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Abstract

Purpose – Lean manufacturing is one of the leading paradigms for fast and proficient manufacturing but its proper implementation is a foremost task due to certain barriers affecting lean and can be handled when utilized with RFID technology. With this aspect in view, the purpose of this paper is to enlighten and present a thorough literature study that can show how RFID-based lean manufacturing is helpful for handling barriers affecting lean manufacturing in light of previous literature available.

Design/methodology/approach – In order to achieve this purpose a systematic literature review is conducted to justify the impacts of RFID technology for handling barriers. The aim of this systematic literature review is to initially find the barriers affecting lean implementation and then to explain the properties of RFID-based lean manufacturing which are highly feasible to handle detected barriers.

Findings – An interrelation is generated in this study which provides a clear indication that the properties of RFID carry significant effects to handle detected barriers in the operational, managerial and financial regime of manufacturing companies. The detected barriers that affect lean implementation are company's cultures, top management commitment, poor employee administration, lack of finances, unbalanced inventory control, unstable customer handling and longer lead times. The properties of RFID-based lean manufacturing like operational visibility, inventory control, production control, minimized lead times and the real-time data information (to facilitate top management and employees on shop floor) are extremely helpful to control these barriers.

Originality/value – The originality of this study is the provision of clarity provided to both academicians and practitioners by citing and utilizing previous research studies which undoubtedly indicates positive impacts of RFID on lean implementation.

Keywords Technology management, Operations improvement, Lean manufacturing, Barriers affecting lean, RFID-based lean, RFID technology

Paper type Literature review

1. Introduction

Lean manufacturing is one of the popular tools in manufacturing companies because of its excellent performance to improve operational efficiency by minimizing wastes (Moyano-Fuentes and Sacristan-Diaz, 2012). The word Lean (with respect to lean

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production and lean manufacturing) means to lessen things rather than mass production and its implementation is basically a continuous process which requires time-to-time assessment (Hines *et al.*, 2004). Most of the companies using lean operations have faced a common problem of its sustainability throughout the system. This inability of lean implementation created a curiosity among researchers to determine why this failure regarding the lean sustainability occurs and tried to find barriers that are affecting its implementation (Martinez-Jurado and Moyano-Fuentes, 2014; Rose *et al.*, 2013a). After in-depth research, the key barriers identified from different studies are lack of lean implementation knowledge, company culture and management attitude, which further create ambiguities like longer lead times, unbalanced inventory control and unstable customer handling (Behrouzi and Wong, 2011; Che Mamat *et al.*, 2014). The reason of these problems are poor employee attitude, unavailability of real-time data information, operational invisibility and lack of understanding of key concepts (Rose *et al.*, 2013a; Eswaramoorthi *et al.*, 2011; Yadav *et al.*, 2010).

To address these issues, different types of lean implementation tools like value stream mapping (VSM) are utilized in combination with a modern electronic technology named as RFID (Rahani and Al-Ashraf, 2012; So, 2010). RFID is a technology which works like a catalyst for the manufacturing industry regarding lean implementation and other supply chain operations (Dai *et al.*, 2012; Chen *et al.*, 2013; Pramatari *et al.*, 2010). RFID possesses abilities like ease of use, information availability, real-time database facility, asset management, production scheduling, warehouse management, inventory and production control, improves customer order delivery and minimizes lead times (So, 2010; Huang *et al.*, 2012; Chen and Chen, 2014; Qu *et al.*, 2013; Gaukler, 2010). These abilities of RFID are highly recommendable to handle lean implementation barriers and it is high time to conduct a detailed literature study, which aims to review and assess the earlier literature and determine the capacities of RFID-based lean manufacturing for tackling the barriers affecting lean. In order to achieve this aim, a comprehensive systematic literature review has been conducted in this study, which intends to attain the following two objectives: first, to determine and highlight barriers affecting lean manufacturing; second, to identify the properties of RFID-based lean manufacturing which are helpful for the handling of detected barriers.

Hence, in order to achieve these objectives the remainder of the paper is structured as follows. Section 2 explains the lean and RFID technology; Section 3 explains the methodology; Section 4 identifies the barriers affecting lean implementation, RFID-based lean manufacturing and how it is helpful in addressing barriers; Section 5 consists of the conclusion and implications of this study; and, finally, section 6 discusses the limitations and future prospects.

2. Theoretical background

2.1 RFID technology and its properties

In recent years, RFID technology has attracted considerable interest from both academics and industries (Sarac *et al.*, 2010; Ju *et al.*, 2008). The main reason for this turn towards RFID is that its technology is 10-20 times faster than that of bar code technology. RFID is an automatic identification system which can identify objects through radio waves within its range without any interference (Vlachos, 2014; Muller-Seitz *et al.*, 2009; Inlogic, 2013; Enasys, 2014; Roberti, 2013).

As Tajima (2007) explains, the RFID system is composed of tags (with a microchip and an antenna), an electronic device termed as a reader (used to communicate

information between the database and the tag) and a middleware, which condenses and filters the data to avoid inaccuracy and feeds the enterprise resource planning (ERP) system to manage the operations. Vlachos (2014) points out that RFID is a highly automated system, which is far better than the manual bar code scanning system. RFID systems thus primarily comprise frequency controlled tags, readers and a tagging system. These systems are wide ranging in terms of price and cost, depending on the manufacturing setup and potential profits (Sarac *et al.*, 2010). RFID implementation also improves overall profitability and performance by improving product availability and traceability (Gaukler, 2010; Aiello *et al.*, 2015). RFID is considered highly effective in material handling and the ordering of stock because of its accurate demand forecasting related to customer requirements (Vlachos, 2014). RFID data and information systems are highly beneficial in planning, implementing, controlling and improving supply chain and manufacturing operations (Ngai *et al.*, 2010; Jimenez *et al.*, 2013). RFID has the ability to reduce inventory issues and the bullwhip effect because of its improved real-time data-based information availability system (Bottani *et al.*, 2010; Kok and Shang, 2014). Figure 1 illustrates the properties of RFID.

Figure 1 shows the major advantages of this technology: it is a fast and low-cost technology which provides an autonomous dedicated coding (for every item). It carries properties like position detailing and recording, operational efficiency, data privacy, real-time traceability, visibility, mass customization, responsive manufacturing, work standardization, process visualization and mentoring. RFID further helps in improving production control, customer order delivery, production lead times, inventory processes and facilitates labour during production (So, 2010; Huang *et al.*, 2010; Qu *et al.*, 2013; Chongwatpol and Sharda, 2013).

Figure 1.
Properties of RFID

2.2 Key concepts of lean manufacturing

Lean was first introduced in 1960 by the Japanese automotive company Toyota as 'Just in Time' (JIT) manufacturing and the "Toyota Production System" (Bruun and Mefford, 2004; Reichhart and Holweg, 2007; Chun Wu 2003; Stentoft Arlbjorn and Vagn Freytag, 2013; Ruiz-De-Arbulo-Lopez *et al.*, 2013). In 1980, because of the growth in Japanese imports, western manufacturers became highly interested in lean manufacturing (Holweg, 2007). In the early 1990s, there was a boom in this interest, with the publication of "The machine that changed the world", at which point the concept of lean manufacturing became known worldwide, particularly for its excellent properties, such as waste elimination (Womack *et al.*, 2008; Martinez-Jurado and Moyano-Fuentes, 2014). The types of wastes that are minimized by lean implementation are unnecessary movements, excessive transportation, overproduction, unnecessary processing, defective products, waiting time and waiting inventory (Shah and Ward, 2007; Ono, 1988; Eroglu and Hofer, 2011; Cagliano and Spina, 2000). The purpose of lean is not to maximize the benefits of only a single unit, but rather a whole group (Chopra and Meindl, 2007). The objective of lean focuses on the abolition of waste and minimizing human efforts, anywhere and at any time. The major problem with respect to waste is the consumption of resources and the non-value-added work, with an additional utilization of the common framework (Seth and Gupta, 2005; Motwani, 2003). Table I further explains that the main objective of lean is to increase value in system.

Table I shows that lean manufacturing is considered to be an effective means of achieving continuous improvement in any system (So and Sun, 2011). The concept of 'manufacturing without waste' is the pioneering slogan generated by lean processes (Taj, 2008). In summary VSM is an excellent guide for implementing lean at dock-to-dock levels within manufacturing operations (Serrano Lasa *et al.*, 2009). Lean manufacturing is also based on the JIT concept of manufacturing, which helps companies to reduce costs, inventory, lead time and down time, thus maximizing productivity and the quality of products. It is a continuous process which aims to eliminate wastes and improve processes by minimizing queue lengths, lot sizes and setup times (Narasimhan *et al.*, 2006; Chen *et al.*, 2013). The common tools utilized for lean implementation are VSM, cellular manufacturing, line balancing, pull systems, Kanban, SMED, QCO, Poka Yoke, 5S, etc. (Sundar *et al.*, 2014). Most of these lean implementation tools face common problems for their implementation like a lack of autonomous information sharing among the supply chain players and unavailability of automated systems within plant (Jadhav *et al.*, 2014). To solve such issues, it has been observed that RFID provides a solution like the "RFID-based Kanban" for improvement within the plant operations (Su *et al.*, 2009).

Furthermore, these impressive benefits of lean implementation have inspired different sectors, such as fishing (Yang *et al.*, 2015), accounting (Fullerton *et al.*, 2013; Fullerton *et al.*, 2014), material supply systems (Jimenez-Garcia *et al.*, 2014), quotation processes (Buzby *et al.*, 2002), telecom and IT (Mo, 2009; Andersson *et al.*, 2014), emergency layouts (Wang *et al.*, 2015), environment (Salleh *et al.*, 2012a; Diaz-Elsayed *et al.*, 2013; Jabbour *et al.*, 2013), farming (Salleh *et al.*, 2012b), healthcare (Dickson *et al.*, 2009; Stonier *et al.*, 2009; Hollyman *et al.*, 2014; Robinson *et al.*, 2012), bottling (Bertolini and Romagnoli, 2013; Jovanovic *et al.*, 2014), chemicals (Aqlan and Ali, 2014), furniture (Ray *et al.*, 2006), and most notably the automobile industry (Mabry and Morrison, 1996; Fauske *et al.*, 2008; Azevedo *et al.*, 2012; Elmoselhy, 2013; Chiarini, 2014; Khanchanapong *et al.*, 2014; Kumar and Kumar, 2014) to implement lean in their operations.

Author (year)	Title	Methodology	Research area	Findings (authors point of views)
Soriano-Meier and Forrester (2002)	A model for evaluating the degree of leanness of manufacturing firms	Survey	Ceramic industry	The lean is a philosophy that is implementable in all kinds of industries The lean is a panacea to solve long-term competitor issues rather than short term Lean carries a strong relation with TQM and JIT
Melton (2005)	The benefits of lean manufacturing: what lean thinking has to offer the process industries	Case study	Processing industry	Lean is a revolution. It is about changing the concepts of business by minimizing overheads and waste It is about how the managers manage and employees are involved
Garcia and Drogosz (2006)	Lean engineering – best practice in the automotive industry	Case study	Automotive industry	For lean products there must be lean processes The correct lean tools should be implemented for specific processes Lean implementation depends upon four fundamental aspects: process, standardization, emphasis on training and proper visual management
Negrus *et al.* (2011)	Innovative robust solutions for lean manufacturing in automotive assembly processes	Case study	Automotive assembly line	Focuses on providing a solution for lean Explains the concepts of six sigma, the DMAIC cycle, corrective and preventive actions under the umbrella of lean
Kumar and Abuthakeer (2012)	Implementation of lean tools and techniques in an automotive industry	Case study	Automotive industry	Worked on lean implementation by identifying and eliminating wastes at the incentive of customers Explains setup time reduction through SMED (Single Minute Exchange of Die technique) and Quick Chang-Over (QCO) Lean shows improvement in tool changeover
Wahab *et al.* (2013)	A conceptual model of lean manufacturing dimensions	Survey	Manufacturing process	Based on survey of 91 companies, introducing the concept of lean measurement using a conceptual model The authors identified seven main dimensions: customer relationships, workforce, product development, supplier relationships, planning, manufacturing processes and visual information systems
Bhamu and Singh Sangwan (2014)	Lean manufacturing: literature review and research issues	Literature review	Literature review on lean manufacturing	Explains methodologies, objectives, performance indicators, concepts and scope of manufacturing Lean manufacturing used by industries to reduce cost and to become more responsive to customer demands

(*continued*)

Table I.
Key concepts of lean manufacturing

Table I.

Author (year)	Title	Methodology	Research area	Findings (authors point of views)
Van Der Merwe *et al.* (2014)	The development of a theoretical lean culture causal framework to support the effective implementation of lean in automotive component manufacturers	Case studies	Automotive component supplier	Focuses on the development in lean culture frameworks Lean culture as highly helpful to improve organizational performance
Sundar *et al.* (2014)	Lean manufacturing: literature review and research issues	Survey	Manufacturing implementation techniques	The major concept of lean is to maximize resources and minimize wastes to achieve positive changes Lean tools, such as VSM, cellular manufacturing (CM), line balancing, inventory control, pull systems, Kanban, SMED, QCO and production levelling are explained and an attempt is made to make a lean road map on the basis of these tools
Aqlan and Ali (2014)	Integrating lean principles and fuzzy bow-tie analysis for risk assessment in chemical industries	Case study	Chemical industry	A framework combining lean tools (like FMEA and fishbone diagram) and bow-tie analysis is validated by case study to assess process risks
Sloan *et al.* (2014)	Lean in healthcare from employees' perspectives	Case study	Healthcare	The teamwork and authority decentralization concept of lean implementation had a positive effect to improve company environment and to achieve a better structure to handle employees
Bortolotti *et al.* (2015)	Successful lean implementation: organizational culture and soft lean practices	Survey	Lean implementation culture	Lean manufacturing is a managerial approach that is centred on the culture of the organization. A comparison is made between the successful and unsuccessful plants which clearly indicates that the successful plants commonly have soft lean cultures and practices which give them good human orientation, collectivism, and a low level of assertiveness
Susilawati *et al.* (2015)	Fuzzy logic-based method to measure the degree of lean activity in manufacturing industry	Survey	Manufacturing industry	Lean manufacturing approach to achieve significant improvements Lean is not easy to implement The greatest complexity is the measure of leanness because of the unavailability of data on inherent concepts and wrong practices
Yang *et al.* (2015)	Lean production system design for fishing net manufacturing using lean principles and simulation optimization	Case study	Fishing net manufacturing industry	Lean implementation is achieved by VSM which helped in waste reduction and validations was done through simulations

3. Methodology

In order to fulfil these research objectives, an in-depth evaluation is conducted in the form of a systematic literature review of the previously published research studies. The literature review is considered a vital step in enabling researchers to derive advantages from previous research and empowering them to discover new areas (Webster and Watson, 2002). Previously, Levy and Ellis (2006) proposed the way to attain a systematic literature review by following the steps – choose, know, understand, apply, examine, combine and evaluate. Martinez-Jurado and Moyano-Fuentes (2014) employed an excellent strategy for reviewing literature, applying it to lean management, supply chain management and sustainability and attaining excellent results. Keeping these experiences in mind, the same literature review strategy, i.e. a systematic literature review, has been adopted by authors with respect to their own topics.

This study seeks to review publications that are closely linked to lean manufacturing, RFID in manufacturing, barriers in the implementation of lean and RFID as a means to address barriers. Figure 2 shows the objectives and scope of this study. In this systematic literature review a proper search and selection criteria protocol was required, which has been explained in Figure 3.

In order to design the search and selection criteria, the authors have designed their protocol by utilizing the earlier studies by Kitchenham and Brereton (2013) and Jadhav *et al.* (2014), who have brilliantly utilized the systematic literature review methodology. Figure 3 clearly indicates that, in order to conduct a search, both the manual and the automated citation-based search methods were considered. Initially, a search has been conducted using the manual option, and then, to attain more rigorous results, an automated citation-based search was conducted by utilizing citation check option provided by the databases which leads to achieve more related research studies (Kitchenham and Brereton, 2013). The results of automatic citation-based search helped to attain more related articles, which were further supported through manual search

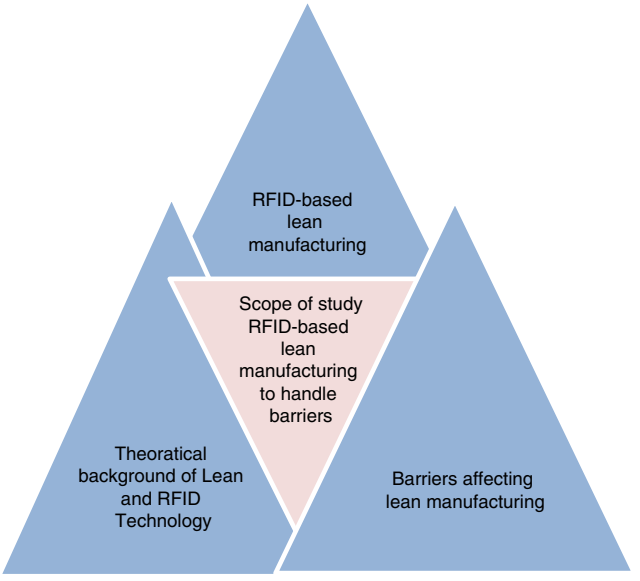

Figure 2.
Objectives and scope of study

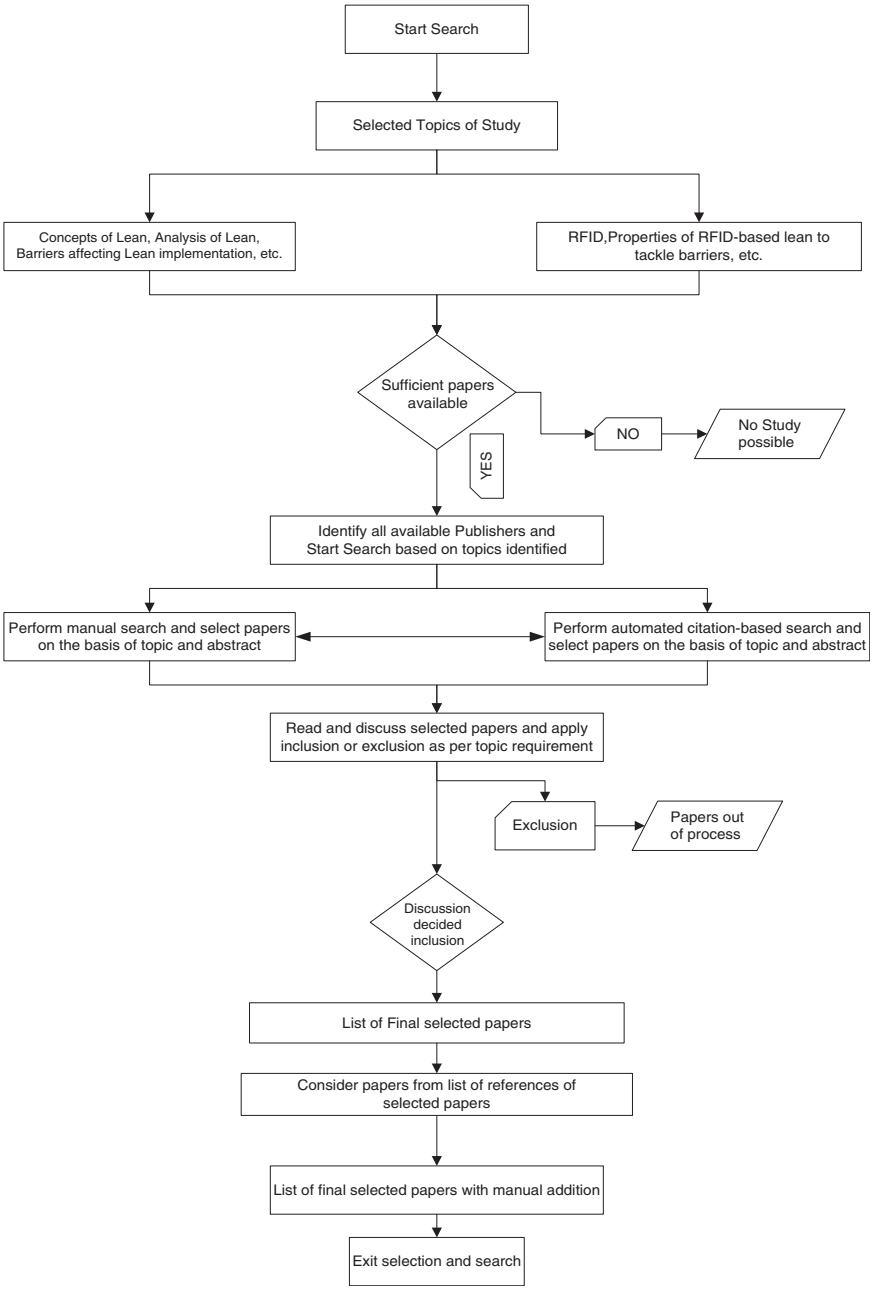

Figure 3.
Search and selection criteria

and this process continued until satisfactory results were achieved. The bibliography that is considered for this systematic literature survey is specifically based on articles from high-impact journals and some conference proceedings available through authentic publishers. A majority of the literature has been taken from journals.

Low-quality journals and theses were omitted. During this literature survey, each database provided several articles related to the field. A search on databases like Emerald, Elsevier, Scopus, Springer, Taylor & Francis online, ISI web of science, IEEE explorer, Inderscience Publishers and World Scientific Publishers provided numerous articles related to the field. The terms and the keywords that are more specifically related to research topics are mentioned in Table II. These keywords are searched in the database to find the related topics. The relevance of each article related to the required field is first ensured by the authors. After confirmation of relevance, each article is completely studied to determine its objective and relevance to the topic under study.

Table II further explains that 139 papers are considered. Out of these 139 papers, there are 120 journal papers from 63 good ranking journals and 11 conference papers, which are related to this study. The remaining include four book references, three website references and one press release, which have been mentioned in the reference section but have not been considered in the selection process. Table II further explains that the journal *Industrial Management & Data Systems* is considered to be one of the leading potential journals for this paper and it shares 4.58 per cent of the total references. Furthermore, the details of all of the articles, authors and journals are provided in Table II.

4. Results and discussion

4.1 Barriers affecting lean manufacturing implementation

Nowadays, every company is in line with global challenges and tries to enhance their on-going systems (Lei, 2000; Tang *et al.*, 2007; Garnsey and Wright, 1990; Jadhav *et al.*, 2014). In order to achieve improvements and to become a competent member of the manufacturing world, companies rush towards lean (Nordin *et al.*, 2010). A detailed discussion provided in Table III clearly indicates that lean manufacturing has gained worldwide acceptance and its practices are adaptable across industries but there are certain barriers associated with its implementation (Nordin *et al.*, 2010). From this perspective, it is necessary to determine potential barriers that affect implementation of lean principles. Determining the lean barriers is not only helpful to detect problems related to lean implementation but also helpful to determine the current situation regarding its sustainability in any company. Many researchers have suggested that lean implementation is based on the application of the complete set of lean principles, but realistically it is not possible for all companies to implement them fully (Herron and Braiden, 2007; James, 2006; Papadopoulou and Ozbayrak, 2005; Balle, 2005; Alblas and Wortmann, 2012). Its execution is one of the important tasks in manufacturing industries because of its dependence upon critical barriers like management and leadership attitude, supportive organization culture, finances and availability of expertise (Saad *et al.*, 2006).

In summary, Table III clearly indicates barriers detected by the authors and explains the authors' point of views about the research that has been considered in this study. It has been observed that the common barriers that affect lean manufacturing are senior and middle management attitude, company culture, poor employee administration, lack of finance and awareness, unbalanced inventory control, shop floor employee attitude, unstable customer scheduling, long-lead times and a lack of visibility of information in the system. These selected barriers are then further classified into three different regimes (managerial, operational and financial regime) in order to achieve a clearer picture. The leading barriers in managerial regime are lack of lean culture, awareness, top management attitude, shop floor employee attitude, poor

Methodology summary		
Research material		Research articles and conference papers
Literature review methodology		Systematic literature review
Period covered		1988-2015
Databases used		Emerald, Science direct (Elsevier), Scopus, Springer, Taylor & Francis online, ISI web of science, IEEE explorer, Scientific.net, Inderscience publishers
Keywords and phrases used to search database		Lean, lean manufacturing, lean implementation, lean manufacturing in automotive industry, benefits of lean, lean concepts, lean production, lean strategies, lean importance, lean implementation in automotive manufacturing, RFID in lean manufacturing, RFID in lean implementation, RFID and lean, RFID implementation in lean manufacturing, basics of RFID, RFID sciences, RFID as a modern technology, RFID for manufacturing, RFID in automotive sector, lean implementation through RFID in manufacturing industry, lean implementation through RFID in automotive industry, combination of lean manufacturing and RFID, barriers to implementing lean in manufacturing industry, barriers to implementing lean manufacturing in automotive manufacturing industry, RFID and lean relationship, RFID involved in lean implementation
Total number of papers considered		131
Names of journals involved		
Journal name	No. of papers	%
Journal of Operations Management	7	5.34
International Journal of Production Economics	7	5.34
Industrial Management & Data Systems	6	4.58
International Journal of Operations & Production Management	6	4.58
International Journal of Technology Management	6	4.58
European Journal of Operational Research	5	3.82
Journal of Cleaner Production	5	3.82
International Journal of Productions Research	5	3.82
Journal of Manufacturing Technology Management	4	3.05
Computers & Industrial Engineering	4	3.05
Procedia Engineering	4	3.05
Journal of Manufacturing Systems	3	2.29
International Journal of Lean Six Sigma	3	2.29

Table II.
Summary of methodology

(*continued*)

The International Journal of Advanced Manufacturing Technology	2	1.53
International Journal of Computer Integrated Manufacturing	2	1.53
International Journal of Automotive Technology and Management	2	0.53
Production Planning & Control	2	1.53
Manufacturing Engineer	2	1.53
Applied Mechanics and Materials	2	1.53
Advanced Materials Research	2	1.53
Expert Systems with Applications	2	1.53
SAE Technical Paper	2	1.53
Procedia CIRP	2	1.53
Journal of Engineering and Technology Management	1	0.76
Procedia Computer Science	1	0.76
Food Control	1	0.76
Industrial Engineering and Systems Management (IESM)	1	0.76
International Journal of Manufacturing Research	1	0.76
Industrial Engineering and Engineering Management	1	0.76
Integrated Manufacturing Systems	1	0.76
Computer Aided Chemical Engineering	1	0.76
Service Operations and Logistics	1	0.76
Wood and Fibre Science	1	0.76
International Journal Automotive Mechanical Engineering	1	0.76
Jurnal Teknologi	1	0.76
Journal of Purchasing and Supply Management	1	0.76
South African Journal of Industrial Engineering	1	0.76
Procedia Technology	1	0.76
Management Information Systems	1	0.76
European Journal of Scientific Research	1	0.76
Computer Network and Multimedia Technology	1	0.76
International Journal of Services and Operations Management	1	0.76
Journal of Loss Prevention in the Process Industries	1	0.76
Resources, Conservation and Recycling	1	0.76
APMS Conference Proceedings	1	0.76
Accounting, Organizations and Society	1	0.76
Journal of Business & Industrial Marketing	1	0.76

(*continued*)

Table II.

Cytotherapy	1	0.76
CIRP Annals-Manufacturing Technology	1	0.76
The Journal of Emergency Medicine	1	0.76
Journal of Applied Sciences	1	0.76
Procedia Materials Science	1	0.76
International Journal of an Emerging Trans discipline	1	0.76
Chemical Engineering Research and Design	1	0.76
Journal of Retailing and Consumer Services	1	0.76
Proceedings of the World Congress on Engineering	1	0.76
Electrical Engineering and Intelligent Systems	1	0.76
International Journal of Innovation, Management and Technology	1	0.76
Asia-Pacific Journal of Operational Research	1	0.76
Strategy Planning and Operations	1	0.76
Computers in Industry	1	0.76
Journal of Applied Research and Technology	1	0.76
IET International Conference on Agile Manufacturing (ICAM)	1	0.76
Information and Software Technology	1	0.76
European Business Review	1	0.76
Journal of Technology Management in China	1	0.76
Benchmarking: An International Journal	1	0.76
Journal of International Technology and Information Management	1	0.76
Control and Decision Conference	1	0.76

Topic wise detail of authors

Topics name	Related heading	Authors
Lean and RFID technology	Theoretical background	Bruun and Mefford (2004), Reichhart and Holweg (2007), Taj (2008), Chun Wu (2003), Chen *et al.* (2013), Nordin *et al.* (2010), Martinez-Jurado and Moyano-Fuentes (2014), Holweg (2007), Womack and Jones (1990), Womack*et al.* (2008), Narasimhan *et al.* (2006), Karlsson and Ahlstrom (1996), Sahwan *et al.* (2012), Eswaramoorthi *et al.* (2011), Shah and Ward (2007), Ono (1988), Muslimen *et al.* (2011), Wahab *et al.* (2013), Ray *et al.* (2006), Bayou and De Korvin (2008), Wong *et al.* (2009), Seth and Gupta (2005), So, and Sun (2011), Serrano Lasa *et al.* (2009), Melton (2005), Garcia and Drogosz (2006), Yadav *et al.* (2010),

Table II.

(*continued*)

		Negrus *et al.* (2011), Rahani and Al-Ashraf (2012), Kumar and Abuthakeer (2012), Azevedo *et al.* (2012), Van Der Merwe *et al.* (2014), Sundar *et al.* (2014), Bortolotti *et al.* (2015), Susilawati *et al.* (2015), Bhamu and Singh Sangwan (2014), Narasimhan *et al.* (2006), Karlsson and Ahlstrom (1996), Sahwan *et al.* (2012), Eswaramoorthi *et al.* (2011), Ono (1988), Ray *et al.* (2006), Bayou and De Korvin (2008), Nordin *et al.* (2010), Braiden and Morrison (1996), Mabry and Morrison (1996), Fauske *et al.* (2008), Dickson *et al.* (2009), Mo (2009), Stonier *et al.* (2009), Negrus *et al.* (2011), Salleh *et al.* (2012a, b), Bertolini and Romagnoli (2013), Zapp *et al.* (2013), Matt and Rauch (2013), Diaz-Elsayed *et al.* (2013), Fullerton *et al.* (2013), Jabbour *et al.* (2013), Elmoselhy (2013), Chiarini (2014), Fullerton *et al.* (2014), Khanchanapong *et al.* (2014), Jimenez-Garcia *et al.* (2014), Hollyman *et al.* (2014), Jovanovic *et al.* (2014), Aqlan and Ali (2014), Kumar and Kumar (2014), Yang *et al.* (2015), Soriano-Meier and Forrester (2002)
Barriers affecting lean implementation	Results and discussion	Holweg (2007), Herron and Braiden (2007), James (2006), Papadopoulou and Ozbayrak (2005), Balle (2005), Nordin *et al.* (2010), Behrouzi and Wong (2011), Nordin *et al.* (2011), Eswaramoorthi *et al.* (2011), Nasab and Zare (2012), Sahwan *et al.* (2012), Rose *et al.* (2013b, 2013a), Che Mamat *et al.* (2014), Mothersell (2009), Shang and Sui Pheng (2014), Jasti *et al.* (2015), Panwar *et al.* (2015)
RFID-based lean manufacturing	Results and discussion	Sarac *et al.* (2010), Vlachos (2014), Muller-Seitz *et al.* (2009), Tajima (2007), Gaukler (2010), Bottani *et al.* (2010), Ngai *et al.* (2010), Bertolini and Romagnoli (2013), Xiu-Xu and Lin-Yan (2009), So (2010), Huang *et al.* (2010, 2012), Saygin and Sarangapani (2011), Ramadan *et al.* (2012), Dai *et al.* (2012), Qu *et al.* (2013), Chen and Chen (2014), Roberti (2013), Inlogic (2013), Enasys (2014), Brintrup *et al.* (2010), Powell and Skjelstad (2012), Haddud *et al.* (2015)
RFID-based lean manufacturing to overcome barriers	Results and discussion	Holweg (2007), Herron and Braiden (2007), James (2006), Papadopoulou and Ozbayrak (2005), Balle (2005), Nordin *et al.* (2010, 2011), Behrouzi and Wong (2011), Eswaramoorthi *et al.* (2011), Nasab and Zare (2012), Sahwan *et al.* (2012), Rose *et al.* (2013a, b), Che Mamat *et al.* (2014), Mothersell (2009), Sarac *et al.* (2010), Vlachos (2014), Muller-Seitz *et al.* (2009), Tajima (2007), Gaukler (2010), Bottani *et al.* (2010), Ngai *et al.* (2010), Bertolini and Romagnoli (2013), Xiu-Xu and Lin-Yan (2009), So (2010), Huang *et al.* (2010, 2012), Saygin and Sarangapani (2011), Ramadan *et al.* (2012), Dai *et al.* (2012), Qu *et al.* (2013), Chen and Chen (2014), Roberti (2013), Smart *et al.* (2010), So (2010), Guo *et al.* (2015)

Table II.

Table III.
Barriers affecting lean manufacturing

Author (year)	Title	Research area	Methodology	Barriers	Findings (author's point of views)
Nordin *et al.* (2010)	A survey on lean manufacturing implementation in Malaysian automotive industries	Automotive component manufacturer	Survey approach	Main barriers for companies in the non-lean stage: Lack of lean concepts Senior and middle management attitudes Companies in the transition phase towards lean face barriers such as: Lack of lean concepts Shop floor employee attitudes	Findings from the survey show that most of the companies are in a stage of transition towards lean manufacturing. Factors involved in lean implementation emphasize on continuous improvement in the organization and focus on customers
Behrouzi and Wong (2011)	Lean performance evaluation of manufacturing systems: a dynamic and innovative approach	Manufacturing industries	Case study	Lack of clear understanding of lean implementation No tools available for lean evaluation	Introduced fuzzy membership function to measure lean
Karim *et al.* (2011)	Implementation of lean manufacturing in Saudi manufacturing organizations: an empirical study	Manufacturing industries of different sectors	Survey	Lack of skilled labour Lack of organizational culture Lack of management commitment	Companies require lean manufacturing tools such as Computerized planning systems Maintenance optimization
Muslimen *et al.* (2011)	Lean manufacturing implementation in Malaysian automotive components manufacturer: a case study	Automotive component manufacturing	Case study Questionnaire semi-structured interviews	How to implement inventory control through lean	Used project approach and formed teams of five people This strategy helped them to reduce excessive motion, waiting time, overproduction, excessive transport, excessive processing and defective products

(*continued*)

Table III.

Author (year)	Title	Research area	Methodology	Barriers	Findings (author's point of views)
Nordin *et al.* (2011)	Managing change in lean manufacturing implementation	Automotive sector	Survey	Transition towards lean manufacturing requires total reform of culture, purpose and system	Companies should emphasize Leadership and management Effective communication Change agent systems Training and team development Worker empowerment
Eswaramoorthi *et al.* (2011)	A survey on lean practices in Indian machine tool industries	Machine tool manufacturing industry	Survey	Long-lead times Resource constraints	Proper education and research setups to educate employees regarding the importance of lean
Nasab and Zare (2012)	Finding a probabilistic approach to analyse lean manufacturing	Lean production analysis	Literature review	Lean production is costly and time consuming	Applied an artificial neural network, which is complicated and based on primitive assessment but helps to measure lean production in a short time and at little cost
Sahwan *et al.* (2012)	Barriers to implement lean manufacturing in Malaysian automotive industry	Automotive sector	Survey	Lack of skilled people Lack of company culture Lack of finance Lack of awareness	Suggested are as follows: Management should motivate employees to participate in lean activities Management should clarify lean strategies and policies
Rose *et al.* (2013b)	A study on lean manufacturing implementation in Malaysian automotive component industry	Automotive component industry	Survey questionnaire	Difference between perceived and practiced lean implementation	People perceive lean to be very important, but its actual implementation is at a lower level
Rose *et al.* (2013a)	Lean manufacturing practices implementation in Malaysian's SME automotive component industry	SME automotive component industry	Survey	Unstable customer scheduling Lack of knowledge Poor employee involvement Employees resistant to change	Respondents agreed in survey that the implementation of Kaizen and 5S, would be helpful

(*continued*)

Table III.

Author (year)	Title	Research area	Methodology	Barriers	Findings (author's point of views)
Che Mamat *et al.* (2014)	Employees' perception on lean production system implementation: a case of Malaysia automotive component manufacturer	Automotive component manufacturer	Survey questionnaire	Lack of training and knowledge	More training is required for employees regarding lean implementation
Shang and Sui Pheng (2014)	Barriers to lean implementation in the construction industry in China	Construction industry	Survey	Top management issues Employees' attitude Lack of commitment Lack of culture	The leading problems observed for lean implementation were lack of long-term policies because of management and culture
Jasti *et al.* (2015)	An empirical study for implementation of lean principles in Indian manufacturing industry	Manufacturing industries of different sectors		Employees' attitude towards lean implementation Lack of knowledge	Findings from survey confirm that employees considered lean implementation against their job security because of lack of knowledge
Panwar *et al.* (2015)	Lean implementation in Indian process industries – some empirical evidence	Furniture and boat manufacturing companies		Longer lead times Large batch productions Lack of knowledge	The leading challenge towards lean implementation is that the employees and management are not comfortable to produce in small batches, which will be helpful to achieve shorter lead times. This is because of lack of knowledge of lean and its application by modern technologies

employee management and lack of skilled labour. The barriers that lie in operational regime are unstable customer handling, poor inventory control and longer lead times. Lastly, the leading barriers related to financial regime are resource constraints, lean implementation cost and lack of finances. Section 4.3 and Table V will further explain how to handle these barriers in detail.

4.2 RFID-based lean manufacturing

In recent years, the concept of RFID has become prominent in the field of engineering. In his recent survey, Mothersell (2009), showed that a proper use of technical systems in lean production helps management and employees to improve their performance. Table IV presents previous literature regarding the implementation of based on lean manufacturing. In 2009, RFID-based lean manufacturing was utilized to handle wastes for inventory control and to minimize logistic delays (Xiu-Xu and Lin-Yan, 2009). Lean services in the form of VSM and RFID properties are then employed together, resulting in cost reduction and they also help in data privacy and to obtain operational efficiency (So, 2010). Huang *et al.* (2010) deployed an RFID-based lean system for JIT production. By joining the two, they attained a visibility and a real-time traceability, but they realized that the deployment of RFID in small and medium-sized enterprises requires a considerable investment and higher risks.

To address this, they introduced the product services system, which enables automotive members to share RFID-enabled services. In 2012, in their continued work, they found three key problems with the RFID (cost, risk and commitment) which could be resolved through the application of a system called as the AUTOPS. The limitation of this system is that it is costly in terms of time, but it is helpful in RFID properties (Huang *et al.*, 2012). Qingyun *et al.* (2012) in a case study of automotive engine valve manufacturing found that RFID-based real-time data help to integrate manufacturing with the ERP and confirmed that RFID is not only applicable in large industries but also helpful for small manufacturing enterprises.

Chen and Chen (2014) examined an ORFPM (online RFID frequency-based facility performance monitoring) system, which works with lean and automatically generates a real-time VSM. This system is also helpful to attain visibility and successful tracking of time which are extremely beneficial to handle employee management. Furthermore, it can also provide a real-time shop floor data, which is useful for top management in decision making. Then, Haddud *et al.* (2015) conducted a survey in US manufacturing industries, which include fabricated metal products, machinery manufacturing, computers and electronics, electrical equipment, transportation equipment, furniture and related products and confirms that RFID is helpful to handle seven wastes due to its ability of eliminating queues of materials. This property is not only helpful to tackle wastes but also helpful for the implementation of JIT.

To summarize, Table IV discusses in detail the RFID-based lean manufacturing systems. It is clearly indicated that the RFID is suitable for lean implementation in manufacturing industry and certain properties of RFID like ease of use, availability of real-time information system (that helps top management in decision making), labour guidance, cost reductions, asset tracking, compatibility, information visibility, process visualization, and increase in operational efficiency, are highly beneficial for controlling the barriers affecting lean implementation (Chen and Chen, 2014; Dai *et al.*, 2012; Huang *et al.*, 2010). In Section 4.3 and Table V, we will further explain how the properties of RFID technology are helpful to handle barriers.

Table IV.
RFID-based lean manufacturing

Author (year)	Title	Research area	Methodology	Findings (author's point of views)
Xiu-Xu and Lin-Yan (2009)	Study of the lean logistics operating model based on RFID and its application in the automotive industry	Automotive industry	Case study	RFID-based lean operating model proposed to solve issues such as Unbalanced inventory and excessive waste Information distortion Logistics delays RFID further helped to attain a real-time information system for supply and production logistics through a model drawn for the automotive industry
So (2010)	A novel RFID application for realizing lean services based on a customer chain operations reference model	Customer chain operations	Case study	RFID and lean services in the form of VSM, linked to attain and improve Operational efficiency Data privacy Cost advantages Ease of use Compatible with time and market Essentially, the integration of VSM and customer chain operations through RFID and lean concepts
Huang *et al.* (2010)	RFID-enabled real-time manufacturing for automotive parts and accessory suppliers	Automotive parts and assembly	Case studies Series of industrial field studies	RFID helped to attain JIT and lean responsive manufacturing and attain Real-time traceability Visibility Mass customization Fast responsive manufacturing However, deployment of RFID in SMEs faces three key issues: high investment costs, medium-term commitment and high risk. These issues can be resolved using the product services system (PSS) if automotive members are willing to share RFID-enabled services

(*continued*)

Author (year)	Title	Research area	Methodology	Findings (author's point of views)
Brintrup *et al.* (2010)	RFID opportunity analysis for leaner manufacturing	Food and cosmetics industry	Case studies	RFID is utilized to implement lean by minimize seven wastes. RFID has been of great help to the managers by providing visibility, inventory control and data storage systems
Saygin and Sarangapani (2011)	Radio frequency identification (RFID) enabling lean manufacturing	Prototype manufacturing	Case study Pilot implementation at industrial site	RFID-based manufacturing helps to attain lean implementation and carries properties such as operational visibility, asset tracking and aiding decision making. Also provides data input for Six Sigma implementation. RFID-based laboratory-level prototyping and pilot implementation at industrial site are discussed
Ramadan *et al.* (2012)	RFID-enabled dynamic value stream mapping	Manufacturing plants	Case study	RFID is used together with VSM, which helps to improve Work standardization Process visualization and mentoring Reduction in costs Production control Production lead times Customer order deliveries Inventory/warehouse processes Labour guidance during production This system helps interaction between people, material and processes, in particular creating live interaction between labourers through animated flow

(*continued*)

Table IV.

Table IV.

Author (year)	Title	Research area	Methodology	Findings (author's point of views)
Huang *et al.* (2012)	RFID-enabled product-service system for automotive part and accessory manufacturing alliances	Automotive parts and assembly	Case studies	Research continued from Huang *et al.* (2010) on SMEs. The three key problems of RFID (cost, risk and commitment) can be resolved through the time consuming but applicable system, AUTOPS. This system will be helpful to utilize RFID properties, e.g. time traceability and visibility integration
Dai *et al.* (2012)	Radio frequency identification-enabled real-time manufacturing execution system: a case study in an automotive part manufacturer	Automotive engine valve manufacturer	Case study	Case study of RFID implementation in an SME RFID real-time data helps companies to integrate manufacturing through ERP Concludes that RFID is not only suitable for large structures but is also helpful in SMEs
Powell and Skjelstad (2012)	RFID for the extended lean enterprise	Dairy foods manufacturers and doors manufacturers	Case study	A conceptual model is first built through detailed literature review and then validated through case studies. The findings confirm that RFID is very helpful for lean implementation because of its track control abilities
Qu *et al.* (2013)	RFID-enabled smart assembly workshop management system	Automobile workshop management, automobile assembly line	Case study Pilot of laboratory version of system	Study based on next generation of RFID-based lean manufacturing, focused on filling the gap in area of material handling operations in real-time lean control Examines RFID in lean control and a smart management tool providing real-time infrastructure for small processes A limitation is that the proposed system is a laboratory version and does not provide an adaptive production plan or 3D visible leading plan

(*continued*)

Table IV.

Author (year)	Title	Research area	Methodology	Findings (author's point of views)
Chen and Chen (2014)	Application of ORFPM system for lean implementation: an industrial case study	Agriculture devices manufacturing company	Case study	Examines the ORFPM (online RFID frequency-based facility performance monitoring) system integrated with lean, which generates real-time VSM automatically. It helps: provides visibility in tracking time consumption, which is helpful for labourers, reduce time required, and Minimize errors It also helps top management to take appropriate decisions by providing real-time shop floor data
Haddud *et al.* (2015)	Lean manufacturing control, asset tracking, and asset maintenance: assessing the impact of RFID technology adoption	Fabricated metal products, machinery manufacturing, computers and electronics, electrical equipment, transportation equipment, furniture and related products	Survey on US manufacturing industries	The implementation of RFID-based lean is helpful to minimize wastes because of elimination of material queuing which helps in implementation of autonomous JIT strategies and availability of autonomous assets

Table V.
RFID-based lean manufacturing to overcome barriers

		Barriers in Lean											
Properties of RFID based Lean Manufacturing		How to implement inventory control through lean [m]	Long lead times[p]	Unstable customer scheduling[k]	Senior and middle management attitudes[i, j]	Shop floor employee attitudes[i, k]	Transition towards lean manufacturing requires reform of culture[n, o]	Lack of skilled labour[i, o]	Lack of management commitment[j]	Lack of awareness[o]	Poor employee management[k]	Resource constraints[p]	Lack of finance[o]
		Barriers in Operational Regime			***Barriers in Managerial Regime***							***Barriers in Financial Regime***	
Inventory control/ control of unbalanced inventory[a, b]	**Properties to handle barriers in operational regime**	•											
Control of long lead times and logistics delays[b]			•										
Improve customer order delivery[b]				•									
Information visibility/ process visualization/real-time information[d, e, f]			•			•	•						
Improve operational efficacy/ production control[e]			•							•			
Time-to-market/ real-time traceability[c]							•						
Asset tracking and decision making[d]	**Properties to handle barriers in managerial regime**				•		•		•				
Facilitate labour guidance[b, d]						•	•	•					
Help top management decision-making through real-time shop floor facility[d, g]					•		•		•	•	•		
Resolve lean implementation issues[h]									•				
Ease of understanding and use[c]	**Properties to handle barriers in Financial Regime**						•					•	
Cost advantages[b, c]							•					•	•

Notes: [a]Xiu-Xu and Lin-Yan (2009), [b]Ramadan *et al*. (2012), [c]So (2010), [d]Chen and Chen (2014), [e]Dai and Tseng (2012), [f]Huang *et al*. (2010), [g]Saygin and Sarangapani (2011), [h]Qu *et al*. (2013), [i]Nordin *et al*. (2010), [j]Karim *et al*. (2011), [k]Rose *et al*. (2013b), [L]Behrouzi and Wong (2011), [m]Muslimen *et al*. (2013), [n]Nordin *et al*. (2011), [o]Sahwan *et al*. (2012), [p]Eswaramoorthi *et al*. (2011), [q]Nasab and Zare (2012), [r]Che Mamat *et al*. (2014)

4.3 RFID-based lean manufacturing to overcome barriers

As Table III of Section 4.1 clearly indicated the barriers affecting lean implementation and Table IV of Section 4.2 helped us to detect the properties of RFID-based lean manufacturing; in Table V an interrelationship is generated between these two. Table V clearly indicates that the leading barriers affecting lean implementation are categorized in three different regimes, which are operational, managerial and financial regimes, based on their instincts and characteristics. So, the barriers which are considered in operational regime are longer lead times, inventory control issues and unstable customer scheduling. It has been observed that these barriers are mostly because of improper handling of customers' orders and wrong scheduling, which results in an unbalanced inventory control and longer production lead times and consequences extreme instability in the plant operations (Eswaramoorthi *et al.*, 2011; Muslimen *et al.*, 2013; Rose *et al.*, 2013b). These operational barriers create such a dilemma in companies which not only results in high costs but also affects the positive attitudes of employees and management towards lean. Keeping these aspects in view and based on previous works on RFID-based lean manufacturing by researchers and specialists, Table V clearly explains that the use of the properties of RFID like real-time traceability and automated information visibility helps to achieve excellent customer handling and improved inventory control which results in decreased production lead times (Xiu-Xu and Lin-Yan, 2009; Ramadan *et al.*, 2012; Dai and Tseng, 2012). So, these properties are extremely helpful to handle barriers in operational regime and also support top management and employees in decision making and work scheduling. Therefore, this handling of barriers in operational regime also leads to handle barriers in managerial regime.

Table V indicates that top management commitment and attitudes, poor employee management, shop floor employee attitude and company culture are the leading barriers in managerial regime and greatly affects lean implementation. Many times, the top management and employees have a fear regarding the handling of floor movements and asset tracking, which are the leading requirements of lean culture. Based on details that have been depicted in Table V, it has been observed that the properties of RFID-based lean manufacturing processes (like process visualization, improved operational efficiency, asset tracking and production control) not only help to facilitate top management in decision making but also help to facilitate employees by providing them an autonomous asset tracking system. Therefore, these properties of RFID attract both management and employees towards lean culture and help to achieve an awareness and transition towards lean. This awareness towards lean and business benefits attached with RFID-based lean manufacturing (like ease of use and compatibility, customer handling, improved inventory systems and cost advantages) helps to convince top management to invest in lean implementation. Table V indicates that the barriers in financial regime are lack of finances (Sahwan *et al.*, 2012) and resource constraints (Eswaramoorthi *et al.*, 2011). So, this awareness also helps in handling barriers affecting financial regime. Furthermore, So (2010) in their research work developed an RFID applied lean services-based reference model on the customer chain operations and it clearly indicates that the properties of RFID are advantageous to achieve cost effectiveness and an ease of use in the operations. In summary, Table V indicates that the RFID is beneficial for handling barriers affecting lean implementation in the operational, managerial and financial regime.

5. Conclusion and implications

Lean manufacturing is one of the leading tools to provide operational efficiency in the manufacturing industry but facing a lot of implementation issues due to barriers

affecting its implementation. Recently, it has been observed that electronically controlled RFID-based lean manufacturing has begun to play an important role in the manufacturing industries and considered as an emerging technology for the lean implementation. With respect to this, it is essential to explain, which properties of RFID-based lean manufacturing can be beneficial in controlling the barriers affecting manufacturing industry. In order to explicate that, this study has undertaken a comprehensive systematic literature review which classifies the literature in a way that initially it identifies the barriers affecting lean and then describes the properties of RFID-based lean implementation which are suitable to handle highlighted barriers. The aim of this study is to provide theoretical and managerial implications, in the field of manufacturing through findings as mentioned below.

First, this literature survey highlights the barriers, which affect the lean implementation in the manufacturing industry. The highlighted barriers are the company culture, top management commitment, poor employee administration, lack of finances, unbalanced inventory control, unstable customer handling and longer lead times. To obtain a better idea, these highlighted barriers are then further categorized into three different regimes (managerial, operational and financial regime). The barriers present in the operational regime are unstable customer handling, poor inventory control and longer lead times. The leading barriers in the managerial regime are a lack of lean culture, awareness, top management attitude, shop floor employee attitude, poor employee management and the barriers in financial regime are resource constrains and lack of finances.

Second, based on the previously published research, our study sheds light on the leading attributes of RFID like real-time traceability and automated information visibility which helps to attain an inventory control, production control and minimized lead times in RFID-based lean manufacturing. These properties help in reducing the barriers affecting operational regime and also support top managers in decision making. Hence, this handling of barriers in an operational regime also triggers the handling of the barriers in the managerial regime. The other properties of RFID, such as asset tracking for labour guidance and production control to improve operational efficiency, further facilitate the managers and the employees to attain better employee management on shop floor and ease in work, respectively. This helps in the development of a positive attitude amongst the managers and the employees towards lean and helps to attain lean culture, which is one of the major barriers in the managerial regime. Furthermore, this awareness in top management and long-term business benefits (that they can foresee with operational improvements through RFID) encourages them to invest more for lean implementation and helps to minimize barriers affecting lean implementation in financial regime.

This study can help engineering managers, academicians and lean experts, who are willing to handle barriers affecting lean through modernization lean implementation. The findings from this systematic literature review confirm that RFID-based lean manufacturing could be of great help in handling barriers affecting lean implementation in the operational, managerial and financial regimes. These findings help to implicate and convince practicing managers to focus and invest in RFID-based lean implementation, which help to achieve automated operations to support both top management and employees in decision making and work scheduling, respectively. In last, the impact of this study is a critical systematic literature review which clearly reviews and concludes previous literature and confirms RFID as a striking tool to handle lean implementation barriers.

6. Limitations and future prospects

Many researchers think that RFID has many limitations: it is complex, complicated and a costly technology (So Park *et al.*, 2010; Smart *et al.*, 2010). Undoubtedly, RFID startups require initial investments and its implementation is complex (Sahwan *et al.*, 2012) but if it is initiated by expert compatibility studies like utilization of technology-organization and environment framework (TOE) and implemented through proper selection of RFID tags then it can achieve very positive results (Wang *et al.*, 2010). However, in future the complexity issues of RFID (like handling of thousands of RFID tags of shop floor) can be dealt, if incorporated with latest functionalities like "RFID integrated cloud-based systems" which has emerged as a leading paradigm in the field of IT and can be very beneficial to support RFID-based lean production (Guo *et al.*, 2015). Furthermore, in order to minimize compatibility issues and to achieve accurate initial investments, certain technology combined lean implementation frameworks can be proposed in future which functions by integrating TOE framework with lean implementation tool like VSM. Such lean implementation frameworks will be helpful in future to initiate RFID-based lean manufacturing in a planned way.

References

Aiello, G., Enea, M. and Muriana, C. (2015), "The expected value of the traceability information", *European Journal of Operational Research*, Vol. 244 No. 1, pp. 176-186.

Alblas, A. and Wortmann, H. (2012), "Impact of product platforms on lean production systems: evidence from industrial machinery manufacturing", *International Journal of Technology Management*, Vol. 57 Nos 1/2/3, pp. 110-131.

Andersson, R., Hilletofth, P., Manfredsson, P. and Hilmola, O.-P. (2014), "Lean six sigma strategy in telecom manufacturing", *Industrial Management & Data Systems*, Vol. 114 No. 6, pp. 904-921.

Aqlan, F. and Ali, E.M. (2014), "Integrating lean principles and fuzzy bow-tie analysis for risk assessment in chemical industry", *Journal of Loss Prevention in the Process Industries*, Vol. 29, pp. 39-48.

Azevedo, S.G., Govindan, K., Carvalho, H. and Cruz-Machado, V. (2012), "An integrated model to assess the leanness and agility of the automotive industry", *Resources, Conservation and Recycling*, Vol. 66, pp. 85-94.

Balle, M. (2005), "Lean attitude – considering attitude in lean production", *Manufacturing Engineer*, Vol. 84 No. 2, pp. 14-19.

Bayou, M. and De Korvin, A. (2008), "Measuring the leanness of manufacturing systems – a case study of ford motor company and general motors", *Journal of Engineering and Technology Management*, Vol. 25 No. 4, pp. 287-304.

Behrouzi, F. and Wong, K.Y. (2011), "Lean performance evaluation of manufacturing systems: a dynamic and innovative approach", *Procedia Computer Science*, Vol. 3, pp. 388-395.

Bertolini, M. and Romagnoli, G. (2013), "Lean manufacturing in the valve pre-assembly area of a bottling lines production plant: an Italian case study", *Proceedings of 2013 International Conference on Industrial Engineering and Systems Management (IESM), IEEE*, pp. 1-8.

Bhamu, J. and Singh Sangwan, K. (2014), "Lean manufacturing: literature review and research issues", *International Journal of Operations & Production Management*, Vol. 34 No. 7, pp. 876-940.

Bortolotti, T., Boscari, S. and Danese, P. (2015), "Successful lean implementation: organizational culture and soft lean practices", *International Journal of Production Economics*, Vol. 160, pp. 182-201.

Bottani, E., Montanari, R. and Volpi, A. (2010), "The impact of RFID and EPC network on the bullwhip effect in the Italian FMCG supply chain", *International Journal of Production Economics*, Vol. 124 No. 2, pp. 426-432.

Braiden, B.W. and Morrison, K.R. (1996), "Lean manufacturing optimization of automotive motor compartment system", *Computers & Industrial Engineering*, Vol. 31 No. 1, pp. 99-102.

Brintrup, A., Ranasinghe, D. and Mcfarlane, D. (2010), "RFID opportunity analysis for leaner manufacturing", *International Journal of Production Research*, Vol. 48 No. 9, pp. 2745-2764.

Bruun, P. and Mefford, R.N. (2004), "Lean production and the internet", *International Journal of Production Economics*, Vol. 89 No. 3, pp. 247-260.

Buzby, C.M., Gerstenfeld, A., Voss, L.E. and Zeng, A.Z. (2002), "Using lean principles to streamline the quotation process: a case study", *Industrial Management & Data Systems*, Vol. 102 No. 9, pp. 513-520.

Cagliano, R. and Spina, G. (2000), "Advanced manufacturing technologies and strategically flexible production", *Journal of Operations Management*, Vol. 18 No. 2, pp. 169-190.

Che Mamat, R., Deros, B.M., Ab Rahman, M.N. and Jamil, N.A. (2014), "Employees' perception on lean production system implementation: a case of malaysia automotive component manufacturer", *Applied Mechanics and Materials*, Trans Tech Publications, pp. 1032-1037.

Chen, J.C. and Chen, K.-M. (2014), "Application of ORFPM system for lean implementation: an industrial case study", *The International Journal of Advanced Manufacturing Technology*, Vol. 72 No. 5, pp. 839-852.

Chen, J.C., Cheng, C.-H. and Huang, P.B. (2013), "Supply chain management with lean production and RFID application: a case study", *Expert Systems with Applications*, Vol. 40 No. 9, pp. 3389-3397.

Chiarini, A. (2014), "Sustainable manufacturing-greening processes using specific lean production tools: an empirical observation from European motorcycle component manufacturers", *Journal of Cleaner Production*, Vol. 85, pp. 226-233.

Chongwatpol, J. and Sharda, R. (2013), "RFID-enabled track and traceability in job-shop scheduling environment", *European Journal of Operational Research*, Vol. 227 No. 3, pp. 453-463.

Chopra, S. and Meindl, P. (2007), *Supply Chain Management. Strategy, Planning & Operation*, Springer, NJ.

Chun Wu, Y. (2003), "Lean manufacturing: a perspective of lean suppliers", *International Journal of Operations & Production Management*, Vol. 23 No. 11, pp. 1349-1376.

Dai, H. and Tseng, M.M. (2012), "The impacts of RFID implementation on reducing inventory inaccuracy in a multi-stage supply chain", *International Journal of Production Economics*, Vol. 139 No. 2, pp. 634-641.

Dai, Q., Zhong, R., Huang, G.Q., Qu, T., Zhang, T. and Luo, T. (2012), "Radio frequency identification-enabled real-time manufacturing execution system: a case study in an automotive part manufacturer", *International Journal of Computer Integrated Manufacturing*, Vol. 25 No. 1, pp. 51-65.

Diaz-Elsayed, N., Jondral, A., Greinacher, S., Dornfeld, D. and Lanza, G. (2013), "Assessment of lean and green strategies by simulation of manufacturing systems in discrete production environments", *CIRP Annals-Manufacturing Technology*, Vol. 62 No. 1, pp. 475-478.

Dickson, E.W., Singh, S., Cheung, D.S., Wyatt, C.C. and Nugent, A.S. (2009), "Application of lean manufacturing techniques in the emergency department", *The Journal of Emergency Medicine*, Vol. 37 No. 2, pp. 177-182.

Elmoselhy, S.A. (2013), "Hybrid lean-agile manufacturing system technical facet, in automotive sector", *Journal of Manufacturing Systems*, Vol. 32 No. 4, pp. 598-619.

Enasys (2014), "Asset tracking and inventory management in the data centre", available at: http://new.edpllc-usa.com/wp-content/uploads/2014/06/EnaSys_Whitepaper.pdf (accessed December 13, 2014).

Eroglu, C. and Hofer, C. (2011), "Lean, leaner, too lean? The inventory-performance link revisited", *Journal of Operations Management*, Vol. 29 No. 4, pp. 356-369.

Eswaramoorthi, M., Kathiresan, G., Prasad, P. and Mohanram, P. (2011), "A survey on lean practices in Indian machine tool industries", *The International Journal of Advanced Manufacturing Technology*, Vol. 52 No. 9, pp. 1091-1101.

Fauske, H., Alfnes, E. and Semini, M. (2008), "Lean supply chain control in Hydro Automotive Structures", *APMS 2008 Conference Proceedings*.

Fullerton, R.R., Kennedy, F.A. and Widener, S.K. (2013), "Management accounting and control practices in a lean manufacturing environment", *Accounting, Organizations and Society*, Vol. 38 No. 1, pp. 50-71.

Fullerton, R.R., Kennedy, F.A. and Widener, S.K. (2014), "Lean manufacturing and firm performance: the incremental contribution of lean management accounting practices", *Journal of Operations Management*, Vol. 32 No. 1, pp. 414-428.

Garcia, P. and Drogosz, J. (2006), "Lean engineering – best practice in the automotive industry", Technical Paper No. 2007: 01-0532, SAE, Detroit, MI.

Garnsey, E. and Wright, S.M. (1990), "Technical innovation and organisational opportunity", *International Journal of Technology Management*, Vol. 5 No. 3, pp. 267-291.

Gaukler, G.M. (2010), "Preventing avoidable stockouts: the impact of item-level RFID in retail", *Journal of Business & Industrial Marketing*, Vol. 25 No. 8, pp. 572-581.

Guo, Z., Ngai, E., Yang, C. and Liang, X. (2015), "An RFID-based intelligent decision support system architecture for production monitoring and scheduling in a distributed manufacturing environment", *International Journal of Production Economics*, Vol. 159, pp. 16-28.

Haddud, A., Dugger, J.C. and Lee, H. (2015), "Lee manufacturing control, asset tracking, and asset maintenance: assessing the impact of RFID technology adoption", *Journal of International Technology and Information Management*, Vol. 24 No. 3, pp. 35-54.

Herron, C. and Braiden, P.M. (2007), "Defining the foundation of lean manufacturing in the context of its origins (Japan)", ICAM 2007, IET International Conference on 2007, IET, 4 July, pp. 148-157.

Hines, P., Holweg, M. and Rich, N. (2004), "Learning to evolve: a review of contemporary lean thinking", *International Journal of Operations & Production Management*, Vol. 24 No. 10, pp. 994-1011.

Hollyman, D., Thompson, J., Guttridge, M., Wiggins, C., Lubenko, A., Day, V., Austin, E., Ash, C., Hurren, S. and Smythe, J. (2014), "The application of lean manufacturing principles to a national network of cellular therapy laboratories", *Cytotherapy*, Vol. 16 No. 4, p. S44.

Holweg, M. (2007), "The genealogy of lean production", *Journal of Operations Management*, Vol. 25 No. 2, pp. 420-437.

Huang, G.Q., Qu, T., Zhang, Y. and Yang, H. (2010), " RFID-enabled real-time manufacturing for automotive part and accessory suppliers", *40th International Conference on Computers and Industrial Engineering (CIE), IEEE*, pp. 1-6.

Huang, G.Q., Qu, T., Zhang, Y. and Yang, H. (2012), "RFID-enabled product-service system for automotive part and accessory manufacturing alliances", *International Journal of Production Research*, Vol. 50 No. 14, pp. 3821-3840.

Inlogic (2013), "RFID versus bar codes comparison", available at: www.inlogic.com/rfid/rfid_vs_barcode.aspx (accessed 31 December 2014).

Jabbour, C.J.C., Jabbour, A.B.L.D.S., Govindan, K., Teixeira, A.A. and Freitas, W.R.D.S. (2013), "Environmental management and operational performance in automotive companies in Brazil: the role of human resource management and lean manufacturing", *Journal of Cleaner Production*, Vol. 47, pp. 129-140.

Jadhav, R.J., Mantha, S.S. and Rane, S.B. (2014), "Exploring barriers in lean implementation", *International Journal of Lean Six Sigma*, Vol. 5 No. 2, pp. 122-148.

James, T. (2006), "Wholeness as well as leanness-lean production", *Manufacturing Engineer*, Vol. 85 No. 5, pp. 14-17.

Jasti, N.V.K., Kodali, R. and Gunasekaran, A. (2015), "An empirical study for implementation of lean principles in Indian manufacturing industry", *Benchmarking: An International Journal*, Vol. 23 No. 1, pp. 183-207.

Jimenez, C., Dauzère-Pérès, S., Feuillebois, C. and Pauly, E. (2013), "Optimizing the positioning and technological choices of RFID elements for aircraft part identification", *European Journal of Operational Research*, Vol. 227 No. 2, pp. 350-357.

Jimenez-Garcia, J., Téllez-Vázquez, S., Medina-Flores, J., Rodríguez-Santoyo, H. and Cuevas-Ortuño, J. (2014), "Materials supply system analysis under simulation scenarios in a lean manufacturing environment", *Journal of Applied Research and Technology*, Vol. 12 No. 5, pp. 829-838.

Jovanovic, V., Stevanov, B., Šešlija, D., Dudić, S. and Tešić, Z. (2014), "Energy efficiency optimization of air supply system in a water bottle manufacturing system", *Journal of Cleaner Production*, Vol. 85, pp. 306-317.

Ju, T.L.J., Patricia, H. and Sun, S.-Y. (2008), "A strategic examination of radio frequency identification in supply chain management", *International Journal of Technology Management*, Vol. 43 No. 4, pp. 349-362.

Karim, M.A., Aljuhani, M., Duplock, R. and Yarlagadda, P. (2011), *Implementation of Lean Manufacturing in Saudi Manufacturing Organisations: An Empirical Study. Advanced Materials Research*, Trans Tech Publications, pp. 250-253.

Karlsson, C. and Ahlstrom, P. (1996), "Assessing changes towards lean production", *International Journal of Operations & Production Management*, Vol. 16 No. 2, pp. 24-41.

Khanchanapong, T., Prajogo, D., Sohal, A.S., Cooper, B.K., Yeung, A.C. and Cheng, T. (2014), "The unique and complementary effects of manufacturing technologies and lean practices on manufacturing operational performance", *International Journal of Production Economics*, Vol. 153, pp. 191-203.

Kitchenham, B. and Brereton, P. (2013), "A systematic review of systematic review process research in software engineering", *Information and Software Technology*, Vol. 55 No. 12, pp. 2049-2075.

Kok, A.G. and Shang, K.H. (2014), "Evaluation of cycle-count policies for supply chains with inventory inaccuracy and implications on RFID investments", *European Journal of Operational Research*, Vol. 237 No. 1, pp. 91-105.

Kumar, B.S. and Abuthakeer, S.S. (2012), "Implementation of lean tools and techniques in an automotive industry", *Journal of Applied Sciences (Faisalabad)*, Vol. 12 No. 10, pp. 1032-3037.

Kumar, S.S. and Kumar, M.P. (2014), "Cycle time reduction of a truck body assembly in an automobile industry by lean principles", *Procedia Materials Science*, Vol. 5, pp. 1853-1862.

Lei, D.T. (2000), "Industry evolution and competence development: the imperatives of technological convergence", *International Journal of Technology Management*, Vol. 19 Nos 7-8, pp. 699-738.

Levy, Y. and Ellis, T.J. (2006), "A systems approach to conduct an effective literature review in support of information systems research", *Informing Science: International Journal of an Emerging Transdiscipline*, Vol. 9 No. 1, pp. 181-212.

Mabry, B.G. and Morrison, K.R. (1996), "Transformation to lean manufacturing by an automotive component supplier", *Computers & Industrial Engineering*, Vol. 31 No. 1, pp. 95-98.

Martinez-Jurado, P.J. and Moyano-Fuentes, J. (2014), "Lean management, supply chain management and sustainability: a literature review", *Journal of Cleaner Production*, Vol. 85, pp. 134-150.

Matt, D. and Rauch, E. (2013), "Implementation of lean production in small sized enterprises", *Procedia CIRP*, Vol. 12, pp. 420-425.

Melton, T. (2005), "The benefits of lean manufacturing: what lean thinking has to offer the process industries", *Chemical Engineering Research and Design*, Vol. 83 No. 6, pp. 662-673.

Mo, J.P. (2009), "The role of lean in the application of information technology to manufacturing", *Computers in Industry*, Vol. 60 No. 4, pp. 266-276.

Mothersell, W.M. (2009), "The role of technology and people in the diffusion of lean production in the automotive supplier industry", *International Journal of Automotive Technology and Management*, Vol. 9 No. 3, pp. 290-315.

Motwani, J. (2003), "A business process change framework for examining lean manufacturing: a case study", *Industrial Management & Data Systems*, Vol. 103 No. 5, pp. 339-346.

Moyano-Fuentes, J. and Sacristan-Diaz, M. (2012), "Learning on lean: a review of thinking and research", *International Journal of Operations & Production Management*, Vol. 32 No. 5, pp. 551-582.

Muller-Seitz, G., Dautzenberg, K., Creusen, U. and Stromereder, C. (2009), "Customer acceptance of RFID technology: evidence from the German electronic retail sector", *Journal of Retailing and Consumer Services*, Vol. 16 No. 6, pp. 31-39.

Muslimen, R., Yusof, S.M. and Abidin, A.S.Z. (2011), "Lean manufacturing implementation in Malaysian automotive components manufacturer: a case study", *Proceedings of the World Congress on Engineering*, pp. 6-8.

Muslimen, R., Yusof, S.M. and Abidin, A.S.Z. (2013), *A Case Study of Lean Manufacturing Implementation Approach in Malaysian Automotive Components Manufacturer. Electrical Engineering and Intelligent Systems*, Springer, New York, NY.

Narasimhan, R., Swink, M. and Kim, S.W. (2006), "Disentangling leanness and agility: an empirical investigation", *Journal of Operations Management*, Vol. 24 No. 5, pp. 440-457.

Nasab, H.H. and Zare, H.K. (2012), "Finding a probabilistic approach to analyze lean manufacturing", *Journal of Cleaner Production*, Vol. 29, pp. 73-81.

Negrus, A.M., Mihail, L.A. and Chiru, A. (2011), "Innovative robust solutions for lean manufacturing in automotive assembly processes", technical paper, SAE, April 12.

Ngai, E., To, C.K., Moon, K.K., Chan, L., Yeung, P.K. and Lee, M.C. (2010), "RFID systems implementation: a comprehensive framework and a case study", *International Journal of Production Research*, Vol. 48 No. 9, pp. 2583-2612.

Nordin, N., Deros, B.M. and Wahab, D.A. (2010), "A survey on lean manufacturing implementation in Malaysian automotive industry", *International Journal of Innovation, Management and Technology*, Vol. 1 No. 4, pp. 374-380.

Nordin, N., Deros, B.M., Abd Wahab, D. and Ab Rahman, M.N. (2011), "Managing change in lean manufacturing implementation", *Advanced Materials Research*, Vol. 314, pp. 2105-2111.

Ono, T. (1988), *Toyota Production System: Beyond Large-Scale Production*, Productivity Press, New York, NY.

Panwar, A., Jain, R. and Rathore, A. (2015), "Lean implementation in Indian process industries – some empirical evidence", *Journal of Manufacturing Technology Management*, Vol. 26 No. 1, pp. 131-160.

Papadopoulou, T. and Ozbayrak, M. (2005), "Leanness: experiences from the journey to date", *Journal of Manufacturing Technology Management*, Vol. 16 No. 7, pp. 784-807.

Powell, D. and Skjelstad, L. (2012), "RFID for the extended lean enterprise", *International Journal of Lean Six Sigma*, Vol. 3 No. 3, pp. 172-186.

Pramatari, K., Karagiannaki, A. and Bardaki, C. (2010), "21-radio frequency identification (RFID) as a catalyst for improvements in food supply chain operations", in Mena, C. and Stevens, G. (Eds), *Delivering Performance in Food Supply Chains*, Woodhead Publishing, pp. 432-453.

Qingyun, D., Zhong, R., Huang, G.Q., Qu, T., Zhang, T. and Luo, T. (2012), "Radio frequency identification-enabled real-time manufacturing execution system: a case study in an automotive part manufacturer", *International Journal of Computer Integrated Manufacturing*, Vol. 25 No. 1, pp. 51-65.

Qu, T., Zhang, L., Huang, Z., Dai, Q., Chen, X., Huang, G.Q. and Luo, H. (2013), "RFID-enabled smart assembly workshop management system", *10th IEEE International Conference on Networking, Sensing and Control (ICNSC), IEEE*, 895-900.

Rahani, A. and Al-Ashraf, M. (2012), "Production flow analysis through value stream mapping: a lean manufacturing process case study", *Procedia Engineering*, Vol. 41, pp. 1727-1734.

Ramadan, M., Wang, Z. and Noche, B. (2012), "RFID-enabled dynamic value stream mapping", *IEEE International Conference on Service Operations and Logistics, and Informatics (SOLI), IEEE*, pp. 117-122.

Ray, C.D., Zuo, X., Michael, J.H. and Wiedenbeck, J.K. (2006), "The lean index: operational 'lean' metrics for the wood products industry", *Wood and Fiber Science*, Vol. 38 No. 2, pp. 238-255.

Reichhart, A. and Holweg, M. (2007), "Lean distribution: concepts, contributions, conflicts", *International Journal of Production Research*, Vol. 45 No. 16, pp. 3699-3722.

Roberti, M. (2013), "How much time is require to read RFID tag", available at: www.rfidjournal.com/blogs/experts/entry?10736 (accessed 21 January 2014).

Robinson, S., Radnor, Z.J., Burgess, N. and Worthington, C. (2012), "SimLean: utilising simulation in the implementation of lean in healthcare", *European Journal of Operational Research*, Vol. 219 No. 1, pp. 188-197.

Rose, A., Deros, B.M. and Ab Rahman, M.A. (2013a), "Lean manufacturing practices implementation in Malaysian's SME automotive component industry", *Applied Mechanics and Materials*, Vol. 315, pp. 686-690.

Rose, A., Deros, B.M. and Ab Rahman, M.A. (2013b), "A study on lean manufacturing implementation in Malaysian automotive component industry", *International Journal Automotive Mechanical Engineering*, Vol. 8, pp. 1467-1476.

Ruiz-De-Arbulo-Lopez, P., Fortuny-Santos, J. and Cuatrecasas-Arbós, L. (2013), "Lean manufacturing: costing the value stream", *Industrial Management & Data Systems*, Vol. 113 No. 5, pp. 647-668.

Saad, S., Perera, T., Achanga, P., Shehab, E., Roy, R. and Nelder, G. (2006), "Critical success factors for lean implementation within SMEs", *Journal of Manufacturing Technology Management*, Vol. 17 No. 4, pp. 460-471.

Sahwan, M.A., Ab Rahman, M.N. and Deros, B.M. (2012), "Barriers to implement lean manufacturing in Malaysian automotive industry", *Jurnal Teknologi, (Sciences and Engineering)*, Vol. 59 No. 2, pp. 107-110.

Salleh, N.A.M., Kasolang, S. and Jaffar, A. (2012a), "Green lean total quality information management in Malaysian automotive companies", *Procedia Engineering*, Vol. 41, pp. 1708-1713.

Salleh, N.A.M., Kasolang, S. and Jaffar, A. (2012b), "Simulation of integrated total quality management (TQM) with lean manufacturing (LM) practices in forming process using delmia quest", *Procedia Engineering*, Vol. 41, pp. 1702-1707.

Sarac, A., Absi, N. and Dauzère-Pérès, S. (2010), "A literature review on the impact of RFID technologies on supply chain management", *International Journal of Production Economics*, Vol. 128 No. 1, pp. 77-95.

Saygin, C. and Sarangapani, J. (2011), "Radio frequency identification (RFID) enabling lean manufacturing", *International Journal of Manufacturing Research*, Vol. 6 No. 4, pp. 321-336.

Serrano Lasa, I., Castro, R.D. and Laburu, C.O. (2009), "Extent of the use of Lean concepts proposed for a value stream mapping application", *Production Planning & Control*, Vol. 20 No. 1, pp. 82-98.

Seth, D. and Gupta, V. (2005), "Application of value stream mapping for lean operations and cycle time reduction: an Indian case study", *Production Planning & Control*, Vol. 16 No. 1, pp. 44-59.

Shah, R. and Ward, P.T. (2007), "Defining and developing measures of lean production", *Journal of Operations Management*, Vol. 25 No. 4, pp. 785-805.

Shang, G. and Sui Pheng, L. (2014), "Barriers to lean implementation in the construction industry in China", *Journal of Technology Management in China*, Vol. 9 No. 2, pp. 155-173.

Sloan, A.F., Kathryn, J.H., Zoe Radnor, S.R., Amrik Sohal, T., Drotz, E. and Poksinska, B. (2014), "Lean in healthcare from employees' perspectives", *Journal of Health Organization and Management*, Vol. 28 No. 2, pp. 177-195.

Smart, A.U., Bunduchi, R. and Gerst, M. (2010), "The costs of adoption of RFID technologies in supply networks", *International Journal of Operations & Production Management*, Vol. 30 No. 4, pp. 423-447.

So, S. and Sun, H. (2011), "An extension of IDT in examining the relationship between electronic-enabled supply chain integration and the adoption of lean production", *International Journal of Production Research*, Vol. 49 No. 2, pp. 447-466.

So, S.C.A. (2010), "A novel RFID application for realizing lean services based on customer chain operations reference model", *IEEE International Conference on Industrial Engineering and Engineering Management (IEEM), IEEE*, pp. 400-404.

So Park, K., Koh, C.E. and "Ted" Nam, K. (2010), "Perceptions of RFID technology: a cross-national study", *Industrial Management & Data Systems*, Vol. 110 No. 5, pp. 682-700.

Soriano-Meier, H. and Forrester, P.L. (2002), "A model for evaluating the degree of leanness of manufacturing firms", *Integrated Manufacturing Systems*, Vol. 13 No. 2, pp. 104-109.

Stentoft Arlbjorn, J. and Vagn Freytag, P. (2013), "Evidence of lean: a review of international peer-reviewed journal articles", *European Business Review*, Vol. 25, pp. 174-205.

Stonier, A.S., Martin, H.N. and Farid, S.S. (2009), "Dynamic simulation framework for design of lean biopharmaceutical manufacturing operations", *Computer Aided Chemical Engineering*, Vol. 26, pp. 1069-1073.

Su, W., Ma, L., Hu, K. and Zhang, L. (2009), "A research on integrated application of RFID-based lean manufacturing", *Chinese Control and Decision Conference, CCDC'09, IEEE*, pp. 5781-5784.

Sundar, R., Balaji, A. and Kumar, R.S. (2014), "A review on lean manufacturing implementation techniques", *Procedia Engineering*, Vol. 97, pp. 1875-1885.

Susilawati, A., Tan, J., Bell, D. and Sarwar, M. (2015), "Fuzzy logic based method to measure degree of lean activity in manufacturing industry", *Journal of Manufacturing Systems*, Vol. 34, pp. 1-11.

Taj, S. (2008), "Lean manufacturing performance in China: assessment of 65 manufacturing plants", *Journal of Manufacturing Technology Management*, Vol. 19 No. 2, pp. 217-234.

Tajima, M. (2007), "Strategic value of RFID in supply chain management", *Journal of Purchasing and Supply Management*, Vol. 13 No. 4, pp. 261-273.

Tang, C., Chan, C.-Y. and Yung, K.-L. (2007), "Formation of a generic technique for manufacturing systems monitoring", *International Journal of Technology Management*, Vol. 38 No. 4, pp. 392-423.

Van Der Merwe, K.R., Pieterse, J. and Lourens, A. (2014), "The development of a theoretical lean culture causal framework to support the effective implementation of lean in automotive component manufacturers", *South African Journal of Industrial Engineering*, Vol. 25 No. 1, pp. 131-144.

Vlachos, I.P. (2014), "A hierarchical model of the impact of RFID practices on retail supply chain performance", *Expert Systems with Applications*, Vol. 41 No. 1, pp. 5-15.

Wahab, A.N.A., Mukhtar, M. and Sulaiman, R. (2013), "A conceptual model of lean manufacturing dimensions", *Procedia Technology*, Vol. 11, pp. 1292-1298.

Wang, Y.-M., Wang, Y.-S. and Yang, Y.-F. (2010), "Understanding the determinants of RFID adoption in the manufacturing industry", *Technological Forecasting and Social Change*, Vol. 77 No. 5, pp. 803-815.

Wang, T.-K., Yang, T., Yang, C.-Y. and Chan, F.T. (2015), "Lean principles and simulation optimization for emergency department layout design", *Industrial Management & Data Systems*, Vol. 115 No. 4, pp. 678-699.

Webster, J. and Watson, R.T. (2002), "Analyzing the past to prepare for the future: writing a literature review", *Management Information Systems Quarterly*, Vol. 26 No. 3.

Womack, J.P. and Jones, D.T. (1990), *The Machine that Changed the World*, Macmillan Publishing Company, New York, NY.

Womack, J.P., Jones, D.T. and Daniel, R (2008), *The Machine that Changed the World*, Simon and Schuster, New York, NY.

Wong, Y.C., Wong, K.Y. and Ali, A. (2009), "A study on lean manufacturing implementation in the Malaysian electrical and electronics industry", *European Journal of Scientific Research*, Vol. 38 No. 4, pp. 521-535.

Xiu-Xu, Z. and Lin-Yan, N. (2009), "Study of the lean logistics operating model based on RFID and its application in auto industry", International Symposium on Computer Network and Multimedia Technology, IEEE, Wuhan.

Yadav, O.P., Nepal, B., Goel, P.S. and Jain, R. (2010), "Insights and learnings from lean manufacturing implementation practices", *International Journal of Services and Operations Management*, Vol. 6 No. 4, pp. 398-422.

Yang, T., Kuo, Y., Su, C.-T. and Hou, C.-L. (2015), "Lean production system design for fishing net manufacturing using lean principles and simulation optimization", *Journal of Manufacturing Systems*, Vol. 34, pp. 66-73.

Zapp, M., Hoffmeister, M. and Verl, A. (2013), "Methodology to apply semantic wikis as lean knowledge management systems on the shop floor", *Procedia CIRP*, Vol. 12, pp. 444-449.

Further reading

Bourlakis, M., Vlachos, I.P. and Zeimpekis, V. (2011), *Intelligent Agrifood Chains and Networks*, John Wiley & Sons.

De Treville, S., Bicer, I., Chavez-Demoulin, V., Hagspiel, V., Schürhoff, N., Tasserit, C. and Wager, S. (2014), "Valuing lead time", *Journal of Operations Management*, Vol. 32 No. 6, pp. 337-346.

Jasti, N.V.K. and Kodali, R. (2015), "Lean production: literature review and trends", *International Journal of Production Research*, Vol. 53 No. 3, pp. 867-885.

Schulze, A. and Stormer, T. (2012), "Lean product development – enabling management factors for waste elimination", *International Journal of Technology Management*, Vol. 57 Nos 1/2/3, pp. 71-91.

Zhang, J. and Sobel, M.J. (2010), "Financially optimal inventory policies with non-linear replenishment costs", *Asia-Pacific Journal of Operational Research*, Vol. 27 No. 4, pp. 477-492.

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