Two Perspectives on Multiskilling and Product Market Volatility

DeVaro, Jed and Farnham, Martin

University of Victoria, California State University, East Bay

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Jed DeVaro*
Department of Management and Department of Economics
College of Business and Economics
California State University, East Bay
Hayward, CA 94542
E-mail: jed.devaro@csueastbay.edu

and

Martin Farnham
Department of Economics
University of Victoria
Victoria, BC, Canada, V8W 2Y2
E-mail: mfarnham@uvic.ca

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Abstract

We study the effect of product market volatility on a firm's choice between multiskilling and specialization. We construct a theoretical model that captures the tradeoff between multiskilling (which gives greater flexibility to reassign workers in production) and specialization (which provides workers with the expertise to respond to product market signals in their area of specialty). Using data from the 2004 WERS, a nationally-representative cross section of British establishments, we find that greater volatility is associated with greater specialization. This result holds both inside and outside of manufacturing, but consistent with our model, it holds only in multi-product establishments and not in single-product ones.

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I. INTRODUCTION

A fundamental question in job design is whether employers should have workers specialize in certain tasks or whether workers should be multiskilled so that they are able to perform multiple tasks. Two broad perspectives might be taken concerning the benefits of multiskilling relative to specialization. The first, which we refer to as the "flexibility perspective," is that a key advantage of multiskilling relative to specialization is flexibility in labor allocation. That is, if workers are multiskilled, they are able to switch quickly from one task to another in response to changing production requirements or product demand. The second, which we refer to as the "productivity perspective," concerns the benefits of specialization that have been well known since Smith (1776). That is, specialized workers, either due to more intensive training or due to more focused learning-by-doing, are more skilled at the task they are specialized in than are workers whose training and labor are spread across multiple tasks. This suggests that specialized workers will have deeper knowledge of a given task and will be more productive at it than will multiskilled workers, who are "jacks of all trades and masters of none."[1]

In this paper we explore, theoretically and empirically, how the relative benefits of multiskilling versus specialization change when the market for a multi-product firm's products (or services) becomes more volatile. We argue that as product market volatility increases, so does the importance of being able to innovate—to adjust product specifications in response to changing market conditions.[2] Since workers specialized in one good know their product better than multiskilled workers, whose training is spread across multiple goods, specialists have a productivity advantage in their greater ability to adapt their product to changing market conditions. Therefore, we argue that as product market volatility,

[1] The "jack of all trades, master of none" notion that it is rare for someone who is excellent in one activity to be excellent in another is quite intuitive. A formal argument establishing the result can be found in Lazear (1998), pp. 469 – 473.

[2] Changing product specifications can occur in both manufacturing and non-manufacturing contexts, and can involve formal product changes (e.g. those involving creation of a new model of the product) or tailoring a good or service to a particular client need. For example, a lawyer specializing in divorce law is likely to be more capable than a generalist lawyer of crafting an innovative negotiation strategy on behalf of her client.

and hence the need for innovation, increases, so does the importance of the productivity perspective relative to the flexibility perspective. This in turn implies that as volatility rises, firms will engage in less multiskilling and more specialization.

We present a simple theoretical model that incorporates both the flexibility and productivity perspectives and illustrates the tradeoffs between multiskilling and specialization. We demonstrate that for most plausible parameter values, firms decrease multiskilling as product market volatility rises. Then, in an empirical analysis of a large, nationally-representative cross section of British employers, we present evidence consistent with our theoretical model that product market volatility is, on average, associated with a lower degree of multiskilling. Also consistent with our theoretical model, we find that this result holds for multi-product firms but not for single-product firms.

Additionally, we show that the result holds both inside and outside of manufacturing. The fact that the result holds strongly outside of manufacturing is interesting. While the job design literature has focused heavily on manufacturing, that sector has declined in recent decades, and less than 13 percent of the establishments in our 2004 sample are in manufacturing. Given the trends in the modern economy, we see it as important for the job design literature to move beyond a narrow focus on the manufacturing sector, and our paper is a step in that direction.

The idea of innovation used in this paper warrants a brief discussion. We argue that specialized workers have a productivity advantage over multiskilled workers because their expert knowledge of a given product makes them better at adapting that product to changing consumer demand. This adaptation, or product innovation, can take the form of changing the product in small ways or large. And the adaptation can be done either at the instruction of a manager—in which case the specialist's expertise makes her more capable of implementing the manager's instructions—or the adaptation can be instigated by the worker herself, as in the case of delegated authority.

In assuming that specialists have superior innovation skills, we are implicitly distinguishing between *product innovation* (the adaptation of a product in response to changing market signals), and *process innovation* (such as occurs when workers suggest cost-cutting measures—for instance in the case of continuous process improvement). We argue that specialists are better at *product* innovation, while multiskilled workers are likely better at *process* innovation (this latter point has been suggested by various authors, including Koike (1985), Aoki (1986), and Morita (2005)). Our data explicitly address product market volatility, so our use of the term innovation throughout this paper will refer to product innovation. We discuss this distinction further in Section IV.

Our model concerns the training decision of a two-product firm operating over two periods and employing two *ex ante* identical workers. Product market volatility comes in the form of changing consumer demand for product specifications, which requires innovation by the firm's workers and which may lead the firm to want to reallocate labor as relative profitability of the goods changes. In the first period workers can both be trained to produce both goods (i.e. multiskilled) or one can be trained to produce one good and the other to produce the other good (i.e. specialized). In the second period, the firm learns the latest product specifications demanded by consumers for each of the two goods it produces. The firm's workers must innovate to meet these latest specifications. Multiskilled labor can innovate up to a point. However, if the specifications demanded by consumers require an extremely high level of innovation, only workers specialized in that good can perform the necessary innovation. This means that a firm that multiskills its labor force risks being unable to produce one or both goods, if the level of innovation required is extremely high. On the other hand, if the level of innovation required of the firm's workers is such that it is feasible to produce both goods, the firm then has the flexibility to assign both multiskillled workers to the more profitable good. In our model, which assumes a degree of product differentiation, firms offering more innovative goods can charge a premium for their innovation. Hence more innovative goods are more profitable.

An example of how a firm's choice of multiskilling versus specialization can be affected by product market volatility will serve to make these ideas more concrete. Consider a firm that provides business consulting services. Suppose that it provides clients with services in two areas of business consulting—management strategy and human resources consulting. This firm could train all its workers to do both management strategy and human resources consulting (hence multiskilling its workforce), or it could specialize workers in each area. Suppose that *ex ante*, the expected profitability of each consulting area is equal, but *ex post*, one area will turn out to have consumers who demand particularly innovative solutions and are willing to reward such innovation with a higher price.

In a relatively stable product market, the degree of innovation required by clients is not likely to be particularly high, *ex post*, and the expected difference in *ex post* profitability between services offered will be small. Hence the return to innovation will be low, as will the return to flexibility in labor allocation.

If product market volatility rises, uncertainty about client needs rises. The possibility of clients demanding highly innovative services increases, thus raising the return to specialized workers. On the other hand, relative differences in *ex post* profitability of the firm's services also rise, thus raising the return to flexibility in labor allocation. Similar examples are found in a diverse range of employment settings, from manufacturing to services, where employers face a tradeoff in their choice of training mix between the flexibility advantage of multiskilled workers and the productivity advantage of specialists. In our model, for most plausible parameter values, the return to innovation rises faster than the return to flexibility. As a result the productivity perspective on multiskilling dominates—that is, as product market volatility rises, firms tend to choose specialization over multiskilling. The theoretical prediction is confirmed by our empirical results.

The key theoretical contributions of our paper are 1) examining the role of product market volatility in the firm's decision to multiskill workers, which has not been addressed in the literature to date; 2) highlighting productivity gains from specialization, which have been underemphasized in the literature on multiskilling; 3) highlighting gains from multiskilling in the form of flexible labor allocation, which have also been underemphasized in the literature; and 4) drawing a link between specialization and increased product innovation by workers.

The key empirical contributions of our paper are 1) testing a new theory of multiskilling and providing empirical results consistent with that model and with the existing theoretical literature; 2) introducing a new stylized fact to the job design literature—that higher levels of product market volatility are associated with less multiskilling in multi-product establishments; and 3) providing empirical results that, because they are based on a nationally-representative sample of establishments in Britain, can be demonstrated to be applicable across sectors and firm sizes. Thus, our paper contributes to the broadening of the empirical job design literature beyond manufacturing, a sector that has long been in relative decline in most developed economies.

Following the presentation of our main empirical results, in Section IV we discuss how our findings relate to the existing literature on multiskilling. We note some novel theoretical predictions that result from synthesizing our findings with the existing literature and test two of these predictions empirically. In particular, we integrate our theory with that of Morita's (2005) paper on continuous process improvement, providing empirical tests of both integrative extensions.

II. A THEORETICAL MODEL

One perspective is that multiskilling allows firms to flexibly reallocate labor in response to changing demand conditions. We refer to this as the "flexibility perspective." Another perspective is that specialization gives workers deep expertise that enables them to innovate and rapidly tailor products and services to the changing specifications demanded by consumers. This ability to innovate, deriving from intensively specializing in one area, is lacking in multiskilled workers who are "jacks of all trades and masters of none." We refer to this second perspective as the "productivity perspective." We now present a model that incorporates both perspectives and describes how their relative importance, and the firm's decision to multiskill or specialize its workers, changes when the degree of product market volatility increases.

Consider a firm that has two tasks (A and B) which we shall think of as separate products or services. The firm employs two *ex ante* identical workers. The model consists of two periods. We assume that product differentiation is the source of at least some degree of market power in the product market.

In the first period, the employer makes training decisions (i.e. deciding whether each worker will be trained on a separate product or whether they will both be trained on both products) without knowledge of what the specifications will be of the products/services demanded in the next period. The employer must pay a per-worker training cost of *c* to train a worker. A worker's training can be spread across both products, in which case we refer to the worker as multiskilled. Or the training can be focused entirely on one product, in which case we refer to the worker as a specialist.[3]

In a relatively stable product market, product specifications demanded by consumers will not change dramatically from one period to the next, so relatively low levels of innovation will be required from the firm's workers in the second period. But in a volatile product market, product specifications demanded by consumers can change dramatically. In these instances, a considerable level of worker innovation is needed in the second period to execute production to meet the specifications demanded by consumers. The firm knows that if it can successfully meet the product specifications it will be able to charge a higher price to consumers, whereas if it cannot tailor the product so as to meet demand it will be unable to sell at all.

In the second period, the employer observes the specifications at which products are demanded and can allocate labor accordingly to products A and B. Workers can only produce a product if they were trained on it in the previous period. When making first-period training decisions, the employer observes the distribution from which the degree of "innovation required to meet the demanded product specifications" is drawn. We normalize to zero the average degree of innovation required. Thus, positive realizations reflect a greater-than-average level

[3] In practice, training costs might be higher for multi-skilled workers than for specialized workers given that they must be trained on both products. We assume equal training costs to emphasize the point that, for a given amount (and cost) of training, specialists in a product will have higher expected productivity than multiskilled workers in that product, as a consequence of their more intensive focus on that product.

of innovation required, and negative realizations reflect a smaller-than-average level. Henceforth, we refer to a draw from this distribution as the "degree of innovation required", where it is understood that this degree is "relative to the average." The two realizations (one for each product) from this distribution are independent and are observed at the start of the second period. Let the degree of innovation required be denoted I_j for product j, which is distributed uniformly on $[-\alpha, \alpha]$, where $0 < \alpha \leq p$, and p is the baseline, or expected, price of product j when the average level of innovation is required. An increase in α is interpreted as an increase in the degree of product market volatility.

If the innovation realization is negative then the firm charges less for the product, whereas when the realization is positive, the firm charges more as long as it is able to meet the specifications. If the degree of innovation required is sufficiently high (i.e. above a critical threshold, k, where $0 \leq k \leq \alpha$) then multiskilled labor is unable to produce the good at all, meaning the firm can produce and sell it only if there are specialized workers. Only specialized workers, with their deep expertise, possess sufficiently high innovation to enable them to meet demand in these instances, and when that happens, the firm can charge a higher price for the product. Product prices are given by $p_j = p + I_j$, meaning both prices are distributed independently and uniformly on $[p - \alpha, p + \alpha]$ with expected price of p for each product. Since the product prices are i.i.d., there is no reason for the employer to prefer one product over the other when making first-period training decisions. Thus, if specialization is chosen, then one worker will be trained on product A and the other on product B. Once trained on a particular product, an individual worker's productivity on that product is V, unless the worker is multiskilled and the degree of innovation required exceeds k, in which case productivity is zero.

The employer is pre-committed to paying a fixed wage, w, to all workers in the second period, regardless of whether they are multiskilled or specialized, regardless of what they produce, and regardless of whether second-period revenue is large enough to offset the wage bill. This gives rise to the possibility that realized second-period profit can be negative for sufficiently low realizations of prices. The assumption is made for simplicity and is not essential for the results.

The key tradeoff the employer faces when making first-period training decisions is flexibility versus productivity. If both workers are multiskilled, then if the realized price of product A is higher than the realized price of product B, both workers can be assigned to product A, and *vice versa*, so long as extremely high levels of innovation (i.e. $I_j > k$) are not required. In contrast, if the workers are specialized, then only one worker is trained to produce the product for which the realized price is higher. So in the multiskilling case, in the second period both workers can, in many cases, be assigned to the product for which the realized price is higher. The downside to multiskilling is that, given that workers are trained on both products, they become "jacks of all trades and masters of none." For levels of required innovation in the "normal" range (i.e. $I_j < k$) this is not a problem. But with some probability, market demand will be such that a very high degree of innovation is required to tailor product specifications to consumer tastes, and in those cases, only specialized labor possesses the skills needed to produce. Thus, the risk that the employer runs by choosing multiskilling is that very high levels of innovation will be required on one or both of the products. If high innovation is required on one product, then both multiskilled workers will (out of necessity) be assigned to the other product. If high innovation is required on both products, then a firm in which both workers are multiskilled cannot produce at all. In contrast, specialized workers can always produce the product they are trained on, regardless of the required level of innovation.

Let π_S and π_M denote the employer's profit given that its workers are specialized and multiskilled, respectively. Expected profit from specialization is: $E(\pi_S) = 2(pV - c - w)$. Let $\theta = \text{Prob}(p_A > p + k) = \text{Prob}(p_B > p + k) = (\alpha - k)/2\alpha$. Expected profit from multiskilling is:

$$E(\pi_M) = 2\theta(1 - \theta)(2p + k - \alpha)V + (1 - \theta)^2 2[p + (2k - \alpha)/3]V - 2c - 2w$$

where $p + (2k - \alpha)/3$ is $E(\max[p_A, p_B] \mid p_A \leq p + k, p_B \leq p + k)$, or the expected value of the second order statistic based on two draws from the uniform distribution on $[p - \alpha, p + k]$. We assume that V is large enough so that $\max[E(\pi_M), E(\pi_S)] > 0$, which guarantees that the firm operates. Then the employer chooses multiskilling when making first-period training decisions if $E(\pi_M) > E(\pi_S)$, which reduces to:

(1) $f(\alpha) \equiv \theta(1-\theta)(2p+k-\alpha) + (1-\theta)^2[p + (2k-\alpha)/3] - p > 0$

Letting f_α and $f_{\alpha k}$ denote $\partial f/\partial\alpha$ and $\partial^2 f/\partial\alpha\partial k$, the main result is:

Proposition 1:

i) If $k = 0$, the firm chooses specialization $\forall\alpha$.

ii) If $k = \alpha$, the firm chooses multiskilling $\forall\alpha$.

iii) If $k \in (0,\alpha)$, then $f_\alpha < 0$ and $f_{\alpha k} < 0$. Furthermore, if $f(p) < 0$ there exists α' in (k,p) such that the firm chooses multiskilling if $\alpha < \alpha'$, the firm chooses specialization if $\alpha > \alpha'$, and $d\alpha'/dk > 0$.

Proof: If $k = 0$, (1) never holds, establishing point i). If $k = \alpha$, (1) always holds, establishing point ii). The first sentence of point iii) follows from $f_\alpha = (3pk^2 + k^3 - 3\alpha k^2 - 2\alpha^3 - 3p\alpha k)/(6\alpha^3) < 0$ and $f_{\alpha k} = (6pk + 3k^2 - 6\alpha k - 3p\alpha)/(6\alpha^3) < 0$. Given that $f(k) = k/3 > 0$ and that $f(p)$ can be shown to be negative if p is sufficiently large relative to k, the existence of α' when $f(p) < 0$ follows from the intermediate value theorem, where α' is defined by $f(\alpha') = 0$. Applying implicit differentiation to $f(\alpha') = 0$ establishes $d\alpha'/dk > 0$. *Q.E.D.*

The parameter k captures the relative importance of the productivity perspective versus the flexibility perspective. When $k = 0$, the productivity perspective is at maximal importance, since specialized workers are needed to produce even when the level of required innovation is only slightly above average. Given that multiskilled labor is unable to produce at all for any above-average levels of required innovation, the firm never multiskills its workers, regardless of α. At the other extreme, when $k = \alpha$, the productivity perspective vanishes from the model, since there exists no level of required innovation beyond which specialized workers would have a productivity advantage over multiskilled workers.[4] Point iii) of the

[4] Note that under an alternative assumption that per-worker training costs are higher for multiskilled workers than for specialists, the firm would hire specialists in this case for sufficiently small α and would otherwise hire multiskilled labor. Intuitively, the reason why the firm's likelihood of multiskilling in this case would be increasing in α is that the advantage to the firm of being able to allocate all of its labor to the more profitable good is increasing in the expected profitability of the most profitable good (i.e. the expected value of the maximum order statistic is increasing in the variance of the underlying distribution), and this advantage would ultimately overwhelm the higher training costs for multi-skilled workers.

proposition shows that the firm's propensity to multiskill its workers is decreasing in the degree of product market volatility, which is the main result of the paper. The threshold α' increases with k, because increases in k diminish the importance of the productivity perspective, thereby expanding the range of values of product market volatility over which the firm finds it profitable to choose multiskilling.

The theoretical model characterizes the problem facing a single employer. To apply the model to analyze a cross section of employers, we incorporate establishment-level heterogeneity by attaching a subscript i to the parameters of the theoretical model, where i indexes establishments. Then, we can rewrite (1) as:

(2) $f(\alpha_i) \equiv \theta_i(1 - \theta_i)(2p_i + k_i - \alpha_i) + (1 - \theta_i)^2[p_i + (2k_i - \alpha_i)/3] - p_i > 0$

Next, approximating $f(\alpha_i)$ by the latent index $y_i^* \equiv \boldsymbol{X}_i\boldsymbol{\beta} - \varepsilon_i$, where $\boldsymbol{X}_i$ is a vector of observed employer characteristics (including a proxy for α_i, measuring the degree of product market volatility faced by establishment i), $\boldsymbol{\beta}$ is a vector of parameters to be estimated, and ε_i is a random variable with the standard normal distribution, we have the following probit model:

$\text{Prob}(y_i = 1) = \text{Prob}(y_i^* > 0) = \Phi(\boldsymbol{X}_i\boldsymbol{\beta})$

$\text{Prob}(y_i = 0) = \text{Prob}(y_i^* \leq 0) = 1 - \Phi(\boldsymbol{X}_i\boldsymbol{\beta})$

where Φ denotes the standard normal cumulative distribution function, and y_i is a binary indicator equaling 1 if establishment i chooses multiskilling and 0 if establishment i chooses specialization.

The primary question we address in our analysis is how the employer's multiskilling-versus-specialization decision varies with volatility in the product market. The statistic of interest is, therefore, the average value of the marginal effect $\partial\Phi(\boldsymbol{X}_i\boldsymbol{\beta})/\partial\alpha_i$ across all sample observations in the cross section. From Proposition 1, we would expect a negative sign on this statistic. With the exception of a small group of workers in "skilled metal and electrical trades", this is in fact the case, as we show empirically in the following section.[5]

[5] Our empirical analysis is based on ordered probit models, rather than binary probit models, since the "multiskilling" dependent variable is an ordered discrete response with seven categories.

III. DATA AND EMPIRICAL ANALYSIS

Our data source is the management questionnaire from the 2004 British Workplace Employee Relations Survey (WERS), jointly sponsored by the Department of Trade and Industry, the Advisory, Conciliation and Arbitration Service, the Economic and Social Research Council, and the Policy Studies Institute. Distributed via the UK Data Archive in November 2005, the WERS data are a nationally representative stratified random sample covering British workplaces with at least 5 to 9 employees, except for local units in Northern Ireland and those in the following 2003 Standard Industrial Classification (SIC) divisions: agriculture, hunting, and forestry; fishing; mining and quarrying; private households with employed persons; and extra-territorial organizations. The 2004 WERS was the fifth such survey, following earlier waves in 1980, 1984, 1990, and 1998. The sampling frame used for WERS 2004 is the Inter-Departmental Business Register (IDBR) which is maintained by the Office for National Statistics (ONS). As noted by Chaplin *et al.* (2005), "The IDBR is undoubtedly the highest quality sample frame of organisations and establishments in Britain. The frame is continuously up-dated from [administrative tax] records and establishments that no longer exist are removed reasonably quickly."

Our measure of multiskilling is the answer to the following question: "Approximately, what proportion of [workers in the establishment's largest occupational group] are formally trained to be able to do jobs other than their own?" From this we define the following discrete response variable:

Multiskilling = 1 if "None (0%)"
= 2 if "Just a few (1-19%)"
= 3 if "Some (20-39%)"
= 4 if "Around half (40-59%)"
= 5 if "Most (60-79%)"
= 6 if "Almost all (80-99%)"
= 7 if "All (100%)"

The distribution of responses for *Multiskilling* is displayed in Figure 1.

The following binary measure captures volatility in the product market:

Volatility = 1 if the current state of the market for the main product or service of the establishment is described as "turbulent" (= 0 otherwise)[6]

Note that the volatility measure allows for volatility in services as well as products. A limitation of the measure is that it permits a diversity of interpretations of "turbulence", including interpretations that might differ from the notion of volatility in our theoretical model.

An alternative interpretation of product market volatility could be one of volatility in the quantity of goods demanded from the firm by its customers. This differs from volatility in the specifications of the product demanded by its customers, which is the notion of volatility in our theoretical model. A firm facing the first type of volatility (quantity volatility) is uncertain how much it will have to produce in the future. A firm facing the second type of volatility (product specification volatility) is uncertain what the goods it produces will look like in the future.

Throughout our analysis, we assume that firms reporting product market volatility may be experiencing either or both forms of volatility but that, on average, product specification volatility (the form of volatility that we model) is an important dimension of product market volatility reported by firms in our data. In part, we assume this because the data on volatility that we use are derived from a question in which the interviewee is asked whether her firm's product market is presently growing, mature, declining, or turbulent. We denote firms facing a "turbulent" product market as experiencing product market volatility. Since interviewees are likely to interpret "growing" and "declining" as referring largely to quantity, it seems likely that "turbulent" captures other aspects of product market conditions, including product specification volatility, to a significant degree. Note that even if the notion of product market volatility in our data differs somewhat from the notion

[6] Other possible responses were "growing", "mature", or "declining."

in our theoretical model, this should simply make the empirical finding more difficult to discern.

Descriptive statistics for all variables in the analysis are displayed in Table 1; we use establishment sampling weights when computing the statistics in this table and in all of our subsequent analyses. Some of the variables contain missing values, and we estimate all of our models using listwise deletion.[7] Our analyses include controls for industry and employer characteristics, defined in the appendix.

We start with analysis based on the full sample and then show how our main result is significantly sharpened by some subsequent refinements of the analysis sample. The first column of Table 2 displays coefficients from an ordered probit model using *Multiskilling* as the dependent variable, with the incremental effects of an increase of *Volatility* from 0 to 1 appearing in the lower portion of the table. The main result is that, controlling for establishment characteristics, higher volatility in the product market is associated with a lower probability of multiskilling (and therefore a higher probability of specialization). This result is consistent with the main case of $0<k<\alpha$ in the theoretical model of Section II. The result is quantitatively significant but estimated with modest precision. More specifically, the incremental effect of an increase in *Volatility* from 0 to 1 is associated with an increase of 7.5 percentage points in the probability that *no* multiskilling is used in the establishment's largest occupational group. The base probability that no multiskilling is used is 0.40, so 7.5 percentage points represents an increase of 19 percent in the probability that no multiskilling is used. The z-statistic associated with this incremental effect is 1.53, so it is statistically significant at the ten percent level for a one-tailed test.

Further analysis reveals that the relationship between volatility and multiskilling is reversed for a small set of establishments for which the largest occupational group is the two-digit category "skilled metal and electrical trades".[8]

[7] In Table 1, we use all available observations for each variable to compute summary statistics. Analogous tables that compute summary statistics based on the smaller subsamples on which the multivariate statistical models are estimated closely match Table 1.

[8] These include (at the three-digit level) metal forming, welding, and related trades; metal machining, fitting, and instrument making trades; vehicle trades; and electrical trades.

For this group the incremental effect of an increase in *Volatility* from 0 to 1 is associated with a decrease of 45 percentage points (z=-2.79) in the probability that *no* multiskilling is used in the establishment's largest occupational group. Because the relationship between volatility and multiskilling is strongly positive for this small group and negative for the remainder of the sample, pooling all observations would misleadingly mask this stark difference. For this reason, in the subsequent analysis we exclude this small group of establishments while clearly acknowledging that our theory cannot explain the result for this group.[9] Excluding only those 78 establishments from the sample and re-estimating our model yields the results in the second column of Table 2. The main result is significantly strengthened in both an economic and statistical sense (the incremental effect increases from 7.5 percent to 10.8 percent with a z-statistic of 2.12, so the percent increase in the probability that multiskilling is not used increases from 19 percent to 27.3 percent).

The fundamental tradeoff underlying our theoretical model of multiskilling is the benefit of flexibility versus the cost of having workers who are "jacks-of-all-trades and masters of none". We formalize this idea by developing a model of a two-product production process, suggesting that our empirical analysis should also be based on multi-product firms. The survey allows us to stratify our sample based on "single product" versus "multi-product".[10] Table 3 displays ordered probit results for the multi-skilling model. Column 1 is for multi-product establishments and column 2 is for single-product establishments. Consistent with our theoretical model, the main empirical result is strengthened in the multi-product subsample

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[9] In a modified version of our model, if this group were characterized by higher per-worker training costs for multi-skilled workers than for specialists, and if $k = \alpha$ so that the productivity perspective vanishes from the model, then the firm would hire specialists for sufficiently small α and would otherwise hire multiskilled labor, thereby explaining the result for this group. Intuitively, the reason why the firm's likelihood of multiskilling in this case would be increasing in α is that the advantage to the firm of being able to allocate all of its labor to the more profitable good is increasing in the expected profitability of the most profitable good (i.e. the expected value of the maximum order statistic is increasing in the variance of the underlying distribution), and this advantage would ultimately overwhelm the higher training costs for multi-skilled workers. While we note this as a theoretical possibility, we do not emphasize the point given that $k = \alpha$ is an extreme parameterization and that is unclear why it would apply to this group (and only this group).

[10] The survey question is: "Is the output of this establishment concentrated on one product or service or are there several different products or services?" Responses are either "Single product or service" or "Different products or services".

(versus the full sample) and it disappears in the single-product subsample. In the multi-product sample (column 2), the incremental effect on the probability of no multiskilling is 0.175 (z=2.78) which, from a base probability of 0.34, implies an increase of 51.5 percent in the probability of no multiskilling. In the single-product sample (column 4), the incremental effect is only 0.013 and is far from statistically significant (z=0.16). We view the subsample in column 2 of Table 3 as the preferred subsample for empirically testing our theoretical model.

The literature on job design (both theoretical and empirical) has focused heavily on the manufacturing sector since its inception. Yet, in the 2004 British WERS, as seen in Table 1, less than 13 percent of the establishments are in manufacturing.[11] Given that the manufacturing sector has declined over time and is now small (relative to the entire economy) in most developed economies, it is particularly interesting to address our research question in the non-manufacturing sector as well as in manufacturing. Recall that the tradeoff between the flexibility and productivity that we model in Section 2 is applicable to a wide range of goods, services, and sectors in the economy.

Table 4 displays results of our model in multi-product establishments for a manufacturing subsample (column 1) and a non-manufacturing subsample (column 2). In manufacturing, the incremental effect of *Volatility* on the probability of no multiskilling is 0.393 (z = 2.50), with a base probability of 0.23, implying a 169 percent increase in the probability of no multiskilling. In non-manufacturing, the incremental effect is 0.159 (z = 2.24), with a base probability of 0.346, implying a 46 percent increase in the probability of no multiskilling. While the estimates suggest that evidence of our main result is stronger in manufacturing than outside, the

[11] While the manufacturing sector is relatively small overall, and declining, Eriksson and Ortega (2006) note that broad job designs (i.e. job rotation) are more prevalent in the manufacturing sector than outside it, so it is reasonable to question how important our research question is outside the context of manufacturing. We find in the WERS data that multiskilling is more prevalent in manufacturing than outside of manufacturing, though the difference is not dramatic. More precisely, the distribution of establishments across the seven multiskilling categories [recalling that 1="None (0%)"; 2="Just a few (1-19%)"; 3="Some (20-39%)"; 4="Around half (40-59%)"; 5="Most (60-79%)"; 6="Almost all (80-99%)"; 7="All (100%)"] is (0.33, 0.16, 0.15, 0.07, 0.09, 0.07, 0.13) for manufacturing and (0.41, 0.19, 0.12, 0.09, 0.04, 0.04, 0.11) for non-manufacturing.

important point is that the result is clearly present in both sectors and that it is both economically and statistically significant.

To summarize our results, we find that higher product market volatility is associated with less multiskilling (i.e. more specialization) for most firms in our sample, consistent with the predictions of our theoretical model for most plausible parameter values. This result exists for multi-product establishments but not for single-product establishments, also consistent with our theoretical model. The result goes in the opposite direction (i.e. higher volatility is associated with more multiskilling) for a small set of establishments for which "skilled metal and electrical trades" is the largest occupational group. We also find that the main result is not specific to manufacturing; it is clearly present in both manufacturing and non-manufacturing subsamples.

IV. DISCUSSION AND FURTHER ANALYSIS

Some natural extensions arise from synthesizing our findings with the existing literature on multiskilling. In this section we discuss some of these extensions, providing additional empirical evidence, and then turn to a more general discussion of our approach and findings and how they relate to the existing literature.

Morita (2005) notes that firms employing continuous process improvement need workers who understand the production process beyond a narrow area of specialization. Job rotation provides workers with the broad understanding needed to contribute productivity-enhancing ideas to management.[12] Furthermore, when firms provide workers with a large amount of firm-specific human capital, those workers become less subject to poaching by other firms, reinforcing the returns to training investments made by the firm through job rotation (Morita 2001, 2005).

Combining Morita's model with an assumption about how continuous process improvement varies with product market volatility offers a potential alternative explanation for our main empirical result. In particular, it can be argued

[12] Gibbs *et al.* (2007) make a similar point when they argue that "combining interdependent tasks in a job may enable the worker to learn process improvements."

that the returns to continuous process improvement are higher when the product market is more stable. When the product market is stable, process improvements, which Morita (2001) defines as involving "a number of small changes and modifications," yield dividends for many periods into the future. By contrast, in a volatile market, dividends from small improvements are short lived because heavily modified (or entirely new) processes are required with high frequency.[13] Thus, one might expect that increased product-market volatility would reduce the incentive for employers to engage in continuous process improvement and hence job rotation (and multiskilling, which is a necessary prerequisite to job rotation).

To verify whether employers engage less in process improvement practices in the face of product-market volatility, we estimate an empirical model of the role of product-market volatility in determining whether establishments employ quality circles.[14] We estimate a probit model using a dummy variable for the use of quality circles (=1 if the establishment uses quality circles) as the dependent variable and product-market volatility as an independent variable, including the same controls as in our previous specifications. Estimates of this model are given in Table 5. The coefficient on *Volatility* is negative and statistically significant, providing evidence that a highly volatile product market is indeed associated with less continuous process improvement. Quantitatively, volatility is associated with a decrease of 7.6 percentage points (or 53 percent) in the probability that quality circles are used. This evidence empirically supports the assumption that, when combined with Morita's model, could potentially explain the main empirical result in Table 2. However, in contrast to the model of Section II, the alternative explanation would appear to apply equally well to single-product and multi-product establishments, whereas in Table 3 we find a stark difference between these two types of

[13] For example, volatility in the product market might reflect rapidly changing consumer tastes with respect to the quality or type of product or service demanded. Thus, today's process for producing a good or service of a particular type and quality level might become obsolete if the product is demanded at a different quality level or with different specifications tomorrow, as would be true in a volatile product market with unpredictable and rapidly changing consumer tastes.

[14] Our use of quality circles as a measure of continuous process improvement is motivated by Koike (1988) and Morita (2005), who both cite quality circles as essential features of continuous process improvement.

establishments (with the result holding strongly in multi-product establishments but disappearing in single-product establishments).[15] Our reading of Table 3 is that the single-product versus multi-product distinction is likely an important component to explaining why the degree of multiskilling versus specialization varies as it does with product market volatility.

A number of studies address the impact of multiskilling on worker incentives. For example, Carmichael and MacLeod (1993) note that workers often possess information about the best ways to adopt technological change that is unavailable to owners. Workers, in some cases, fear that labor-displacing technological change will make them redundant and so have an incentive to hide this information from owners. By multiskilling workers, firms can credibly commit to retain workers in one task, should they be made redundant in another. This improves incentives for workers to facilitate adoption of technological change. Carmichael and MacLeod's theory suggests an additional cost to specializing workers not taken into account in our model. Alternatively, our empirical finding suggests that product-market volatility may shift risk from firms to workers by limiting the willingness of firms to offer workers insurance against job loss (in the form of multiskilling).

Owan (2001) argues that multiskilling workers makes worker skills substitutable by creating task overlap. This substitutability creates competition between workers, which provides an incentive for workers to acquire firm specific human capital.

Ortega (2001) argues that job rotation allows management to observe employee-position matches and thus better optimize matching of workers to jobs. Eriksson and Ortega (2006) provide empirical evidence in support of this claim. Ortega (2001) predicts that there will be more job rotation when there is less prior information about employees' abilities and about the profitability of different jobs.

[15] When we estimated the model of Table 5 on the subsample of single-product establishments, we found essentially the same result as in the sample of multi-product establishments. In particular, volatility is associated with a decrease of 5.7 percentage points (or 52 percent) in the probability that quality circles are used. However, precision was somewhat lower in this smaller subsample (560 observations versus 773) and statistical significance is attained at the ten percent level only on a one-tailed test (Z = 1.56).

The firm will use job rotation to learn what the optimal worker-job matches are, when faced with imperfect information about which jobs are more profitable or which employees are better at them. Although Ortega does not explicitly address volatility in the product market, it might be argued that with higher levels of volatility, the firm has less information about the profitability of different jobs and will therefore use more job rotation (i.e. less specialization). This result runs counter to our model's prediction and to the empirical evidence we present.

A number of papers discuss the fact that multiskilling facilitates coordination between production units. Hart and Moore (2005) argue that optimal hierarchies will tend to place specialists at the bottom of an organizational pyramid and coordinators (with broader understanding) higher up. Multiskilled workers tend to be managers in their paper and hence its applicability to our work (which focuses on multiskilling by core production workers) is limited. Dessein and Santos (2006) argue that firms face a tradeoff between adaptation and coordination.[16] When firms give workers the flexibility to respond to local (hence unobservable to management) information, this improves adaptation, but at a cost of coordination. Firms can multiskill workers to improve coordination, though at a productivity cost.

Dessein and Santos predict that "organizations reduce the division of labor as the business environment becomes more uncertain." While our model and empirical results support the opposite contention, it is possible their argument plays a role in the different findings we obtain for single- versus multi-product firms. Arguably the relative importance of coordination versus adaptation is greater for single-product firms, as all workers are producing the same product. By contrast, in a multi-product firm workers on different products may have no need to coordinate with each other across products,[17] thus the relative importance of coordination versus adaptation is likely to be diminished. Recalling that we control for firm size in our empirical analysis, our finding that product market volatility leads to less multiskilling for multi-product firms but that volatility has no effect on multiskilling for single-

[16] The same tradeoff features in Kato and Owan (2010).
[17] Managers, purchasers, and salespeople may need to coordinate across products, but recall that our analysis is of core production workers.

product firms is consistent with the notion that returns to coordination (and hence multiskilling) may be greater for single-product firms.

Other benefits of a broad job design cited by past authors include productivity gains from task complementarities (Lindbeck and Snower, 2000; Boucekkine and Crifo, 2008); improved communication within and between work units and between workers and management (Aoki, 1986; Morita, 2001 and 2005; Wang, 2002); improved incentives for workers (Itoh, 1994); and contribution to learning by workers and remedy against worker boredom (Lindbeck and Snower, 2000).

In the introduction, we noted that the key theoretical contributions of our paper are 1) addressing the role of product market volatility in the firm's decision to multiskill workers, 2) highlighting productivity gains to specialization; 3) highlighting gains from multiskilling in the form of flexible labor allocation; and 4) drawing a link between specialization and increased product innovation by workers.

Regarding the second of these contributions, much of the existing literature considers the main return to specialization to be lower training costs (e.g. Carmichael and MacLeod, 1993, Garg, *et al.*, 2002, Wang, 2002, and Morita, 2005). Exceptions that note productivity gains to specialization are Cosgel and Miceli (1999), Lindbeck and Snower (2000) and Boucekkine and Crifo (2008). Given that the intuition held by most economists since Adam Smith is that specialization brings greater productivity, we feel it is important to include a more substantial form of returns to specialization in models of multiskilling.

Regarding the third contribution, while a common intuition about the benefit of multiskilling is that it provides flexibility in labor allocation, very little of the existing literature actually focuses on this point. Garg, *et al* (2002) come closest to our interpretation of the benefits of multiskilling by arguing that the practice gives firms increased flexibility in responding to demand variability. In Garg, *et al*, firms can reduce inventories of finished goods needed to satisfy customer orders by multiskilling workers so that workers can be shifted to more quickly address production bottlenecks. Firms therefore trade off costly inventories against higher training costs in choosing to multiskill workers. It should be noted that Garg's model does not apply to service firms and other firms that cannot keep inventories of finished goods.

Regarding the fourth contribution, in our model multiskilling brings flexibility in production, but at the cost of a productivity advantage associated with the ability of specialized workers to innovate. This productivity advantage interacts in a crucial way with volatility in the product market. Specialized workers can innovate quickly in response to sudden changes in market conditions in ways that multiskilled workers cannot. Our assumption that multiskilled workers cannot respond as adeptly to changing market conditions as specialized workers can warrants discussion in light of the past literature.

In particular, Koike (1985), Aoki (1986) and Morita (2005) make reference to the enhanced ability of multiskilled workers to respond to "emergent events" on the production line in a manufacturing context. These include emergencies such as equipment breakdowns, inventory imbalances, and nascent product flaws. Morita (2005), for example, argues that "multiply skilled employees can make better decisions than single skilled employees concerning how to cope with irregular and emergent events." Wang (2001) makes a similar assumption, in arguing that multiskilled workers can coordinate better with other work units to correct product misspecifications. These authors argue that multiskilled workers respond better to uncertain events, while we argue that specialized workers respond better to uncertain events.

This appears, on the surface, to be a contradiction. However, we argue that it is not. The "emergent events" to which Koike, Aoki, and Morita refer are unexpected events occurring on the production floor—production line volatility. Clearly multiskilled workers provide a potential advantage over specialized workers when something like a machine breakdown occurs because the multiskilled worker on that machine may be able to quickly repair it without calling in a manager or specialized repair person. In examples like this, the key return to multiskilling is flexibility to respond to problems that arise with uncertainty in the otherwise well-defined production of an unchanging product. We can think of this as *process innovation*.

By contrast, our assumption that it is *specialized* workers who respond better to uncertain events pertains to a different source of uncertainty—volatility in the product market. In our model, this uncertainty is faced by a multiproduct (or multiservice) firm, not necessarily in manufacturing. In the case of product market volatility, it seems reasonable to assume that a jack-of-all-trades worker will be less capable of adapting a product to changing consumer whims than a specialized worker who is a trained expert in that product. When it comes to *product innovation*, specialists in those products or services are likely to do a better job than generalists.

The distinction that we draw between our model assumptions and those of Koike, Aoki, and Morita is very similar to that drawn by Carmichael and MacLeod (1993). They note that "multiskilling firms will exhibit a comparative advantage in 'process' style innovation, which makes it possible to produce given products more cheaply, while single skilling firms will be relatively better suited to 'product' innovations such as the development of entirely new commodities." In our model, positive values of I can be interpreted as product innovations demanded by consumers, and by our assumptions, such innovations are best captured by product experts—specialized workers.

In our model, as in Koike, Aoki, Wang, and Morita, multiskilling provides a form of flexibility that cannot be provided by specialized workers. In all these models, firms face a tradeoff between flexibility advantages of multiskilling and some advantage to specialization. The most fundamental difference between our model and those of Koike, Aoki, Wang, and Morita, therefore, is our incorporation of productivity gains resulting from the increased ability to innovate associated with specialization.

Relatively little empirical work has been done to date to confirm or refute the various theories explaining multiskilling. Simons and Berri (2009) examine the returns to specialization among NFL running backs who perform two primary tasks—rushing and receiving. They find evidence that among players in the top half of the salary distribution there are higher returns to specialization in one of those tasks than to versatility.[18] Carstensen (2002) tests some of the Lindbeck and Snower hypotheses using firm-level data from Germany and finds marginally statistically significant support for some of their hypotheses. Eriksson and Ortega (2006) provide empirical tests of three alternative hypotheses for job rotation: 1) that rotation is useful for employee learning; 2) that rotation is useful for employer learning about job matches; and 3) that rotation keeps workers motivated. Using a Danish data set, they reject the worker motivation hypothesis but provide empirical support for the employee learning and employer learning hypotheses.

Our work contributes to the empirical literature on job design in three ways. First, we test a new theory of multiskilling and provide empirical results consistent with that model and with the existing theoretical literature. Second, we introduce a new stylized fact to the job design literature—that higher levels of product market volatility are associated with less multiskilling. Third, we contribute to the broadening of the empirical job design literature beyond manufacturing, a sector that has long been in relative decline in most developed economies.

V. CONCLUSION

In this paper we introduced a new stylized fact into the job design literature, namely that multiskilling is more prevalent when the degree of product market volatility is low. The result holds both inside and outside of the manufacturing sector, and it holds only for multi-product (or multi-service) establishments and not for single-product ones. This is the first paper to study how job design varies with the degree of volatility in the product market. Apart from being a novel question and uncovering a new stylized fact, the focus on volatility offers a useful mechanism for deepening our understanding of the firm's decision to multiskill versus specialize its workers, which is a central and fundamental question in job design. To further that aim, we proposed a new theory that explains the empirical relationship between

[18] The idea of players making split-second strategic readjustments in a complex environment matches well with the notion underlying our model that specialization enhances innovation. Thus this empirical finding could be interpreted as corroborating our results.

product market volatility and the degree of multiskilling. At the heart of the theory is a tradeoff between the benefits of flexibility in labor allocation (which is offered by multiskilled workers) and the benefits of intensive expertise in product lines (which is offered by specialized workers as opposed to multiskilled workers who, while flexible, are "jacks of all trades and masters of none").

Much of the job design literature derives from a comparison of work practices in Japan versus those in the United States, especially in the 1980s when Japanese manufacturing was ascendant. A common theme from that literature is that the more "flexible" and "innovative" (e.g. Osterman, 1994) work practices of Japan are superior to those in the US. Yet, our findings suggest that while multiskilling may be good for cost-cutting and other forms of *process* innovation, specialization may yield important advantages for *product* innovation. This is consistent with the commonly held notion that Asian manufacturers are better than the West at producing products cheaply, but less good at inventing new products. Thus, our findings suggest a note of caution to firms rushing to embrace multiskilling.

More generally, we feel that a fruitful and underexplored area of research is how product market conditions and the internal labor market interact to shape job design and the firm's policy with respect to its human resource management practices. This paper offers one example of what new insights can be gained from such an exploration.

REFERENCES

Aoki, M. (1986). "Horizontal vs. Vertical Information Structure of the Firm." *The American Economic Review,* 76(5), 971-983.

Boucekkine, R. & Crifo, P. (2008). Human capital accumulation and the transition from specialization to multitasking. *Macroeconomic Dynamics,* 12, 320-344.

Carmichael, H. & MacLeod, W. (1993). Multiskilling, technical change and the Japanese firm. *The Economic Journal*, 103, 142-160.

Carstensen, V. (2002). "The From-Tayloristic-to-Holistic-Organization-Model From an Empirical Perspective." *University of Hannover Discussion Paper No. 256.*

Chaplin , Joanna, Jane Mangla, Susan Purdon, and Colin Airey. "The Workplace Employment Relations Survey (WERS) 2004 Technical Report (Cross-section and Panel Surveys)", Prepared for Department of Trade and Industry, November 2005.

Cosgel Metin M. and Thomas J. Miceli (1999). "Job Rotation: Cost, Benefits, and Stylized Facts." *Journal of Institutional and Theoretical Economics.* 155, 301-320.

Dessein, W. and Santos, T. (2006). "Adaptive Organizations." *Journal of Political Economy.* 114(5), 956-995.

Eriksson, T. and Ortega, J. (2006). "The Adoption of Job Rotation: Testing the Theories." *Industrial and Labor Relations Review.* 59(4), 653-666.

Garg, H., Vrat, P., & Kanda, A. (2002). Trade-offs between multiskilling and inventory in assembly line operations under demand variability. *International Journal of Operations and Production Management,* 22 (5), 565-583.

Gibbs, M., Levenson, A., and Zoghi, C. (2007). "Why Are Jobs Designed the Way They Are?" *BLS Office of Productivity and Technology Working Paper #382.*

Hart, O., and Moore, J. (2005). "On the Design of Hierarchies: Coordination Versus Specialization." *Journal of Political Economy*. 113(4), 675-702.

Itoh, H. (1994). Job design, delegation, and cooperation: a principal-agent analysis. *European Economic Review,* 38, 691-700.

Kato, T., and Owan, H. (2010). "Market Characteristics, Intra-Firm Coordination, and the Choice of Human Resource Management Systems: Evidence from New Japanese Data," manuscript.

Koike, K. (1985). "Human Resource Development in the Japanese Industry," manuscript.

Koike, K. (1988). *Understanding Industrial Relations in A Modern Japan*. New York: St. Martin's Press.

Lindbeck, A. & Snower, D. (2000). Centralized bargaining and reorganized work: are they compatible? *European Economic Review*, 45, 1851-1875.

Lazear, E. (1998). *Personnel Economics for Managers.* New York: John Wiley & Sons.

Morita, H. (2001). Choice of Technology and Labour Market Consequences: An Explanation of U.S.-Japanese Differences. *The Economic Journal,* 111(468), 29-50.

Morita, H. (2005). Multi-skilling, delegation and continuous process improvement: a comparative analysis of US-Japanese work organizations. *Economica,* 72, 69-93.

Ortega, J. (2001). Job rotation as a learning mechanism. *Management Science*, 47 (10), 1361-1370.

Osterman, P. (1994). "How Common is Workplace Transformation and Who Adopts It?" *Industrial and Labor Relations Review,* 47(2), 173-188.

Owan, H. (2001). Specialization, multiskilling and allocation of decision rights. *Washington University Working Paper,* 2001*.*

Simmons, R. & Berri, D. (2009). Gains from specialization and free agency: the story from the gridiron. *Review of Industrial Organization*, 34, 81-98.

Smith, Adam (1776). *An Inquiry into the Nature and Causes of the Wealth of Nations.* 1776. Reprint. Edited by Edwin Cannan. Chicago: University of Chicago Press, 1976.

Wang, Y. (2002). Product market conditions and job design. *HRRI Working paper 04-02*, Industrial Relations Center, University of Minnesota

FIGURE 1: Incidence of Multiskilling Among WERS Establishments

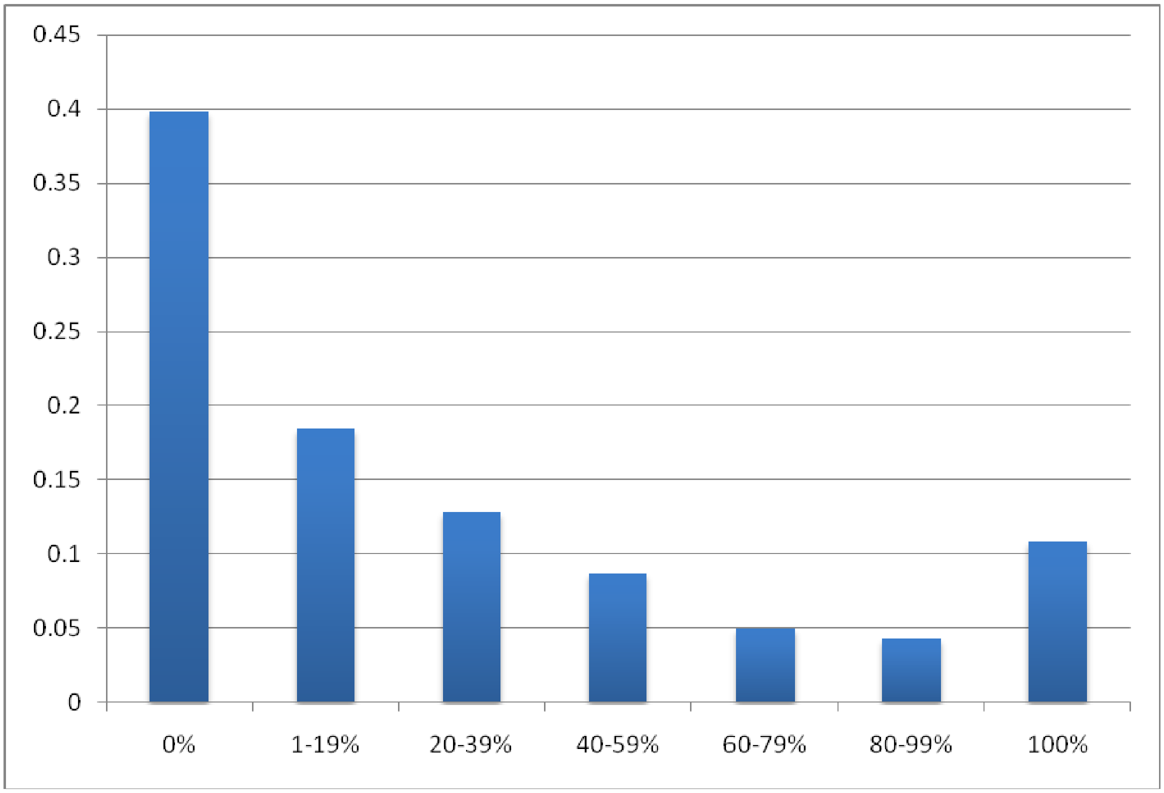

TABLE 1: Descriptive Statistics

	Fractions	***Mean***	***Standard Error***
Multiskilling			
1 = "None (0%)"	0.397		
2 = "Just a few (1-19%)"	0.178		
3 = "Some (20-39%)"	0.132		
4 = "Around half (40-59%)"	0.092		
5 = "Most (60-79%)"	0.050		
6 = "Almost all (80-99%)"	0.045		
7 = "All (100%)"	0.106		
Volatility		0.169	0.015
Establishment size		27.266	0.902
Union		0.211	0.015
Fraction of Part Time Workers		0.322	0.012
Fraction of Temporary Workers		0.018	0.004
Percent Union		8.804	0.843
Number of Recognized Unions		0.161	0.014
Owner Manager		0.278	0.018
Foreign Owned		0.105	0.012
Establishment is at least 5 years old		0.882	0.014
Franchise		0.029	0.006
Fixed Term Percentage		4.862	0.653
Fixed Term		0.170	0.013
Temporary Workers		0.100	0.010
Private		0.986	0.005
Industry:			
Manufacturing		0.125	0.014
Electricity, Gas, and Water		0.001	0.0003
Construction		0.053	0.009
Wholesale and Retail		0.291	0.019
Hotels and Restaurants		0.101	0.012
Transport and Communication		0.054	0.009
Financial Services		0.060	0.009
Other Business Services		0.157	0.014
Public Administration		0.0005	0.0002
Education		0.011	0.003
Health		0.092	0.010
Other Community Services		0.054	0.008
Largest Occupational Group at Workplace:			
Professionals		0.039	0.007
Associate Professional and Technical		0.074	0.010
Administrative and Secretarial Occupations		0.120	0.013
Skilled Trades		0.111	0.013
Caring, leisure, and personal service		0.081	0.010
Sales and customer service		0.275	0.018
Process, Plant and Machine Operatives and Drivers		0.134	0.014
Routine Unskilled		0.166	0.015
Quality Circles		0.158	0.013
Training Days			
1 = "No time"	0.280		

2 = "Less than one day"	0.044		
3 = "1 to less than 2 days"	0.200		
4 = "2 to less than 5 days"	0.264		
5 = "5 to less than 10 days"	0.104		
6 = "10 days or more"	0.107		
Sample Size = 1622			

Note: Statistics are computed on the full sample, excluding observations for which *Volatility* is unobserved. Due to missing values, the sample size varies across variables; all non-missing observations were used to compute each statistic. Summary statistics based on the analysis subsample are available upon request and are similar to those reported here.

TABLE 2: Multiskilling and Product Market Volatility (ordered probit)
Dependent Variable: *Multiskilling* (1=low, 7=high)

	Full Sample	Excluding "Skilled metal and electrical trades"
Volatility	-0.193 (0.126)	-0.276 (0.129)
Establishment size	0.0001 (0.0002)	0.0001 (0.0002)
Union	-0.074 (0.173)	0.005 (0.176)
Fraction of Part Time Workers	-0.206 (0.211)	-0.220 (0.215)
Fraction of Temporary Workers	-0.106 (0.173)	-0.120 (0.173)
Percent Union	-0.0001 (0.003)	-0.0005 (0.003)
Number of Recognized Unions	0.251 (0.121)	0.231 (0.120)
Owner Manager	-0.077 (0.124)	-0.068 (0.130)
Foreign Owned	0.113 (0.165)	0.148 (0.170)
Establishment is at least 5 years old	0.022 (0.161)	-0.038 (0.168)
Franchise	-0.029 (0.222)	-0.207 (0.243)
Fixed Term Percentage	-0.003 (0.004)	-0.002 (0.004)
Fixed Term	0.219 (0.144)	0.200 (0.148)
Temporary Workers	-0.325 (0.141)	-0.333 (0.144)
Private	-0.230 (0.387)	-0.261 (0.379)
Industry:		
Electricity, Gas, and Water	-0.376 (0.260)	-0.458 (0.267)
Construction	-0.595 (0.224)	-0.331 (0.260)
Wholesale and Retail	-0.396 (0.202)	-0.460 (0.217)
Hotels and Restaurants	-0.466 (0.265)	-0.421 (0.277)
Transport and Communication	-0.638 (0.266)	-0.654 (0.272)
Financial Services	-0.041 (0.261)	-0.074 (0.263)
Other Business Services	-0.387 (0.222)	-0.408 (0.232)
Public Administration	-1.107 (0.489)	-1.142 (0.491)
Education	-0.205 (0.339)	-0.270 (0.341)
Health	-0.469 (0.263)	-0.483 (0.268)

Other Community Services	-0.268 (0.257)	-0.253 (0.262)
<u>Largest Occupational Group at Workplace:</u>		
Administrative and Secretarial Occupations	0.307 (0.207)	0.313 (0.207)
Skilled Trades	-0.273 (0.243)	-0.733 (0.280)
Caring, leisure, and personal service	0.282 (0.229)	0.262 (0.228)
Sales and customer service	0.202 (0.220)	0.238 (0.221)
Process, Plant and Machine Operatives and Drivers	0.058 (0.237)	0.056 (0.238)
Routine Unskilled	0.395 (0.236)	0.350 (0.237)
<u>Ordered Probit Cutoffs</u>		
Cutoff 1	-0.759 (0.475)	-0.872 (0.475)
Cutoff 2	-0.296 (0.476)	-0.388 (0.475)
Cutoff 3	0.073 (0.476)	-0.030 (0.475)
Cutoff 4	0.379 (0.477)	0.276 (0.477)
Cutoff 5	0.574 (0.480)	0.467 (0.479)
Cutoff 6	0.809 (0.486)	0.688 (0.485)
<u>Incremental Effect of *Volatility* on:</u>		
Prob(Multiskilling = 1) “None 0%”	**0.075 (0.049) [0.396]**	**0.108 (0.051) [0.395]**
Prob(Multiskilling = 2)	**-0.001 (0.003) [0.182]**	**-0.004 (0.005) [0.191]**
Prob(Multiskilling = 3)	**-0.011 (0.008) [0.136]**	**-0.017 (0.009) [0.132]**
Prob(Multiskilling = 4)	**-0.013 (0.009) [0.094]**	**-0.019 (0.009) [0.093]**
Prob(Multiskilling = 5)	**-0.009 (0.006) [0.049]**	**-0.013 (0.006) [0.047]**
Prob(Multiskilling = 6)	**-0.010 (0.007) [0.047]**	**-0.014 (0.007) [0.044]**
Prob(Multiskilling = 7) “All (100%)”	**-0.030 (0.018)**	**-0.042 (0.018)**

	[0.096]	**[0.098]**
Sample Size	1407	1329

Note: Cell entries are ordered probit coefficients with standard errors in parentheses beside each estimate. Incremental effects at the bottom of the table give the change in the predicted probability of *Multiskilling* = k (for k = 1,2,…,7) when *Volatility* increases from 0 to 1, evaluating other covariates at their means. For the incremental effects at the bottom of the table, the numbers in square brackets, [], are the baseline probabilities for the corresponding row title. Dummy variable omitted categories are "Professionals" and "Associate professional and technical" for the establishment's largest occupational group, and "Manufacturing" for industry.

TABLE 3: Multiskilling and Product Market Volatility (Multi-Product vs. Single-Product Establishments) (ordered probit)
Dependent Variable: *Multiskilling* (1=low, 7=high)

	Multi-Product Establishments		Single-Product Establishments	
	Full Sample	Excluding "Skilled metal and electrical trades"	Full Sample	Excluding "Skilled metal and electrical trades"
Volatility	-0.261 (0.161)	-0.456 (0.160)	-0.065 (0.201)	-0.032 (0.205)
Establishment size	0.0001 (0.0003)	0.0001 (0.0003)	0.0003 (0.0003)	0.0003 (0.0003)
Union	-0.029 (0.247)	0.173 (0.244)	0.060 (0.263)	0.058 (0.264)
Fraction of Part Time Workers	0.215 (0.321)	0.194 (0.328)	-0.775 (0.283)	-0.772 (0.285)
Fraction of Temporary Workers	-0.034 (0.098)	-0.048 (0.096)	-1.626 (0.997)	-1.609 (1.000)
Percent Union	0.003 (0.004)	0.0001 (0.004)	-0.003 (0.006)	-0.003 (0.006)
Number of Recognized Unions	0.231 (0.154)	0.197 (0.156)	0.125 (0.155)	0.126 (0.157)
Owner Manager	0.187 (0.163)	0.211 (0.172)	-0.367 (0.195)	-0.353 (0.198)
Foreign Owned	0.272 (0.204)	0.286 (0.209)	-0.196 (0.261)	-0.165 (0.265)
Establishment is at least 5 years old	-0.055 (0.236)	-0.077 (0.245)	0.101 (0.218)	0.049 (0.226)
Franchise	-0.588 (0.312)	-0.683 (0.311)	0.437 (0.280)	0.262 (0.346)
Fixed Term Percentage	0.001 (0.005)	0.002 (0.005)	-0.008 (0.005)	-0.008 (0.005)
Fixed Term	0.205 (0.175)	0.187 (0.184)	0.227 (0.255)	0.234 (0.256)
Temporary Workers	-0.315 (0.184)	-0.313 (0.192)	-0.061 (0.214)	-0.068 (0.215)
Private	-0.148 (0.448)	-0.177 (0.441)	-0.249 (0.524)	-0.249 (0.520)
Industry:				
Electricity, Gas, and Water	-0.729 (0.413)	-0.361 (0.483)	0.088 (0.354)	-0.150 (0.389)
Construction	-0.429 (0.275)	-0.079 (0.307)	-0.821 (0.381)	-0.629 (0.424)
Wholesale and Retail	-0.405 (0.257)	-0.520 (0.269)	-0.404 (0.354)	-0.320 (0.398)
Hotels and Restaurants	-0.506 (0.390)	-0.501 (0.400)	-0.397 (0.429)	-0.313 (0.451)
Transport and Communication	-0.454 (0.359)	-0.487 (0.379)	-0.798 (0.361)	-0.749 (0.374)
Financial Services	-0.094 (0.310)	-0.151 (0.317)	-0.389 (0.510)	-0.377 (0.518)

Other Business Services	-0.140 (0.272)	-0.151 (0.283)	-0.562 (0.419)	-0.556 (0.444)
Public Administration	-0.878 (0.608)	-0.887 (0.639)	-1.318 (0.630)	-1.323 (0.640)
Education	0.019 (0.422)	-0.162 (0.422)	-1.075 (0.475)	-1.042 (0.492)
Health	-0.101 (0.373)	-0.165 (0.378)	-0.510 (0.425)	-0.469 (0.444)
Other Community Services	-0.222 (0.355)	-0.249 (0.359)	-0.289 (0.391)	-0.225 (0.413)
Largest Occupational Group at Workplace:				
Administrative and Secretarial Occupations	0.461 (0.270)	0.491 (0.272)	0.133 (0.302)	0.138 (0.303)
Skilled Trades	-0.112 (0.323)	-0.831 (0.374)	-0.548 (0.374)	-0.687 (0.426)
Caring, leisure, and personal service	0.289 (0.346)	0.244 (0.349)	0.351 (0.294)	0.340 (0.292)
Sales and customer service	0.228 (0.292)	0.284 (0.295)	0.233 (0.310)	0.202 (0.313)
Process, Plant and Machine Operatives and Drivers	0.254 (0.292)	0.242 (0.294)	-0.092 (0.369)	-0.123 (0.370)
Routine Unskilled	0.560 (0.347)	0.520 (0.351)	0.371 (0.318)	0.325 (0.316)
Ordered Probit Cutoffs				
Cutoff 1	-0.450 (0.581)	-0.556 (0.582)	-1.001 (0.718)	-1.004 (0.733)
Cutoff 2	-0.003 (0.582)	-0.076 (0.582)	-0.480 (0.712)	-0.474 (0.726)
Cutoff 3	0.364 (0.581)	0.286 (0.582)	-0.074 (0.711)	-0.088 (0.726)
Cutoff 4	0.654 (0.584)	0.577 (0.586)	0.296 (0.707)	0.280 (0.721)
Cutoff 5	0.870 (0.587)	0.793 (0.589)	0.472 (0.710)	0.446 (0.723)
Cutoff 6	1.113 (0.595)	1.014 (0.597)	0.719 (0.713)	0.695 (0.726)
Incremental Effect of *Volatility* on:				
Prob(Multiskilling = 1) "None (0%)"	**0.099 (0.062) [0.341]**	**0.175 (0.063) [0.340]**	**0.026 (0.080) [0.468]**	**0.013 (0.081) [0.464]**
Prob(Multiskilling = 2)	**0.004 (0.003) [0.174]**	**0.001 (0.007) [0.187]**	**-0.003 (0.009) [0.202]**	**-0.001 (0.008) [0.206]**
Prob(Multiskilling = 3)	**-0.011 (0.009) [0.142]**	**-0.024 (0.012) [0.139]**	**-0.005 (0.017) [0.131]**	**-0.003 (0.016) [0.126]**
Prob(Multiskilling = 4)	**-0.016 (0.010) [0.099]**	**-0.029 (0.011) [0.098]**	**-0.006 (0.018) [0.087]**	**-0.003 (0.018) [0.088]**
Prob(Multiskilling = 5)	**-0.013 (0.009)**	**-0.023 (0.009)**	**-0.003 (0.008)**	**-0.001 (0.008)**

	[0.062]	**[0.061]**	**[0.030]**	**[0.029]**
Prob(Multiskilling = 6)	**-0.015 (0.009)** **[0.057]**	**-0.023 (0.009)** **[0.051]**	**-0.003 (0.009)** **[0.031]**	**-0.002 (0.010)** **[0.033]**
Prob(Multiskilling = 7) "All (100%)"	**-0.048 (0.028)** **[0.124]**	**-0.077 (0.025)** **[0.124]**	**-0.007 (0.020)** **[0.051]**	**-0.003 (0.022)** **[0.054]**
Sample Size	812	767	594	561

Note: Cell entries are ordered probit coefficients with standard errors in parentheses beside each estimate. Incremental effects at the bottom of the table give the change in the predicted probability of *Multiskilling* = k (for k = 1,2,…,7) when *Volatility* increases from 0 to 1, evaluating other covariates at their means. For the incremental effects at the bottom of the table, the numbers in square brackets, [], are the baseline probabilities for the corresponding row title. Dummy variable omitted categories are "Professionals" and "Associate professional and technical" for the establishment's largest occupational group, and "Manufacturing" for industry.

TABLE 4: Multiskilling and Product Market Volatility (Manufacturing vs. Non-Manufacturing) (ordered probit)
Dependent Variable: *Multiskilling* (1=low, 7=high)

	Manufacturing	Non-manufacturing
Volatility	-1.091 (0.423)	-0.415 (0.180)
Establishment size	-0.001 (0.001)	0.0001 (0.0003)
Union	-0.044 (0.683)	0.079 (0.265)
Fraction of Part Time Workers	-1.710 (3.372)	0.149 (0.317)
Fraction of Temporary Workers	-4.711 (2.132)	-0.017 (0.072)
Percent Union	0.004 (0.013)	0.002 (0.004)
Number of Recognized Unions	-0.316 (0.313)	0.281 (0.183)
Owner Manager	0.441 (0.492)	0.177 (0.180)
Foreign Owned	1.001 (0.455)	0.132 (0.222)
Establishment is at least 5 years old	1.907 (0.438)	-0.356 (0.244)
Franchise	1.255 (0.453)	-0.826 (0.390)
Fixed Term Percentage	-0.048 (0.020)	0.004 (0.004)
Fixed Term	1.237 (0.496)	0.057 (0.197)
Temporary Workers	-0.029 (0.339)	-0.203 (0.194)
Private	-1.651 (1.269)	0.008 (0.358)
Largest Occupational Group at Workplace:		
Administrative and Secretarial Occupations	2.340 (0.458)	0.337 (0.267)
Skilled Trades	2.321 (0.608)	-1.135 (0.319)
Caring, leisure, and personal service	--	0.112 (0.293)
Sales and customer service	0.460 (0.446)	-0.019 (0.270)
Process, Plant and Machine Operatives and Drivers	2.335 (0.407)	-0.027 (0.314)
Routine Unskilled	3.275 (0.518)	0.169 (0.296)
Ordered Probit Cutoffs		
Cutoff 1	1.429 (1.465)	-0.549 (0.484)
Cutoff 2	1.843 (1.443)	-0.041 (0.485)
Cutoff 3	2.698 (1.428)	0.295 (0.485)

Cutoff 4	2.890 (1.427)	0.609 (0.488)
Cutoff 5	3.259 (1.433)	0.820 (0.493)
Cutoff 6	3.667 (1.433)	1.029 (0.502)
Incremental Effect of *Volatility* on:		
Prob(Multiskilling = 1) "None (0%)"	**0.393 (0.157) [0.232]**	**0.159 (0.071) [0.346]**
Prob(Multiskilling = 2)	**0.020 (0.039) [0.143]**	**-0.00002 (0.008) [0.199]**
Prob(Multiskilling = 3)	**-0.133 (0.080) [0.329]**	**-0.021 (0.012) [0.128]**
Prob(Multiskilling = 4)	**-0.046 (0.021) [0.063]**	**-0.029 (0.013) [0.104]**
Prob(Multiskilling = 5)	**-0.083 (0.053) [0.097]**	**-0.021 (0.010) [0.058]**
Prob(Multiskilling = 6)	**-0.071 (0.041) [0.070]**	**-0.020 (0.010) [0.047]**
Prob(Multiskilling = 7) "All (100%)"	**-0.081 (0.041) [0.066]**	**-0.069 (0.027) [0.119]**
Sample Size	151	616

Note: Cell entries are ordered probit coefficients with standard errors in parentheses beside each estimate. Incremental effects at the bottom of the table give the change in the predicted probability of *Multiskilling* = k (for k = 1,2,…,7) when *Volatility* increases from 0 to 1, evaluating other covariates at their means. Dummy variable omitted category is "Professionals" and "Associate professional and technical" for the establishment's largest occupational group. Dummy variable for largest occupational group of "caring, leisure, and personal service" dropped in the manufacturing subsample. Both samples are restricted to multi-product establishments and exclude establishments for which "skilled metal and electrical trades" is the largest occupational group.

TABLE 5: Probit results for Quality Circles and Volatility
Dependent Variable: *Quality Circles* (1=yes, 0=no)

Volatility	-0.387 (0.196)
Establishment size	0.001 (0.0004)
Union	0.601 (0.291)
Fraction of Part Time Workers	0.285 (0.362)
Fraction of Temporary Workers	-0.083 (0.215)
Percent Union	-0.003 (0.006)
Number of Recognized Unions	0.014 (0.200)
Owner Manager	-0.089 (0.211)
Foreign Owned	0.066 (0.232)
Establishment is at least 5 years old	0.113 (0.321)
Franchise	-0.165 (0.521)
Fixed Term Percentage	0.002 (0.005)
Fixed Term	-0.020 (0.200)
Temporary Workers	0.320 (0.216)
Private	0.317 (0.687)
Industry:	
Manufacturing	0.547 (0.549)
Construction	-0.255 (0.637)
Wholesale and Retail	-0.646 (0.557)
Hotels and Restaurants	-1.061 (0.735)
Transport and Communication	-0.232 (0.642)
Financial Services	-0.456 (0.555)
Other Business Services	-0.241 (0.566)
Public Administration	-0.137 (0.809)
Education	-0.453 (0.640)
Health	0.112 (0.594)
Other Community Services	-0.800 (0.969)
Largest Occupational Group at Workplace:	

Administrative and Secretarial Occupations	-0.086 (0.282)
Skilled Trades	-1.123 (0.447)
Caring, leisure, and personal service	-1.039 (0.464)
Sales and customer service	-0.459 (0.307)
Process, Plant and Machine Operatives and Drivers	-1.058 (0.303)
Routine Unskilled	-0.483 (0.375)
Constant	-0.800 (0.969)
Incremental Effect of *Volatility* on:	
Prob(*Quality Circles* = 1)	**-0.076 (0.033) [0.143]**
Sample Size	773

Note: Cell entries are ordered probit coefficients with standard errors in parentheses beside each estimate. Incremental effects at the bottom of the table give the change in the predicted probability of *Multiskilling* = k (for k = 1,2,…,7) when *Volatility* increases from 0 to 1, evaluating other covariates at their means. Dummy variable omitted categories are "Professionals" and "Associate professional and technical" for the establishment's largest occupational group, and "Electricity, gas, and water" for industry. Sample is restricted to multi-product establishments excluding those for which the largest occupational group is "skilled metal and electrical trades".

APPENDIX: Variable Definitions

Multiskilling = 1 if "None (0%)"
= 2 if "Just a few (1-19%)"
= 3 if "Some (20-39%)"
= 4 if "Around half (40-59%)"
= 5 if "Most (60-79%)"
= 6 if "Almost all (80-99%)"
= 7 if "All (100%)"

Volatility = 1 if the current state of the market for the main product or service of the establishment is described as "turbulent" (= 0 if described as "growing", "mature", or "declining")

Establishment Size: number of workers at the establishment

Union: dummy equaling 1 if there are any workers at the establishment are covered by a union (=0 otherwise)

Fraction of Part Time Workers: fraction of part-time workers at the establishment

Fraction of Temporary Workers: fraction of temporary workers at the establishment

Percent Union: percentage of workers at the establishment covered by a union

Number of Recognized Unions: (at the establishment)

Owner Manager: dummy equaling 1 if there is an owner-manager (=0 otherwise)

Foreign Owned: dummy equaling 1 if foreign owned (=0 otherwise)

Establishment is at least 5 years old: dummy equaling 1 if this is true, (=0 otherwise)
Franchise: dummy equaling 1 if establishment is a franchise (=0 otherwise)

Fixed Term Percentage: percentage of workers on fixed term contracts at the establishment

Fixed Term: dummy equaling 1 if any workers are on fixed-term contracts (=0 otherwise)

Temporary Workers: dummy equaling 1 if any temporary workers at the establishment (=0 otherwise)

Private: dummy equaling 1 if private sector establishment (=0 otherwise)

Industry categories: (Manufacturing; Electricity, Gas, and Water; Construction; Wholesale and Retail; Hotels and Restaurants; Transport and Communication; Financial Services; Other Business Services; Public Administration; Education; Health; Other Community Services)

Largest occupational group at the establishment categories: Professionals; Associate Professional and Technical; Administrative and Secretarial; Skilled Trades; Caring, leisure, and personal service; Sales and customer service; Process, Plant and Machine Operatives and Drivers; Routine Unskilled

Quality Circles: dummy equaling 1 if affirmative response to: "Do you have groups of non-managerial employees at this workplace that solve specific problems or discuss aspects of performance or quality? They are sometimes known as problem-solving groups or quality circles or continuous improvement groups."

Training Days: number of days of training that experienced workers in the establishment's largest occupational group had on average during the previous 12 months (1 = "No time", 2 = "Less than one day", 3 = "1 to less than 2 days", 4 = "2 to less than 5 days", 5 = "5 to less than 10 days", 6 = "10 days or more")