Employee turnover and its effect on sustainable manufacturing operations

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Abstract: This paper analyses the relationship between employee turnover, time-based manufacturing practices, manufacturing performance and manufacturing efficiency. Consistent with theory, the results show that employee turnover is negatively associated to the implementation of some practices, and also to manufacturing efficiency. These results are discussed within the context of sustainable manufacturing operations.

Keywords: Employee turnover, time-based manufacturing practices, manufacturing performance, manufacturing efficiency

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1. Introduction

Sustainability of manufacturing operations has become an important issue in recent years. There is vast evidence (both academic and practical) that points to the fact that, when properly implemented, continuous improvement practices such as TQM, JIT, Lean Manufacturing, etc; positively affect manufacturing performance. The key question here is, how can these concepts become permanent and sustained practices in the daily operations of manufacturing companies?

As practices that emphasise the active involvement of employees, it is expected that employee (labour) turnover represents an obstacle to the sustained and effective implementation of the above mentioned practices. However, the constant replacement of the labour force can also have direct implications not only on the implementation of these practices, but also on performance measures such as costs, output, timely deliveries, quality, etc. Thus, employee turnover can potentially cost a company indirectly (through the failed implementation of continuous improvement practices) and also directly (through the mistakes that untrained, unskilled new employees might cause).

To state that the human resources of any company are a central element of its everyday operations might seem redundant and obvious. After all, it is humans who ultimately operate and put to work the process and procedures in any firm. That is why it is surprising to find that very few studies have tried to examine the effect of employee turnover on several aspects of manufacturing operations. In our opinion, this issue has been understudied, a fact that gives the opportunity for innovative research. This study tries to address this gap. It explores the effect of labour turnover on the implementation of time-based manufacturing practices, manufacturing performance and manufacturing efficiency.

The paper is structured as follows: Section 2 reviews the studies that examine the effect of labour turnover on manufacturing improvement practices. Section 3 reviews the literature on employee turnover and manufacturing performance. Section 4 discusses the literature review and establishes the research hypotheses. Section 5 describes the data, research methods and data collection. Section 6 examines and discusses the results. Finally, section 7 offers some conclusions and suggestions for future research.

2. Employee turnover and its effect on manufacturing improvement practices

The positive impact on performance of manufacturing improvement practices such as total quality management (TQM), total preventive maintenance (TPM), just in time (JIT) and others is well-documented (see for example Sakakibara et al, 1997; Cua et al, 2001). Thus, the causes and variables associated to the successful implementation of these practices, particularly in a manufacturing setting has become a central topic for practitioners and researchers.

Central to the successful implementation of this type of practices is the active role and participation of all employees. Early proponents such as Juran (1988) and
Deming (1986) stress the importance of committed, empowered and well-trained human resources in order to fully benefit from the implementation of continuous improvement practices. Accordingly, almost without exception, studies that have conceptualised these practices and examined their effect on manufacturing performance have included and acknowledged the human factor in them (see for example Ahire et al, 1996; Koufteros et al, 1998)

Expectedly, employee turnover has been identified as a potential obstacle in the implementation of these practices. As any practice/system that relies greatly on the active involvement of the workforce, the constant substitution of workers should naturally be a critical factor in the successful implementation and sustainability of continuous improvement practices.

A review of the literature reveals very few studies that have reported labour turnover as an obstacle to the implementation of TQM in manufacturing companies (McDermott, 1994; Dowlatshahi, 1998; Jun et al, 2004). This is surprising, as it would be expected that such an important factor in the implementation of this type of practices would have received more attention. Moreover, the reviewed studies base their results on the respondents’ perceived obstacles to TQM and anecdotic evidence, with little statistical analysis. Also, these studies concentrate only on TQM, and do not include other type of practices such as JIT production, cellular manufacturing, preventive maintenance, etc. These limitations offer scope for future research.

3. Employee turnover and its effect on manufacturing performance

Labour turnover can also negatively affect manufacturing performance. Arguably, this is one of the uncertainties that companies face in their internal process, uncertainties they have to plan for, as they may result in failed commitments to customers (Koh and Jones, 1999). Issues with uncertainties, including labour shortages, might induce companies to spend costly resources (safety inventory of materials, labour overtime) in order to lessen the impact of those uncertainties (Koh et al, 2000).

Through a review of the literature, some papers that report on the effect of labour turnover on manufacturing capabilities are found. For instance, Hutchinson et al (1997) explain that labour turnover costs are divided into input and output costs; the former relating to separation, replacement and training costs, and the latter to the reduced production rate of an inexperienced, untrained recruit. The causes of labour turnover may sometimes be outside the influence of a company (Hutchinson et al 1997), or may be inherent to it (Taplin et al, 2003). Arthur (1994) shows that labour turnover is significantly and negatively associated to scrap rates and efficiency (labour hours/output rates) in an environment where a company is more committed to the development, involvement and training of its employees. In a simulation-based study, Hutchinson et al (1997) find that turnover rate has a large and negative effect on the throughput levels in a serial assembly line.

Previous studies help us to understand the impact of labour turnover on manufacturing performance. However, the number of these studies is very limited. Also, one of them deals with this topic using simulation (Hutchinson et al, 1997). Arthur (1994) deals with this topic in more detail, but his study centres on the steel
industry. Besides, his study does not include other measures of manufacturing performance such as flexibility, inventory costs, etc.

### 4. Discussion of the literature and research hypotheses

Labour turnover and its effect on continuous improvement practices and manufacturing performance is an important issue for both practitioners and academics. Our review of the literature reveals that this topic has been understudied, and that previous papers that have dealt with it have several limitations. Thus, we think our paper is an advance over previous studies on various levels:

1. Our paper studies the effect of labour turnover on manufacturing practices, manufacturing performance, and manufacturing efficiency together. Past studies have examined these relationships separately.

2. Previous authors have mainly concentrated on the effect of labour turnover on TQM. Also, the results of previous studies are based mainly on perceived obstacles to TQM implementation and anecdotic evidence, with limited statistical analyses. Apart from TQM-related items, our paper includes other practices/concepts that can also be affected by employee turnover. Moreover, this study measures these practices by using well-accepted statistical analyses and methods, which make the constructs both valid and reliable.

3. When analysing the impact of labour turnover on performance, previous studies have used limited approaches (e.g. simulation) and/or have used a limited set of manufacturing performance measures. This study is based on a survey of manufacturing companies, which includes a more comprehensive set of manufacturing performance measures that are well-accepted in the operations management field (inventory costs, flexibility, delivery reliability, etc).

Now that the justification for the study has been established, and based on previous evidence and theory, we proceed to state the research hypotheses:

**Hypothesis 1:** Labour turnover is negatively associated with the implementation levels of continuous improvement practices (time-based manufacturing practices).

**Hypothesis 2:** Labour turnover is negatively associated with manufacturing performance levels.

**Hypothesis 3:** Labour turnover is negatively associated with manufacturing efficiency levels.

### 5. Description of the data, research methods and data collection

A mail survey was sent in the summer of 2002 to a group of companies listed in the Kompass (2002) and FAME (2002) websites. The questionnaires were sent to 653
companies included in the category “electricity, electronics and nuclear” in the Kompass database and 923 companies in the FAME database classified under the US SIC code 36, which corresponds to the category “electronic and other electrical equipment and components, except computer equipment”. Responses from the recipients arrived over a period of several weeks after sending questionnaires. Various questionnaires were returned with incomplete answers. The respondents were contacted again in order to have the incomplete items answered. In some instances, respondents were not available or did not want to provide more information. Thus, it was decided to discard the questionnaires that did not have some of the main dependent variables fully answered from further analysis (on-time delivery measure, inventory turnover, safety production capacity, labour overtime and defective product return rates). This is consistent with the recommendations from Hair et al (1998). With regards to the rest of the variables, it was decided to adopt the mean value of the whole sample in the case of missing values. In the final sample, only one variable presented one missing value (stock keeping units). Furthermore, as the FAME database includes companies from Ireland, and for homogeneity purposes, it was decided to exclude them from the study and use only UK companies.

Companies from the Kompass sample returned a total of 49 questionnaires. However, only 18 of these met the established criteria. 26 respondents indicated they are not manufacturers. One questionnaire was incomplete, another company indicated they are no longer manufacturers, two questionnaires were returned totally unanswered, and one company decided not to participate. Thus, the rate of usable questionnaires for the Kompass sample was 2.75 % (18/653).

Respondents from the FAME sample returned a total of 60 questionnaires. Nevertheless, only 30 of these met the required criteria. 12 companies indicated they are not manufacturers. 3 questionnaires were returned due to wrong addresses. 2 questionnaires were returned because people decided not to participate or were not available. 2 companies were no longer in manufacturing or had closed down operations. Two more companies returned the questionnaires with no answers at all. Therefore, the rate of usable questionnaires for the FAME sample was 3.25 % (30/923). The total rate of usable questionnaires combining the Kompass and FAME populations was 3.04 % (48/1576). Thus, the final sample consisted of 48 UK companies that responded to the “electronic and other electrical equipment and components, except computer equipment” category.

To measure time-based manufacturing practices, a revised version of the questionnaire proposed by Koufteros et al (1998) was used. We decided on the use of this instrument on the basis of the concepts that it includes (JIT related practices, TQM related practices, and TPM related practices), and the revised approach was taken in order to reduce the number of items and hence increase the chances of a greater response rate. The revised version of the instrument contains five-point, likert-type items that are intended to measure the implementation levels of practices such as “shop-floor employee involvement in problem solving”, “reengineering setup”, “cellular manufacturing”, “preventive maintenance”, “quality improvement efforts”, “dependable suppliers” and “pull production”. These seven practices (each measured by four items) make a total of twenty-eight items for this section of the questionnaire.
Tests of sample adequacy (Bartlett test of sphericity and MSA) were performed. They reveal non-zero correlations (significant at the .000 level), and the overall MSA is .681, which could be deemed as merely acceptable (Hair et al, 1998). No single item falls below the .50 level, so there is no need to take corrective actions at this stage.

The psychometric properties of these constructs were assessed by exploratory factor analysis. It was decided to use principal components extraction method with varimax rotation. It was also decided to delete individual items in order to achieve loadings as close to .80 as possible, and also to obtain a MSA as high as possible. By following these criteria, five factors are obtained. These are representative of five practices (reengineering setup, cellular manufacturing, preventive maintenance, dependable suppliers and pull production). All factors have items with loadings of .789 or higher. The overall MSA is .707, and the Bartlett test is significant at the .000 level. Only the items that measure “quality improvement efforts” did not fall significantly into any factor, so these items and the variable were deleted from further analysis. It is worth noting that all the final items fell into their respective initial factors. For instance, “reengineering setup” is composed of items that initially were labelled as belonging to that measure. Also, the separate analysis of the items that measure “shop-floor employee involvement” activities resulted in a consistent and significant factor, with all items having loadings of .795 or higher, the overall MSA is .789, and the Bartlett test significant at the .000 level.

The next step in the analysis of the instruments that measure manufacturing practices is to create summated scales. This is because, since the manufacturing practices are composed by various items, it is better to combine those items into one single measure for subsequent analyses. Generally, the average score of the variables is used. However, in order to justify the creation of a summated scale, various aspects have to be satisfied. Hair et al (1998, p. 117) write that any summated scale has to deal with basically four issues: conceptual definition and content validity, dimensionality, reliability and validity.

Content validity and conceptual definition are justified in light of the literature review. The items that measure the manufacturing practices are consistent with what is generally accepted in the operations management literature. Reliability of the scales is statistically assessed. Dimensionality in a summated scale means that the items that compose it are one-dimensional and represent a single concept. It can be assessed by exploratory or confirmatory factor analysis. Based on this, dimensionality of the constructs is considered appropriate. A Cronbach’s alpha measure of .70 or higher is generally considered as satisfactory. All six instruments have values of .76 or higher. Hence, the statistical reliability of the instruments is justified. Convergent and discriminant validity are both confirmed by the exploratory factor analysis. Item loadings are .789 or higher, with cross-loadings of .237 or lower.

Since this study also includes measures of manufacturing efficiency, a linear programming tool known as data envelopment analysis (DEA hereafter) will be used to model manufacturing efficiency. The DEA model of efficiency includes performance measures such as inventory turns, safety production capacity and labour overtime as inputs, and on-time delivery rates and “good product with customers” as outputs. To achieve brevity, we refer the reader to Charnes et al (1993), Cooper et al (2000), and Sarmiento (2004) for a better explanation and details about DEA and the manufacturing efficiency model used in this study.
DEA scores of efficiency are nonparametric (Cooper et al, 2000). Thus, in order to achieve consistency across the analyses of the three research hypotheses, the relationships between the variables labour turnover, time-based manufacturing practices, manufacturing performance and manufacturing efficiency will be evaluated with nonparametric correlation analysis. Cause and effect relationships are difficult to evaluate using correlation analysis. However, when there is a strong theoretical background (as in this study) to support such relationship, correlation analysis becomes an acceptable tool to use (Clark-Carter, 1997).

The following table offers a description of the individual variables included in this paper:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>“Best value” (manufacturing capabilities)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>QUALITY</td>
<td>Quality improvements efforts</td>
<td>discarded from further analysis</td>
<td></td>
</tr>
<tr>
<td>SHOPEMP</td>
<td>Shop-floor employee involvement</td>
<td></td>
<td></td>
</tr>
<tr>
<td>REENGI</td>
<td>Reengineering setup</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CELLUMA</td>
<td>Cellular manufacturing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PREVEN</td>
<td>Preventive maintenance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DEPSUPP</td>
<td>Dependable suppliers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PULLPRO</td>
<td>Pull production</td>
<td></td>
<td></td>
</tr>
<tr>
<td>INVTIT</td>
<td>Total inventory levels</td>
<td>Low</td>
<td>INVVTIT= 1/TIT</td>
</tr>
<tr>
<td>OTD</td>
<td>On-time delivery rates</td>
<td>High</td>
<td>Also referred to as “delivery reliability” in the study</td>
</tr>
<tr>
<td>ROM</td>
<td>Rate of manufacturing cycle performance</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>GPC</td>
<td>Good product with customers</td>
<td>High</td>
<td>GPC = 100 – average percentage of defective product return</td>
</tr>
<tr>
<td>DPWP</td>
<td>Defective product whole process</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td>VF</td>
<td>Volume flexibility</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>LO</td>
<td>Labour overtime</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td>SC</td>
<td>Safety production capacity</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td>LABORT</td>
<td>Labour turnover</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1. Description of the individual variables included in the study.

The following table describes the efficiency model used in the study:
Table 2. Variables included in the manufacturing efficiency model.

<table>
<thead>
<tr>
<th>Model</th>
<th>Inputs</th>
<th>Outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>3IOTDGPC</td>
<td>INVTIT, LO, SC</td>
<td>OTD, GPC</td>
</tr>
</tbody>
</table>

The next section tests the research hypotheses and discusses the results of the study.

**6. Results and discussion**

In this section, the research hypotheses will be tested using correlation analysis, and the results will be discussed.

The first research hypothesis states that:

**H1: Labour turnover is negatively associated with the implementation levels of continuous improvement practices (time-based manufacturing practices).**

The following table shows the effect of labour turnover on the implementation of time-based manufacturing practices:

<table>
<thead>
<tr>
<th>SHOEMP</th>
<th>REENGI</th>
<th>CELLUMA</th>
<th>PREVEN</th>
<th>DEPSUPP</th>
<th>PULLPRO</th>
</tr>
</thead>
<tbody>
<tr>
<td>LABORT (Spearman coefficient)</td>
<td>-0.033</td>
<td>-0.138</td>
<td><strong>-0.288</strong></td>
<td>-0.052</td>
<td>-0.217</td>
</tr>
</tbody>
</table>

Table 3. Correlation analysis between labour turnover and time-based manufacturing practices.

n = 48

**BOLD** = significant at the .05 level.

As predicted by theory and previous evidence, labour turnover has a significant and negative relation with cellular manufacturing. Thus, hypothesis 1 is accepted in the case of the "cellular manufacturing" variable.

Hypothesis 2 states that:

**H2: Labour turnover is negatively associated with manufacturing performance levels.**

The following table shows the relationship between labour turnover and manufacturing performance:
Table 4. Correlation analysis between labour turnover and manufacturing performance measures.

Con contrary to evidence and theory, employee turnover does not appear to have a significant relationship with any of the measures of manufacturing performance included in the study. Thus, hypothesis 2 is rejected in all cases.

Hypothesis 3 states that:

**H3: Labour turnover is negatively associated with manufacturing efficiency levels.**

Table 5 shows the effect of employee turnover on manufacturing efficiency:

<table>
<thead>
<tr>
<th>LABORT</th>
<th>3IOTDGPC</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.158</td>
<td>-0.417</td>
</tr>
</tbody>
</table>

Table 5. Correlation analysis between labour turnover and manufacturing efficiency.

It is observed that labour turnover has a significant, negative effect on manufacturing efficiency and on the implementation of cellular manufacturing. These results seem to be consistent with the scant evidence from previous studies. Though previous results have identified employee turnover as an obstacle to the implementation of TQM, it can be expected that other similar practices that depend greatly on the active involvement of employees should be negatively affected. In fact, though not statistically significant, the sign of the relationship between labour turnover and the rest of the practices (shop-floor employee involvement, pull production, reengineering, etc) is negative. Given the small sample and the low response rate, based on these results, it could be expected that with a larger and more representative sample these relationships could become significant and negative.
Labour turnover did not have a significant relationship with any of the manufacturing performance measures. This is contrary to previous results and theory. However, it is interesting to note that just as in the case of the manufacturing practices, all the relationships between labour turnover and manufacturing performance measures have the expected sign. For instance, labour turnover can be expected to cause more uncertainties in the daily operations of plants. Consequently, companies may find themselves trying to deal with these uncertainties by investing in costly resources such as safety inventory of materials (INTIT), labour overtime (LO) and safety production capacity (SC). Likewise, untrained, unskilled new employees might cause more scrap and defective product in the whole production process (DPWP). With a larger and more representative sample, these relationships could be confirmed.

Interestingly, when a model of manufacturing efficiency is constructed with some manufacturing performance measures as inputs and outputs, its relationship with labour turnover becomes highly significant and negative. This means that while the effect of labour turnover on each individual variable is not statistically significant, when analysed together as one measure of efficiency, the real and negative impact of labour turnover on manufacturing operations becomes clearer. The extra analysis of performance and labour turnover in the form of a model of manufacturing efficiency helps the analyst to understand better that relationship. This result is partly consistent with that obtained by Arthur (1994). In his study, he also observes a negative relationship between employee turnover and a measure of efficiency (total labour hours per ton of steel) in the presence of human resource practices. However, as pointed out before, the present study includes more traditional and consistent measures of manufacturing performance and arguably a more complete and sound model of efficiency.

7. Conclusions and suggestions for future research

A literature review on the effects of labour turnover on manufacturing operations reveals that this issue has been understudied. This paper has tried to address this gap by analysing the impact of labour turnover on time-based manufacturing practices, individual measures of manufacturing performance, and manufacturing efficiency.

The results are generally consistent with previous evidence and theory. Practices that depend on the active involvement of the workforce should be expected to be negatively affected by the constant replacement of the labour force. Our results partly support this notion. The literature review offers some evidence about the potential effects that labour turnover can have on manufacturing capabilities (Arthur, 1994; Hutchinson et al., 1997). It is interesting that while the effect of labour turnover on each manufacturing performance variable that is part of the efficiency model is not significant, this effect becomes significant when all variables are put together as one model of efficiency. Thus, by combining the “little” effects that labour turnover has on internal operations, a clearer picture of its impact on the operations as a whole can be obtained. With this in mind, now the question would be whether manufacturing firms can do something to avoid high labour turnover levels. The literature review suggests that in some occasions this issue may be outside the control of the company (Hutchinson et al., 1997), and sometimes may be inherent to it. For instance, Taplin et al (2003) found that in labour intensive industry such as clothing
manufacturing, low earnings (low pay) is the factor most subjects see as a reason for leaving the company. Therefore, this evidence should be of some help for companies in terms of how they deal with the issue of labour turnover.

When speaking of successful and sustainable manufacturing operations, we agree with Vastag (2002) when he affirms that “As the success and manufacturing prowess of the Japanese car manufacturers illustrated, heavy investments in soft, infrastructural factors can lead to sustained competitive advantages”.

In terms of the final sample of subjects, it is observed that the number of participants (48) is relatively low. Thus, the implications and conclusions derived from the analysis cannot be easily extrapolated. It is possible that with a larger sample further, or different, significant associations may be discovered.

In terms of the research design and the response rate, the percentage of valid responses from the survey questionnaire is also low (3.04 %). This has direct implications on the representativeness of the sample and thus the appropriateness to generalise the findings. Although the survey instrument was designed with the idea and recommendations on how to obtain better response rates, the results are less than satisfactory. This could be due to a problem with the design and strategy of the survey questionnaire. However, it could also be that other factors arguably outside the control of the researcher also had something to do with the low response rate. For instance, various companies simply declined to participate due to internal policies/regulations. Another company indicated that they receive too many student surveys, something they consider a waste of their time. In short, it could be argued that factors outside/inside the control range of the researcher contributed to a low response rate. These factors should be taken into consideration in future studies.

The items that measure manufacturing capabilities also could be refined. While there is justification for using a measure of total inventory levels as an input, future studies could also consider analysing measures of raw materials inventory and/or finished goods inventory as inputs. The rationale is that the more disaggregated the data, the better the understanding of the factors that affect particular aspects within manufacturing firms.

In terms of the analysis of the information, the results, conclusions and suggestions of the paper are based on correlation analysis between labour overtime and different individual variables. However, if the conditions permit, a more strict approach such as regression analysis could also be employed. The use of a regression analysis could complement the results obtained by correlation analysis.

In spite of its limitations, we think that this study represents a good start, and we hope it will encourage future researchers to analyse in more depth and detail the impact of labour turnover on manufacturing operations.

Note: the items and constructs used in the survey, as well as statistical information about the variables in this paper are available upon request.
References


• Kompass database (2002). www.kompass.com


