International Journal of Production Research
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/tprs20

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Published online: 04 Nov 2014.

To cite this article: Juan A. Marin-Garcia & Tomas Bonavia (2015) Relationship between employee involvement and lean manufacturing and its effect on performance in a rigid continuous process industry, International Journal of Production Research, 53:11, 3260-3275, DOI: 10.1080/00207543.2014.975852

To link to this article: http://dx.doi.org/10.1080/00207543.2014.975852

International Journal of Production Research, 2015
Vol. 53, No. 11, 3260–3275, http://dx.doi.org/10.1080/00207543.2014.975852

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(*Received 1 August 2013; accepted 30 September 2014*)

This research aims to empirically test the effect of employee involvement on lean manufacturing (LM), and the effect of LM on production outcomes. Employee involvement is operationalised through four related variables: empowerment, training, contingent remuneration and communication. The effects are tested by recording management perceptions in a different industrial sector from those usually studied in previous research – ceramic manufacturers, a highly competitive and internationally successful sector. We obtained data from 101 ceramic tile plants (64% of response rate) in the Valencia region of Spain. This approach is developed using a statistical method called partial least squares. All paths are significant except for contingent remuneration; specifically, relationships were found between empowerment, training, communication and LM, and between LM and performance.

Keywords: lean production; human resource management; high-performance work practices; participation in decision-making; compensation; information sharing

1. Introduction

The paradigm of lean production in its different modalities has become a reality in our times (Holman et al. 2005; Spear and Bowen 1999). Numerous articles and books have been published on this topic (Marodin and Saurin 2013; Moyano-Fuentes and Sacristan-Diaz 2012), which is not surprising because most industrial enterprises operate today in an environment of increasing competition, fast change, fluctuating demand and uncertainty (Azadegan et al. 2013). Most markets are mature, and customers demand quality products adapted to their specific needs (Hallgren and Olhager 2009). Consequently, one would expect some degree of implementation of lean manufacturing (LM) practices in any sector with strong competition (Shah and Ward 2003; Vinodh and Joy 2012).

Some LM studies have been based on samples of companies from different sectors (Cua, McKone, and Schroeder 2001; Fullerton, McWatters, and Fawson 2003; Shah and Ward 2003; Vinodh and Joy 2012). Others have focused on a broad sample of firms from a few sectors, usually the automobile, electronics and machinery industries, although much of the research in these sectors consists of studies of isolated cases (Kim and Bae 2005; Power and Sohal 2000; Sakakibara et al. 1997). There is also some evidence of the successful implementation of LM in sectors such as construction (Pheng and Teo 2004), assembly (Jun, Cai, and Shin 2006), optics (Wang 2008) and food processing (Dora et al. 2013). Therefore, various authors have considered it necessary to widen the range of industries in which LM is studied (Hallgren and Olhager 2009; Sakakibara et al. 1997; Shah and Ward 2003; Snell and Dean 1992), especially taking into account that the development of LM began in discrete manufacturing and that its application in process industries has hardly been studied and almost always based on results obtained from only one case (Lyons et al. 2013).

Process manufacturing can be defined as 'production that adds value by mixing, separating, forming and/or performing chemical reactions. It may be done in either batch or continuous mode' (Blackstone 2008). In this category, different types of firms can be included, and we can classify them in seven distinct process industry subgroups: process job shop, custom blending, fast batch, custom hybrid, stock hybrid, multi-stage continuous and rigid continuous (Dennis and Meredith 2000). There seems to be some evidence, not yet contrasted in large-scale studies, confirming that the use and outcomes of LM practices are different for each type of process industry subgroup (Lyons et al. 2013).

On the other hand, several studies have explained an improvement in performance by suggesting a close relationship between LM, high-involvement work practices and human resource management (Bonavia and Marin-Garcia 2011;

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Das and Jayaram 2003; Holman et al. 2005; Kochan and Lansbury 1997; Yates, Lewchuk, and Stewart 2001). Several of these studies have proposed that the successful implementation of different operation management philosophies, such as total quality management (TQM) or just-in-time (JIT), would depend on simultaneously implementing high employee involvement practices (Ahmad, Schroeder, and Sinha 2003; Alfalla-Luque, Marin-Garcia, and Medina-López 2012; Birdi et al. 2008). Furthermore, various studies have mentioned the need to include workforce involvement practices in the analysis of LM models (Flynn and Sakakibara 1995; Sakakibara et al. 1997; Cua, McKone, and Schroeder 2001). Specifically, Cua, McKone, and Schroeder (2001) respond to this demand by establishing a framework in which workforce management is an antecedent of basic LM practices, which fully mediate the effect of workforce management on performance.

Among the most common human resources practices that favour employee involvement, the literature highlights those that provide workers with information, skills, motivation and power (Benson and Lawler 2005; Lawler 1991; MacDuffie 1995). These practices can result in the transformation of the workforce into a source of sustainable competitive advantage (Guerrero and Barraud-Didier 2004; Guthrie, Spell, and Nyamori 2002; Wood and de Menezes 2008; Zatzick and Iverson 2006) and have proven keys in the process of implementation of the LM (Nordin et al. 2011).

A review of the literature (Cappelli and Neumark 2001, 748) suggests that employee involvement is the main concept behind virtually all of the studies examining high-performance work systems and organisational performance. Forza (1996) indicates that the majority of the authors would agree with the statement that employee involvement is a key element of LM. On the other hand, some studies have reported that employee involvement does not directly affect operational results, but it does help to implement LM – which has a direct relationship with the performance (Fullerton and McWatters 2002; Sakakibara et al. 1997; Sila 2007).

However, only a few studies have analysed the characteristics of the relationship between employee involvement and LM. Some of these studies look at the relationships with some components of employee involvement and only one component of LM, for example, TQM (Nair 2006; Sila 2007; Tarí, Molina, and Castejón 2007) or Pull Systems (Koufteros et al. 2007). Others focus on studying employee involvement in detail, but only relating these practices to TQM (Alfalla-Luque, Marin-Garcia, and Medina-López 2012; Lawler, Mohrman, and Benson 2001). Finally, a series of papers discuss in depth the relationships among the components of LM: TQM, JIT, and total productive maintenance (TPM), as well as some components of employee involvement in terms of organisational performance (Birdi et al. 2008; Cua, McKone, and Schroeder 2001; Fullerton and McWatters 2001; Sakakibara et al. 1997).

These studies are often incomplete because their main focus has generally been on either analysing LM practices or analysing employee involvement, while the other sets of practices have been somewhat tangential additions, and not a major part of the research. Therefore, extensive research seems essential to facilitate theory development (Sila 2007). Consequently, there is a need to broaden the empirical research in the direction of determining the performance implications of employee involvement as an antecedent of LM implementation. For instance, this research could be based on analyses carried out in countries and industries other than those usually studied (Jiménez et al. 2012; Mehrjerdi 2012; Panizzolo et al. 2012; Wickramasinghe and Wickramasinghe 2011).

In summary, numerous articles have been written about LM. To date, the most recent literature review is probably the one by Marodin and Saurin (2013), which analyses articles published between 1996 and 2012. The authors of the review select 102 articles, identify research areas related to LM implementation and propose research opportunities.

Marodin and Saurin (2013) conclude that 33 studies have analysed the factors that affect LM implementation. The majority of the studies have focused on the manufacturing, electronic components and automotive sectors. Of course, other sectors have also been studied (services, aerospace, agricultural, food, textile or ceramics) but to a lesser degree. In these other sectors, they only find one or two studies, which makes it difficult to extract conclusive results (as the replication is missing that would allow the conclusions to be generalised). Moreover, only one of the studies in their review analyses the effect of rewards (a theoretical article), and another article includes employee involvement (focused on the automotive sector). In other words, according to these authors, none of the articles published in the past 16 years analyses both employee involvement and LM in process industries.

Furthermore, of the 102 studies analysed by Marodin and Saurin (2013), 48% were carried out in firms in the USA or the UK. Only 17% were conducted in firms in other European countries (of which, only 3 studies use Spain as the data source). Undoubtedly, the research and, therefore, conclusions drawn have a clear bias towards the Anglo-Saxon business context.

For all of these reasons, it is necessary to extend the research on LM implementation, focusing on a specific sector other than discrete manufacturing and using the joint analysis of performance measures related to different business dimensions, such as human and operational, in order to analyse whether LM implementation differs based on the process type (Lyons et al. 2013; Marodin and Saurin 2013).

In this study, our contribution consists of focusing on a processes industry about which very few studies have been published. Ceramic tile manufacturing is an example of a highly competitive process industry in Spain, a leading ceramics producing country (Andrés Romano 2001; Bonavia and Marin-Garcia 2006, 2011; Gil, Guarch, and Andrés 1999; Hervas-Oliver and Albors-Garrigos 2009; Rowley 1996). These firms make their production processes more flexible for various reasons (Ibáñez-Forés, Bovea, and Azapagic 2013; Rowley 1996; Vallada et al. 2005). This exceptionally dynamic industry faces changing demands and increasingly stiff international competition due to globalisation (Alegre-Vidal, Lapiedra-Alcamí, and Chiva-Gómez 2004). The manufacturers are found in very specific geographical areas where news about innovations in products and processes spreads fast (Gil, Guarch, and Andrés 1999). Therefore, firms are under strong pressure to constantly improve if they want to have an advantage over their competitors. The Spanish firms have achieved a wide variety of constantly changing products where design and quality play an essential role (Alegre-Vidal, Lapiedra-Alcamí, and Chiva-Gómez 2004; Chiva and Alegre 2009). The product life cycle becomes even shorter and is currently less than 5 years. There are a growing number of formats and models in an attempt to customise the goods offered, while producers attempt to reduce delivery times (Albors-Garrigos, Oliver, and Marquez 2008). Everything seems to indicate that this tendency will increase in the future (Tomás Carpi et al. 1996).

Therefore, the aim of this research is to investigate the effect employee involvement has on LM, and the effect LM practices have on performance in a process industry. This approach is developed using partial least squares (PLS) to determine whether the relationships between these practices and their effects on performance can be replicated in firms operating in the tile industry in Spain.

This study makes it possible to extend the existing results on LM using an industry that is different from the ones usually analysed, but that has many of the necessary characteristics for implementing LM.

2. Theoretical framework and hypotheses

The complete lean enterprise model includes not only LM, but also the activities of lean product development, lean procurement and lean distribution (Karlsson and Ahlström 1996). However, our research interest focuses on the activities that take place in the manufacturing activity, which leads us to analyse and describe only aspects related to LM. The term 'lean' has been used to denote the set of tools designed to increase business competitiveness by systematically eliminating all types of waste, the alignment of production with demand, and the involvement of the workforce (Lyons et al. 2013; Shah and Ward 2007).

In general, it seems that in sectors other than the automobile sector, the use of LM takes place through the selective and not very integrated use of disperse practices, rather than as a complete system. In fact, many authors state that some LM practices are not appropriate or generalisable to just any sector (Lyons et al. 2013; White and Prybutok 2001). Certain widely used practices only have moderate deployment in processes firms, for example, 5S and visual systems. Moreover, TPM is usually extensively used in firms with rigid continuous processes, but not in others. On the other hand, certain restrictions in the production system make it unlikely that all the LM practices will be adopted, for example, in cases where there are highly automated lines but without flexible manufacturing systems, or when firms try to maintain the maximum production capacity of the ovens to avoid energy loss and the difficulty involved in adjusting the firing process during batch changes. In these cases, the batch size is large, and the use of LM practices such as cellular manufacturing, set-up time reduction, levelling production and pull systems is unlikely in this sector (Lyons et al. 2013). In this study, we focus mainly on practices of waste elimination (5s, visual controls, standard operations, TPM, quick changeover and statistical process control) and workforce involvement (quality circles and cross-functional training/job rotation), although the latter are usually implemented less in rigid continuous processes than in other types of processes (Lyons et al. 2013).

Numerous studies have concluded that applying this LM practices enables businesses to improve their performance (Cua, McKone, and Schroeder 2001; Fullerton and McWatters 2001; Hallgren and Olhager 2009; Wang 2008; White and Prybutok 2001), both large companies and SMEs – small and medium enterprises– (Panizzolo et al. 2012; White, Pearson, and Wilson 1999; Vinodh and Joy 2012). Moreover, a positive association was also found between the use of LM practices for waste elimination and improvements in manufacturing performance in various types of process industries (Lyons et al. 2013).

In the literature review carried out by Marodin and Saurin (2013), the main results are positive, showing that the application of LM improves productivity, reduces cost or improves performance in general. Different studies in some countries and manufacturing industries seem to point in this direction, but the lack of homogeneity in the measurement instruments used and the lack of replication of the studies makes it difficult to confirm these results or generalise them to firms in other countries or other sectors. In addition, there are numerous studies on discrete manufacturing but very few in process industries. The most frequently mentioned benefits include the following: reduced production costs, shorter lead time, better product quality, adaptation of the product to the characteristics requested by the client, and the capacity to adjust production to meet fluctuating demand (Cua, McKone, and Schroeder 2001; Fullerton and McWatters 2001; Jackson and Dyer 1998; Marodin and Saurin 2013; Nair 2006; Sakakibara et al. 1997; Shah and Ward 2003;

Sila 2007; White, Pearson, and Wilson 1999). Some of these studies include the employees' motivation as a performance measure. However, in reality, very few studies have included the human dimension to analyse the performance outcomes of the implementation of LM practices.

Based on these ideas, the following hypothesis is proposed:

H1. LM has a positive effect on performance.

Part of the LM research has considered its relationship with human resource management programmes and work organisation practices that encourage employee involvement in companies (Cua, McKone, and Schroeder 2001; Das and Jayaram 2003; Fullerton and McWatters 2002; MacDuffie 1995; Holman et al. 2005; Shah and Ward 2007; Snell and Dean 1992). These programmes for managing human resources are labelled in different ways (high-performance work systems, high-involvement work practices …), and the list of practices included varies among authors (Combs et al. 2006; Guthrie, Spell, and Nyamori 2002). The same applies to the concepts of employee participation, job involvement, etc. (Wickramasinghe and Wickramasinghe 2011). However, there is some agreement about how these employee involvement practices can be classified (Combs et al. 2006; Gibson et al. 2007; Guerrero and Barraud-Didier 2004; Marin-Garcia and Conci 2009; Wood and de Menezes 2008; Zatzick and Iverson 2006), with the most cited categories being those proposed by Lawler (1991): empowerment (power), training (knowledge), communication (information) and remuneration (rewards). As Benson and Lawler (2005, 154–155) stated, among the different theories of employee involvement, the practices are commonly categorised in the following way: practices that put the decision-making power in the hands of employees, practices that provide the skills or information needed to make informed decisions and practices that provide incentives for employees to take responsibility for their jobs.

Starting with the first practice mentioned by Lawler (1991), empowerment can be characterised as sharing power with employees and increasing their level of autonomy (Guerrero and Barraud-Didier 2004). Two influences can be studied: first, the influence of employees in the design and implementation of LM policies or programmes (Knudsen 1995; Poole 1995); second, the influence of employees in daily decisions such as setting objectives, assigning tasks or job rotation (Delbridge, Lowe, and Oliver 2000). Empowerment has been described as critical to successful JIT initiation and implementation (Koufteros and Vonderembse 1998; Bayo-Moriones, Bello-Pintado, and Merino-Díaz 2008). It would seem clear that companies implementing a higher degree of LM practices need to have previously increased empowerment (Fullerton and McWatters 2002). Empowerment can improve trust and communication between employees and employers (Spreitzer and Mishra 1999). It also heightens the commitment to company goals and encourages better relationships between individuals sharing tasks and procedures (Gibson et al. 2007). These ideas suggest the following hypothesis:

H2. Empowerment has a positive effect on LM.

If employees receive suitable information and training, the workforce may develop shared abilities and a better understanding of the processes in which they participate (Guerrero and Barraud-Didier 2004). For this reason, various studies have shown the association between LM and training programmes (Bonavia and Marin-Garcia 2011; Hiltrop 1992). Employees must also be instructed in self-development and problem-solving techniques (Benson, Finegold, and Mohrman 2004). Training is also essential for tasks related to tool and machinery maintenance. Brown and Mitchell (1991), Fortuny-Santos et al. (2008) and Martínez-Jurado, Moyano-Fuentes, and Gómez (2013) showed that training is the critical variable that minimises obstacles to an optimal performance in the transition from mass production to LM. Other authors have highlighted the need to invest in long-term training programmes when companies attempt to increase productivity by introducing LM (Molleman and van den Beukel 2007; Murphy and Southley 2003). These contributions lead to the following hypothesis:

H3. Training on LM practices has a positive effect on LM.

Practices that encourage top–down communication (feedback, charts showing operational performance measurements, financial or strategic information) help employees to feel that their role in the company is important (Gibson et al. 2007). LM seems to imply improved communications (Cua, McKone, and Schroeder 2001); nevertheless, the relationship between communication and company results has not yet been demonstrated (Guerrero and Barraud-Didier 2004). Therefore, it would be useful to test this hypothesis:

H4. Top–down communication has a positive effect on LM.

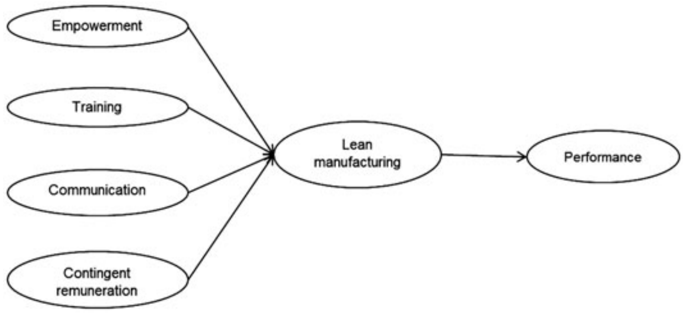

Figure 1. Theoretical model.

Although various authors have included variable remuneration in their studies on LM (Fullerton and McWatters 2002), the link between remuneration plans and successful LM has received little attention in the literature (Sakakibara et al. 1997). In our country there is an added problem; in the previous research (EPOC Research Group 1997), Spain is shown in logistic regression models as a factor with a significant negative effect in the use of profit-sharing schemes. In other words, while in Spain fixed salary predominate, other European countries and EEUU use a greater amount of salary complements with a much greater proportion of employees (Marin-Garcia, Bonavia, and Miralles Insa 2008a). However, it has been argued that remuneration based on group effort (incentives for reaching group targets) and gain sharing related to individual or group suggestions help to align employee interests with the organisation's interests (Cappelli and Neumark 2001). These incentives also mean that employees are more likely to make a greater effort and contribute more fully to the organisation (Lawler 1996; Snell and Dean 1992; Zatzick and Iverson 2006) and the success of the LM implementation (Forza 1996; Hiltrop 1992). Therefore, the following hypothesis can be proposed:

H5. Contingent remuneration has a positive effect on LM.

Based on the literature reviewed in this section, the research model is shown in Figure 1.

3. Research method

3.1 *Sample*

The studied population consisted of ceramics companies in the Valencia region that are members of ASCER ($N = 157$), which represents more than 85% of Spanish ceramic tile manufacturing firms (ASCER 2003, 2007). The final response rate was 64% (101 visits completed). The data were compiled between July and September 2001. Most of the companies were SMEs. The mean company size, measured as number of employees was 154 (median: 92; standard deviation: 175.45; minimum: 24; maximum: 935).The questionnaire was completed by the plant manager during a personal interview that lasted an average of 30 min. Immediately after the interview, a visit to the facilities was made to obtain some of the data through direct observation of graphs and panels with SQCDP data and find out whether there is any evidence of group technology or pull system (Kanban) in the plant. This observation method made it possible, in addition to gathering the previous information, to clarify any doubts that might arise and confirm the responses obtained in the interview. These visits took an average of 40 min per plant. Two researchers took part in the process. Participating plants received a detailed profile of their own results and a sample means profile for comparison. The size of the sample is sufficient because it satisfies the rule (Hair et al. 2013) that the number of cases should be ten times the number of items in the construct with the most items (eight in our case).

3.2 *Questionnaire*

We developed an *ad hoc* data collection questionnaire, as most other researchers have also done (Birdi et al. 2008; Cua, McKone, and Schroeder 2001; Forza 1996; Fullerton and McWatters 2001; Lawler 1991; Marin-Garcia and Conci 2009; McKone, Schroeder, and Cua 2001; White, Pearson, and Wilson 1999). We worked with several highly experienced technicians from ASCER (Spanish Ceramic Tile Manufacturers' Association) in order to make the necessary adaptations to the peculiarities of the ceramic tile industry. We held two working sessions with production and human resource managers of firms that are members of ASCER. Details about the questionnaire can be requested from the first author.

To measure the implementation of LM practices, we asked what percentage of employees used a given tool during their shift (White, Pearson, and Wilson 1999). All of these LM practices were measured on a scale from 0 to 5 (0%, 1–20%, 21–40%; 41–60%; 61–80% and 81–100%). The list of LM practices may vary in number from 8 to nearly 30 according Marodin and Saurin (2013). The practices included were selected from the most common ones gathered by various authors (Ahmad, Schroeder, and Sinha 2003; Birdi et al. 2008; Dabhilkar and Ahlstrom 2007; Lyons et al. 2013; Marodin and Saurin 2013; White and Prybutok 2001): suggestion groups (quality circles, etc.), TPM, total quality control, reduced set-up times, multi-function employees and standard operations. The questionnaire includes an additional variable (5s-housekeeping) that proved to be practically a constant in the companies in the sample, so that it was eliminated from the analyses. In the initial versions of the questionnaire, it was also considered that the employees might participate in the development of other practices, such as group technology, cellular manufacturing, pull system (Kanban), small-batches and smoothed (levelled) production (all of which are tools designed to establish the one-piece-flow). However, it became evident in the preliminary interviews with plant managers of the companies and ASCER technicians that these practices did not have an application in the target population, and so they were no longer asked about them during the interview. Instead, during the visit it was verified that these practices were not used in these firms.

Regarding the employee involvement variables, Benson and Lawler (2005) state that while the specific practices included in the scales vary from study to study, they all support employee decision-making (empowerment) and provide workers with appropriate skills (training), access to information about firm performance (communication) and incentive rewards (compensation).

Empowerment was measured using a Likert scale from 1 to 4 (employees are informed, employees are consulted, decision-making is shared with employees and decisions are delegated to employees) for decisions about (six items): production targets, setting quality standards, synchronisation and work pace, machines and tools to be used in a task, assignment of tasks and job rotation, and problem-solving for simple tasks (Cua, McKone, and Schroeder 2001; Marin-Garcia, Bonavia, and Miralles Insa 2008a; Poole 1995).

Training (eight items) was measured as the percentage of production employees receiving systematic and programmed training about tidiness and cleanliness in the workplace, data collection and data interpretation, group problem-solving, preventive maintenance, standardisation of operations, quality control, reduction in machine start-up times and teamwork (Benson, Finegold, and Mohrman 2004; Tarí, Molina, and Castejón 2007). The same 0–5 scale used to measure the use of LM tools was also used for this variable.

Communication was measured (Cua, McKone, and Schroeder 2001; Huselid and Becker 1996; Shah and Ward 2007) with a question about the percentage of shop floor zones where charts are posted to show employees the SQCDP data (Safety, Quality, Cost, Delivery and Productivity). Contingent remuneration was measured with two items asking what percentage of production workers received incentives for group results or suggestions implemented (Benson, Finegold, and Mohrman 2004; Lawler, Mohrman, and Benson 2001; Marin-Garcia, Val, and Martín 2008b). In both cases, we used the same scale indicated above, from 0 to 5 (0%, 1–20%, 21–40%; 41–60%; 61–80% and 81–100%).

Performance was measured on a Likert scale from 1 to 5 (not very satisfied to very satisfied) regarding 6 aspects of the business: adaptation of the product to the characteristics requested by the client, product quality, the capacity to adjust production to meet fluctuating demand, production costs, speed of order completion (lead time to consumer) and employee motivation (Gibson et al. 2007; Lawler, Mohrman, and Benson 2001; Marodin and Saurin 2013). All these measures were answered by the plant manager.

3.3 *Analysis*

In the research on different practices, whether dealing with LM, human resources or high involvement, it is common to use a multi-item questionnaire to measure the degree of implementation of these practices, which is also the case in this study. To do so, it is necessary to specify whether the measurement model should be reflective or formative (Hair et al. 2013; Jarvis, MacKenzie, and Podsakoff 2003; Marin-Garcia and Carneiro 2010). In this study, the measurement model for all of the constructs has been considered formative, given that the items do not have to be correlated with each other (for this reason, it does not make sense to calculate Cronbach's alpha), changes in the construct do not cause changes in items, dropping an item changes the content of the construct, and items do not have to have the same antecedents (Jarvis, MacKenzie, and Podsakoff 2003).

The effect of the relationship between LM and employee involvement on performance is evaluated using PLS. For a detailed description of this technique and its application to the LM field, see the previous work by Vinodh and Joy (2012). PLS is particularly suitable when sample sizes are small, when the data are not normally distributed, when formative measures are used, or when complex models with many indicators and relationships are estimated (Hair et al. 2013). All of these conditions are met in this study.

PLS belongs to the family of structural equation modelling methods, and its main application is to explain how the dependent construct varies depending on the other constructs in the model. In this sense, it provides richer information than other techniques, such as, for example, ANOVA, as it makes it possible to simultaneously estimate the parameters of a causal path model, including both the measurement model and the structural model. The sequence of the constructs in the path models is established based on previous theoretical literature. In the representation, the constructs situated in the left part of the model are the independent constructs, and on the right are the dependent constructs. Thus, the constructs on the left precede and predict the constructs on the right.

The estimation of the PLS parameters is performed with an ordinary least squares regression that attempts to maximise the R^2 (R squared, value between 0 and 1 that represents the explained variance) of the dependent constructs. The estimated coefficients on the paths in a PLS model can be considered analogous to the beta in regression models. They are values between −1 and 1 that represent the strength and direction of the association between the constructs.

One of the main details to consider when proposing a PLS model with formative constructs (which is the case here, as explained below) is to show that there are no problems of collinearity among the items that make up a construct. Collinearity could cause the weights between the formative indicators and the construct to be inconsistent or non-significant.

In another vein, the PLS models do not have goodness of fit measures (such as those used in structural equation modelling based on covariance). Instead, a nonparametric test is performed to estimate whether the values of the paths are significantly different from zero. To do so, the most common procedure is bootstrapping, which consists of making a high number of subsamples with replacement randomly drawn. The estimated parameters in each of the subsamples are used to extract a mean and standard deviation from the estimations. Later, a t-test is performed (with degrees of freedom equal to the number of observations minus (1) to test the significance of the parameter estimations (t-value above 1.96 for $\alpha = 0.05$ two tailed).

We will analyse the path weighting scheme with standardised data metrics, nonparametric bootstrapping (101 cases, 1000 samples and individual sign change), the weights of the inner model (>0.1), and bootstrapping significance with t-student one-tailed and nonparametric confidence intervals (Christophersen and Konradt 2008; Hair et al. 2012, 2013; Henseler, Ringle, and Sinkovics 2009). In the descriptive statistics analysis, special attention will be paid to missing values, patterns of no response, ranges of response values, skewness and kurtosis (Doval Dieguez and Viladrich Segués 2011; Viladrich Segués and Doval Dieguez 2011). Inter/item correlations will also be analysed to detect whether any of them are higher than 0.4 (Petter, Straub, and Rai 2007). The collinearity of the items in a construct will be analysed, checking that variance inflation factor (VIF) values are below 3.3 (Diamantopoulos and Winklhofer 2001; Hair et al. 1999; Henseler, Ringle, and Sinkovics 2009; Wilcox, Howell, and Breivik 2008) and that condition indices are below 30 (Coltman et al. 2008; Thongrattana 2010). All analyses were performed using Smart PLS 2.0 (Ringle, Wende, and Will 2005).

Table 1a. Descriptive statistics of the items.

Code	Code	Description	N	Min	Max	Mean	Std. dev.	Skewness	Kurtosis
		What percentage of production workers have received systematic training on …							
TrainClean	p34aform	Tidiness and cleanliness in the workplace	100	0	5	1.41	2.109	0.959	−0.972
TrainData	p34bform	data collection and data interpretation	100	0	5	0.40	1.189	3.148	8.828
TrainGPS	p34cform	Group problem-solving	100	0	5	0.42	1.231	3.076	8.375
TrainTPM	p34dform	Preventive maintenance	100	0	5	0.96	1.786	1.646	1.035
TrainSOP	p34eform	Standardisation of operations	100	0	5	0.81	1.716	1.796	1.471
TrainQC	p34fform	Quality control	100	0	5	1.27	1.974	1.183	−0.376
TrainSmed	p34gform	Reduction in machine change over times	100	0	5	0.52	1.382	2.584	5.258
TrainTeam	p34ifrom	Teamwork	100	0	5	0.34	1.027	3.382	10.935
		Degree of influence of the operators in decisions about …							
EmpTarg	p28ainfl	Production targets	101	0	3	1.10	0.686	1.391	2.857
EmpQStand	p28binfl	Setting quality standards	101	0	4	1.10	0.671	1.910	5.554
EmpWpace	p28cinfl	Synchronisation and work pace	101	0	3	1.37	0.773	0.872	0.239
EmpTools	p28dinfl	Machines and tools to be used on a task	101	0	4	1.61	0.966	1.085	0.292
EmpTask	p28einfl	Assignment of tasks and job rotation	101	0	4	1.60	0.957	0.926	−0.023
EmpPrbSolv	p28finfl	Problem-solving for simple tasks	101	0	4	2.30	1.251	0.138	−1.473

Table 1b. Descriptive statistics of the items.

Code	Code	Description	*N*	Min	Max	Mean	Std. dev.	Skewness	Kurtosis
ContRewGr	p33cmeta	Incentives for group results	100	0	5	0.39	1.180	3.188	9.143
ContRewGain	p33epago	Gain-sharing plans	100	0	5	0.16	0.735	5.976	37.443
CommSQCDP	p11agest	Show employees SQCDP data	101	0	5	0.79	1.608	1.921	2.234
LeanSugGr	Lean1–14b	Suggestion groups (quality circles, etc.)	101	0	5	0.47	1.162	2.950	8.255
LeanTPM	Lean2–19a	Total productive maintenance (TPM)	101	0	5	1.31	1.984	1.163	−0.393
LeanSOP	Lean3–21	Standard operations	98	0	5	0.84	1.697	1.798	1.541
LeanTQC	Lean4–23a	Total quality control	101	0	5	2.73	2.172	−0.126	−1.777
LeanSMED	Lean5–26	Set-up time reduction	101	0	5	4.01	1.847	−1.512	0.497
LeanMultiFunc	Lean6–34poliv	Multi-function employees	100	0	5	0.77	1.441	1.859	2.262
PerfAdapt	p30asat	Adaptation of the product to the characteristics requested by the client	100	3	5	4.09	0.555	0.062	0.223
PerfQ	p30bsat	Product quality	101	3	5	4.13	0.627	−0.099	−0.463
PerfFluctDem	p30csat	Capacity to adjust production to meet fluctuating demand	101	1	5	3.58	1.013	−0.087	−0.831
PerfCost	p30dsat	Production costs	101	1	5	3.13	1.093	−0.379	−0.464
PerfSpeed	p30esat	Speed of order completion	101	1	5	3.60	0.960	−0.925	0.955
PerfMot	p30gsat	Employee motivation	101	1	5	3.28	0.991	−0.397	−0.253

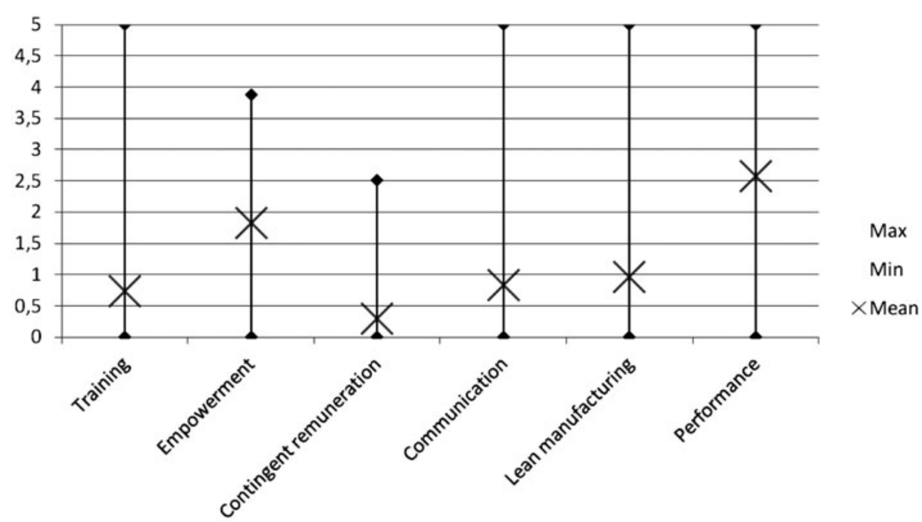

Figure 2. Minimum, maximum and mean of the variables.

4. Results and discussion

Tables 1a and 1b and Figure 2 show the descriptive statistics of the items. Practically, all the plants responded to the 30 items on the questionnaire. The missing data are scarce and not a problem for the set of data collected. For most items, the distribution of responses has an average that is very low or medium-to-low on the scale. On some items, standard deviations are a little high for a scale with 5 response levels (TrainClean, TrainSOP, LeanTPM, LeanTQC, LeanSMED). Skewness is high in several items (TrainData, TrainGPS, TrainSmed, TrainTeam, ContRewGr, ContRewGain, LeanSugGr), and kurtosis is extremely high in the same items. In other words, there is a clear departure from a normal curve, and most of the responses are distributed throughout the scale with more peaks than in a normal distribution, concentrating at the lower part of the scale. The only exceptions to this are the LeanTQC and LeanSMED variables and the result variable (PerfAdapt), which present a distribution that is more similar to the normal curve, with the responses somewhat concentrated in the higher part of the scale. The results variables have a floor effect (the first or third value on the scale), and the all the empowerment items have a ceiling effect.

All the plants visited have a very similar plant distribution, and none can be classified as cellular manufacturing plants. Likewise, the Kanban system was absent from all of them. Some plants were using material requirement planning systems for production planning, but none of them used a pull system or levelled the production. We can classify the ceramic tile industry as a rigid continuous process (Lyons et al. 2013): equipment flexibility is limited and flow is unidirectional. Manufacturing is supported by structured quality and process systems, and procedures including ISO9000 or equivalent standards. The production process involves dispersing active components into solutions in either aqueous or organic media. These are then applied using a variety of methods onto a tile in a continuous process. The product itself has a very simple structure, but glazing or product formulations are complex. Production is not pulled or paced to a takt time; instead, production is make-to-stock, and the notions of 'pull' and takt time are not identified within the facilities. Manufacturing equipment is not dedicated, so that production is mixed on the same line. Yields are often unpredictable, which means that production is done in large lots – at least one shift per batch – and buffers are set cautiously.

Table 2 shows descriptive statistics of the variables calculated using direct data. These practices are used very little in these industries, since the average level of use of these tools is between 0.29 and 1.83 (the value that represents 100% use in the factory is 5). However, the variation among factories is very large. Some companies have reached the maximum value on training and communication. However, the most advanced companies are only just above the mid-point of the scale in the use of contingent remuneration. In terms of results, we note that the plant managers' satisfaction with the perceived results is moderately high.

The correlations between items are mostly positive, although low or very low. The maximum correlation value is 0.63 (between TrainClean and LeanMultiFunc), and only 37 out of 450 correlations are higher than 0.40. Most of these moderate correlations are in the construct of training. The values of the collinearity statistics are lower than the cut-off values. All items associated with one construct (communication has only one item) have VIF values below 2.1, and the condition indices are as follows: 4.8 for the training construct, 7.59 for empowerment, 1.7 for contingent remuneration, 6.9 for LM and 26.29 for the performance construct. Moreover, the VIF values for the employee involvement constructs are less than 1.21, and the condition index for the construct scores is 5.19. The correlations between constructs (Table 3) are moderatelylow, with the exception of the relationship between training and LM.

Statistics for the structural model (PLS) are presented in Figure 3 and Table 4. All paths on LM are significant, except contingent remuneration (the R2 explained in LM is 0.767). The relationship between LM and performance is relevant and significant ($R^2 = 0.119$). Relationships were found between LM and empowerment (although with a lower level of significance than the rest), training and communication. In sum, the data from our sample confirm that the more employee involvement, the more LM; and the more LM, the greater the performance. Analysing the paths shown in Figure 3, performance seems to be directly affected by LM (direct path = 0.344), while empowerment, training and communication show indirect paths to influence performance (0.042; 0.288; and 0.058 respectively).

Reviewing the coefficients that were found to be significant, there is a positive association between employees' involvement and LM activities, and between LM and performance (like other authors have reported: Ahmad, Schroeder, and Sinha 2003; Bonavia and Marin-Garcia 2006, 2011; Cua, McKone, and Schroeder 2001; Das and Jayaram 2003; Fullerton and McWatters 2002; Holman et al. 2005; Sakakibara et al. 1997; Shah and Ward 2007; Sila 2007), relationships that have not always been found in the literature (Birdi et al. 2008). Only contingent remuneration is not associated with LM. That is, all of the hypotheses have been corroborated except H5, with a lower level of significance for H2.

The first hypothesis, which relates LM and performance, is significant, as in a similar previous study by Vinodh and Joy (2012), except that in this study the type of industry variable has been controlled, which strengthens this relationship (Shah and Ward 2003). LM streamlines the processes, reduces process variations and wastes and, thus, contributes to improving organisational performance and the firm's competitiveness (Fullerton and McWatters 2002; Hallgren and Olhager 2009; Sakakibara et al. 1997).

Regarding the second hypothesis, although there is theoretical evidence that sharing power with employees and increasing their level of autonomy are necessary in order to implement LM (Koufteros and Vonderembse 1998), many

Table 2. Descriptive statistics of the variables.

Description	*N*	Min	Max	Mean	Std. dev.	Skewness	Kurtosis
Training	96	0	5.00	0.73	1.06	2.09	4.24
Empowerment	96	0	3.88	1.83	0.90	0.20	−0.92
Contingent remuneration	96	0	2.51	0.29	0.69	2.51	4.96
Communication	96	0	5.00	0.83	1.64	1.84	1.91
Lean manufacturing	96	0	5.00	0.96	1.19	1.83	2.74
Performance	96	0	5.00	2.58	1.15	−0.13	−0.64

Table 3. Correlations between variables.

	1	2	3	4	5	6
1. Training	1					
2. Empowerment	0.172	1				
3. Contingent remuneration	0.373**	0.064	1			
4. Communication	0.038	0.026	0.083	1		
5. Lean manufacturing	0.850**	0.268**	0.295**	0.202*	1	
6. Performance	0.324**	0.238*	0.106	−0.090	0.344**	1

**indicates $p < .01$.
*indicates $p < .05$.

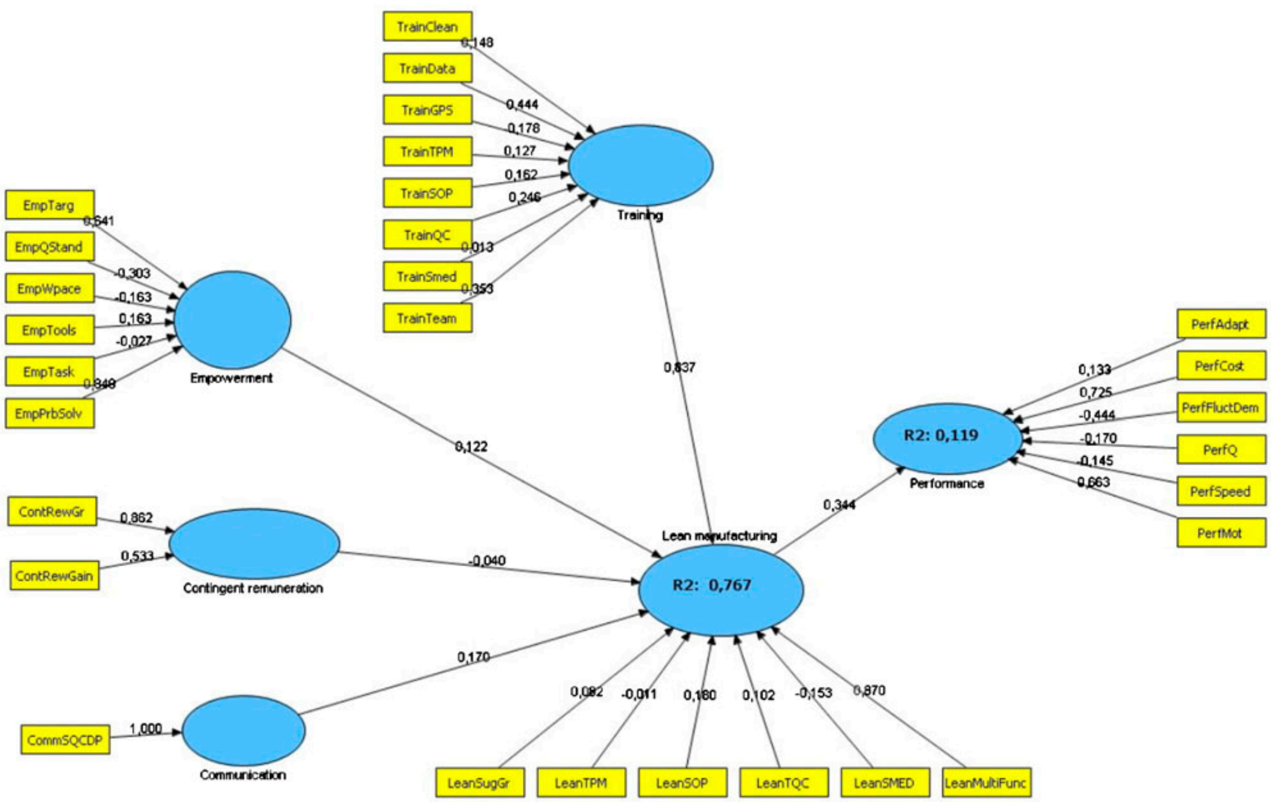

Figure 3. PLS model.

companies may be resisting because they fear that employees could behave opportunistically and against the shared interests of the organisation (Spreitzer and Mishra 1999). These results support the idea that, in this sector, LM has been introduced with some employee consultation, but without changes in the traditional power structures (Fullerton and McWatters 2002; McKone, Schroeder, and Cua 2001). It could be argued that the production process or the technology could impose restrictions that impede greater empowerment of employees. To point out just a few examples, quality standards may be dictated by the customer or the work pace may be controlled by machinery. Even so, the results reveal that in cases where the level of employees' empowerment increases, there is a greater deployment of LM.

Without a doubt, the strongest relationship appears for the effects of training on LM, coinciding with results from many other studies (Bonavia and Marin-Garcia 2011; Brown and Mitchell 1991; Forza 1996; Hiltrop 1992; Molleman and van den Beukel 2007; Power and Sohal 2000; Sakakibara et al. 1997). The difference lies in the fact that this study has used a rigorous and potent methodology for detecting these relationships (PLS), which makes it possible, based on the use of different methods, to corroborate the hypotheses proposed and increase the confidence in the results obtained, thus making a new contribution to the previous research.

Table 4. PLS analysis, paths and bootstrapping values.

Endogenous construct	Exogenous construct	Hypothesis	Path coefficients	Sample mean	Standard Error	t-value	Lower 95% CI	Upper 95% CI
Lean manufacturing	Empowerment	H2	**0.122***	0.113	0.062	1.989	0.012	0.243
	Training	H3	**0.837****	0.842	0.084	9.949	0.633	0.974
	Communication	H4	**0.170****	0.126	0.069	2.476	0.006	0.273
	Contingent remuneration	H5	−0.040	−0.079	0.057	0.695	−0.211	−0.004
Performance	Lean manufacturing	H1	**0.344****	0.451	0.085	4.067	0.291	0.610

Notes: In bold significant paths *t*-value above 1.65 marked as * (5%) and 2.32 marked as ** (1%). One-tailed and 999 degrees of freedom. Confidence interval (CI) calculated with nonparametric bootstrap procedure.

Regarding the fourth hypothesis, providing employees with information about costs, productivity, quality and performance favours the implementation of LM. As Gibson et al. (2007) stated, employees who have a greater understanding of results can be more adept at adjusting their behaviours to achieve the goals set, increasing their ability to be proactive, identify and act on opportunities, display initiative, and persevere until change occurs. For this reason, Cua, McKone, and Schroeder (2001) have considered the use of information and feedback to be a practice that is common to TQM, JIT and TPM. This practice, together with other common practices such as training and empowerment (which Cua, McKone, and Schroeder 2001, called employee involvement), guarantees the success of the implementation of LM programmes.

However, the fifth hypothesis, which states that contingent remuneration is positively related to LM, was not supported. Companies that had decided to adopt LM could be expected to similarly adapt their compensation systems (Fullerton and McWatters 2002), favouring gain-sharing plans and remuneration based on group effort, but this was not the case. The firms, regardless of their interest in LM, mainly continued to pay their employees a fixed salary established by their job classification and/or seniority (Bonavia and Marin-Garcia 2011; EPOC Research Group 1997; Marin-Garcia, Bonavia, and Miralles Insa 2008a; Snell and Dean 1992). As Fullerton and McWatters (2002) noted, LM implementation is impeded by an incompatible incentive system; that is, the strategy of some firms has changed to LM, but the motivation to adopt LM by employees has not been put into place. As research has shown (Cappelli and Neumark 2001), the reality is that the management of the companies may not be willing to accept the economic costs that accompany contingent remuneration.

5. Implications, limitations and conclusions

Our study aims to empirically test the effect employee involvement has on LM, and the effect LM has on the outcomes in the factory. These effects are tested by recording plant manager perceptions in an industry different from those usually studied in previous research: ceramic manufacturers in Spain, a highly competitive and internationally successful sector (ASCER 2003, 2007).

Our contribution responds to the need identified in the literature to examine the factors that affect LM implementation (Marodin and Saurin 2013) and its outcomes in process industries (Lyons et al. 2013). First, our study makes it possible to explore the degree of implementation of LM practices in rigid continuous processes, and the positive effect they have on performance, even when not introduced as a compact system and implemented only to a relatively moderate degree. Second, it confirms the role of training, communication and empowerment as antecedents of LM. Finally, it helps to reflect on the contextual determinants that can keep rewards systems from acting as influences or antecedents of LM.

Our results seem to support the idea that success in implementing LM depends as much on mindset changes as on using the practices, tools and techniques (Dabhilkar and Ahlstrom 2007; Martínez-Jurado, Moyano-Fuentes, and Gómez 2013; Nordin et al. 2011; Snell and Dean 1992; Spear and Bowen 1999). In other words, LM depends on employees' involvement in lean activities, which is produced by giving them more empowerment, training, information and new forms of compensation.

However, such changes are uncommon in the traditionally conservative ceramic industry. In the companies studied, advanced operational management and employee involvement practices have scarcely been introduced. Therefore, several interesting issues are raised that we intend to address in future research. For example, why are companies reluctant to empower their employees? Why not update their payment systems? Are there restrictions imposed by the nature of the product being manufactured, or by the process, which prevent a greater use of LM practices? What are management's opinions about LM and employee involvement – and are these views conditioned by the degree of use? Case study work would be especially useful in gathering the data needed for such an analysis.

This study also has implications for company management because it provides a tool for auditing the level of use of various practices and outcomes. An assessment can be made of the current situation, as well as any future changes produced by the introduction of new practices.

Our research has some limitations. First, no previous study has used exactly the same variables together, although all the items used in our research were adapted from previous studies. Therefore, it is not easy to accurately compare equation coefficients with the results of previous investigations. A second limitation stems from the fact that the study was conducted in the context of a single country and industry, and therefore, our results can not be applied to other cases. A third limitation is that there was a certain no response, although the response rate was very high. Furthermore, independent and dependent variables were measured using the same survey instrument, and this may have caused common method variance and potential common method bias. Another potential limitation is the bias of single informants. Although the use of single informants is widespread in operations management research, higher quality data is produced using multiple informants. Accepted methodological guidelines were followed to alleviate potential problems associated with using single informants. For instance, face-to-face interviews were used with the plant manager, and subsequent factory visits were made to confirm and review the responses.

Acknowledgements

This paper has been written with financial support from the Project "Path Dependence and decision-making for selecting LM tools and practices" (PAID-06-12-SP20120717) of the Universitat Politècnica de València.

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