić, G., Kozina, G., & Milković, M. (2015). Assessment of the knowledge management project at Croatian polytechnics. *Tehnicki Vjesnik - Technical Gazette, 22*(2), 359–365.

Dyer, J. H., & Nobeoka, K. (2000). Creating and managing a high performance knowledge-sharing network: The Toyota case. *Strategic Management Journal*, *21*(3), 345–367. doi:10.1002/(SICI)1097-0266(200003)21:3<345::AID-SMJ96>3.0.CO;2-N

Eisenhardt, K. M. (1989). Building theories from case study research. *Academy of Management Review*, *14*(4), 532–550. doi:10.5465/amr.1989.4308385

Erden, Z., von Krogh, G., & Nonaka, I. (2008). The quality of group tacit knowledge. *The Journal of Strategic Information Systems*, *17*(1), 4–18. doi:10.1016/j.jsis.2008.02.002

Fiechter, C. A., Marjanovic, O., Boppert, J. F., & Kern, E. (2011). Knowledge management can be lean: Improving knowledge intensive business processes. *Smart Innovation. Systems and Technologies*, *9*, 31–40.

Garvin, D. A. (1993). Building a learning organization. *Harvard Business Review*, *71*(4), 78–90. PMID:10127041

Gelei, A., Losonci, D., & Matyusz, Z. (2015). Lean production and leadership attributes – The case of Hungarian production managers. *Journal of Manufacturing Technology Management*, *26*(4), 477–500. doi:10.1108/JMTM-05-2013-0059

Genaidy, A. M., & Karwowski, W. (2003). Human performance in lean production environment: Critical assessment and research framework. *Human Factors and Ergonomics in Manufacturing*, *13*(4), 317–330. doi:10.1002/hfm.10047

Gong, Y., & Blijleven, V. (2017). The role of lean principles in supporting knowledge management in IT outsourcing relationships. *Knowledge Management Research and Practice*, *15*(4), 533–541. doi:10.1057/s41275-017-0072-8

Gowen, C. R. III, Stock, G. N., & McFadden, K. L. (2008). Simultaneous implementation of six sigma and knowledge management in hospitals. *International Journal of Production Research*, *46*(23), 6781–6795. doi:10.1080/00207540802496162

Gupta, S., & Jain, S. K. (2013). A literature review of lean manufacturing. *International Journal of Management Science and Engineering Management*, *8*(4), 241–249. doi:10.1080/17509653.2013.825074

Hallam, C. R. (2003). *Lean enterprise self-assessment as a leading indicator for accelerating transformation in the aerospace industry* (Doctoral dissertation). Massachusetts Institute of Technology, Cambridge, MA.

Harris, C., & Harris, R. (2007). *Developing a Lean Workforce a Guide for Human Resources*. Plant Managers, and Lean Coordinators, Productivity Press. doi:10.4324/9781482278552

Hesamamiri, R., Mahdavi Mazdeh, M., Jafari, M., & Shahanaghi, K. (2015). Knowledge management reliability assessment: An empirical investigation. *Aslib Journal of Information Management*, *67*(4), 422–441. doi:10.1108/AJIM-08-2014-0109

Hines, P., Martins, A. L., & Beale, J. (2008). Testing the boundaries of lean thinking: Observations from the legal public sector. *Public Money & Management*, *28*(1), 35–40.

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

Ingvaldsen, J. A. (2015). Organizational learning: Bringing the forces of production back in. *Organization Studies*, *36*(4), 423–444. doi:10.1177/0170840614561567

Junker, B., Maheshwari, G., Ranheim, T., Altaras, N., Stankevicz, M., Harmon, L., & D'Anjou, M. et al. (2011). Design-for-six-sigma to develop a bioprocess knowledge management framework. *PDA Journal of Pharmaceutical Science and Technology*, *65*(2), 140–165. PMID:21502075

Liker, J. K. (2004). *The Toyota Way*. McGraw-Hill.

Liker, J. K. (2007). *Toyota Talent: Developing Your People the Toyota Way*. McGraw-Hill.

Liker, J. K., Fruin, W. M., & Adler, P. S. (1999). *Remade in America: Transplanting and transforming Japanese management systems*. Oxford University Press.

Liker, J. K., & Hoseus, M. (2008). *Toyota Culture: The Heart and Soul of the Toyota Way*. McGraw-Hill.

Lin, C., Chen, F. F., Wan, H., Chen, Y. M., & Kuriger, G. (2013). Continuous improvement of knowledge management systems using Six Sigma methodology. *Robotics and Computer-integrated Manufacturing*, *29*(3), 95–103. doi:10.1016/j.rcim.2012.04.018

Lin, L., Chang, C., & Lin, Y. (2011). Structure development and performance evaluation of construction knowledge management system. *Journal of Civil Engineering and Management*, *17*(2), 184–196. doi:10.3846/13923730.2011.576833

Liu, S., Leat, M., Moizer, J., Megicks, P., & Kasturiratne, D. (2013). A decision-focused knowledge management framework to support collaborative decision making for lean supply chain management. *International Journal of Production Research*, *51*(7), 2123–2137. doi:10.1080/00207543.2012.709646

Losonci, D., Demeter, K., & Jenei, I. (2011). Factors influencing employee perceptions in Lean transformations. *International Journal of Production Economics*, *131*(1), 30–43. doi:10.1016/j.ijpe.2010.12.022

Mann, D. W. (2005). *Creating a Lean Culture Tools to Sustain Lean Conversions*. Productivity Press. doi:10.4324/9781420080971

Manville, G., Greatbanks, R., Krishnasamy, R., & Parker, D. W. (2012). Critical success factors for lean six sigma programmes: A view from middle management. *International Journal of Quality & Reliability Management*, *29*(1), 7–20. doi:10.1108/02656711211190846

Marodin, G. A., Frank, A. G., Tortorella, G. L., & Saurin, T. A. (2016). Contextual factors and Lean production implementation in the Brazilian automotive supply chain. *Supply Chain Management*, *21*(4), 417–432. doi:10.1108/SCM-05-2015-0170

Marodin, G. A., & Saurin, T. A. (2015). Managing barriers to Lean production implementation: Context matters. *International Journal of Production Research*, *53*(13), 3947–3962. doi:10.1080/00207543.2014.980454

Muniz, J. Jr, Batista, E. D. Jr, & Loureiro, G. (2010). Knowledge-based integrated production management model applied to automotive companies. *International Journal of Knowledge Management Studies*, *4*(3), 301–318. doi:10.1504/IJKMS.2010.038171

Muniz, J. Jr, Batista, J. B., Batista, E. D. Jr, & Loureiro, G. (2013). *Lean Management Practice: Toyota Brazilian Plants Case*. POMS-Production and Operations Management Society.

Muniz, J., Jr., Nakano, D. N., & Batista, E. D., Jr. (2012). Knowledge-based industrial assessment method: action research in glass and automotive companies. *OLKC - International Conference for Organisational Learning, Knowledge and Capabilities, Valencia 2012*, 1–12.

Nakano, D., Muniz, J. Jr, & Batista, E. D. Jr. (2013). Engaging environments: Tacit knowledge sharing on the shop floor. *Journal of Knowledge Management*, *17*(2), 290–306. doi:10.1108/13673271311315222

Nakano, D. N., & Muniz, J. Jr. (2018). Writing the literature review for empirical papers. *Production (Abepro)*, *28*(0), 1–9. doi:10.1590/0103-6513.20170086

Narayanamurthy, G., & Gurumurthy, A. (2016). Leanness assessment: A literature review. *International Journal of Operations & Production Management*, *36*(10), 1115–1160. doi:10.1108/IJOPM-01-2015-0003

Nicholas, J. (2016). Hoshin Kanri and critical success factors in quality management and Lean production. *Total Quality Management & Business Excellence*, *27*(3/4), 250–264. doi:10.1080/14783363.2014.976938

Nonaka, I. (1994). A dynamic theory of organizational knowledge creation. *Organization Science*, *5*(1), 14–37. doi:10.1287/orsc.5.1.14

Nonaka, I., & von Krogh, G. (2009). Tacit knowledge and knowledge conversion: Controversy and advancement in organizational knowledge creation theory. *Organization Science*, *20*(3), 635–652. doi:10.1287/orsc.1080.0412

Nonaka, I., Von Krogh, G., & Voelpel, S. (2006). Organizational knowledge creation theory: Evolutionary paths and future advances. *Organization Studies*, *27*(8), 1179–1208. doi:10.1177/0170840606066312

Ohno, T. (1988). *Toyota Production System – Beyond Large Scale Production*. Productivity Press.

Papadopoulou, T. C., & Ozbayrak, M. (2005). Leanness: Experiences from the journey to date. *Journal of Manufacturing Technology Management*, *16*(7), 784–807. doi:10.1108/17410380510626196

Patton, M. Q. (2001). Evaluation, knowledge management, best practices, and high quality lessons learned. *The American Journal of Evaluation*, *22*(3), 329–336. doi:10.1177/109821400102200307

Production Statistics, O. I. C. A. (2020). *Production Statistics.* Disponível em: http://http://www.oica.net/category/production-statistics/2019-statistics/

Psomas, E., & Antony, J. (2019). Research gaps in lean manufacturing: A systematic literature review. *International Journal of Quality & Reliability Management*, *36*(5), 815–839. doi:10.1108/IJQRM-12-2017-0260

Ramamurti, R., & Singh, J. V. (2009). *Emerging multinationals in emerging markets*. Cambridge University Press. doi:10.1017/CBO9780511576485

Reed, M. S., Fazey, I., Stringer, L. C., Raymond, C. M., Akhtar-Schuster, M., Begni, G., Bigas, H., Brehm, S., Briggs, J., Bryce, R., Buckmaster, S., Chanda, R., Davies, J., Diez, E., Essahli, W., Evely, A., Geeson, N., Hartmann, I., Holden, J., & Wagner, L. et al. (2011). Knowledge management for land degradation monitoring and assessment: An analysis of contemporary thinking. *Land Degradation & Development*, *24*(4), 307–322. doi:10.1002/ldr.1124

Secchi, R., & Camuffo, A. (2016). Rolling out Lean production systems: A knowledge-based perspective. *International Journal of Operations & Production Management*, *36*(1), 61–85. doi:10.1108/IJOPM-04-2014-0194

Shadi, R. (2017). The survey of the relationship between the knowledge management and running a lean production system (case study Qazvin's Haft Almas manufacturing company). *Helix*, *8*(2), 1024–1032.

Shingo, S. (1989). *Study of the Toyota Production System: From an Industrial Engineering Viewpoint*. Productivity Press.

Shirouyehzad, H., Rafiee, F. M., & Berjis, N. (2017). Performance evaluation and prioritization of organizations based on knowledge management and safety management approaches using DEA, a case study. *Journal of Modelling in Management*, *12*(1), 77–95. doi:10.1108/JM2-03-2015-0010

Smith, E. A. (2001). The role of tacit and explicit knowledge in the workplace. *Journal of Knowledge Management*, *5*(4), 311–321. doi:10.1108/13673270110411733

Spear, S., & Bowen, H. K. (1999). Decoding the DNA of the Toyota Production System. *Harvard Business Review*, *77*(5), 96–106.

Stone, K. B. (2012). Four decades of lean: A systematic literature review. *International Journal of Lean Six Sigma*, *3*(2), 112–132. doi:10.1108/20401461211243702

Taylor, A., Taylor, M., & McSweeney, A. (2013). Towards greater understanding of success and survival of Lean systems. *International Journal of Production Research*, *51*(22), 6607–6630. doi:10.1080/00207543.2013.825382

Tortorella, G. L., Marodin, G. A., Miorando, R., & Seidel, A. (2015). The impact of contextual variables on learning organization in firms that are implementing Lean: A study in Southern Brazil. *International Journal of Advanced Manufacturing Technology*, *78*(9-12), 1879–1892. doi:10.1007/s00170-015-6791-1

Towill, D. R. (2007). Exploiting the DNA of the Toyota production system. *International Journal of Production Research*, *45*(16), 3619–3637. doi:10.1080/00207540701223436

Treville, S. D., & 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. doi:10.1016/j.jom.2005.04.001

Wang, J., Ding, D., Liu, O., & Li, M. (2015). A synthetic method for knowledge management performance evaluation based on triangular fuzzy number and group support systems. *Applied Soft Computing*, *39*, 11–20. doi:10.1016/j.asoc.2015.09.041

Wickramasinghe, D., & Wickramasinghe, V. (2011). Differences in organizational factors by Lean duration. *Operations Management Research*, *4*(3-4), 111–126. doi:10.1007/s12063-011-0055-5

Wintersberger, D., & Muniz, J., Jr. (2017). Work organization and job design across national contexts. In International Human Resource Management: A Case Study Approach. Kogan Page Publishers.

Worley, J. M., & Doolen, T. L. (2006). The role of communication and management support in a lean manufacturing implementation. *Management Decision*, *44*(2), 228–245. doi:10.1108/00251740610650210

Yang, K., & Cai, X. (2009). The integration of DFSS, lean product development and lean knowledge management. *International Journal of Six Sigma and Competitive Advantage*, *5*(1), 75–99. doi:10.1504/IJSSCA.2009.024216

Zhao, P., Rasovska, I., & Rose, B. (2016). Integrating lean perspectives and knowledge management in services: Application to the service department of a CNC manufacturer. *IFAC-PapersOnLine*, *49*(12), 77–82. doi:10.1016/j.ifacol.2016.07.553

Jorge Muniz Jr. is Associate Professor in the Universidade Estadual Paulista (UNESP), Sao Paulo, Brazil, Editor in Chief of Production Journal (2015–2017), and Coordinator of Executive Master in Production Engineering (2014–2017). He completed his Doctorate (Operation Management) from UNESP, which was awarded by Production Engineering Brazilian Association (ABEPRO), and MS (Operation Management) from USP, Brazil. Additionally, he has worked on FORD as Quality Manager integrating Lean Thinking to the Quality Operations Systems. He researches knowledge management in production systems, quality management and lean thinking.

Vagner Batista Ribeiro is a Master degree student in Production Engineering in the Universidade Estadual Paulista (UNESP), Sao Paulo, Brazil. Post-graduated in Quality Engineering and Production Management, and Graduated in Mechanical Technology. He researches knowledge management in production systems. Additionally, he has worked in the aeronautical industry as Quality Manager and Industrial Director, with experience in production management and continuous improvement.

Ninad Pradhan is a Postdoctoral Researcher in Industrial and Systems Engineering at the University of Tennessee, Knoxville, USA. He completed his Ph.D. (Computer Engineering) and M.S. (Electrical Engineering) from Clemson University, USA. He specializes in the application of computer vision and machine learning to the analysis of production processes. Additionally, he has worked on industry sponsored projects in optimization, warehousing, and risk assessment.