Relationship between Lean Manufacturing and Employee Involvement and its effects on Operational Performance

Juan A. Marin-Garcia

Department of Business Administration-ROGLE
Polytechnic University of Valencia
Valencia
Spain

Tomas Bonavia

Department of Social Psychology
University of Valencia
Valencia
Spain

Corresponding autor: Juan A. Marin-Garcia
ROGLE- Dpto. Organización de Empresas, Universidad Politécnica de Valencia, ETSII-Edificio 7D, Camino de Vera s/n 46022 Valencia (Spain).
Tel.: 34.963 877 707- Ext.: 76853. Fax: 34.963 877 689. E-mail: jamarin@omp.upv.es

Tomas Bonavia
Facultad de Psicología. Dpto. de Psicología Social. Av. Blasco Ibáñez, 21. 46010 Valencia (Spain).
Tel.: ++96 386 45 68. Fax: ++96 386 46 68. E-mail: Tomas.Bonavia@uv.es

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.

Relationship between Employee Involvement and Lean Manufacturing and its effect on Performance in a Rigid Continuous Process Industry

Abstract

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 operationalized through 4 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 (PLS). 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 et al. 2001; Fullerton et al. 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 et al. 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, multistage 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; Das and Jayaram 2003; Holman et al. 2005; Kochan and Lansbury 1997; Yates et al. 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 et al. 2003; Alfalla-Luque et al. 2012; Birdi et al. 2008). Furthermore, various studies have mentioned the need to include workforce involvement practices in the analysis of LM models (Flynn et al. 1995; Sakakibara et al. 1997; Cua et al. 2001). Specifically, Cua et al. (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 work force into a source of sustainable competitive advantage (Guerrero and Barraud-Didier 2004; Guthrie et al. 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 organizational 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; Tari et al. 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 et al. 2012; Lawler et al. 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 organizational performance (Birdi et al. 2008; Cua et al. 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 generalized). 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 toward 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 et al. 1999; Hervas-Oliver and Albors-Garrigos 2009; Rowley 1996). These firms make their production processes more flexible for various reasons (Ibañez-Fores et al. 2013; Rowley 1996; Vallada et al. 2005). This exceptionally dynamic industry faces changing demands and increasingly stiff international competition due to globalisation (Alegre-Vidal et al. 2004). The manufacturers are found in very specific geographical areas where news about innovations in products and processes spreads fast (Gil et al. 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 et al. 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 et al. 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.

The present study makes it possible to extend the existing results on LM by 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 generalizable 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 the present study, we focus mainly on practices of waste elimination (5s, visual controls, standard operations, TPM, quick changeover, statistical process control) and workforce involvement (quality circles, 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 et al. 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 et al. 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 generalize 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: 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 et al. 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 et al. 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 organization practices that encourage employee involvement in companies (Cua et al. 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 et al. 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) state, among the different theories of employee involvement, the practices are commonly categorized 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); and second, the influence of employees in daily decisions such as setting objectives, assigning tasks or job rotation (Delbridge et al. 2000). Empowerment has been described as critical to successful Just-in-Time (JIT) initiation and implementation (Koufteros and Vonderembse 1998; Bayo-Moriones et al. 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 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 et al. 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 et al. (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 et al. 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.

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 et al. 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 organization’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 organization (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.

INSERT FIGURE 1, PLEASE

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 was 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 minutes. 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 minutes 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 et al. 2001; Forza 1996; Fullerton and McWatters 2001; Lawler 1991; Marin-Garcia and Conci 2009; McKone et al. 2001; White et al. 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 et al. 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 et al. 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 setup 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, 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 et al. 2001; Marin-Garcia et al. 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 et al. 2004; Tari et al. 2007). The same 0 to 5 scale used to measure the use of LM tools was also used for this variable.

Communication was measured (Cua et al. 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 et al. 2004; Lawler et al. 2001; Marin-Garcia et al. 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 1-5 (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 et al. 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 the present study. To do so, it is necessary to specify whether the measurement model should be reflective or formative (Hair et al. 2013; Jarvis et al. 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 et al. 2003).

The effect of the relationship between LM and employee involvement on performance is evaluated using Partial Least Squares (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 the present 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 maximize the R2 (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 non-parametric 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 α=0.05 two tailed).

We will analyse the path weighting scheme with standardized 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 non-parametric confidence intervals (Christophersen and Konradt 2008; Hair et al. 2012, 2013; Henseler et al. 2009). In the descriptive statistics analysis, special attention will be paid to missing values, patterns of no response, ranges of response values, skewedness and kurtosis (Doval Dieguez and Viladrich Segués 2011; Viladrich Segués and Doval Dieguez 2011). Inter/item correlations will also be analysed to detect the maximum value on training and communication. However, the most advanced companies are only just above the midpoint 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.

INSERT TABLE 2, PLEASE

INSERT FIGURE 2, PLEASE

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: 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 moderate-low, with the exception of the relationship between training and LM.

INSERT TABLE 3, PLEASE

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 (R2 = 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).

INSERT FIGURE 3, PLEASE

INSERT TABLE 4, PLEASE

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 et al. 2003; Bonavia and Marin-Garcia 2006, 2011; Cua et al. 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 the present 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 organizational 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 companies may be resisting because they fear that employees could behave opportunistically and against the shared interests of the organization (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 et al. 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 the present 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.

Regarding the fourth hypothesis, providing employees with information about costs, productivity, quality and performance favours the implementation of LM. As Gibson et al. (2007) state, 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 et al. (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 et al. 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 et al. 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 et al. 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 by 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.

6. References

Ahmad, S., Schroeder, R.G., and Sinha, K.K. 2003. "The Role of Infrastructure Practices in the Effectiveness of JIT Practices: Implications for Plant Competitiveness". *Journal of Engineering and Technology Management* 20 (3) 161-191.

Albors-Garrigos, J., Hervas-Oliver, J.L., and Beatriz-Marquez, P. 2008. "When Technology Innovation is not Enough: New Competitive Paradigms. Revisiting the Spanish Ceramic Tile Sector". *International Journal of Technology Management* 44 (3/4) 406–426.

Alegre-Vidal, J., Lapiedra-Alcamí, R., and Chiva-Gómez, R. 2004. "Linking Operations Strategy and Product Innovation: An Empirical Study of Spanish Ceramic Tile Producers". *Research Policy* 33(5) 829-839.

Alfalla-Luque, R., Marin-Garcia, J.A., and Medina-López, C. 2012. "Is Worker Commitment Necessary for Achieving Competitive Advantage and Customer Satisfaction when Companies Use HRM and TQM Practices?" *Universia Business Review* (36) 64-89.

Andrés Romano, C. 2001. *Problemática de programación de producción en la empresa cerámica.* PhD diss., Universitat Politecnica de Valencia.

ASCER 2003. *El sector español de fabricantes de baldosas cerámicas*. Castellón: Asociación de Fabricantes de Azulejos, Pavimentos y Baldosas Cerámicas. Área de Estudios y Asuntos Económicos.

ASCER 2007. *El sector en cifras. Informe anual*. Castellón: Asociación de Fabricantes de Azulejos, Pavimentos y Baldosas Cerámicas (available from: www.spaintiles.info).

Azadegan, A., Patel P.C., Zangoueinezhad, A., and Linderman, K. 2013. "The Effect of Environmental Complexity and Environmental Dynamism on Lean Practices". *Journal of Operations Management* 31 (4) 193-212.

Bayo-Moriones, A., Bello-Pintado, A., and Merino-Díaz, J. 2008. "The Role of Organizational Context and Infrastructure Practices in JIT Implementation". *International Journal of Operations & Production Management* 28 (11) 1042-1066.

Benson, G.S., Finegold, D., and Mohrman, S. 2004. "You Paid for the Skills, Now Keep Them: Tuition-Reimbursement and Voluntary Turnover". *Academy of Management Journal* 47 (3) 315-333.

Benson, G.S. and Lawler III, E.E. 2005. "Employee Involvement: Utilization, Impacts, and Future Prospects". In Holman, D., Wall, T.D., Clegg C.W., Sparrow, P., and Howard, A. *The Essentials of the New Workplace: A Guide to the Human Impact of Modern Working Practices*. John Wiley & Sons, 153-172 (Chapter 9).

Birdi, K., Clegg, C., Patterson, M., Robinson, A., Stride, C.B., Wall, T.D., and Wood, S.J. 2008. "The Impact of Human Resource and Operational Management Practices on Company Productivity: A Longitudinal Study". *Personnel Psychology* 61 (3) 467-501.

Blackstone, J.H. 2008. APICS Dictionary. *The Standard for the Excellence in the Operations Management Profession*. APICS.

Bonavia, T. and Marin-Garcia, J.A. 2006. "An Empirical Study of Lean Production in Ceramic Tile Industries in Spain". *International Journal of Operations & Production Management* 26 (5) 505-531.

Bonavia, T. and Marin-Garcia, J. A. 2011. "Integrating Human Resource Management into Lean Production and their Impact on Organizational Performance". *International Journal of Manpower* 32 (8) 923-938.

Brown, K.A. and Mitchell, T.R. 1991. "A Comparison of Just-in-Time and Batch Manufacturing: The Role of Performance Obstacles". *Academy of Management Journal* 34 (4) 906-917.

Cappelli, P. and Neumark, D. 2001. "Do High-Performance Work Practices Improve Establishment-Level Outcomes?". *Industrial and Labor Relations Review* 54 (4) 737-775.

Chiva, R. and Alegre, J. 2009. "Organizational Learning Capability and Job Satisfaction: An Empirical Assessment in the Ceramic Tile Industry". *British Journal of Management* 20 (3) 323-340.

Christophersen, T. and Konradt, U. 2008. "The Development of a Formative and a Reflective Scale for the Assessment of On-Line Store Usability". *Journal of Systemics, Cybernetics and Informatics* 6 (5) 36-41.

Coltman, T., Devinney, T.M., Midgley, D.F., and Venaik, S. 2008. "Formative versus Reflective Measurement Models: Two Applications of Formative Measurement". *Journal of Business Research* 61 (12) 1250-1262.

Combs, J., Liu, Y., Hall, A., and Ketchen, D. 2006. "How Much Do High-Performance Work Practices Matter? A Meta-Analysis of their Effects on Organizational Performance". *Personnel Psychology* 59 (3) 501-528.

Cua, K., McKone, K., and Schroeder, R.G. 2001. "Relationships between Implementation of TQM, JIT, and TPM and Manufacturing Performance". *Journal of Operations Management* 19 (6) 675-694.

Dabhilkar, M. and Ahlstrom, P. 2007. "The Impact of Lean Production Practices and Continuous Improvement Behavior on Plant Operating Perfomance". Paper presented at the 8th International CINet Conference.

Das, A. and Jayaram, J. 2003. "Relative Importance of Contingency Variables for Advanced Manufacturing Technology". *International Journal of Production Research* 41 (18) 4429-4452.

Delbridge, R., Lowe, J., and Oliver, N. 2000. "Shopfloor Responsibilities under Lean Teamworking". *Human Relations* 53 (11) 1459-1479.

Dennis, D. and Meredith, J. 2000. "An Empirical Analysis of Process Industry Transformation Systems". *Management Science* 46 (8) 1085-1099.

Diamantopoulos, A. and Winklhofer, H.M. 2001. "Index Construction with Formative Indicators: An Alternative to Scale Development". *Journal of Marketing Research* 38 (2) 269-277.

Dora, M., Kumar, M., Van Goubergen, D., Molnara, A., and Gellynck, X. 2013. "Operational Performance and Critical Success Factors of Lean Manufacturing in European Food Processing SMEs". *Trends in Food Science & Technology* 31 (2) 156-164.

Doval Dieguez, E. and Viladrich Segués, M.C. 2011. *Desarrollo y adaptación de cuestionarios en el ámbito de la salud*. Bellaterra: Laboratori d'Estadística Aplicada i de Modelització (UAB).

EPOC Research Group. 1997. *New Forms of Work Organisation: Can Europe Realise its Potential? Results of a Survey of Direct Employee Participation in Europe*. Luxembourg: European Foundation for the Improvement of Living and Working Conditions.

Flynn, B.B. and Sakakibara, S. 1995. "Relationship between JIT and TQM: Practices and Performance". *Academy of Management Journal* 38 (5), 1325-1338.

Fortuny-Santos, J., Cuatrecasas-Arbos, L., Cuatrecasas-Castellsaques, O., and Olivella-Nadal, J. 2008. "A Methodology to Implement Lean Management in Industrial Plants". *Universia Business Review* (20) 28-41.

Forza, C. 1996. "Work Organization in Lean Production and Traditional Plants: What are the Differences". *International Journal of Operations & Production Management* 16 (2) 42-62.

Fullerton, R.R. and McWatters, C.S. 2001. "The Production Performance Benefits from JIT Implementation". *Journal of Operations Management* 19 (1) 81-96.

Fullerton, R.R. and McWatters, C.S. 2002. "The Role of Performance Measures and Incentive Systems in Relation to the Degree of JIT Implementation". *Accounting, Organizations and Society* 27 (8) 711-735.

Fullerton, R.R., McWatters, C.S., and Fawson, C. 2003. "An Examination of the Relationships between JIT and Financial Performance". *Journal of Operations Management* 21 (4) 383-404.

Gerhart, B., Wright, P., McMahan, G., and Snell, S. 2000. "Measurement Error in Research on Human Resources and Firm Performance: How much Error is there and does it Influence Effect Size Estimates?". *Personnel Psychology* 53 (4) 803-834.

Geyskens, I., Krishnan, R., Steenkamp, J.B., and Cunha, P.V. 2009. "A Review and Evaluation of Meta-Analysis Practices in Management Research". *Journal of Management* 35 (2) 393-419.

Gibson, C.B., Porath, C.L., Benson, G.S., and Lawler III, E.E. 2007. "What Results When Firms Implement Practices: The Differential Relationship Between Specific Practices, Firm Financial Performance, Customer Service, and Quality". *Journal of Applied Psychology* 92 (6) 1467-1480.

Gil, I., Guarch, J.J., and Andrés, C. 1999. "La industria cerámica de la comunidad valenciana en el ámbito nacional y europeo". *Boletín de la Sociedad Española de Cerámica y Vidrio* 38 (2) 133-141.

Guerrero, S. and Barraud-Didier, V. 2004. "High-Involvement Practices and Performance of French Firms". *International Journal of Human Resource Management* 15 (8) 1408-1423.

Guthrie, J.P., Spell, C.S., and Nyamori, R.O. 2002. "Correlates and Consequences of High Involvement Work Practices: the Role of Competitive Strategy". *International Journal of Human Resource Management* 13 (1) 183-197.

Hair, J.F., Anderson, R.E., Tatham, R.L., and Black, W.C. 1999. *Análisis de datos multivariante*. 4º ed. Prentice Hall.

Hair, J.F., Hult, G.T., Ringle, C.M., and Sarstedt, M. 2013. *A Primer on Partial Least Squares Structural Equation Modelling (PLS-SEM).* Thousand Oaks: Sage.

Hair, J.F., Sarstedt, M., Ringle, C.M., and Mena, J. 2012. "An Assessment of the Use of Partial Least Squares Structural Equation Modelling in Marketing Research". *Journal of the Academy of Marketing Science* 40 (3) 414-433.

Hallgren, M. and Olhager, J. 2009. "Lean and Agile Manufacturing: External and Internal Drivers and Performance Outcomes". *International Journal of Operations & Production Management* 29 (10) 976-999.

Henseler, J., Ringle, C. M., and Sinkovics, R. R. 2009. "The Use of Partial Least Squares Path Modeling in International Marketing". In Sinkovics, R.R. and Pervez, N.G. *New Challenges to International Marketing*. Emerald, 277-319.

Hervas-Oliver, J.L. and Albors-Garrigos, J. 2009. "The Role of the Firm's Internal and Relational Capabilities in Clusters: When Distance and Embeddedness Are Not Enough to Explain Innovation". *Journal of Economic Geography* 9 (2) 263-283.

Hiltrop, J.M. 1992. "Just-in-time Manufacturing: Implications for the Management of Human Resources". *European Management Journal* 10 (1) 49-55.

Holman, D., Wall, T.D., Clegg C.W., Sparrow, P., and Howard, A. 2005. *The Essentials of the New Workplace: A Guide to the Human Impact of Modern Working Practices*. John Wiley & Sons.

Huselid, M. and Becker, B. 1996. "Methodological Issues in Cross-sectional and Panel Estimates of the Human Resource-firm Performance Link". *Industrial Relations* 35 (3) 400-422.

Ibañez-Fores, V., Bovea, M.D., and Azapagic, A. 2013. "Assessing the Sustainability of Best Available Techniques (BAT): Methodology and Application in the Ceramic Tiles Industry". *Journal of Cleaner Production* 51 162-176.

Jackson, T. and Dyer, C. 1998. *Diagnóstico corporativo: una herramienta para alcanzar la excelencia*. Madrid: TGP Hoshin (Productivity Press).

Jarvis, C.B., MacKenzie, S.B., and Podsakoff, P.M. 2003. "A Critical Review of Construct Indicators and Measurement Model Misspecification in Marketing and Consumer Research". *Journal of Consumer Research* 30 (2) 199-218.

Jiménez, E., Tejeda, A., Pérez, M., Blanco, J., and Martínez, E. 2012. "Applicability of Lean Production with VSM to the Rioja Wine Sector". *International Journal of Production Research* 50 (7) 1890-1904.

Jun, M., Cai, S., and Shin, H. 2006. "TQM Practice in Maquiladora: Antecedents of Employee Satisfaction and Loyalty". *Journal of Operations Management* 24 (6) 791-812.

Karlsson, C. and Ahlström, P. 1996. "Assessing Changes toward Lean Production". *International Journal of Operations & Production Management* 16 (2) 24-41.

Kim, D.O. and Bae, J. 2005. "Workplace Innovation, Employment Relations and HRM: Two Electronics Companies in South Korea". *International Journal of Human Resource Management* 16 (7) 1277-1302.

Knudsen, H. 1995. *Employee Participation in Europe*. London: Sage.

Kochan, T.A. and Lansbury, R.D. 1997. "Lean Production and Changing Employment Relations in the International Auto Industry". *Economic and Industrial Democracy* 18 (4) 597-620.

Koufteros, X.A., Nahm, A.Y., Edwin Cheng, T.C., and Lai, K.H. 2007. "An Empirical Assessment of a Nomological Network of Organizational Design Constructs: From Culture to Structure to Pull Production to Performance". *International Journal of Production Economics* 106 (2) 468-492.

Koufteros, X.A. and Vonderembse, M.A. 1998. "The Impact of Organizational Structure on the Level of JIT Attainment: Towards Theory Development". *International Journal of Production Research* 36 (10) 2863-2878.

Lawler III, E.E. 1991. *High Involvement Management.* San Francisco: Jossey-Bass.

Lawler III, E.E. 1996. *La ventaja definitiva.* Barcelona: Granica.

Lawler III, E.E., Mohrman, S., and Benson, G. 2001. *Organizing for High Performance: Employee Involvement, TQM, Reengineering, and Knowledge Management in the Fortune 1000. The CEO Report.* San Francisco: Jossey-Bass.

Lyons, A.C., Vidamour, K., Jain, R., and Sutherland, M. 2013. "Developing an Understanding of Lean Thinking in Process Industries". *Production Planning & Control* 24 (6) 475-494.

MacDuffie, J.P. 1995. "Human Resource Bundles and Manufacturing Performance: Organizational Logic and Flexible Production Systems in the World Auto Industry". *Industrial & Labor Relations Review* 48 (2) 199-221.

Marin-Garcia, J.A., Bonavia, T., and Miralles Insa, C. 2008a. "The Use of Employee Participation in the USA and Spanish Companies". *International Journal of Management Science and Engineering Management* 3 (1) 71-80.

Marin-Garcia, J.A. and Carneiro, P. 2010. "Desarrollo y validación de un modelo multidimensional de la producción ajustada". *Intangible Capital* 6 (6) 78-127.

Marin-Garcia, J.A. and Conci, G. 2009. "Exploratory Study of High Involvement Work Practices: Identification of the Dimensions and Proposal of a Questionnaire to Measure the Degree of Use in the Company". *Intangible Capital* 5 (3) 278-300.

Marin-Garcia, J.A., Pardo del Val, M., and Bonavia, T. 2008b. "Longitudinal Study of the Results of Continuous Improvement in an Industrial Company". *Team Performance Management* 14 (1/2) 56-69.

Marodin, G.A. and Saurin, T.A. 2013. "Implementing Lean Production Systems: Research Areas and Opportunities for Future Studies". *International Journal of Production Research* 51 (22) 6663-6680.

Martínez-Jurado, P.J., Moyano-Fuente, J., and Jerez, P. 2013. "HR Management during Lean Production Adoption". *Management Decision* 51 (4) 742-760.

McKone, K.E., Schroeder, R.G., and Cua, K.O. 2001. "The Impact of Total Productive Maintenance Practices on Manufacturing Performance". *Journal of Operations Management* 19 (1) 39-58.

Mehrjerdi, Y.Z. 2012. "Measuring the Leanness of Suppliers Using Principal Component Analysis Technique". *South African Journal of Industrial Engineering* 23 (1) 130-138.

Molleman, E. and van den Beukel, A. 2007. "Worker Flexibility and Its Perceived Contribution to Performance: The Moderating Role of Task Characteristics". *Human Factors and Ergonomics in Manufacturing* 17 (2) 117-135.

Moyano-Fuentes J. and Sacristan-Diaz, M. 2012. "Learning on Lean: A Review of Thinking and Research". *International Journal of Operations & Production Management* 32 (5) 551-582.

Murphy, G.D. and Southley, G. 2003. "High Performance Work Practices: Perceived Determinants of Adoption and the Role of the HR Practitioner". *Personnel Review* 32 (1) 73-92.

Nair, A. 2006. "Meta-Analysis of the Relationship between Quality Management Practices and Firm Performance: Implications for Quality Management Theory Development". *Journal of Operations Management* 24 (6) 948-975.

Nordin, N., Deros, B.M., Wahab, D.A., and Ab Rahman, M.N. 2011. "Managing Change in Lean Manufacturing Implementation". *Advanced Materials Research* 314 2105-2111.

Panizzolo, R., Garengo, P., Kumar-Sharma, M., and Gore, A. 2012. "Lean Manufacturing in Developing Countries: Evidence from Indian SMEs". *Production Planning & Control* 23(10) 769-788.

Petter, S., Straub, D., and Rai, A. 2007. "Specifying Formative Constructs in Information Systems Research". *Mis Quarterly* 31 (4) 623-656.

Pheng, L.S. and Teo, J.A. 2004. "Implementing Total Quality Management in Construction Firms". *Journal of Management in Engineering* 20 (1) 8-15.

Poole, M. 1995. *Hacia una nueva democracia industrial: la participación de los trabajadores en la industria.* Madrid: Ministerio de Trabajo y Seguridad Social.

Power, D.J. and Sohal, A.S. 2000. "An Empirical Study of Human Resource Management Strategies and Practices in Australia Just-In-Time Environments: Australian Case Study Evidence". *International Journal of Operations & Production Management* 20 (8) 932-958.

Ringle, C. M., Wende, S., and Will, A. 2005. *SmartPLS 2.0 (Beta)*. Available from: http://www.smartpls.de. Hamburg, Germany.

Rodriguez, J.M. and Ventura, J. 2003. "Human Resource Management Systems and Organizational Performance: An Analysis of the Spanish Manufacturing Industry". *International Journal of Human Resource Management* 14 (7) 1206-1226.

Rowley, C. 1996. "Flexible Specialisation: Some Comparative Dimensions and Evidence from the Ceramic Tile Industry". *New Technology, Work and Employment* 11 (2) 125-136.

Sakakibara, S., Flynn, B.B., Schroeder, R.C., and Morris, W.T. 1997. "The Impact of Just-In-Time Manufacturing and its Infrastructure on Manufacturing Performance". *Management Science* 43 (9) 1246-1257.

Shah, R. and Ward, P.T. 2003. "Lean Manufacturing: Context, Practice Bundles, and Performance". *Journal of Operations Management* 21 (2) 129-149.

Shah, R. and Ward, P.T. 2007. "Defining and Developing Measures of Lean Production". *Journal of Operations Management* 25 (4) 785-805.

Sila, I. 2007. "Examining the Effects of Contextual Factors on TQM and Performance through the Lens of Organizational Theories: An Empirical Study". *Journal of Operations Management* 25 (1) 83-109.

Snell, S.A. and Dean, J.W. 1992. "Integrated Manufacturing and Human Resource Management: A Human Capital Perspective". *Academy of Management Journal* 35 (3) 467-504.

Spear, S. and Bowen, H.K. 1999. "Decoding the DNA of the Toyota Production System". *Harvard Business Review* (Sept. - Oct.) 97-106.

Spreitzer, G.M. and Mishra, A.K. 1999. "Giving Up Control Without Losing Control: Trust and its Substitutes' Effects on Managers' Involving Employees in Decision Making". *Group & Organization Management* 24 (2) 155-187.

Tari, J.J., Molina, J.F., and Castejón, J.L. 2007. "The Relationship between Quality Management Practices and Their Effects on Quality Outcomes". *European Journal of Operational Research* 183 (2) 483-501.

Thongrattana, P. T. 2010. "Assessing Reliability and Validity of a Measurement Instrument for Studying Uncertain Factors in Thai Rice Supply Chain". Paper presented at SBS HDR Student Conference.

Tomás Carpi, J.A., Banyuls i Llopis, J., Cano Cano, E., Contreras Navarro, J.L., Gallego Bono, J.R., Picher i Campos, J.V., Such Juan, J., and Torrejón Velardiez, M. 1996. *Cambio técnico-organizativo e impacto en el mercado de trabajo: La industria valenciana. Análisis de los sectores cerámico, calzado, textil y mueble*. Informe de investigación. Valencia: Grupo de Estudios sobre la Dinámica Industrial y Laboral (GREDIL).

Vallada, E., Maroto, C., Ruiz, R., and Segura, B. 2005. "Análisis de la programación de la producción en el sector cerámico español". *Boletín de la Sociedad Española de Cerámica y Vidrio* 44 (1) 39-44.

Viladrich Segués, M.C. and Doval Dieguez, E. 2011. *Medición: fiabilidad y validez*. Bellaterra: Laboratori d'Estadística Aplicada i de Modelització (UAB).

Vinodh, S. and Joy, D. 2012. "Structural Equation Modelling of Lean Manufacturing Practices". *International Journal of Production Research* 50 (6) 1598-1607.

Wang, B.J. 2008. "Analysis of Efficiency of Lean Production Implemented in Multi-National Optic Enterprises". *International Journal of Technology Management* 43 (4) 304-319.

White, R.E., Pearson, J.N., and Wilson, J.R. 1999. "JIT Manufacturing: A Survey of Implementations in Small and Large U.S. Manufacturers". *Management Science* 45 (1) 1-16.

White, R.E. and Prybutok, V. 2001. "The Relationship between JIT Practices and Type of Production System". *Omega* 29 (2) 113-124.

Wickramasinghe, D. and Wickramasinghe, V. 2011. "Perceived Organisational Support, Job Involvement and Turnover Intention in Lean Production in Sri Lanka". *International Journal of Advanced Manufacturing Technology* 55 (5-8) 817-830.

Wilcox, J.B., Howell, R.D., and Breivik, E. 2008. "Questions about Formative Measurement". *Journal of Business Research* 61 (12) 1219-1228.

Wong, C.S., Law, K.S., and Huang, G.H. 2008. "On the Importance of Conducting Construct-Level Analysis for Multidimensional Constructs in Theory Development and Testing". *Journal of Management* 34 (4) 744-764.

Wood, S. and de Menezes, L.M. 2008. "Comparing Perspectives on High Involvement Management and Organizational Performance across the British Economy". *The International Journal of Human Resource Management* 19 (4) 639-683.

Wright, P.M., Gardner, T., Moynihan, L.M., and Allen, M.R. 2005. "The Relationship between HR Practices and Firm Performance: Examining Causal Order". *Personnel Psychology* 58 (2) 409-446.

Yates, C., Lewchuk, W., and Stewart, P. 2001. "Empowerment as a Trojan Horse: New Systems of Work Organization in the North American Automobile Industry". *Economic and Industrial Democracy* 22 (4) 517-541.

Zatzick, C.D. and Iverson, R.D. 2006. "High-Involvement Management and Workforce Reduction: Competitive Advantage or Disadvantage?". *Academy of Management Journal* 49 (5) 999-1015.

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

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 $p < .05$.

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

Note: 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 non-parametric bootstrap procedure.

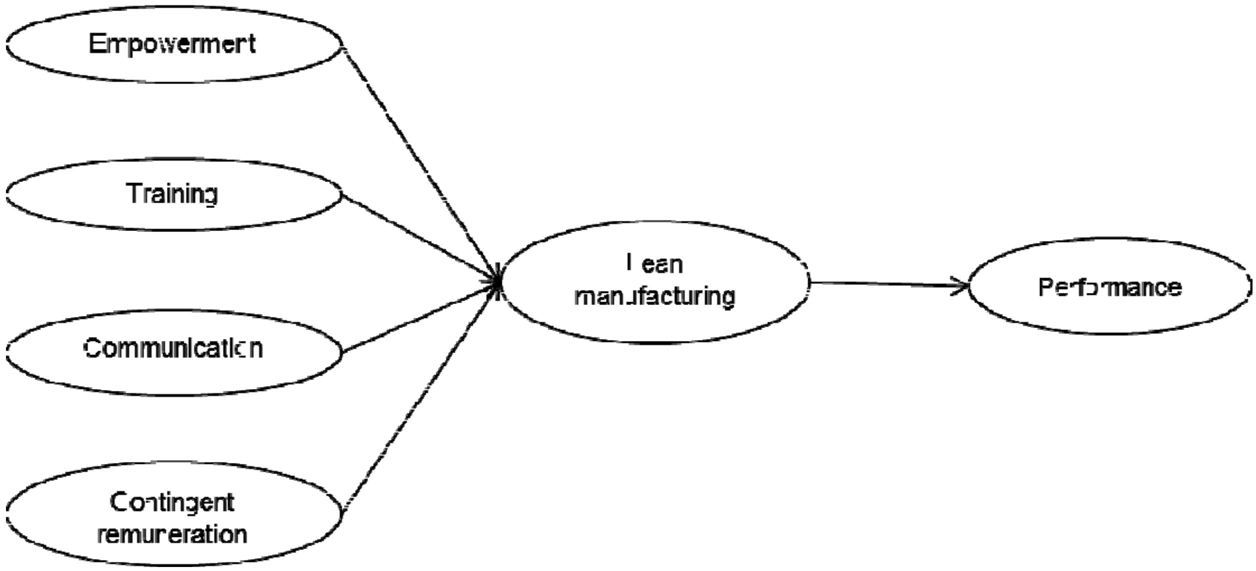

Figure 1. Theoretical Model.

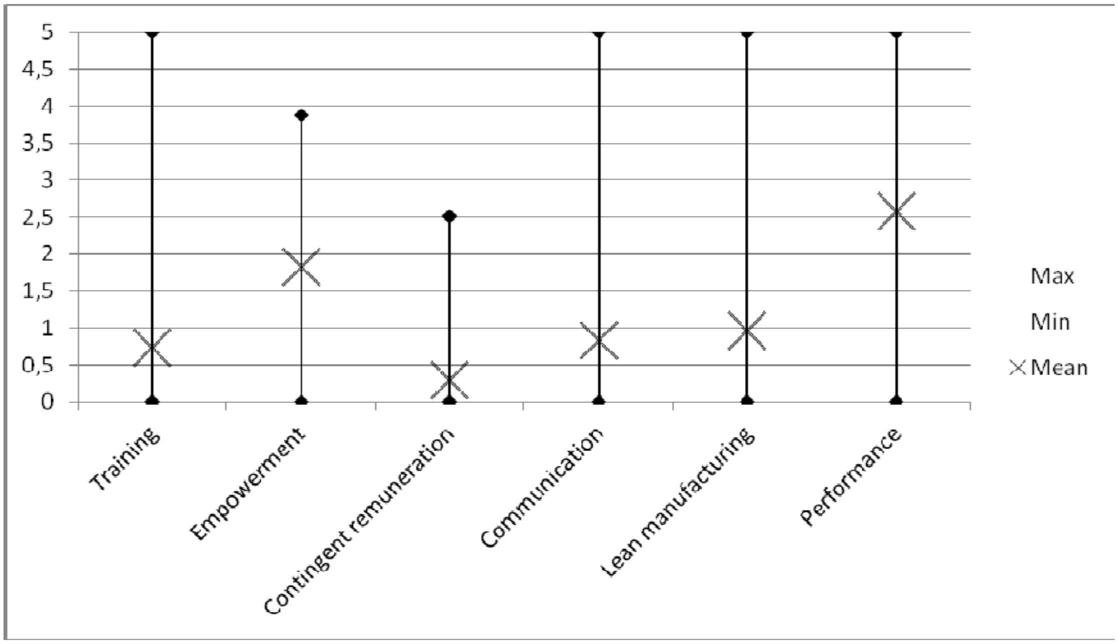

Figure 2. Minimum, maximum and mean of the variables.

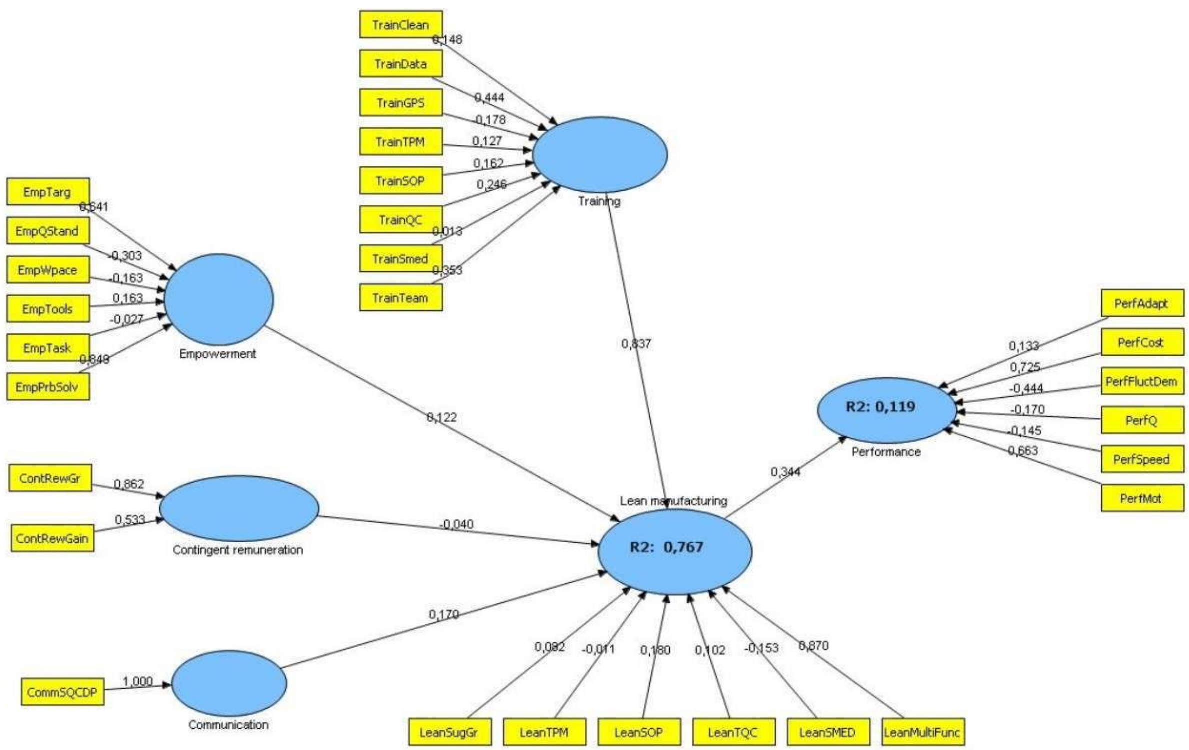

Figure 3. PLS model.