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Marín García, JA.; Bonavía Martín, T. (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.



The final publication is available at

<http://dx.doi.org/10.1080/00207543.2014.975852>

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

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49
50 **Acknowledgements**

51 This paper has been written with financial support from the Project "Path Dependence
52 and decision-making for selecting LM tools and practices" (PAID-06-12-SP20120717)

53 of the Universitat Politècnica de València.
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Relationship between Employee Involvement and Lean Manufacturing and its effect on Performance in a Rigid Continuous Process Industry

11

Abstract

12 This research aims to empirically test the effect of employee involvement on Lean Manufacturing (LM),
13 and the effect of LM on production outcomes. Employee involvement is operationalized through 4 related
14 variables: empowerment, training, contingent remuneration, and communication. The effects are tested by
15 recording management perceptions in a different industrial sector from those usually studied in previous
16 research -ceramic manufacturers, a highly competitive and internationally successful sector. We obtained
17 data from 101 ceramic tile plants (64% of response rate) in the Valencia region of Spain. This approach is
18 developed using a statistical method called Partial Least Squares (PLS). All paths are significant except
19 for contingent remuneration; specifically, relationships were found between empowerment, training,
20 communication and LM, and between LM and performance.
21

22 **Keywords:** Lean production; human resource management; high performance work practices;
23 participation in decision-making; compensation; information-sharing.
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1. Introduction

28 The paradigm of lean production in its different modalities has become a reality in
29 our times (Holman et al. 2005; Spear and Bowen 1999). Numerous articles and books
30 have been published on this topic (Marodin and Saurin 2013; Moyano-Fuentes and
31 Sacristan-Diaz 2012), which is not surprising because most industrial enterprises
32 operate today in an environment of increasing competition, fast change, fluctuating
33 demand and uncertainty (Azadegan et al. 2013). Most markets are mature, and
34 customers demand quality products adapted to their specific needs (Hallgren and
35 Olhager 2009). Consequently, one would expect some degree of implementation of
36 Lean Manufacturing (LM) practices in any sector with strong competition (Shah and
37 Ward 2003; Vinodh and Joy 2012).
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41 Some LM studies have been based on samples of companies from different sectors
42 (Cua et al. 2001; Fullerton et al. 2003; Shah and Ward 2003; Vinodh and Joy 2012).
43 Others have focused on a broad sample of firms from a few sectors, usually the
44 automobile, electronics and machinery industries, although much of the research in
45 these sectors consists of studies of isolated cases (Kim and Bae 2005; Power and Sohal
46 2000; Sakakibara et al. 1997). There is also some evidence of the successful
47 implementation of LM in sectors such as construction (Pheng and Teo 2004), assembly
48 (Jun et al. 2006), optics (Wang 2008) and food processing (Dora et al. 2013). Therefore,
49 various authors have considered it necessary to widen the range of industries in which
50 LM is studied (Hallgren and Olhager 2009; Sakakibara et al. 1997; Shah and Ward
51 2003; Snell and Dean 1992), especially taking into account that the development of LM
52 began in discrete manufacturing and that its application in process industries has hardly
53 been studied and almost always based on results obtained from only one case (Lyons et
54 al. 2013).
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57 Process manufacturing can be defined as ‘production that adds value by mixing,
58 separating, forming and/or performing chemical reactions. It may be done in either
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3 batch or continuous mode' (Blackstone 2008). In this category, different types of firms
4 can be included, and we can classify them in seven distinct process industry subgroups:
5 process job shop, custom blending, fast batch, custom hybrid, stock hybrid, multistage
6 continuous and rigid continuous (Dennis and Meredith 2000). There seems to be some
7 evidence, not yet contrasted in large-scale studies, confirming that the use and outcomes
8 of LM practices are different for each type of process industry subgroup (Lyons et al.
9 2013).

10
11 On the other hand, several studies have explained an improvement in performance
12 by suggesting a close relationship between LM, High Involvement Work Practices, and
13 Human Resource Management (Bonavia and Marin-Garcia 2011; Das and Jayaram
14 2003; Holman et al. 2005; Kochan and Lansbury 1997; Yates et al. 2001). Several of
15
16 these studies have proposed that the successful implementation of different operation
17 management philosophies, such as Total Quality Management (TQM) or Just-in-Time
18 (JIT), would depend on simultaneously implementing high employee involvement
19 practices (Ahmad et al. 2003; Alfalla-Luque et al. 2012; Birdi et al. 2008). Furthermore,
20 various studies have mentioned the need to include workforce involvement practices in
21 the analysis of LM models (Flynn et al. 1995; Sakakibara et al. 1997; Cua et al. 2001).
22 Specifically, Cua et al. (2001) respond to this demand by establishing a framework in
23 which workforce management is an antecedent of basic LM practices, which fully
24 mediate the effect of workforce management on performance.

25
26 Among the most common human resources practices that favour employee
27 involvement, the literature highlights those that provide workers with information,
28 skills, motivation and power (Benson and Lawler 2005; Lawler 1991; MacDuffie 1995).
29 These practices can result in the transformation of the work force into a source of
30 sustainable competitive advantage (Guerrero and Barraud-Didier 2004; Guthrie et al.
31 2002; Wood and de Menezes 2008; Zatzick and Iverson 2006) and have proven keys in
32 the process of implementation of the LM (Nordin et al. 2011).

33
34 A review of the literature (Cappelli and Neumark 2001, 748) suggests that
35 employee involvement is the main concept behind virtually all of the studies examining
36 high performance work systems and organizational performance. Forza (1996) indicates
37 that the majority of the authors would agree with the statement that employee
38 involvement is a key element of LM. On the other hand, some studies have reported that
39 employee involvement does not directly affect operational results, but it does help to
40 implement LM –which has a direct relationship with the performance (Fullerton and
41 McWatters 2002; Sakakibara et al. 1997; Sila 2007).

42
43
44 However, only a few studies have analysed the characteristics of the relationship
45 between employee involvement and LM. Some of these studies look at the relationships
46 with some components of employee involvement and only one component of LM, for
47 example, TQM (Nair 2006; Sila 2007; Tari et al. 2007) or Pull Systems (Koufteros et al.
48 2007). Others focus on studying employee involvement in detail, but only relating these
49 practices to TQM (Alfalla-Luque et al. 2012; Lawler et al. 2001). Finally, a series of
50 papers discuss in depth the relationships among the components of LM: TQM, JIT, and
51 Total Productive Maintenance (TPM), as well as some components of employee
52 involvement in terms of organizational performance (Birdi et al. 2008; Cua et al. 2001;
53 Fullerton and McWatters 2001; Sakakibara et al. 1997).

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55 These studies are often incomplete because their main focus has generally been on
56 either analysing LM practices or analysing employee involvement, while the other sets
57 of practices have been somewhat tangential additions, and not a major part of the

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3 research. Therefore, extensive research seems essential to facilitate theory development
4 (Sila 2007). Consequently, there is a need to broaden the empirical research in the
5 direction of determining the performance implications of employee involvement as an
6 antecedent of LM implementation. For instance, this research could be based on
7 analyses carried out in countries and industries other than those usually studied
8 (Jiménez et al. 2012; Mehrjerdi 2012; Panizzolo et al. 2012; Wickramasinghe and
9 Wickramasinghe 2011).

10
11 In summary, numerous articles have been written about LM. To date, the most
12 recent literature review is probably the one by Marodin and Saurin (2013), which
13 analyses articles published between 1996 and 2012. The authors of the review select
14 102 articles, identify research areas related to LM implementation, and propose research
15 opportunities.

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

28
29 Furthermore, of the 102 studies analysed by Marodin and Saurin (2013), 48%
30 were carried out in firms in the USA or the UK. Only 17% were conducted in firms in
31 other European countries (of which, only 3 studies use Spain as the data source).
32 Undoubtedly, the research and, therefore, conclusions drawn have a clear bias toward
33 the Anglo-Saxon business context.

34
35 For all of these reasons, it is necessary to extend the research on LM
36 implementation, focusing on a specific sector other than discrete manufacturing and
37 using the joint analysis of performance measures related to different business
38 dimensions, such as human and operational, in order to analyse whether LM
39 implementation differs based on the process type (Lyons et al. 2013; Marodin and
40 Saurin 2013).

41
42 In this study, our contribution consists of focusing on a processes industry about
43 which very few studies have been published. Ceramic tile manufacturing is an example
44 of a highly competitive process industry in Spain, a leading ceramics producing country
45 (Andrés Romano 2001; Bonavia and Marin-Garcia 2006, 2011; Gil et al. 1999; Hervas-
46 Oliver and Albors-Garrigos 2009; Rowley 1996). These firms make their production
47 processes more flexible for various reasons (Ibañez-Fores et al. 2013; Rowley 1996;
48 Vallada et al. 2005). This exceptionally dynamic industry faces changing demands and
49 increasingly stiff international competition due to globalisation (Alegre-Vidal et al.
50 2004). The manufacturers are found in very specific geographical areas where news
51 about innovations in products and processes spreads fast (Gil et al. 1999). Therefore,
52 firms are under strong pressure to constantly improve if they want to have an advantage
53 over their competitors. The Spanish firms have achieved a wide variety of constantly
54 changing products where design and quality play an essential role (Alegre-Vidal et al.
55 2004; Chiva and Alegre 2009). The product life cycle becomes even shorter and is
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3 currently less than 5 years. There are a growing number of formats and models in an
4 attempt to customise the goods offered, while producers attempt to reduce delivery
5 times (Albors-Garrigos et al. 2008). Everything seems to indicate that this tendency will
6 increase in the future (Tomás Carpi et al. 1996).
7

8 Therefore, the aim of this research is to investigate the effect employee
9 involvement has on LM, and the effect LM practices have on performance in a process
10 industry. This approach is developed using Partial Least Squares (PLS) to determine
11 whether the relationships between these practices and their effects on performance can
12 be replicated in firms operating in the tile industry in Spain.
13

14 The present study makes it possible to extend the existing results on LM by using
15 an industry that is different from the ones usually analysed, but that has many of the
16 necessary characteristics for implementing LM.
17

18 19 20 **2. Theoretical framework and hypotheses**

21 The complete Lean Enterprise model includes not only LM, but also the activities
22 of Lean product development, Lean procurement, and Lean distribution (Karlsson and
23 Ahlström 1996). However, our research interest focuses on the activities that take place
24 in the manufacturing activity, which leads us to analyse and describe only aspects
25 related to LM. The term ‘Lean’ has been used to denote the set of tools designed to
26 increase business competitiveness by systematically eliminating all types of waste, the
27 alignment of production with demand, and the involvement of the workforce (Lyons et
28 al. 2013; Shah and Ward 2007).
29

30 In general, it seems that in sectors other than the automobile sector, the use of LM takes
31 place through the selective and not very integrated use of disperse practices, rather than
32 as a complete system. In fact, many authors state that some LM practices are not
33 appropriate or generalizable to just any sector (Lyons et al. 2013; White and Prybutok
34 2001). Certain widely-used practices only have moderate deployment in processes
35 firms, for example, 5S and visual systems. Moreover, TPM is usually extensively used
36 in firms with rigid continuous processes, but not in others. On the other hand, certain
37 restrictions in the production system make it unlikely that all the LM practices will be
38 adopted, for example, in cases where there are highly automated lines but without
39 Flexible Manufacturing Systems, or when firms try to maintain the maximum
40 production capacity of the ovens to avoid energy loss and the difficulty involved in
41 adjusting the firing process during batch changes. In these cases, the batch size is large,
42 and the use of LM practices such as cellular manufacturing, set-up time reduction,
43 levelling production and pull systems is unlikely in this sector (Lyons et al. 2013). In
44 the present study, we focus mainly on practices of waste elimination (5s, visual
45 controls, standard operations, TPM, quick changeover, statistical process control) and
46 workforce involvement (quality circles, cross functional training/job rotation), although
47 the latter are usually implemented less in rigid continuous processes than in other types
48 of processes (Lyons et al. 2013).
49

50 Numerous studies have concluded that applying this LM practices enables
51 businesses to improve their performance (Cua et al. 2001; Fullerton and McWatters
52 2001; Hallgren and Olhager 2009; Wang 2008; White and Prybutok 2001), both large
53 companies and SMEs -small and medium enterprises- (Panizzolo et al. 2012; White et
54 al. 1999; Vinodh and Joy 2012). Moreover, a positive association was also found
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3 between the use of LM practices for waste elimination and improvements in
4 manufacturing performance in various types of process industries (Lyons et al. 2013).
5

6 In the literature review carried out by Marodin and Saurin (2013), the main results
7 are positive, showing that the application of LM improves productivity, reduces cost or
8 improves performance in general. Different studies in some countries and
9 manufacturing industries seem to point in this direction, but the lack of homogeneity in
10 the measurement instruments used and the lack of replication of the studies makes it
11 difficult to confirm these results or generalize them to firms in other countries or other
12 sectors. In addition, there are numerous studies on discrete manufacturing but very few
13 in process industries. The most frequently mentioned benefits include: reduced
14 production costs, shorter lead time, better product quality, adaptation of the product to
15 the characteristics requested by the client, and the capacity to adjust production to meet
16 fluctuating demand (Cua et al. 2001; Fullerton and McWatters 2001; Jackson and Dyer
17 1998; Marodin and Saurin 2013; Nair 2006; Sakakibara et al. 1997; Shah and Ward
18 2003; Sila 2007; White et al. 1999). Some of these studies include the employees'
19 motivation as a performance measure. However, in reality, very few studies have
20 included the human dimension to analyse the performance outcomes of the
21 implementation of LM practices.
22

23
24 Based on these ideas, the following hypothesis is proposed:

25 *H1. LM has a positive effect on performance.*
26

27 Part of the LM research has considered its relationship with human resource
28 management programmes and work organization practices that encourage employee
29 involvement in companies (Cua et al. 2001; Das and Jayaram 2003; Fullerton and
30 McWatters 2002; MacDuffie 1995; Holman et al. 2005; Shah and Ward 2007; Snell and
31 Dean 1992). These programmes for managing human resources are labelled in different
32 ways (high-performance work systems, high involvement work practices...), and the list
33 of practices included varies among authors (Combs et al. 2006; Guthrie et al. 2002). The
34 same applies to the concepts of employee participation, job involvement, etc.
35 (Wickramasinghe and Wickramasinghe 2011). However, there is some agreement about
36 how these employee involvement practices can be classified (Combs et al. 2006; Gibson
37 et al. 2007; Guerrero and Barraud-Didier 2004; Marin-Garcia and Conci 2009; Wood
38 and de Menezes 2008; Zatzick and Iverson 2006), with the most cited categories being
39 those proposed by Lawler (1991): empowerment (power), training (knowledge),
40 communication (information) and remuneration (rewards). As Benson and Lawler
41 (2005, 154-155) state, among the different theories of employee involvement, the
42 practices are commonly categorized in the following way: practices that put the
43 decision-making power in the hands of employees, practices that provide the skills or
44 information needed to make informed decisions, and practices that provide incentives
45 for employees to take responsibility for their jobs.
46
47

48 Starting with the first practice mentioned by Lawler (1991), empowerment can be
49 characterised as sharing power with employees and increasing their level of autonomy
50 (Guerrero and Barraud-Didier 2004). Two influences can be studied: first, the influence
51 of employees in the design and implementation of LM policies or programmes
52 (Knudsen 1995; Poole 1995); and second, the influence of employees in daily decisions
53 such as setting objectives, assigning tasks or job rotation (Delbridge et al. 2000).
54 Empowerment has been described as critical to successful Just-in-Time (JIT) initiation
55 and implementation (Koufteros and Vonderembse 1998; Bayo-Moriones et al. 2008). It
56 would seem clear that companies implementing a higher degree of LM practices need to
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3 have previously increased empowerment (Fullerton and McWatters 2002).
4 Empowerment can improve trust and communication between employees and
5 employers (Spreitzer and Mishra 1999). It also heightens commitment to company goals
6 and encourages better relationships between individuals sharing tasks and procedures
7 (Gibson et al. 2007). These ideas suggest the following hypothesis:
8

9 *H2. Empowerment has a positive effect on LM.*

10 If employees receive suitable information and training, the workforce may develop
11 shared abilities and a better understanding of the processes in which they participate
12 (Guerrero and Barraud-Didier 2004). For this reason, various studies have shown the
13 association between LM and training programmes (Bonavia and Marin-Garcia 2011;
14 Hiltrop 1992). Employees must also be instructed in self-development and problem-
15 solving techniques (Benson et al. 2004). Training is also essential for tasks related to
16 tool and machinery maintenance. Brown and Mitchell (1991), Fortuny-Santos et al.
17 (2008) and Martínez-Jurado et al. (2013) showed that training is the critical variable that
18 minimises obstacles to an optimal performance in the transition from mass production
19 to LM. Other authors have highlighted the need to invest in long-term training
20 programmes when companies attempt to increase productivity by introducing LM
21 (Molleman and van den Beukel 2007; Murphy and Southley 2003). These contributions
22 lead to the following hypothesis:
23
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25 *H3. Training on LM practices has a positive effect on LM.*

26
27 Practices that encourage top-down communication (feedback, charts showing
28 operational performance measurements, financial or strategic information) help
29 employees to feel that their role in the company is important (Gibson et al. 2007). LM
30 seems to imply improved communications (Cua et al. 2001); nevertheless, the
31 relationship between communication and company results has not yet been
32 demonstrated (Guerrero and Barraud-Didier 2004). Therefore, it would be useful to test
33 this hypothesis:
34

35 *H4. Top-down communication has a positive effect on LM.*

36 Although various authors have included variable remuneration in their studies on LM
37 (Fullerton and McWatters 2002), the link between remuneration plans and successful
38 LM has received little attention in the literature (Sakakibara et al. 1997). In our country
39 there is an added problem; in the previous research (EPOC Research Group 1997) Spain
40 is shown in logistic regression models as a factor with a significant negative effect in
41 the use of profit-sharing schemes. In other words, while in Spain fixed salary
42 predominate, other European countries and EEUU use a greater amount of salary
43 complements with a much greater proportion of employees (Marin-Garcia et al. 2008a).
44 However, it has been argued that remuneration based on group effort (incentives for
45 reaching group targets) and gain-sharing related to individual or group suggestions help
46 to align employee interests with the organization's interests (Cappelli and Neumark
47 2001). These incentives also mean that employees are more likely to make a greater
48 effort and contribute more fully to the organization (Lawler 1996; Snell and Dean 1992;
49 Zatzick and Iverson 2006) and the success of the LM implementation (Forza 1996;
50 Hiltrop 1992). Therefore, the following hypothesis can be proposed:
51
52

53 *H5. Contingent remuneration has a positive effect on LM.*

54
55 Based on the literature reviewed in this section, the research model is shown in
56 Figure 1.
57

58 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

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3 (levelled) production (all of which are tools designed to establish the one-piece-flow).
4 However, it became evident in the preliminary interviews with plant managers of the
5 companies and ASCER technicians that these practices did not have an application in
6 the target population, and so they were no longer asked about them during the
7 interview. Instead, during the visit it was verified that these practices were not used in
8 these firms.
9

10 Regarding the employee involvement variables, Benson and Lawler (2005) state
11 that while the specific practices included in the scales vary from study to study, they all
12 support employee decision-making (empowerment) and provide workers with
13 appropriate skills (training), access to information about firm performance
14 (communication), and incentive rewards (compensation).
15

16 Empowerment was measured using a Likert scale from 1 to 4 (employees are
17 informed, employees are consulted, decision-making is shared with employees,
18 decisions are delegated to employees) for decisions about (six items): production
19 targets, setting quality standards, synchronisation and work pace, machines and tools to
20 be used in a task, assignment of tasks and job rotation, and problem-solving for simple
21 tasks (Cua et al. 2001; Marin-Garcia et al. 2008a; Poole 1995).
22

23 Training (eight items) was measured as the percentage of production employees
24 receiving systematic and programmed training about tidiness and cleanliness in the
25 workplace, data collection and data interpretation, group problem-solving, preventive
26 maintenance, standardisation of operations, quality control, reduction in machine start-
27 up times, and teamwork (Benson et al. 2004; Tari et al. 2007). The same 0 to 5 scale
28 used to measure the use of LM tools was also used for this variable.
29

30 Communication was measured (Cua et al. 2001; Huselid and Becker 1996; Shah
31 and Ward 2007) with a question about the percentage of shop floor zones where charts
32 are posted to show employees the SQCDP data (Safety, Quality, Cost, Delivery and
33 Productivity). Contingent remuneration was measured with two items asking what
34 percentage of production workers received incentives for group results or suggestions
35 implemented (Benson et al. 2004; Lawler et al. 2001; Marin-Garcia et al. 2008b). In
36 both cases, we used the same scale indicated above, from 0 to 5 (0%, 1-20%, 21-40%;
37 41-60%; 61-80% and 81-100%).
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40 Performance was measured on a Likert scale from 1-5 (not very satisfied to very
41 satisfied) regarding 6 aspects of the business: adaptation of the product to the
42 characteristics requested by the client, product quality, the capacity to adjust production
43 to meet fluctuating demand, production costs, speed of order completion (lead time to
44 consumer), and employee motivation (Gibson et al. 2007; Lawler et al. 2001; Marodin
45 and Saurin 2013). All these measures were answered by the plant manager.
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48

49 **3.3 Analysis**

50 In the research on different practices, whether dealing with LM, human resources
51 or high involvement, it is common to use a multi-item questionnaire to measure the
52 degree of implementation of these practices, which is also the case in the present study.
53 To do so, it is necessary to specify whether the measurement model should be reflective
54 or formative (Hair et al. 2013; Jarvis et al. 2003; Marin-Garcia and Carneiro 2010). In
55 this study the measurement model for all of the constructs has been considered
56 formative, given that the items do not have to be correlated with each other (for this
57 reason, it does not make sense to calculate Cronbach's alpha), changes in the construct
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3 do not cause changes in items, dropping an item changes the content of the construct,
4 and items do not have to have the same antecedents (Jarvis et al. 2003).
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6 The effect of the relationship between LM and employee involvement on
7 performance is evaluated using Partial Least Squares (PLS). For a detailed description
8 of this technique and its application to the LM field, see the previous work by Vinodh
9 and Joy (2012). PLS is particularly suitable when sample sizes are small, when the data
10 are not normally distributed, when formative measures are used, or when complex
11 models with many indicators and relationships are estimated (Hair et al. 2013). All of
12 these conditions are met in the present study.
13

14 PLS belongs to the family of Structural Equation Modelling methods, and its main
15 application is to explain how the dependent construct varies depending on the other
16 constructs in the model. In this sense, it provides richer information than other
17 techniques, such as, for example, ANOVA, as it makes it possible to simultaneously
18 estimate the parameters of a causal path model, including both the measurement model
19 and the structural model. The sequence of the constructs in the path models is
20 established based on previous theoretical literature. In the representation, the constructs
21 situated in the left part of the model are the independent constructs, and on the right are
22 the dependent constructs. Thus, the constructs on the left precede and predict the
23 constructs on the right.
24

25 The estimation of the PLS parameters is performed with an ordinary least squares
26 regression that attempts to maximize the R² (R squared, value between 0 and 1 that
27 represents the explained variance) of the dependent constructs. The estimated
28 coefficients on the paths in a PLS model can be considered analogous to the Beta in
29 regression models. They are values between -1 and 1 that represent the strength and
30 direction of the association between the constructs.
31

32 One of the main details to consider when proposing a PLS model with formative
33 constructs (which is the case here, as explained below) is to show that there are no
34 problems of collinearity among the items that make up a construct. Collinearity could
35 cause the weights between the formative indicators and the construct to be inconsistent
36 or non-significant.
37

38 In another vein, the PLS models do not have goodness of fit measures (such as
39 those used in Structural Equation Modelling based on covariance). Instead, a non-
40 parametric test is performed to estimate whether the values of the paths are significantly
41 different from zero. To do so, the most common procedure is bootstrapping, which
42 consists of making a high number of subsamples with replacement randomly drawn.
43 The estimated parameters in each of the subsamples are used to extract a mean and
44 standard deviation from the estimations. Later, a t-test is performed (with degrees of
45 freedom equal to the number of observations minus 1) to test the significance of the
46 parameter estimations (t value above 1.96 for $\alpha=0.05$ two tailed).
47

48 We will analyse the path weighting scheme with standardized data metrics,
49 nonparametric bootstrapping (101 cases, 1000 samples and individual sign change), the
50 weights of the inner model (>0.1), and bootstrapping significance with t-student one
51 tailed and non-parametric confidence intervals (Christophersen and Konradt 2008; Hair
52 et al. 2012, 2013; Henseler et al. 2009). In the descriptive statistics analysis, special
53 attention will be paid to missing values, patterns of no response, ranges of response
54 values, skewedness and kurtosis (Doval Dieguez and Viladrich Segués 2011; Viladrich
55 Segués and Doval Dieguez 2011). Inter/item correlations will also be analysed to detect
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3 the maximum value on training and communication. However, the most advanced
4 companies are only just above the midpoint of the scale in the use of contingent
5 remuneration. In terms of results, we note that the plant managers' satisfaction with the
6 perceived results is moderately high.
7

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10 INSERT TABLE 2, PLEASE

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12 INSERT FIGURE 2, PLEASE
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14 The correlations between items are mostly positive, although low or very low. The
15 maximum correlation value is 0.63 (between TrainClean and LeanMultiFunc), and only
16 37 out of 450 correlations are higher than 0.40. Most of these moderate correlations are
17 in the construct of training. The values of the collinearity statistics are lower than the
18 cut-off values. All items associated with one construct (communication has only one
19 item) have VIF values below 2.1, and the condition indices are: 4.8 for the training
20 construct, 7.59 for empowerment, 1.7 for contingent remuneration, 6.9 for LM, and
21 26.29 for the performance construct. Moreover, the VIF values for the employee
22 involvement constructs are less than 1.21, and the condition index for the construct
23 scores is 5.19. The correlations between constructs (Table 3) are moderate-low, with the
24 exception of the relationship between training and LM.
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28 INSERT TABLE 3, PLEASE
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31 Statistics for the structural model (PLS) are presented in Figure 3 and Table 4. All
32 paths on LM are significant, except contingent remuneration (the R2 explained in LM is
33 0.767). The relationship between LM and performance is relevant and significant (R2 =
34 0.119). Relationships were found between LM and empowerment (although with a
35 lower level of significance than the rest), training and communication. In sum, the data
36 from our sample confirm that the more employee involvement, the more LM; and the
37 more LM, the greater the performance. Analysing the paths shown in Figure 3,
38 performance seems to be directly affected by LM (direct path= 0.344), while
39 empowerment, training and communication show indirect paths to influence
40 performance (0.042; 0.288 and 0.058 respectively).
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44 INSERT FIGURE 3, PLEASE
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48 INSERT TABLE 4, PLEASE
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51 Reviewing the coefficients that were found to be significant, there is a positive
52 association between employees' involvement and LM activities, and between LM and
53 performance (like other authors have reported: Ahmad et al. 2003; Bonavia and Marin-
54 Garcia 2006, 2011; Cua et al. 2001; Das and Jayaram 2003; Fullerton and McWatters
55 2002; Holman et al. 2005; Sakakibara et al. 1997; Shah and Ward 2007; Sila 2007),
56 relationships that have not always been found in the literature (Birdi et al. 2008). Only
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3 contingent remuneration is not associated with LM. That is, all of the hypotheses have
4 been corroborated except H5, with a lower level of significance for H2.
5

6 The first hypothesis, which relates LM and performance, is significant, as in a
7 similar previous study by Vinodh and Joy (2012), except that in the present study the
8 type of industry variable has been controlled, which strengthens this relationship (Shah
9 and Ward 2003). LM streamlines the processes, reduces process variations and wastes
10 and, thus, contributes to improving organizational performance and the firm's
11 competitiveness (Fullerton and McWatters 2002; Hallgren and Olhager 2009;
12 Sakakibara et al. 1997).
13

14 Regarding the second hypothesis, although there is theoretical evidence that
15 sharing power with employees and increasing their level of autonomy are necessary in
16 order to implement LM (Koufteros and Vonderembse 1998), many companies may be
17 resisting because they fear that employees could behave opportunistically and against
18 the shared interests of the organization (Spreitzer and Mishra 1999). These results
19 support the idea that, in this sector, LM has been introduced with some employee
20 consultation, but without changes in the traditional power structures (Fullerton and
21 McWatters 2002; McKone et al. 2001). It could be argued that the production process or
22 the technology could impose restrictions that impede greater empowerment of
23 employees. To point out just a few examples, quality standards may be dictated by the
24 customer or the work pace may be controlled by machinery. Even so, the results reveal
25 that in cases where the level of employees' empowerment increases, there is a greater
26 deployment of LM.
27

28 Without a doubt, the strongest relationship appears for the effects of training on
29 LM, coinciding with results from many other studies (Bonavia and Marin-Garcia 2011;
30 Brown and Mitchell 1991; Forza 1996; Hiltrop 1992; Molleman and van den Beukel
31 2007; Power and Sohal 2000; Sakakibara et al. 1997). The difference lies in the fact that
32 the present study has used a rigorous and potent methodology for detecting these
33 relationships (PLS), which makes it possible, based on the use of different methods, to
34 corroborate the hypotheses proposed and increase the confidence in the results obtained,
35 thus making a new contribution to the previous research.
36

37 Regarding the fourth hypothesis, providing employees with information about
38 costs, productivity, quality and performance favours the implementation of LM. As
39 Gibson et al. (2007) state, employees who have a greater understanding of results can be
40 more adept at adjusting their behaviours to achieve the goals set, increasing their ability
41 to be proactive, identify and act on opportunities, display initiative, and persevere until
42 change occurs. For this reason, Cua et al. (2001) have considered the use of information
43 and feedback to be a practice that is common to TQM, JIT, and TPM. This practice,
44 together with other common practices such as training and empowerment (which Cua et
45 al. 2001, called employee involvement), guarantees the success of the implementation
46 of LM programmes.
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48

49 However, the fifth hypothesis, which states that contingent remuneration is
50 positively related to LM, was not supported. Companies that had decided to adopt LM
51 could be expected to similarly adapt their compensation systems (Fullerton and
52 McWatters 2002), favouring gain-sharing plans and remuneration based on group effort,
53 but this was not the case. The firms, regardless of their interest in LM, mainly continued
54 to pay their employees a fixed salary established by their job classification and/or
55 seniority (Bonavia and Marin-Garcia 2011; EPOC Research Group 1997; Marin-Garcia
56 et al. 2008a; Snell and Dean 1992). As Fullerton and McWatters (2002) noted, LM
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3 implementation is impeded by an incompatible incentive system; that is, the strategy of
4 some firms has changed to LM, but the motivation to adopt LM by employees has not
5 been put into place. As research has shown (Cappelli and Neumark 2001), the reality is
6 that the Management of the companies may not be willing to accept the economic costs
7 that accompany contingent remuneration.
8

11 **5. Implications, limitations and conclusions**

12 Our study aims to empirically test the effect employee involvement has on LM,
13 and the effect LM has on the outcomes in the factory. These effects are tested by
14 recording plant manager perceptions in an industry different from those usually studied
15 in previous research: ceramic manufacturers in Spain, a highly competitive and
16 internationally successful sector (ASCER 2003, 2007).
17

18 Our contribution responds to the need identified in the literature to examine the
19 factors that affect LM implementation (Marodin and Saurin 2013) and its outcomes in
20 process industries (Lyons et al. 2013). First, our study makes it possible to explore the
21 degree of implementation of LM practices in rigid continuous processes, and the
22 positive effect they have on performance, even when not introduced as a compact
23 system and implemented only to a relatively moderate degree. Second, it confirms the
24 role of training, communication and empowerment as antecedents of LM. Finally, it
25 helps to reflect on the contextual determinants that can keep rewards systems from
26 acting as influences or antecedents of LM.
27

28 Our results seem to support the idea that success in implementing LM depends as
29 much on mindset changes as on using the practices, tools and techniques (Dabhilkar and
30 Ahlstrom 2007; Martínez-Jurado et al. 2013; Nordin et al. 2011; Snell and Dean 1992;
31 Spear and Bowen 1999). In other words, LM depends on employees' involvement in
32 lean activities, which is produced by giving them more empowerment, training,
33 information and new forms of compensation.
34

35 However, such changes are uncommon in the traditionally conservative ceramic
36 industry. In the companies studied, advanced operational management and employee
37 involvement practices have scarcely been introduced. Therefore, several interesting
38 issues are raised that we intend to address in future research. For example, why are
39 companies reluctant to empower their employees? Why not update their payment
40 systems? Are there restrictions imposed by the nature of the product being
41 manufactured, or by the process, which prevent a greater use of LM practices? What are
42 management's opinions about LM and employee involvement– and are these views
43 conditioned by the degree of use? Case study work would be especially useful in
44 gathering the data needed for such an analysis.
45

46 This study also has implications for company management because it provides a
47 tool for auditing the level of use of various practices and outcomes. An assessment can
48 be made of the current situation, as well as any future changes produced by the
49 introduction of new practices.
50

51 Our research has some limitations. First, no previous study has used exactly the
52 same variables together, although all the items used in our research were adapted from
53 previous studies. Therefore, it is not easy to accurately compare equation coefficients
54 with the results of previous investigations. A second limitation stems from the fact that
55 the study was conducted in the context of a single country and industry and therefore
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3 our results can not be applied to other cases. A third limitation is that there was a certain
4 no-response, although the response rate was very high. Furthermore, independent and
5 dependent variables were measured using the same survey instrument, and this may
6 have caused common method variance and potential common method bias. Another
7 potential limitation is the bias of single informants. Although the use of single
8 informants is widespread in operations management research, higher quality data is
9 produced by using multiple informants. Accepted methodological guidelines were
10 followed to alleviate potential problems associated with using single informants. For
11 instance, face-to-face interviews were used with the plant manager, and subsequent
12 factory visits were made to confirm and review the responses.
13
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Table 1a. Descriptive statistics of the items.

Code	Code	Description	N	Min	Max	Mean	Std. Dev.	Skewness	Kurtosis
		<i>What percentage of production workers have received systematic training on...</i>							
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	p34iform	Teamwork	100	0	5	0.34	1.027	3.382	10.935
		<i>Degree of influence of the operators in decisions about...</i>							
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.

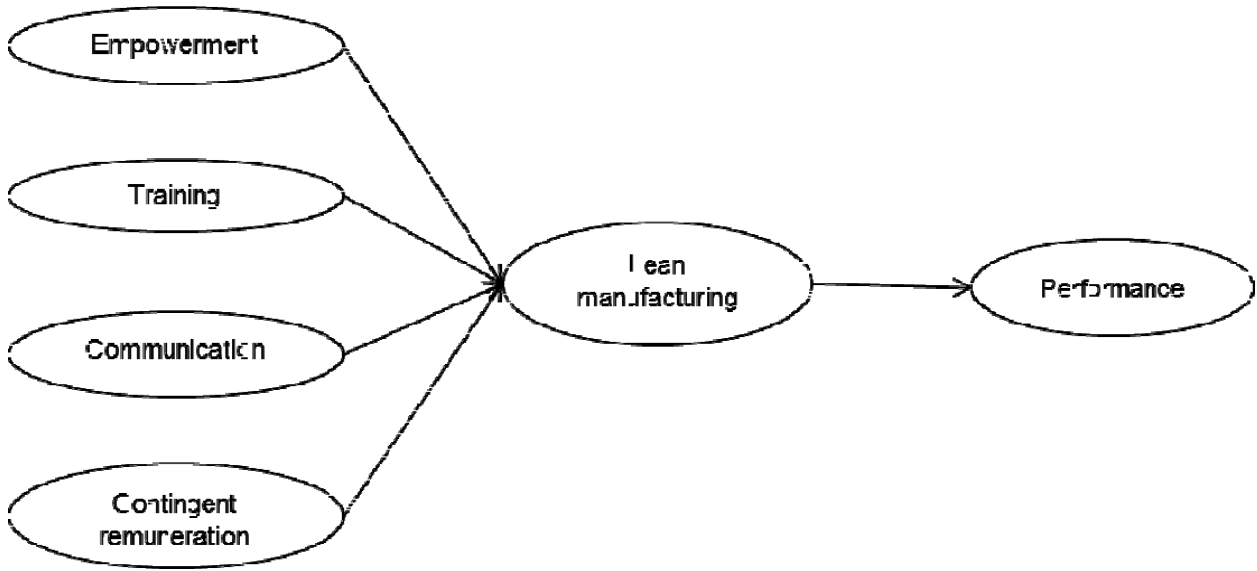


Figure 1. Theoretical Model.

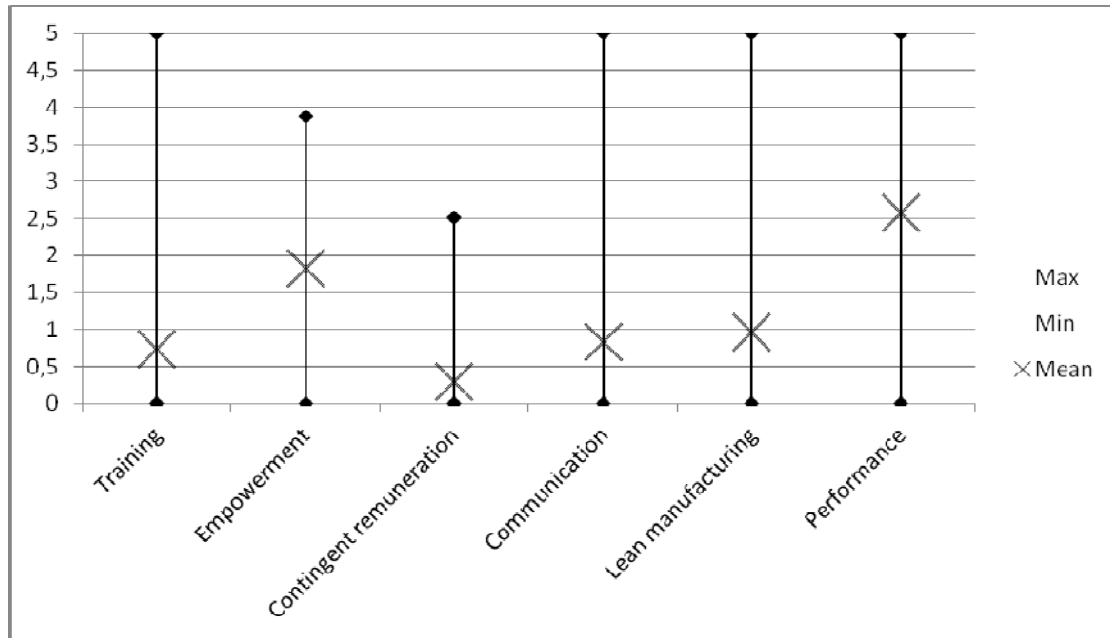


Figure 2. Minimum, maximum and mean of the variables.

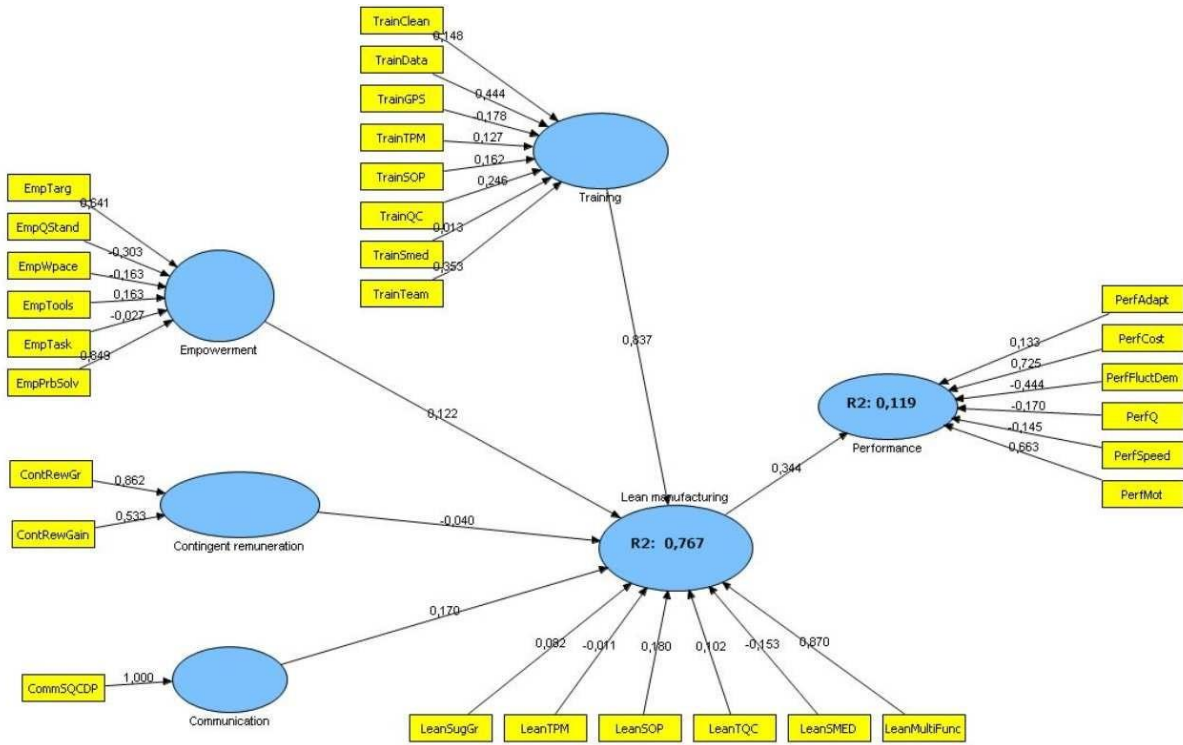


Figure 3. PLS model.