

**LEAN PRODUCTION AND PERFORMANCE IN BRITISH
WORKPLACES**

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Abstract

“Lean production”, “integrated manufacturing” and “world-class manufacturing” describe an ensemble of modern operational management practices, whose possible effects on performance have been discussed for the last twenty years. Nevertheless, empirical studies of such effects are still in their infancy. In this paper, we report research designed to test whether a lean production philosophy, which might underlie the use of the total quality and just-in-time practices associated with the lean concept, is related to superior organizational performance. Data from the Workplace Employee Survey of 2004, which is a large representative sample of British workplaces and their employees, is used to address these questions. The research shows that high involvement management and work enrichment are likely to have more effect on performance than lean management, but this may play a role in enhancing the positive effect.

1. Introduction and Hypotheses

“Lean production” (Womack et al., 1990), “integrated manufacturing” (Dean and Snell, 1991), and “world-class manufacturing” (Schonberger, 1986) are umbrella terms used to describe an ensemble of modern operational management practices. More fundamentally, they are seen as holistic approaches. Hence, managers are exhorted to use their components in an integrated way and adopt them as philosophies that should guide and underlie all their actions. “Lean production”, in particular, was presented by its creators, Womack et al., as a panacea for the ills of western economies – low productivity, poor quality and industrial conflict – which should be extended across the whole economy and not just within mass production manufacturing. It would, they prophesized, become “the standard global production system of the twenty-first century” (ibid: 277). Perhaps the best evidence of its influence well beyond its birthplace in the car industry is the way it is most recently explored as an approach to reform in the public and health care sectors.

Any assessment of lean production must consider first the extent of its implementation, and if managers are embracing it as a holistic philosophy or are simply adopting practices associated with it in a selective or piecemeal way. Second, it must consider whether adopting such practices, in whatever form, has been associated with superior organizational performance. This paper tackles these issues, using data from the UK Workplace Employee Relations Survey.

We assume that if a lean philosophy or orientation is developing amongst management it will be expressed in the use of the management practices that are associated with the lean model, such as total quality control, just-in-time, total preventive management and supply chain partnering. There ought to be then some pattern in the use of lean practices: all or least a core set should be used in association with each other. Moreover, the relationship between these practices would reflect an underlying philosophy. In statistical terms, this implies that the correlation between practice use is explained by an underlying common factor that reflects the lean philosophy, and not by reasons that are specific to particular pairs or combinations of practices. We thus first test the following hypothesis:

Hypotheses 1: Lean production practices are positively associated and this association stems from a common factor.

An issue underlying both questions is the range of practices and nature of this lean philosophy. Lean production is generally taken to involve operational techniques

concerned with production, work organization, quality, logistics, supply-chain, customer satisfaction methods and continuous improvement methods. Yet there is still the question, which has also arisen in the more limited total quality management literature, of the extent to which the holism of any new production concept embraces, both in theory and practice, human resource management practices (Cooney and Sohal, 2002: 45). A key issue is then whether managers have emphasized operational matters at the expense of the importance of human resource management and employee involvement. As indeed one practicing manager at Nissan UK (Wickens, 1995) argued was likely to be the case, if one simply followed the Womack et al model, and not the “people-oriented” approach that he promulgated. The question then is firstly have the operational management methods been used in isolation of the high involvement work organization and human resource management practices generally linked to lean production (Appelbaum, et al., 2000), or, at the other extreme, have they been used together in a holistic manner. We therefore test: *Hypotheses 2: Lean production practices and high involvement practices are positively associated and this association stems from a common factor.*

How we consider the question of the links between lean production and performance will depend on whether the two hypotheses are supported. If both are, we concentrate on whether the holistic (lean-high involvement) philosophy is associated with organizational performance. If the first is supported, but the second is not, then we first exam if there are distinct factors underlying the use of each type of practice and, if there is, we might test if there is an interaction or synergistic effect between them. Alternatively, it might be that the lean production and high involvement management have independent effects on performance; or that, high involvement management mediates some of the impact of lean production on performance. That is, lean production has driven sufficient managers to adopt high involvement management and consequently some of the impact of lean production on performance is indirect (via high involvement management). If a common factor does not explain any association between the practices, or if there is little correlation in use of practices to be explained, then we would simply have to investigate the link between practices and performance.

In our analysis, we found that a discrete common factor partially explains the association between the lean practices. In the case of high involvement practices, a continuous factor explains all the relationship between the core flexible work organization and skill acquisition practices associated with high involvement management, but a common factor does not underlie the use of these and lean practices. The (flexible-skill-based) high involvement management is discrete from work

enrichment or the use of motivational devices such as performance-related pay or internal promotion that is sometimes associated with this approach. Consequently, we test:

Hypotheses 3a: Lean production, high involvement management and work enrichment are positively associated with organizational performance.

Hypotheses 3b: Lean production, high involvement management and work enrichment are positively associated with organizational performance and the interaction between lean production and (a) high involvement management and (b) work enrichment are also associated with organizational performance.

Hypotheses 3c: The relationship between Lean Production and organizational performance is mediated by high involvement management and work enrichment.

Research that has spanned both operational and human resource practices has concentrated mainly on assessing which if any of “just-in-time” (JIT), total quality management (TQM), or human resource management (and particularly employee involvement) is most associated with performance. Each of these has typically been measured by a number of sub-practices. Key literature in the operational management area has also attempted to test whether the widely assumed synergistic relationship between practices exists, often though using inappropriate methods.

The results of the studies so far are mixed, as findings on the effects of lean production on performance are uneven both across and within studies, but taken together they suggest a promising line of enquiry. The least supportive of the lean production model is Patterson et al.’s UK-based study (2004), which showed that work enrichment, an element of involvement, was the most significant factor. MacDuffie’s study testing the impact of just-in-time, lean-type work organization, quality practices, and high involvement human resource practices found a synergistic effect for productivity, but not for quality, though lean-type work organization or quality practices and high involvement human resource practices were associated with higher quality. Three operational management studies show that either all or some of all three types of practices, TQM, JIT and human resource management practices, have effects (Cua et al, 2001; Shah and Ward, 2003; and Kaynak, 2003). In contrast, other studies (e.g. Flynn et al., 1995; Samson and Terziovski; 1999) have found much weaker effects, particularly for the operational management practices.

An additional question that has arisen in the social science literature on lean production is the extent to which it enhances the stress of workers. On the one hand, Womack et al (1990) and others see it as providing more challenging work and hence associate it with higher levels of well-being; and the operational methods may also mean

that work processes are better organized and the frustrations associated with badly organized and managed systems may be reduced. On the other hand, critics have implied that it will lead to excessive demands being placed on employees to work more intensively. If the former is the case, we would expect lean production to be positively associated with lean production, while if the latter is the case, it would be negatively associated. It could even be that both processes are at work and they cancel each other out, or some people are most affected by the intensification while for another group lean production presents a challenge and provides better work processes; and hence there is no strong general relationship. We therefore test the alternative hypotheses thus:

Hypotheses 4a: Lean production either alone or in conjunction with high involvement management is positively associated with a contented workforce.

Hypotheses 4b: Lean production either alone or in conjunction with high involvement management is positively associated with an anxious or ill-contented workforce.

2. The Study

The Data

We use data from the Workplace Employee Relations Survey of 2004 (WERS2004), which is the fifth of a series of surveys involving representative samples of workplaces across the British economy. The research involves the use of several instruments. The survey of workplace practices based on a face-to-face interview with a single respondent from within management is used in our study for the practices and organizational performance measures. The respondent was a senior person at the workplace with day-to-day responsibility for industrial relations, employee relations or personnel matters. In some cases this would be a personnel specialist. In others, it would be a general manager or a person with a different functional specialty, such as finance. Interviews were conducted with managers in a total of 2,295 workplaces from an in-scope sample of 3,587 addresses, representing a response rate of 64 per cent. The sample covers the private and public sector and all industries with the establishments engaged in primary industries and private households with domestic staff (7 per cent of all workplaces). Establishments with fewer than five employees (60 per cent of all workplaces) are also excluded. The sample was taken from the Inter Departmental Business Register, maintained by the Office of National Statistics.

A second instrument, an eight-page, self-completion questionnaire that was distributed within workplaces, where WERS surveyors had conducted the management interview,

was used to acquire the wellbeing measure in our study. This employee survey within WERS 2004 comprises a sample of 22,451 employees, achieved through a response rate of 61 per cent. The aim was to achieve a maximum of 25 randomly selected employee respondents in each workplace. However, employee questionnaires were distributed in 86 per cent of the workplaces where the WERS surveyors had conducted the management interview. A further 12 percent of workplaces did not return any questionnaires, and in those workplaces with 10 or more employees these were treated for purposes of the calculating the 61 per cent response rate, as the same as those who had initially declined to distribute questionnaires. The median number of employees per workplace that completed the questionnaire was 13, with the most frequent (in 100 workplaces) being 16 employees. In our analysis of the association with a contented workforce, we exclude those workplaces where there were less than three employee respondents, since analysis of the distribution of this variable revealed that workplaces with either one or two employee respondents were the main source of outliers.

In contrast to many surveys, the WERS sample design involves many significant departures from the principle of simple random sampling that underpins most standard statistical procedures (e.g. correlation and regression analysis). As a result, one must account for the sample design by applying weights to the data, if one wishes to obtain unbiased population estimates. Standard weights that are scaled so that they add to 100 are provided in both surveys and we use these when we address the population.

The Measures

Within the management questionnaire of WERS2004, there are data on core elements of total quality management: training in quality, training in problem solving, self-inspection of quality, the keeping of records of faults or complaints, the keeping of records on quality customer surveying, ,; quality targets; customer service targets; team briefings that involve quality. There is a single item measure of just-in-time procedures based on the following question: “Does this workplace operate a system designed to minimize inventories, supplies or work-in-progress? This is sometimes known as Just - in -Time”.

We classify the human resource practices associated with high involvement and lean management that are measured in the management survey into four types, which are consistent with de Menezes and Wood (2006) and Bailey (1993):

1. *work enrichment*: task variety, method control, timing control;
2. *flexible working practices*: teamwork, functional flexibility, quality circles, and suggestion schemes;

3. *skill acquisition supports*: teambriefing, induction, training in human relations skills, information disclosure and appraisal;
4. *motivational supports*: survey feedback, priority given to internal recruitment, motivation as a selection criterion, job security guarantees, minimal status differences (single status) and variable pay.

Most measures were originally coded as binary in the data set and thus indicate whether the practice is available in a workplace and is applicable to the majority of the non-managerial workforce. A few measures were originally based on a five-point scale that indicated the amount of adoption in a workplace; in these cases we calculated a corresponding binary measure, by using the median amount of adoption as the cut-off point, so that values below the median category were coded as zero. Table 1 summarizes the definitions of practices.

- *Insert Table 1* -

There are three organizational performance measures in the data, namely: financial performance, labour productivity and quality. These measures rely on an assessment made by the managerial respondent according to five-point scales, which vary from “a lot better than average for industry” to “a lot below average”.

We measure the level of contentment workforce on the basis of the average score on a contentment-anxiety scale, which is derived from questions in the employee survey. First, an employee’s contentment is computed as the mean scores of six items from the anxiety-contentment scale (Warr, 1990; see also Wood, 2007), these are: being relaxed, calm, content, not tense, worried and not uneasy. When three or more of these items were missing, the measure was coded as missing. The reliability of this scale, as measured by Cronbach’s alpha, is 0.85 and is consistent with the range reported across previous studies (0.71 to 0.88) that used this as a measure of well-being, though these were predominantly in manufacturing companies (as reported in Mullarkey, et al.1999: 63). Second, we compute the mean per workplace, which is the measure that is used in subsequent analyses.

The control variables used in our regression models are constructed from either the management survey or the basic employment profile data: union density, size of establishment, industry group, private or public workplace, years operating at present address, proportion of females, proportion of operational and routine workers, proportion of young workers (measured by employees aged 21 or below), proportion of older

employees (measured by aged 50 or above), proportion of part-time workers and proportion of new recruits (measured by workers that commenced work in the past 12 months).

Analysis Procedure

We test hypotheses one and two by first using correlation analysis in order to establish if there is sufficient association between practice-use to suggest a common factor. Second, we use latent variable analysis to test for a common factor. Given that our indicators of practice-use are binary, we use latent trait models following Bartholomew and Knott (1999 – see Wood, 1999 for another application of this approach to operational and human resource practices). To test hypotheses three and four, which are concerned with the connection between lean and high involvement managements and performance or a contented workforce, we use regression analysis (weighted ordered logit or weighted least squares).

Results

Hypothesis 1: Lean Production Practices are positively associated and this association stems from a common factor.

We first considered the in-sample correlation of lean production practices. Correlation coefficients are positive and significant at a 1% level, with the exception of training in problem solving and team briefings that involve discussions on quality or product services. Hence, the overall correlation is weak and a single factor based on all practices is unlikely to fit the data well. Indeed, the fit of a latent trait model is poor (47.92 percent of the log-likelihood ratio that was explained by the model and the goodness-of-fit Chi-square statistic (158 degrees of freedom) was equal to 679). Furthermore, the residual correlation indicates that one of the assumptions based on which the model was estimated and which states that the association between practices is uniquely due to a common factor, does not hold for some pairs of practices. For example, the fit of the model to the two-way contingency table shows that training in quality and training in problem solving are directly associated.

A two factor-model also fits poorly. We therefore investigated whether a common discrete factor fits the data, if so, we can identify homogeneous groups of workplaces that have the same likelihood of adopting lean production practices. We performed latent class analysis, for which we used LatentGold 4.0 (Vermunt & Magidson, 2005) and started by investigating the number of classes (clusters of workplaces) that may fit the data. We

sequentially increased the number of classes in unrestricted latent class models and compared model selection and goodness-of-fit criteria. Out of six models, we concluded that four homogeneous clusters of workplaces are present in the data, since model selection criteria improved until four classes, but became worse for larger numbers. Nevertheless, this Four-Class model does not fit the data well: its log-likelihood ratio statistic (L^2) is relatively high when compared to its degrees of freedom (df), its the P-value is equal to 0.004 and residual correlations are very high. Most noticeably, the following pairs of practices appear to be associated independently of the latent variable that is being measured: customer surveys and just-in-time procedures, customer surveys and client satisfaction targets, training in quality and training in problem solving, team briefing involving discussions on quality and just-in-time procedures.

We thus sequentially estimated restricted Four-Class models, which allow for pairs of indicators (practices) to be correlated independently of the common latent variable. In the final model, the linear association between all pairs that were listed above were estimated. The overall fit is good: the log-likelihood ratio statistic ($L^2= 1032$; degrees of freedom=976) has a P-value of 0.1 and the Cressie-Read statistic, which is a more robust measure of fit when data are relatively sparse, is equal to 1006.71 (976 d.f.) with a P-value of 0.24. All associations are significant (Wald statistics' P-values=0). Of the four direct effects, most coefficients are positive and thus indicate a positive correlation between pairs of lean practices, which is independent of the cluster membership. The exception is the pair, customer surveys and JIT, which are negatively associated. In short, a common factor does not explain all the association between lean production practices and consequently hypothesis one is not supported by the data.

- Insert Table 2 -

Nevertheless, we have identified four homogeneous clusters of workplaces with the same likelihood of adopting each practice, as shown in table 2. First, we observe that all latent clusters are as likely to adopt training in problem solving as they are to adopt training in quality. Workplaces in Cluster 4 make more use of lean production practices and correspond to 39% of workplaces in the sample. The probabilities of adoption vary from 53% to 62%, which suggests that lean production practices are not very widespread. Workplaces in Cluster 1, which constitute 20% of the workplaces in the sample, are unlikely to adopt any lean practice, though a few may have some team briefing on quality related issues or problem solving (probability = 0.1). We observe that in the other two

clusters the range of probabilities of adopting a practice is relatively small, but they differ as to the practices that they may use. Cluster 2 (17% of the workplaces in the sample) is unlikely to keep records on faults, self inspect or survey customers (probabilities < 0.1), but may have quality and satisfaction targets and keep quality records. Cluster 3 (24% of the workplaces in the sample) may adopt quality monitoring practices, but is very unlikely to have quality targets (probability = 0.07). Those workplaces in Cluster 3 may thus have some core Total Quality Management, while those in Cluster 2 may be targeted towards quality/client satisfaction.

Hypothesis 2: Lean Production Practices and High Involvement practices are positively associated and this association stems from a common factor.

The correlation between the lean and high involvement practices was weak or non-significant. The high involvement practices that were not associated with lean practices were the work enrichment practices (task variety, method control, time control) and some of the motivational supports (e.g. job security and motivation as a selection criterion). As a result, neither a one nor a two-factor logit-probit latent trait model (Bartholomew and Knott, 1999) could be fitted to the data. Consequently, we reject hypotheses 2, since the associations in practice-use do not stem from either one or two common factors.

We thus investigate high involvement practices alone. A preliminary analysis of the in-sample correlation indicated that subsets of practices may load into different factors. Our analysis revealed two distinct factors; latent trait one-factor models could be fitted to two sets of practices: (1) work enrichment practices; (2) the flexible work organization and skill acquisition practices. This is consistent with earlier analysis of the 1998 Workplace Employee relations survey (de Menezes and Wood, 2006), in which high involvement management was measured by teamwork, functional flexibility, quality circles, suggestion schemes, team briefing, induction, training for human relations skills, information disclosure and appraisal. The motivational practices are discrete from these factors and do not load into a factor.

Table 3 summarizes the quality of fit of the work enrichment and high involvement models. It also shows the standardized discrimination coefficients, which are equivalent to factor loadings in factor analysis, and the probability of the average workplace in the sample adopting a practice. First, method and timing control are the strongest indicators of work enrichment, even though these elements of work enrichment are unlikely to be used in the average workplace in the sample (the probabilities that are shown in the table are less than 0.5). By contrast, the model of high involvement indicates that the majority

of practices, with the exception of quality circles and suggestion schemes, are likely to be used in the average workplace in the sample.

- *Insert Table 3* -

Testing the Link with Performance

We now address the association between lean and high involvement management with performance. The dependent variables follow an ordinal scale and therefore we ran weighted ordered logistic regressions, where we use the weights that are provided in WERS2004 to adjust for any sample bias.

Hypotheses 3a: Lean production, high involvement management and work enrichment are positively associated with organizational performance.

The results of our test of hypothesis 3a are summarized in Tables 4 and 5. They show that lean production is positively associated with quality, even when high involvement management is not controlled for, as Cluster 4 is significantly associated with it. In the case of productivity, as Table 4 shows, lean production is only positively associated with it, when high involvement management is not controlled for. Yet, even then two of the clusters (2 and 4) are equally positively associated with it. Lean production is not associated with financial performance.

- *Insert Table 4* -

Furthermore, when high involvement management and work enrichment are included in the regression models (Table 5), work enrichment is a significant predictor of quality, along with lean management. Neither it nor high involvement management are significantly associated with labour productivity, though work enrichment is associated at the 7% level. This suggests that the human resource management factors share some variance with lean management. In contrast to lean management, both work enrichment and high involvement management are associated with financial performance.

- *Insert Table 5* -

Hypotheses 3b: Lean production, high involvement management and work enrichment are positively associated with organizational performance and the interaction between the two is also associated with organizational performance.

Regression analysis that included the interaction of lean management and (a) work enrichment and (b) high involvement management reveals that there is no positive interaction effect between lean management and work enrichment on any outcome variable. However, there is a negative one between lean management and work enrichment and both labour productivity and financial performance (Table 6). For financial performance, high involvement management and work enrichment are main effects. In the case of labour productivity, the interaction between lean management and high involvement is only significant at the 9% level, and both high involvement and work enrichment are significant main effects. These results explain why none of the triad was significant, when all were placed in the equation without the interaction terms, as in the above analysis (Table 5).

- Insert Table 6 -

Hypotheses 3c: The relationship between Lean production and organizational performance is mediated by high involvement management and work enrichment.

There are only grounds for further investigating whether the association between lean management and labour productivity is mediated by either high involvement management or work enrichment. Membership of the lean production cluster is no longer significant, when work enrichment and high involvement are included in the regression equation. However, neither human resource measure is significantly associated with labour productivity, though work enrichment is significant at the 7% level. Further checks revealed that lean production management is not associated with work enrichment, though it is with high involvement management (Table 7). There is thus no support for hypothesis 3c.

- Insert Table 7 --

Testing the link with contented workforce

Finally, we consider the association between lean management and a contented or anxious workforce.

Hypotheses 4a: Lean production either alone or in conjunction with high involvement management is positively associated with a contented workforce.

Hypotheses 4b: Lean production either alone or in conjunction with high involvement management is positively associated with an anxious or ill-contented workforce.

The results of the regression analysis, as shown in table 8, reveal that when high involvement management and work enrichment are not included in the model, lean management is negatively associated with a contented workforce. However, when the human resource measures are controlled for, the negative association is no longer significant. But, high involvement management is then negatively related to a contented workforce. Work enrichment is not significant. Hypothesis 4b is supported by the results. High involvement management appears to mediate the link between lean management and the anxious workforce. However, job security guarantees are positively associated with a contented workforce. This means that hypothesis 4a is supported for one human resource practice.

- *Insert Table 8* -

3. Conclusion

Following uneven results across previous studies on the effects of lean production, our research was aimed at testing a set of hypotheses on the association of lean production with organizational performance and workforce contentment using data from British workplaces. In addition, we addressed the relative role of high involvement management, first by testing whether it was part of an integrated lean philosophy.

Differently from previous research in the Operations Management literature, we did not address lean production as a set of practices, but first tested whether a philosophy underlies the use of management practices. We did not find a common factor that encompassed human resource management and lean practices or a factor that would on its own explain all the association between lean practices. Nevertheless, we identified four homogeneous groups of workplaces, within each group the probability of using lean management is the same. These results show that in Britain lean production is not widespread and is concentrated in large workplaces. There are many workplaces that barely adopt lean production, among these some emphasise total quality management and others are target-oriented. As for the human resource management practices, we identified two dimensions: work enrichment and high involvement management, which are consistent with previous results that are based on a similar and earlier data set, the Workplace Employee Relations Survey of 1998 (de Menezes and Wood, 2006).

We found that lean production is positively associated with productivity and quality. The association with labour productivity, however, is diluted when we control for high involvement and work enrichment. Yet neither high involvement nor work enrichment mediate the link between lean production and performance. As for the association with a contented workforce, it is negative thus supporting the hypothesis that lean production is linked to an anxious workforce and this association appears to be mediated by high involvement management. In contrast, job security guarantees are associated with a contented workforce and so we have very limited support for the argument that human resource management practices may foster contentment.

This study is one of the few studies of the Lean Production-HRM-performance link that has a large economy-wide sample. We found that our results are consistent across the private and public sectors (as well as the manufacturing sector). It is also distinctive for its use of employee data and thus our ability to address competing hypotheses on workforce contentment within a large and representative sample of British workplaces.

Nonetheless, the present study has some limitations. In particular, the restricted coverage of lean production practices, most noticeably the absences of supply chain partnership and total preventive maintenance, and its reliance on a single manager's assessment of the performance of the workplace. Nonetheless, it has focused on core components of the lean approach, namely the quality and just-in-time elements. There is also some evidence that managers' ratings of performance measures have some validity (Wall *et al.*, 2004), at least in the UK, as they were consistent with the assumed more 'objective' audited accounting data.

The main implication for policy is that the human resource elements that are associated with lean production should not be neglected. The link between lean production and performance may be more complex than envisaged, but it is clear that an emphasis on operational management should not be at the expense of the human resource management.

Acknowledgements

We would thank Melina Dritsaki and Ellen Farleigh for their help with the data preparation and some of the analysis for this study. The UK's Economic and Social Research Council funded this research. The empirical research is based on data from the 2004 *Workplace Employee Relations Survey* (WERS2004), a survey that is jointly sponsored by the Department of Trade and Industry of the United Kingdom (UK), the Advisory, Conciliation and Arbitration Service, the Economic and Social Research Council, and the Policy Studies Institute. The National Centre for Social Research was commissioned to conduct the survey fieldwork on behalf of the sponsors. WERS2004 is deposited at the Data Archive at the University of Essex, UK. Neither the sponsors nor the Data Archive have any responsibility for the analysis or interpretation of the material contained in this paper.

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Table 1: Definition of Management Practices in the Study

Practice	Variable Definition
	WORK ENRICHMENT
Task variety	Employees in the largest occupational group have a lot of variety in their work
Method Control	Employees in the largest occupational group have a lot of discretion over how they do their work
Timing Control	Employees in the largest occupational group have a lot of control over the pace at which they carry out their work
	FLEXIBLE WORK ORGANISATION
Functional flexibility	10 per cent or more of the core occupational group work are formally trained to be able to do jobs other than their own
Teamwork	80 per cent or more of the core occupational group work in formally designated teams
Suggestion Schemes	Management uses suggestion schemes to consult with employees
Quality Circles	Answering positively to question: 'Do you have groups at this workplace that solve specific problems or discuss aspects of performance or quality? They are sometimes known as quality circles or problem-solving or continuous improvement groups'
	SKILL ACQUISITION
Induction	A standard induction programme designed to introduce new employees in the largest occupational group to the workplace
Training for human relations skills	Employees in the largest occupational group have received off-the-job training on improving communication and/or teamwork in the past year
Teambriefing	The workplace has briefing groups or team briefing for all the workers in a section
Information Disclosure	Management gives regular information on one or more of the following, the financial position of the establishment, internal investment plans or staffing plans
Appraisal	Non-managerial staff in the workplace have their performance formally appraised
	MOTIVATIONAL SUPPORTS
Survey feedback method	The management or a third party have conducted a formal survey of employees' views or opinions during the past two years, the results of which are made available in written form to all employees
Internal recruitment	Constructed from a question asking about the 'approach to filling vacancies in the workplace'. 1= where internal applicants are the only source of recruits or are given preference over external applicants. 0= is where internal and external candidates are treated equally
Motivation as a selection criterion	Motivation is an important factor when recruiting new employees
Variable pay	80% or more of non-managerial employees are eligible for share ownership, or received profit-related or performance-related pay over the past 12 months.
Job security guarantees	A policy of guaranteed job security or no-compulsory redundancies for any occupational group other than management
Single status	Managers and non-managerial staff have the same level of benefits in the following areas: pension scheme, private health insurance, four weeks or more paid annual leave, and sick pay in excess of the statutory requirements. It is thus coded 'one' if both managers and non-managers either have or do not have any of these benefits
	LEAN PRODUCTION
Just-in-time	The workplace operates a system designed to minimise inventories, supplies or work-in-progress as in the Just-in-time system
Training in quality	Employees in the largest occupational group have received off-the-job training on quality procedures in the past year
Training in problem solving	Employees in the largest occupational group have received off-the-job training on problem solving in the past year

Self-inspection	Individual employees monitor quality
Records on faults and complaints	Quality monitored by keeping records on levels of faults/complaints
Quality records kept	Quality records kept in the establishment
Customer surveys	Quality monitored through customer surveys
Quality targets	Targets for quality of product or service set
Customer Service targets	Targets for customer service set
Team briefings involves quality	The workplace has a system of briefing for any section or sections of the workforce and discusses quality of products/ services (production issues)

Table 2: The Latent Class Model of Lean Production Practices – Estimated Probabilities

Cluster	1	2	3	4
Size	0.20	0.17	0.24	0.39
Probability of Using a Practice				
Just-in-time	0.09	0.16	0.17	0.59
Training in quality	0.07	0.15	0.21	0.57
Training in problem solving	0.10	0.15	0.21	0.53
Self-inspection	0.08	0.07	0.27	0.58
Records on faults and complaints	0.04	0.07	0.30	0.59
Quality records	0.08	0.21	0.16	0.55
Customer surveys	0.04	0.08	0.28	0.60
Quality targets	0.01	0.28	0.07	0.63
Customer service targets	0.03	0.24	0.11	0.62
Teambriefing involves quality	0.10	0.15	0.21	0.53

Table 3: Latent Trait One-Factor Models
Standardized Discriminant Coefficients & Probability of the Average Workplace in WERS2004 Adopting a Practice

Practice	Work Enrichment		High Involvement Management	
	Alpha	Probability	Alpha	Probability
Task variety	0.617	0.429		
Method Control	0.995	0.001		
Timing Control	0.801	0.141		
Teamwork			0.758	0.641
Functional Flexibility			0.697	0.780
Quality Circles			0.787	0.295
Suggestion Schemes			0.654	0.333
Teambriefing			0.867	0.895
Induction			0.837	0.948
Training in HR skills			0.733	0.541
Information Disclosure			0.835	0.914
Appraisal			0.714	0.684
No of observed response patterns	13		353	
No of $((O-E)^2/E) > 4$	0		1	
Maximum $((O-E)^2/E)$	0.2		7.6	
% G^2 explained	71		63	
Chi-square (df)	18.5 (17)		206.8 (103)	
<i>N</i>	2295		2295	
<i>Reliability (R)</i>	0.82		0.69	

TABLE 4
Lean Management & Performance
Predictors: T-statistics and Respective P-values in Brackets

	Labour productivity	Financial performance	Quality
	<i>Ordered logit</i>	<i>Ordered logit</i>	<i>Ordered logit</i>
Size establishment	-0.77 (0.44)	2.63 (0.01)	-0.10 (0.92)
Manufacturing (reference category)			
Electricity, gas and water	-1.17 (0.24)	3.02 (0.00)	-1.01 (0.31)
Construction	-0.88 (0.38)	1.53 (0.13)	0.69 (0.49)
Wholesale and retail	-0.04 (0.97)	1.89 (0.06)	-0.11 (0.91)
Hotels and restaurants	1.53(0.12)	2.23 (0.03)	-0.06 (0.95)
Transport and communication	-0.05 (0.96)	1.92 (0.06)	-0.78 (0.44)
Financial services	1.36 (0.17)	2.97 (0.00)	0.41 (0.68)
Other business services	1.49 (0.14)	2.08 (0.04)	1.54 (0.13)
Public administration	0.40 (0.68)	0.36 (0.72)	-1.34 (0.18)
Education	0.19 (0.85)	0.75 (0.45)	0.75 (0.45)
Health	1.25 (0.21)	1.45 (0.15)	1.71 (0.09)
Other community services	2.23 (0.03)	2.16 (0.03)	0.32 (0.75)
Public workplace	1.06 (0.29)	-0.14 (0.89)	-2.01 (0.04)
Age of workplace	-0.46 (0.64)	0.00 (1.00)	-0.90 (0.37)
Proportion females	-1.44 (0.15)	0.66 (0.51)	0.63 (0.52)
Proportion operational and routine workers	-0.28 (0.78)	0.23 (0.82)	0.89 (0.37)
Proportion young workers	-1.75 (0.08)	0.34 (0.74)	0.71 (0.48)
Proportion part-time workers	-0.19 (0.85)	-1.08 (0.28)	-1.03 (0.31)
Proportion new recruits	0.64 (0.52)	0.45 (0.65)	-0.55 (0.58)
Union density	-2.57 (0.01)	-1.0 (0.27)	-0.57 (0.57)
Cluster 1- No Lean (reference category)			
Cluster 2- Some Targeting	2.11 (0.04)	0.25 (0.80)	0.97 (0.33)
Cluster 3 – Some TQM	0.03 (0.98)	0.47 (0.64)	0.20 (0.84)
Cluster 4 – Some Lean	2.03 (0.04)	1.27 (0.20)	2.33 (0.02)
F	F(23, 1594) =2.14	F(23, 1639) =1.67	F(23, 1711) =1.80
Prob >F	0.00	0.02	0.00
N	1617	1662	1734

TABLE 5
Lean Management, High Involvement Management & Performance
Predictors: T-statistics and Respective P-values in Brackets

	Labour productivity	Financial performance	Quality
	<i>Ordered logit</i>	<i>Ordered logit</i>	<i>Ordered logit</i>
Size establishment	-0.56 (0.58)	2.03 (0.04)	0.75 (0.45)
Manufacturing (reference category)			
Electricity, gas and water	-1.48 (0.14)	2.14 (0.03)	-0.32 (0.75)
Construction	-0.73 (0.47)	2.06 (0.04)	0.53 (0.59)
Wholesale and retail	-0.47 (0.64)	1.42 (0.16)	0.21 (0.84)
Hotels and restaurants	1.69 (0.09)	2.18 (0.03)	0.55 (0.59)
Transport and communication	-0.28 (0.78)	1.66 (0.09)	-0.56 (0.58)
Financial services	0.72 (0.47)	2.21 (0.03)	0.89 (0.37)
Other business services	1.09 (0.28)	1.89 (0.06)	1.94 (0.05)
Public administration	0.09 (0.93)	0.01 (0.99)	-1.42 (0.16)
Education	-0.33 (0.74)	0.31 (0.75)	0.19 (0.85)
Health	0.84 (0.40)	1.18 (0.24)	1.53 (0.13)
Other community services	1.46 (0.14)	1.57 (0.12)	0.60 (0.55)
Public workplace	1.24 (0.22)	0.16 (0.87)	-1.58 (0.12)
Age of workplace	-0.48 (0.63)	0.08 (0.93)	-0.63 (0.53)
Proportion females	-1.34 (0.18)	0.34 (0.73)	0.74 (0.46)
Proportion operational and routine workers	-0.80(0.43)	0.34 (0.74)	0.76 (0.45)
Proportion young workers	-1.87 (0.06)	0.11 (0.91)	0.67 (0.50)
Proportion part-time workers	-0.09 (0.93)	-0.50 (0.62)	-0.80 (0.42)
Proportion new recruits	0.92 (0.36)	0.90 (0.37)	0.22 (0.83)
Union density	-2.36 (0.02)	-1.10 (0.27)	0.02 (0.98)
High Involvement Management	1.30 (0.20)	2.00 (0.05)	0.09 (0.93)
Cluster 1- No Lean (reference category)			
Cluster 2- Some Targeting	1.03 (0.30)	-1.01 (0.31)	0.75 (0.46)
Cluster 3 – Some TQM	-0.43 (0.67)	-0.22 (0.83)	0.29 (0.77)
Cluster 4 – Some Lean	0.70 (0.49)	-0.37 (0.71)	2.22 (0.03)
Work Enrichment	1.79 (0.07)	2.71 (0.01)	4.02 (0.00)
Variable Pay	1.25 (0.21)	1.07 (0.28)	-0.47 (0.64)
Job Security	1.30 (0.19)	1.56 (0.12)	1.36 (0.17)
Internal Recruitment	-0.49 (0.62)	0.65 (0.52)	0.32 (0.75)
Motivation as a selection criterion	-0.02 (0.98)	-0.09 (0.93)	0.86 (0.39)
Survey Feedback method	0.06 (0.96)	0.57 (0.57)	-0.58 (0.56)
Single Status	-0.52 (0.60)	-2.23 (0.03)	-1.38 (0.17)
F	F(31, 1554) =1.81	F(31, 1597) =2.44	F(31, 1668) =2.37
Prob >F	0.00	0.00	0.00
N	1585	1628	1699

TABLE 6: Lean Management, High Involvement Management & Performance
Predictors: T-statistics and Respective P-values in Brackets

	Labour productivity	Financial performance	Quality
	<i>Ordered logit</i>	<i>Ordered logit</i>	<i>Ordered logit</i>
Size establishment	-0.58 (0.56)	2.08 (0.04)	0.74 (0.46)
Manufacturing (reference category)			
Electricity, gas and water	-1.35 (0.18)	2.36 (0.02)	-0.25 (0.80)
Construction	-0.69 (0.49)	2.14 (0.03)	0.54 (0.59)
Wholesale and retail	-0.58 (0.56)	1.33 (0.19)	0.13 (0.90)
Hotels and restaurants	1.71 (0.09)	2.14 (0.03)	0.49 (0.62)
Transport and communication	-0.33 (0.74)	1.62 (0.11)	-0.56 (0.58)
Financial services	0.69 (0.49)	2.24 (0.03)	0.84 (0.40)
Other business services	1.01 (0.31)	1.82 (0.07)	1.87 (0.06)
Public administration	0.06 (0.95)	0.05 (0.96)	-1.45 (0.15)
Education	-0.51 (0.61)	0.10 (0.92)	0.05 (0.96)
Health	0.70 (0.48)	1.04 (0.30)	1.45 (0.15)
Other community services	1.26 (0.21)	1.48 (0.14)	0.45 (0.65)
Public workplace	1.38 (0.17)	0.22 (0.82)	-1.47 (0.14)
Age of workplace	-0.64 (0.52)	-0.01 (0.99)	-0.77 (0.44)
Proportion females	-1.13 (0.26)	0.51 (0.61)	0.94 (0.35)
Proportion operational and routine workers	-0.79 (0.43)	0.38 (0.71)	0.83 (0.41)
Proportion young workers	-1.84 (0.07)	0.15 (0.88)	0.77 (0.44)
Proportion part-time workers	-0.24 (0.81)	-0.55 (0.59)	-0.91 (0.36)
Proportion new recruits	0.78 (0.44)	0.81 (0.42)	0.09 (0.93)
Union density	-2.40 (0.02)	-1.15 (0.26)	0.00 (0.99)
Cluster 1- No Lean (reference category)			
Cluster 2- Some Targeting	0.77 (0.44)	-1.24 (0.22)	0.55 (0.58)
Cluster 3 – Some TQM	-0.59 (0.55)	-0.43 (0.67)	0.18 (0.86)
Cluster 4 – Some Lean	0.66 (0.51)	-0.45 (0.65)	2.22 (0.03)
Some Lean x High Involvement Management	-1.68 (0.09)	-2.23 (0.03)	-1.34 (0.18)
Some Lean x Work Enrichment	-1.20 (0.23)	-0.44 (0.66)	-1.48 (0.14)
High Involvement Management	1.85 (0.06)	2.50 (0.01)	0.66 (0.51)
Work Enrichment	2.14 (0.03)	2.63 (0.01)	4.13 (0.00)
Variable Pay	1.26 (0.21)	0.98 (0.33)	-0.47 (0.64)
Job Security	1.30 (0.20)	1.62 (0.11)	1.34 (0.18)
Internal Recruitment	-0.56 (0.58)	0.59 (0.55)	0.28 (0.78)
Motivation as a selection criterion	0.06 (0.95)	-0.02 (0.98)	0.89 (0.37)
Survey Feedback Method	-0.17 (0.86)	0.43 (0.67)	-0.80 (0.43)
Single Status	-0.51 (0.61)	-2.20 (0.03)	-1.38 (0.17)
F	F(33, 1552) =1.84	F(33, 1595) =2.41	F(33, 1666) =2.29
Prob >F	0.00	0.00	0.00
N	1585	1628	1699

TABLE 7
High Involvement Management & Work Enrichment
Predictors: T-statistics and Respective P-values in Brackets

	High Involvement Management	Work Enrichment
	<i>Weighted least squares</i>	<i>Weighted least squares</i>
Size establishment	7.83 (0.00)	-3.33 (0.00)
Manufacturing (reference category)		
Electricity, gas and water	6.20 (0.00)	-1.33(0.18)
Construction	-1.02 (0.31)	1.04 (0.30)
Wholesale and retail	1.34 (0.18)	-0.49 (0.62)
Hotels and restaurants	1.93 (0.05)	-1.24 (0.22)
Transport and communication	1.78 (0.07)	-0.03 (0.98)
Financial services	4.47 (0.00)	-2.28 (0.02)
Other business services	1.82 (0.07)	0.05 (0.96)
Public administration	3.91 (0.00)	0.88 (0.38)
Education	0.46 (0.65)	3.24 (0.00)
Health	3.00 (0.00)	0.88 (0.37)
Other community services	3.14 (0.00)	0.85 (0.39)
Public workplace	1.28 (0.20)	-1.24 (0.22)
Age of workplace	-1.20 (0.23)	-0.05 (0.96)
Proportion females	3.91 (0.00)	-0.31 (0.76)
Proportion operational and routine workers	-2.76 (0.01)	0.11 (0.91)
Proportion young workers	0.09 (0.93)	-1.79 (0.07)
Proportion part-time workers	-3.30 (0.00)	-0.82 (0.41)
Proportion new recruits	2.47 (0.01)	-3.52 (0.00)
Union density	1.67 (0.10)	-3.17 (0.00)
Cluster 1- No Lean (reference category)		
Cluster 2- Some Targeting	8.33 (0.00)	-0.86 (0.39)
Cluster 3 – Some TQM	7.00 (0.00)	-2.07 (0.04)
Cluster 4 – Some Lean	11.70 (0.00)	-0.64 (0.53)
F	F(23, 1809) =29.20	F(23, 1809) =5.50
R ²	0.40	0.11
N	1832	1832

Table 8: Lean Management, High Involvement Management and Contented Workforce Predictors: T-statistics and Respective P-values in Brackets

	Contented Workforce	Contented Workforce	Contented Workforce
	<i>Weighted least squares</i>	<i>Weighted least squares</i>	<i>Weighted least squares</i>
Size establishment	-2.64 (0.01)	-1.46 (0.14)	-1.10 (0.27)
Manufacturing (reference category)			
Electricity, gas and water	0.84(0.40)	1.56 (0.12)	2.01 (0.05)
Construction	0.11 (0.91)	0.12 (0.91)	0.16 (0.87)
Wholesale and retail	0.99 (0.32)	1.40 (0.16)	1.41 (0.16)
Hotels and restaurants	-2.69 (0.01)	-2.50 (0.01)	-2.31 (0.02)
Transport and communication	-2.45 (0.01)	-2.36 (0.02)	-2.11 (0.04)
Financial services	-1.41 (0.16)	-0.89 (0.37)	-0.79 (0.43)
Other business services	-2.19 (0.03)	-1.80 (0.07)	-1.60 (0.11)
Public administration	-0.17 (0.86)	0.21 (0.84)	0.24 (0.81)
Education	-0.25 (0.81)	-0.42 (0.67)	-0.54 (0.59)
Health	0.38 (0.70)	0.81 (0.42)	0.70 (0.49)
Other community services	0.98 (0.33)	1.45 (0.15)	1.35 (0.18)
Public workplace	-1.71 (0.01)	-1.43 (0.15)	-1.38 (0.16)
Age of workplace	0.18 (0.86)	0.12 (0.90)	-0.01 (0.99)
Proportion females	-0.06 (0.95)	0.42 (0.67)	0.45 (0.65)
Proportion operational and routine workers	5.13 (0.00)	4.92 (0.00)	4.22 (0.00)
Proportion young workers	-0.35 (0.73)	-0.38 (0.70)	-0.31 (0.76)
Proportion part-time workers	4.16 (0.00)	4.04 (0.00)	4.02 (0.00)
Proportion new recruits	-1.84 (0.07)	-1.34 (0.18)	-1.36 (0.17)
Union density	2.14 (0.03)	-1.80 (0.07)	-1.77 (0.08)
Cluster 1- No Lean (reference category)			
Cluster 2- Some Target	-1.50 (0.13)	-0.56 (0.57)	-0.58 (0.56)
Cluster 3 – Some TQM	-2.65 (0.01)	-1.65 (0.10)	-1.81 (0.07)
Cluster 4 – Some Lean	-3.23 (0.00)	-1.55 (0.12)	-1.48 (0.14)
High Involvement Management		-2.97 (0.00)	-2.37 (0.02)
Work Enrichment		1.08 (0.28)	1.17 (0.24)
Variable Pay			0.39 (0.70)
Job Security			2.16 (0.03)
Internal Recruitment			-0.81 (0.42)
Motivation as a selection criterion			0.99 (0.32)
Survey Feedback Method			-2.31 (0.02)
Single Status			-0.88 (0.38)
F	F(23, 1305) =9.72	F(25, 1303) =10.13	F(31, 1270) =7.72
R ²	0.24	0.26	0.27
N	1328	1328	1301