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Integrating human resource management into lean production and their impact on organizational performance

Structured Abstract

Category of the paper: Research paper

Purpose: Firstly, to analyse the effects of lean production (LP) on the policy of human resource management (HRM). The second goal of this research is to determine whether or not implementation of HRM practices associated with LP explain the differences in organizational performance between manufacturing plants.

Design/methodology/approach: We developed a questionnaire for data collection. Findings are presented from 76 establishments (79.17% of the total sample) that specialise in single-firing ceramic tiles in Spain.

Findings: Companies that make the most of LP practices are also those that take care to train workers in using these practices as well as improving their employment security. However, the same is not true for the pay for performance system. The combination of

LP with HRM practices reduces inventory and boosts productivity but does not appear to affect the other performance variables analysed.

Research limitations/implications: For certain variables we found very little variation between the plants in our samples. The data are cross-sectional, so causality cannot be definitively determined.

Practical implications: This paper indicates the HRM practices associated with the LP and the results obtained. It can thus be used to help human resource and production departments in improving organizational performance.

Originality/value: We extend the work of other researchers by focusing on a sector and a country that have been very little studied to date. The sample consists of a set of plants that are fairly homogeneous, which facilitates the analysis of the relationships between the selected variables while keeping other variables controlled.

Keywords

Training, job security, internal promotion, contingent remuneration, absenteeism, turnover.

1. Introduction

In recent times there has been an increase in research into the effect of the human variable on the success of Lean Production (LP). Prior to 1990 much of this research had focused on the technical aspects of operation, rather than the "people-related" issues (Power and Sohal, 1997, 2000). Since that time there has been increased focus on "why" LP works (or does not work), and as a result the human resource management (HRM) related factors have received greater attention.

All the authors who have studied LP recognise the profound changes that this production system brings about on companies' HRM. Samson et al. (1993), for example, as a result of case study research state that the new systems cannot simply be placed into an organization without carefully attending to a number of human resources (HR) issues. Although the content of new LP systems is well understood, the HR process issues associated with implementing change are not. Forza (1996) highlights the importance of recruiting, compensation, promotion and training in the success of LP. Although his research focussed on an analysis of work organization practices, he concluded his article by describing his concern for a further big issue: the role of the HRM practices which are needed in order to maintain the LP practices in time. We have only been able to find a partial response to this question in a review of the literature.

Since, although LP systems implicitly require different approaches to managing HR, Womack, Jones, and Roos (1990) did not explain how HR practices are integrated into these different production systems, nor did they test the relationship between HR practices and performance. MacDuffie (1995) echoed this criticism and declared that much of the research on the performance of automotive assembly plants has overemphasized either the technical system or the HR system without fully exploring the interaction of the two systems and how it can affect performance.

As Paez et al. (2004) point out LP represents a change in the production system model that calls for integration of human and technological practices. Therefore, one should jointly optimise the technological and human systems for the enterprise to meet its objectives. However, it is not clear how this integration can be brought about nor what results can be achieved (Niepce and Molleman, 1998).

For these reasons, our aims in this paper are the following:

1) In the first place, to analyse the effects of LP on HRM policy.

2) The second goal of this research is to determine whether or not implementation of HRM practices associated with LP explain differences in organizational performance between manufacturing plants.

2. Lean production and human resource management

The term 'lean' has been used to denote the set of tools designed to increase business competitiveness by systematically eliminating all types of waste (Shah and Ward, 2007). Numerous studies have concluded that Lean Production (LP) is a multifaceted construct composed by several bundles of practices (Cua et al., 2001; White and Prybutok, 2001; Shah and Ward, 2003; Bonavia and Marin, 2006): flow production (uniform workload, pull systems, cellular manufacturing, quick changeover techniques...), quality management (quality assurance, statistical process control, continuous improvement, standard operation procedures...), and productive maintenance (preventive maintenance, autonomous maintenance, maintenance optimization...).

On the other hand, dealing effectively with LP requires motivated, skilled workers and the integration of HR practices into a firm's production strategy (MacDuffie, 1995). Skilled and knowledgeable workers who are not motivated are unlikely to contribute any discretionary effort. Motivated workers who lack skills or knowledge may contribute discretionary effort with little impact on performance. That is, LP links together a set of manufacturing practices related to the minimization of waste, with another bundle of HR practices related to the expansion of work force skills and motivation (Flynn and Sakakibara, 1995; MacDuffie, 1995; Forza, 1996; Shah and Ward, 2003; Smith et al., 2003). In short, we agree with Lowe et al. (1997) who consider that HRM is a different bundle that includes some practices that may or may not be associated with LP.

However, this association between HR practices and LP is still practically unexplored. Osterman (1994) believed that supporting HRM practices were necessary for successful implementation of flexible work organization (as, for example, job rotation and TQM). MacDuffie (1995) and Pil and MacDuffie (1996) provided support for complementary hypotheses because they affected separate aspects of a plant's operations and yet mutually reinforced each other. Following the same line, Sakakibara et al. (1997) showed a strong relationship between JIT and what they called infrastructure practices, including workforce management. In addition, the combination of JIT and infrastructure practices was related to manufacturing performance. Cua et al. (2001) also showed how lean programs include some HR practices. Their analysis made clear how the implementation of these human practices, together with TQM, JIT, and TPM programs, provides significant explanation for the differences in performance measures.

However, Lowe et al. (1997) concluded that while the data suggest that there may be generic competitive advantages from operating with LP, the social systems which support this may be highly varied. Their data did not support the notion that the work organization and HRM associated with the LP model represent a universal "best way" for achieving high manufacturing performance.

3. Research hypothesis

Unfortunately, to date, the debate about what HRM practices should be considered remains inconclusive (Cappelli and Neumark, 2001; Ordiz and Fernández, 2003), so there is no clear list of practices, nor is there agreement on how they should be measured (Rogg et al., 2001). For example, Becker and Gerhart (1996) counted 27 different "high-performance" work practices across only five studies and observed that only two practices were the same in the five studies. As we will explain below, among

the most commonly used HRM practices in LP settings we find training, internal promotion, job security, and contingent remuneration.

The idea that LP companies need to actively promote the development of a multi-skilled and flexible workforce has been proposed by different authors (Osterman, 1994; MacDuffie, 1995; Forza, 1996; Pil and MacDuffie, 1996; Sakakibara et al., 1997; Power and Sohal, 1997, 2000; Cappelli and Neumark, 2001; among many others).

Brown and Mitchell (1991) have pointed to particular training strategies as the critical variable in minimising the effect of performance obstacles between Batch and JIT manufacturing environments. Hiltrop (1992) also emphasized the need to invest in long-term training programs when firms implement JIT. Wafa and Yasin (1998) stressed, among other aspects, that obtaining good results depended on having well-trained workers. Power and Sohal (2000) found in a study of three cases that JIT companies needed to actively promote the development of a multi-skilled and flexible workforce by means of training and effective employee-development programs. Workers also need training to engage in improvement activities and problem-solving techniques. Training is also essential for tasks related to maintenance of tools and machinery. In short, training can advance employees' capabilities of accepting new skills and using new knowledge.

For all these reasons, it can be expected that:

> H1A: Lean production plants are characterized by greater use of training in LP practices.

As Ordiz and Fernández (2003, 2005) have pointed out, employment security is closely related to training because companies cannot invest resources in the training of the staff if workers are not going to stay long enough in the company for those investments to be recovered. Another advantage associated with job security is that it facilitates greater

cooperation between employee and company, and at the same time implies having more productive personnel, because workers are aware of the fact that good results are associated with a stable job and the possibility of developing a career in the company (Delery and Doty, 1996).

It is only logical that for employees to be willing to give up work rules that provide them a degree of job security, they must be provided employment guarantees in return (Osterman, 1994). Some researchers have emphasized that the successful implementation of new work practices requires mutual understanding that not only are employees committed to the organization they work for, but that the organization shows commitment to them (Pil and MacDuffie, 1996). On the other hand, there is evidence that security of employment is an advantage in areas such as communication, skill retention and the operation of teams (Power and Sohal, 2000). As a result of the above argument, the following hypothesis will be tested in this paper:

> H1B: Lean production plants are characterized by greater use of employment security.

In relation to this hypothesis, the empirical evidence has verified that workers are more involved in the company when it shows some interest in the long-term development of its employees' careers (Ordiz and Fernández, 2005). Mobility of employees within the organization may improve organizational performance in two ways: directly, through knowledge, experience and satisfaction, and, indirectly, by decreasing recruitment, selection and training costs (Milkovich and Boudreau, 1994). Staff commitment is higher when they are regarded as a valuable resource for the company, rather than an asset to be bought and sold. A company that invests in a worker's training and then promotes him obtains a return on its investment indirectly through the appointment to a post of responsibility of a person of proven competence (Ordiz and Fernández, 2005). In

other words, an employee who hopes to develop a career in the company is more motivated, and this has to have an effect on company results. The fact that a company, unlike its competitors, cares about the job security and career development of its employees, should be a point in its favour in attracting and retaining talented personnel. Osterman (1994) found a direct link between innovative work practices and internal promotion. Hence, we shall test the following hypothesis:

> H1C: Lean production plants are characterized by greater use of internal promotion.

Although various authors have included contingent compensation in their studies on LP and new work practices (MacDuffie, 1995; Lowe et al., 1997; Cappelli and Neumark, 2001; Ordiz and Fernández, 2003), the link between compensation structures and the success of LP or otherwise is an area that appears to have received very little attention in the literature (Power and Sohal, 1997, Sakakibara et al., 1997). Hiltrop (1992) considered the need to adapt the reward systems when firms implement JIT. A firm that makes compensation contingent on performance will have workers that are more likely to engage and motivated to participate in activities that improve the organization's overall performance (Pil and MacDuffie, 1996). The salary structure and the reward systems certainly influence employee loyalty and commitment necessary to LP (Forza, 1996). On the other hand, these firms presumably subscribe to the theory that when employees are given more power, commitment and effort to determine outcomes, they should have a financial stake in enterprise success (Osterman, 1994). We can therefore expect to find that:

> H1D: Lean production plants are characterized by greater use of pay for performance.

Since it has to do with the second objective of this paper, among the benefits most often mentioned of LP are stock reduction, quality improvement, greater productivity, shorter lead time, on-time delivery and reduction on batch sizes (Womack et al., 1990; Flynn and Sakakibara, 1995; Lowe et al., 1997; Sakakibara et al., 1997; Jackson and Dyer, 1998; White et al., 1999; Cua et al., 2001; Fullerton and McWatters, 2001; Shah and Ward, 2003). On the other hand, the principles of lean production are controversial from the point of view of human wellbeing (Hiltrop, 1992; Kochan and Lansbury, 1997; Power and Sohal, 1997; Delbridge et al., 2000; Godard, 2004; Seppälä and Klemola, 2004). It is even discussed whether teamwork or empowerment, for example, there are other ways to persistence of managerial control on the employees in workplaces with LP (Sewell, 2005). It should also be remembered that few studies have analysed the effects of LP on absenteeism and employee rotation. Brown and Mitchell (1991) considered that although some areas of work are made easier after JIT implementation, if certain aspects of interest to workers such as training and scheduling are not favourably resolved there may be an increase in employee turnover. Quintana (1998) has argued that high levels of absenteeism and turnover, which introduce high variability in production rates and lower product quality, could cause an LP system to fail. Lowe et al. (1997) found that high-performance plants that followed the LP model had lower labour turnover. Regarding absenteeism, this was lower in Japanese high performers but was not so in the case of Western plants.

Also, even though the effects of HRM on performance have not been totally clarified, various studies from different countries produce evidence that the effective management of people results in better organizational performance. For instance, Ghebregiorgis and Karsten (2007) found that some of the HRM practices have a significant impact on employee turnover, absenteeism, grievances and productivity. Kim and Bae (2005) also found that the HR practices analysed by them reduced voluntary turnover, employee

absences and late arrivals and increased firm performance. Studies by Ahmad and Schroeder (2003) and Rodríguez and Ventura (2003) indicate that HRM practices have a significant impact on employee turnover and operational performance of firms. Similarly, the research by Björkman and Xiucheng (2002) found a positive relationship between HRM systems and organizational performance. Resulting from the above argument, we can put forward the following hypothesis:

> Hypothesis 2: A greater use of LP and HRM practices will decrease employee turnover and absenteeism and increase manufacturing performance.

4. Methodology

4.1 Compiling the questionnaire

To carry out LP measurements, we developed a data collection questionnaire based principally on the work of White et al. (1999), Karlsson and Ahlstöm (1996) and Jackson and Dyer (1998). For the Spanish equivalents of terms we used Prado Prado (2002) and Marín and Delgado (2000). In order to make the necessary adaptations to the specific conditions of the ceramic tile industry, we worked with technicians from ASCER (Spanish Ceramic Tile Manufacturers' Association) and used consultants with many years of experience in the sector. Once the questionnaire had been compiled, it was tested in three different ceramic tile companies in the pilot phase.

The criterion for scoring most of the replies was the degree of deployment of each LP practice, using a scale of 0-none to 5-complete implementation (Jackson and Dyer, 1998). This response scale was also used to measure HRM practices. The approach taken here is similar to those of Osterman (1994). Respondents indicated the proportion of employees who were affected by each practice used the following scale: 0 – non

implementation, 1 - from 1 to 20% of operational employees, 2 – from 21 to 40%… to 5 – from 81 to 100%.

The training variable was measured by the percentage of production employees that received systematic and programmed training specifically related to LP. Employment security was measured by the percentage of production employees with a permanent employment contract. In the same way, internal promotion was measured by the percentage of production workers promoted to a higher post in the last twelve months. Finally, contingent remuneration was measured by the percentage of production workers that received any of the following bonuses: individual or group incentive payments, share of company profits or gainsharing plans.

The variables selected to measure production indicators: internal quality, productivity, total stock, lead time, on-time delivery and minimum batch size, correspond to the most frequently cited benefits associated with LP implementation (Bonavia and Marin, 2006), but were applied in a different way in our questionnaire. Manufacturing performance was measured by objective (quantitative) variables in order to avoid perceptual bias (Flynn and Sakakibara, 1995; Fullerton and McWatters, 2001). In addition to these production indicators, we collected data on average annual employee turnover (voluntary turnover) and absenteeism. The former was measured as the percentage of employees that left the company voluntarily in the preceding twelve months. Absenteeism was measured as the percentage of total monthly hours lost due to workers not being at their jobs (due to illness, lateness, etc.).

4.2 Sample

We use a sample of Spanish ceramics industries for this study. Spain is the second European country in production of ceramic tiles and the third largest exporter (with a market share exceeding 17% of world exports), behind China and Italy (ASCER, 2007).

At the time of our survey, ASCER had 96 plants located in the Valencian Autonomous Region (mainly in Castellon Province) and were in the business of manufacturing single-fired ceramic tiles (porous tiles, stoneware floor tiles and porcelain stoneware). The final response rate was 79.17% (76 visits completed). The average number of employees of these companies was 152, distributed as follows: 15 companies with <50 workers, 37 with 50-150, 12 with 151-250, and 12 firms with >250 employees. Average monthly productivity was 4,155 m^2 per worker (1,615 m^2 SD) with a profit margin of 8.32% (10.54% SD).

The questionnaire was completed by the manufacturing manager for a personal interview lasting 30 minutes on average. Immediately after the interview, a visit to the facilities was made to obtain some of the data by direct observation. These visits took an average of 40 minutes per plant.

5. Results

The first task was to identify those firms that made the greatest use of LP. For this, we carried out a cluster analysis based on the common practices by which LP is defined. The Euclidean measure for distance between cluster centroids and the within-group average method of forming clusters was used to derive two clusters. The 'high-LP adopter' group (the highest scoring in LP practices) comprised of 34 plants (44.7%) and the 'low-LP adopter' (the lowest scoring) consisting of 42 plants (55.3%). A univariate

analysis of variance was conducted to determine whether there were significant differences between the two clusters. The results are shown in Table 1. With this information, we created a dummy variable that took the value of 1 if the plant belonged to the highest LP cluster and 0 if otherwise.

TABLE 1

Table 2 shows the descriptive statistics for the four HRM variables. It can be seen that only a small percentage of production employees receive training, internal promotion or contingent remuneration, in comparison with the very high percentage of employees with a permanent contract.

TABLE 2

In order to validate the four initial hypotheses, we carried out four oneway ANOVA using the independent variable low-high LP and as dependent variables the HRM practices (see table 3). From the results it was concluded that H1A was confirmed, since the firms with the highest level of LP implementation took care to give training to employees in these practices. H1B could be accepted, assuming a significance level of .10. Job security is better in the high LP firms, although, as the mean score was very high in both groups, this may have influenced the degree of significance. H1C also shows the expected tendency, but the difference in means is not enough to affirm that a high degree of LP implementation helps to put greater emphasis on internal promotion processes. The low percentage of employees promoted may have influenced this factor,

as well as the limited variance detected. H1D was definitely ruled out, since it was shown that a higher degree of LP was in no way associated with greater use of contingent remuneration in the companies studied.

TABLE 3

The second goal of this research was to determine whether or not implementation of HRM practices associated with LP explain differences in performance between manufacturing plants. To construct our dependent variables, we considered as high performance plants (value 1) in the indicators for prime quality, productivity and on-time deliveries those plants whose values were above the mean. The rest (value 0) were considered as low performance for this indicator (Lowe et al., 1997; Cua et al., 2001). For the variables lead time, stock, minimum batch size, percentage absenteeism and personnel turnover, the opposite criterion was used, since the higher these values the lower the plant performance. We also created a new variable by combining the plants with high performance in quality and productivity, following the procedure suggested by Lowe et al. (1997). Plants with high performance in both aspects were considered to be the best performers (value 1).

In order to test the second hypothesis of our study, we used the methodology proposed by Cua et al. (2001). By means of a discriminant analysis we identified the HRM practices which in association with LP best explained differences in organizational performance. We used the discriminant loadings to measure the importance of independent variables in distinguishing between the high and low performance groups. We considered as significant values of discriminant loading those with an absolute value greater than .30 (Hair et al., 1999). A model was constructed for each dependent

variable. The discriminating power of the models was tested by the Wilk's Lambda and Chi-square significance. We also tested discriminating capacity by its hit ratio. The precision of the model should be at least 25% better than random classification (Hair et al., 1999). Random classification capacity was calculated by the proportional randomness criterion Cpro, even though we were aware that by not using a sample-dividing procedure the hit ratio values were somewhat skewed towards randomness (Hair et al., 1999).

We carried out 9 discriminant analyses, one for each dependent variable, the results of which can be seen in Table 4. LP adoption and all HRM variables were included in the model. Goodness of fit was checked by the squared canonic correlation values and Chi-square significance. As an additional measure of the goodness of the model, we also checked whether the hit ratio was higher than the proportional randomness criterion. However, since our aim was to test the explicatory powers of the independent variables, not to establish a classification model, we gave more weight to the significance levels than to the hit ratio (Cua et al., 2001).

Of the nine models proposed, only two reached statistical significance (α<10%). In both cases the explicatory capacity of the model is low (squared canonic correlation between 0.13 and 0.16). In other words, our independent variables explain a little of the variation in the levels of stock and productivity. Variations in the rest of the production indicators do not appear to be explained by the set of variables proposed.

Regarding both reduction of stock levels and increase in productivity, implementation of LP has a positive effect on these variables, as could be expected. This effect is helped by better training and job security in the case of stock levels and by better chances of internal promotion in the case of productivity. However, contingent remuneration does not show any type of effect on either of these dependent variables.

TABLE 4

The combination of HRM practices and LP for the rest of the dependent variables, although not high enough to reach statistical significance, show certain noteworthy features. In all the models it can be seen from the discriminant loadings that different variables have an influence. These results agree with those of Cua et al. (2001), who found that different configurations of practices and techniques affect specific measures of performance.

Training has a positive effect, but not on all performance variables. The same can be said of the other HR variables. Only one result seems to be unexpected, which occurs in the relation between job security and prime quality. This could be due to workers feeling less pressurised to obtain high quality if they had less fear of losing their jobs, although this effect does not appear in the other regressions.

6. Discussion

Regarding our first aim, it was confirmed that higher implementation of LP is associated with a higher level of training and employment security, although it has no influence on the use of contingent remuneration systems. Further studies are needed to determine what really happens in the field of internal promotion.

It may be that only training and employment security are related to LP, since they are surely the minimum LP requirements, as decisions and instructions are taken top-down and managerial and expert knowledge are used (Niepce and Molleman, 1998). This specialised knowledge can be obtained from outside the organization, which would

justify the low level of internal promotion. In LP, HRM aims fundamentally to support the standardization of work processes, the minimizing of deviations from these standards, the efficiency of the production process, the flexibility of workers, and close relations between leaders and workers. To achieve this, what is fundamentally required is a well trained and stable work force. This is even more the case when high worker performance can be guaranteed by tight control systems and direct supervision, other usual aspects in organizations. This implies that contingent remuneration systems become less necessary.

Osterman (1994) compared establishments with flexible and non-flexible work practices and found that all the variables that he measured related to training were significant. He also found that flexible work organizations had fewer contingent employees, although, unlike us, he did not find differences for employment security policies implemented by the firms. Neither did he find significance for promotion, distinguishing between seniority versus merit in promotion. Finally, he obtained mixed results for contingent remuneration.

In relation to the latter variable, Lowe et al. (1997) found a notable difference in the use of pay for performance among the Japanese high-performance plants and the Western high performers. In the former case it was widely used with excellent results, while in the latter it was more usual to pay operators by their job classification and/or seniority. This situation is very usual in Spain in manufacturing industry and has also appeared in our findings, in which we noted the limited use of contingent remuneration (see table 3). As Bayo-Moriones and Huerta-Arribas indicate (2002, p. 129): "Spain is a country where only about 10 percent of firms have put workplace and firm incentives into practice". This could explain why LP implementation is not associated with wider use of contingent remuneration, since it is not a common practice in Spain.

Regarding the second aim, the proposed hypothesis must be rejected insofar as it refers to the joint effects of LP and HRM on absenteeism and rotation. Mixed results were obtained for manufacturing performance. The combined effect of LP and HRM appears regarding stock reduction and higher productivity, but not in the other variables.

The results of Shah and Ward (2003) indicated that lean bundles, including HRM, contribute substantially to the operating performance of plants. In spite of the fact that each of the bundles (JIT, TPM, and TQM) was positively associated with operational performance, HRM showed less influence than the others. The investigation carried out by Sakakibara et al. (1997) suggests that LP practices have value only when they are used together with workforce management. This idea is partially reproduced in our study for the stock and productivity variables, but not in the others. However, it should be pointed out that our findings do not establish any case in which either LP alone or HRM practices alone have a statistically significant influence on performance variables, as Sakakibara et al. (1997) have suggested.

Also, the results obtained by MacDuffie (1995) in which the evidence strongly supported the hypothesis that plants using flexible production systems and HR practices outperformed plants using more traditional mass production systems in both productivity and quality variables (although this result were more consistent for productivity than for quality), are not perfectly applicable to our findings. This is true for productivity, but neither for higher quality nor when quality and productivity are combined in a single index (or for the other variables studied). The reason for this is possibly due to the low variance found in the high quality levels of the firms in our sample, which make it difficult to obtain statistically significant relationships, as well as due to the massive use of quality controls by both clusters in the sample.

Our results do not coincide completely with those of Kim and Bae (2005), who arrived at the conclusion that the alignment among organizational design and work processes, employment relations systems and HRM systems would lead to high organizational performance. The fact that we used a quantitative methodology with a group of firms from the same sector could be the reason for the difference in results. In one of the cases studied by Kim and Bae (2005), they also found that extensive learning and training, various incentive systems and merit-based promotion and staffing decrease voluntary turnover, employee absences and tardiness, and increase firm performance. Our results do not allow us to draw the same conclusion.

Firms with higher level of LP implementation show lower levels of employee rotation (as shown by its discriminant loading), however, absenteeism is higher. On the other hand, it is observed that HRM practices show the expected tendency to reduce levels of absenteeism and rotation. In any case, their joint effect with LP is not enough to obtain statistical significance. It is worth noting that Lowe et al. (1997) also found that high-performance plants, both in Japan and in the West, had lower labour turnover. However, as regards unscheduled absenteeism, this was also lower, but only in the Japanese high-performance plants, i.e. Western high performers show much higher levels of absenteeism, as is also the case in our study.

7. Conclusions

Ordiz and Fernández (2003) concluded their paper by pointing out that more research is needed in the Spanish context to demonstrate the benefits of HR practices in any context at any moment. Our study is one more proof of the low level of the implementation of HRM practices in Spain, at least as regards training, internal promotion or contingent remuneration. The influence of a higher degree of LP implementation is only seen in a

relatively higher level of training and job security. On this basis, the positive effects of HRM practices and LP on organizational performance should be difficult to demonstrate. These have been shown in the case of productivity and stock, but not in the other variables. These conclusions obtained in a non Anglo-Saxon Western country may be of use in generalising the conclusions drawn in other studies.

It is a disadvantage to limit the sample population to a single industry (in our case ceramic tiles), since this reduces the possibilities of generalising the results. This disadvantage is partially corrected if other studies focussed on different industries and arrived at the same findings (Delery and Doty, 1996). Various authors have therefore considered it necessary to widen the range of industries subjected to thorough studies on their use of LP (Sakakibara et al., 1997; Shah and Ward, 2003).

Focussing a study on a single sector also presents added advantages, since it keeps control of a set of variables related to the homogeneity of the products and processes, the performance measures are more comparable across observations, and the concentration in a limited geographical area enables other control variables to be kept very similar.

In addition, we used quantitative values instead of measuring the production efficiency indicators with Likert-type scales that could have introduced an important subjective bias. For this reason, we believe that our work provides added value to previous studies that were based on mere subjective assessments from the people surveyed. Besides, we measured the breadth of implementation of each LP and HRM practice throughout each plant, instead of simply detecting the use or non-use of these practices. We can therefore state that the plant data set used in this study includes more reliable, context-specific measures of performance and LP and HR practices at a common level of analysis. Even so, we cannot be sure that our research is entirely free of the biases due to self-reported

performance data and single respondents. Finally, the data are cross-sectional, so causality cannot be definitively determined.

In conclusion, our paper has shown that some but not all HRM practices are associated with the implementation of LP and the results obtained. We have thus contributed to the development of more accurate theoretical models that may explain the relationships between the variables studied. When other similar studies have been carried out in other industries that provide generally applicable results, researchers will be able to develop models capable of establishing specific relationships between HRM practices and LP for each type of organizational performance, since not all these variables react in the same way.

Human resources and production managers will thus be able to seek help in choosing the best practices to implement in order to improve certain results. For this, they will need to consider the production system chosen, the objectives fixed by directors and the strategic priorities that form the basis of all production systems.

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Table 1. Means of LP practices by cluster

Variable	Cluster 1 Low Lean Production	Cluster 2 High Lean Production	ANOVA F / (Sig.)
Visual factory-housekeeping	1.69	1.99	1.410 (.239)
Visual factory-graphs or panels	0.26	1.85	19.955 (.000)
Group suggestions programmes (quality circles…)	0.77	3.36	34.045 (.000)
Total productive mantenaince (TPM)	3.36	4.65	22.814 (.000)
Standardisation of operations	1.40	4.29	50.650 (.000)
Quality controls during process	4.93	4.94	0.047 (.828)
Statistical quality control methods (SPC)	1.45	2.35	5.469 (.022)
Reduction of set-up time	0.12	0.85	9.049 (.004)
N	42	34	

Implementation of LP practices. Variables measured on a scale of 0 to 5. 0 = non-implementation, 1 = 1-20%, 2 = 21-40%..., 5 = 81-100%.

Table 2. Descriptive statistics of HRM practices (quantitative indicators)

Variable	N	Min	Max	Mean	SD
Training	75	0%	100%	8.5%	11.5%
Employment security	73	0%	100%	80.3%	21.49%
Internal promotion	69	0%	20%	5.4%	4.6%
Pay for performance	75	0%	100%	9.9%	18.4%

Table 3. Oneway ANOVA LP adopter/no-adopter by HRM practices

Variable	Cluster Low Lean Production		Cluster High Lean Production			
	N1	Mean	N2	Mean	F	Significance
Training	41	4.3%	34	13.6%	14.64	0.000
Employment security	40	76%	33	85%	3.01	0.087
Internal promotion	38	4.6%	31	6.3%	2.3	0.129
Pay for performance	41	10.9%	34	8.5%	0.322	0.572

Table 4. Discriminant loadings (structure correlations) of HRM practices

	Prime quality	Less lead time	**Less stock**	**Productivity**	Productivity x Quality	On-time delivery	Less batch size	Less absenteeism	Less turnover
Training			**0.41**		0.41	0.84			0.75
Employment security	-0.72		**0.43**			0.47	0.85	0.39	0.64
Internal promotion	0.47			**0.69**	0.75	0.51		0.38	
Pay for performance	0.47	0.74				0.51		0.58	
High/Low lean production		-0.54	**0.87**	**0.54**	0.56	0.31	0.43	-0.38	0.54
Number of cases	69	65	**63**	**68**	68	56	68	50	69
Group 0 size	31	27	**28**	**34**	50	22	20	20	25
Group 1 size	38	38	**35**	**34**	18	34	48	30	44
Chance-based proportion of correct classification *C*pro	50.5%	51.4%	**50.6%**	**50.0%**	61.1%	52.3%	58.5%	52.0%	53.8%
Limit of correct classification *C*pro (25%)	63.1%	64.3%	**63.3%**	**62.5%**	76.3%	65.4%	73.1%	65.0%	67.2%
Hit ratio	58.0%	56.9%	**71.4%**	**70.6%**	67.6%	46.4%	66.2%	62.0%	63.8%
(Canonical correlation)2	0.08	0.05	**0.16**	**0.13**	0.11	0.03	0.09	0.13	0.05
Wilk's lambda	0.923	0.922	**0.840**	**0.868**	0.896	0.966	0.904	0.867	0.911
Chi-square	5.194	3.095	**10.180**	**8.963**	6.943	1.804	6.410	6.502	6.025
Degrees of freedom	5	5	**5**	**5**	5	5	5	5	5
Significance	0.39	0.68	**0.07**	**0.10**	0.22	0.88	0.27	0.26	0.30

Only correlations greater than .30 are shown.
Performance variables indicated as "Less..." were inversely coded (0 when value was high and 1 when low).