Worker Training and Competing on Product Quality

Christos Bilanakos[a], John S. Heywood[b], John Sessions[c] and Nikolaos Theodoropoulos[d]

[a] *Department of Management Science and Technology*
Athens University of Economics and Business
Greece
Email: xmpilan@aueb.gr

[b] *Department of Economics*
University of Wisconsin-Milwaukee
USA
Email: heywood@uwm.edu

[c] *Department of Economics and IZA*
University of Bath
England
Email: j.g.sessions@bath.ac.uk

[d] *Department of Economics*
University of Cyprus
Cyprus
Email: n.theodoropoulos@ucy.ac.cy

Abstract: We examine the relationship between firm-sponsored training and the sensitivity of product demand to product quality. A quality-adjusted model of monopolistic competition shows the conditions under which the intensity of training increases as product demand becomes more sensitive to quality. Empirical estimates from two cross sections and a panel of British establishments as well as from two matched employee cross sections confirm that training is more intensive when product demand is more sensitive to quality.

JEL: J24, L13, L15.

Keywords: Training, Product Quality, Demand Elasticity, Monopolistic Competition.

1. Introduction

The extent to which firms compete by striving to lower price or to increase quality depends on customer preferences and the nature of the good being produced [Chioveanu (2012), Banker *et al*. (1998)]. If high quality is critical for sales, firms will more likely demand high quality inputs and high quality labor in particular. In turn, this demand for high quality labor may generate substantial firm-provided training. We explore this hypothesis in a theoretical model of product quality and diversity which we then test using linked worker and establishment data. Our theoretical model identifies the circumstances under which greater sensitivity between product demand and quality results in greater firm provided training. Our empirical analysis provides robust and consistent evidence that when quality competition is critical, establishments engage in substantially greater training.

Our exploration of worker training as a response to needed product quality is motivated, in part, by the struggles facing leading firms. The well-known 2012 Foxconn strike in China revolved largely around whether or not workers were given adequate training to meet the exacting quality standards imposed by Apple [China Labor Watch (2012)]. Similarly, Nike explicitly works with contractors within its supply chain to ensure that they 'provide workers the skills and abilities needed to manage production' and 'to produce at the highest quality' [Nike (2014)]. Thus, in markets where customers are sensitive to quality, training appears critical.

The exploration also fits with the theoretical view that producing quality products requires a 'quality-transfer' from inputs to outputs [Bacchiega and Minnitiy (2013)]. Indeed, a long line of work in international trade assumes that country factor endowments in labor quality help drive differences in the quality of final products [see, for example, Courakis (1991), Webster (1993), Maskus *et al*., (1994), Oulton (1996), Greenaway and Torstensson (2000), Martin-Montaner and Rios, (2002), Schott, (2004)]. In the context of industrial

economics, Gabszewicz and Turrini (1999, 2000) examine the explicit choice of product quality by firms but take skill availability as given. As a consequence, the relative scarcity of high quality labor drives the cost of producing quality outputs. We are aware of no theoretical study that imagines, as we do, that endogenous training creates labor quality which, in turn, helps determine product quality.

Empirical studies on the association between labor quality and product quality usually proxy quality by price. Thus, they test whether firms producing higher priced products, employ workers with higher wages [see, for example, Abowd *et al*. (1996)]. In one such study, Kugler and Verhoogen (2012) provide new insights into the well-known pattern that larger plants pay higher wages. They confirm that larger plants both pay higher wages and charge higher product prices but they also demonstrate that larger plants use higher priced material inputs as well. They see this as evidence that larger plants produce higher quality products using higher quality inputs. Not examined in any of the studies of prices and wages is the extent to which quality labor is simply purchased or is created through employer training.

In our model firms make an investment in training that reflects the costs of that training, the extent to which such training increases quality and the extent to which quality increases demand for the product. We use a quality-adjusted model of monopolistic competition to explore the conditions under which firms can profitably expand demand for their product by enhancing the quality of their product through appropriate investment in employee training. In this fashion, our model shares characteristics with an investment in research and development as analysed by Gonzalez and Pazo (2004) and it contributes to the literature on the impact of product quality on firm profitability [Kranton (2003) and Matsa 2011)].

We use British establishment data and matched employee data to examine the statistical association between employer provided training and the importance of product quality in product market competition. In cross-sectional estimates at both the establishment and worker level, increased product demand sensitivity to quality is associated with more extensive training. This might be considered only a function of sorting as unmeasured establishment characteristics such as detailed product specifications or technology drive both, greater demand sensitivity to quality and greater training. In response, we use the panel aspect of the establishment data to hold constant establishment fixed effects and still show that greater sensitivity of demand to quality is associated with greater training investments.

In what follows, Section 2 sets out a theoretical framework that identifies the conditions under which increased training will result from increased sensitivity of demand to quality. Section 3 discusses our data and empirical methodology. Section 4 presents our empirical results and Section 5 collects final comments and suggestions for additional research.

2. Theoretical Framework

2.1 The Model

We develop a Dixit-Stiglitz (1977) framework with a quality augmented production function. Specifically, we consider a monopolistically competitive industry comprised of N firms (indexed $i = 1, 2, \ldots, N$) each of which produces a distinct and uniquely branded product, x_i, with associated quality, s_i. The industry's commodities are strong substitutes for one another but weak substitutes for the other commodities in the economy. To express this simply we aggregate the rest of the economy into a single numeraire good, x_0, the price of which is normalized to unity.

Consider a representative consumer who has an endowment of *Y* units from the numeraire good. Since the profit of each firm will be zero in a monopolistically competitive equilibrium due to free-entry, the consumer's income is simply given by *Y*. We assume the consumer has preferences represented by the homothetic, weakly-separable and quasi-concave utility function:[1]

$$u\left[x_0, v\left(x,s\right)\right] = x_0 + \left[\left(\sum_{i=1}^{N} x_i s_i^{\delta}\right)^{\rho}\right]^{1/\rho} = x_0 + \left(\sum_{i=1}^{N} x_i^{\rho} s_i^{\delta\rho}\right)^{1/\rho} \tag{1}$$

where $x=\left(x_1, x_2, ..., x_N\right)$ and $s=\left(s_1, s_2, ..., s_N\right)$. The parameter ρ denotes the degree of substitution or 'love of variety'. We assume $\rho \in \left(0,1\right)$ to ensure concavity and to allow for zero quantities. We will show that $\delta > 0$ is the sensitivity of demand to product quality.[2]

2.2. *Demand*

The consumer's utility-maximisation problem can be written as:

$$\begin{aligned} &\max_{x_0, x_i} u\left[x_0, v\left(x,s\right)\right] = x_0 + \left(\sum_{i=1}^{N} x_i^{\rho} s_i^{\delta\rho}\right)^{1/\rho} \\ &s.t. \\ &\sum_{i=1}^{N} p_i x_i + x_0 \le Y \\ &x_0, x \ge 0 \end{aligned} \tag{2}$$

The associated Lagrangian has the following form:

$$L = x_0 + \left(\sum_{i=1}^{N} x_i^{\rho} s_i^{\delta\rho}\right)^{\frac{1}{\rho}} + \lambda\left[Y - \left(\sum_{i=1}^{N} p_i x_i + x_0\right)\right] \tag{3}$$

[1] Quality is introduced in a similar way in the context of research and development expenditures by Levin and Rees (1988), Motta (1992), Sutton (1998) and Gonzalez and Pazo (2004).

[2] Note that $\rho = 1$ implies that the $x=\left(x_1, x_2, ..., x_N\right)$ goods are perfect substitutes from one another since the substitutability function reduces to $v\left(x_1, x_2, ..., x_N\right) = x_1 s_1^{\delta} + x_2 s_2^{\delta} + ... + x_N s_N^{\delta}$. Complementarity requires $\rho < 0$ - see Brakman *et al*. (2005).

The Kuhn-Tucker first-order conditions are:

$$\frac{\partial L}{\partial x_0} = 1 - \lambda \leq 0 \tag{4}$$

$$\frac{\partial L}{\partial x_0} \cdot x_0 = 0 \tag{5}$$

$$\frac{\partial L}{\partial x_i} = \left(\sum_{i=1}^{N} x_i^{\rho} s_i^{\delta\rho} \right)^{\frac{1-\rho}{\rho}} x_i^{\rho-1} s_i^{\delta\rho} - \lambda p_i \leq 0 \tag{6}$$

$$\frac{\partial L}{\partial x_i} \cdot x_i = 0 \tag{7}$$

$$\frac{\partial L}{\partial \lambda} = Y - \sum_{i=1}^{N} p_i x_i - x_0 \geq 0 \tag{8}$$

$$\frac{\partial L}{\partial \lambda} \cdot \lambda = 0 \tag{9}$$

Solving these conditions yields the consumer's Marshallian demand function for each brand:

$$x_i = y p_i^{-\alpha} s_i^{\beta} \tag{10}$$

where $p = \sum_{i=1}^{N} \left(s_i^{\delta\rho} / p_i^{\rho} \right)^{\frac{1}{1-\rho}}$ is a quality-adjusted aggregate price index, $\alpha = 1/(1-\rho)$ is the elasticity of substitution between the quality-adjusted goods, $\beta = \delta\rho/(1-\rho)$ and $y = Y/p$. Note that $\partial x_i / \partial s_i > 0$ and $\partial^2 x_i / \partial s_i^2 < 0$ for $\beta < 1 \Leftrightarrow \delta \leq (1-\rho)/\rho$. We assume that the number of firms in the industry is sufficiently large, implying that the price and quality decisions of a single firm have a negligible effect on the aggregate price index. In this case,

the elasticities of demand with respect to price and quality are given by α and β respectively.

2.3 *Supply*

Each firm *i* produces output at a constant unit cost $c>0$ and is able to improve the quality of its brand by making an investment, I_i, in firm-specific training. The cost of training for firm *i* is $g(I_i)=\gamma I_i$, where $\gamma>0$ is the marginal cost of training. Thus, the overall profit of firm *i* is:

$$\pi_i\left(p_i,I_i\right)=\left(p_i-c\right)x_i\left[p_i,s\left(I_i\right)\right]-\gamma I_i \tag{11}$$

We assume a positive relationship between training investment and quality which is subject to diminishing returns – i.e. quality, s_i, increases with training, I_i, at a decreasing rate. This property is captured by the following concave quality production function:

$$s_i\left(I_i\right)=I_i^{\theta} \tag{12}$$

where $\theta\in(0,1)$ is the elasticity of quality with respect to training.

Each firm $i=1,2,...,N$ sets the price of its brand, p_i, and the level of training investment, I_i so as to maximize its profit, implying the following optimization problem:

$$\begin{aligned}&\max_{p_i,I_i}\pi_i\left(p_i,I_i\right)=\left(p_i-c\right)x_i\left[p_i,s\left(I_i\right)\right]-\gamma I_i\\ &s.t.\quad x_i=yp_i^{-\alpha}s_i^{\beta}\\ &\qquad s_i\left(I_i\right)=I_i^{\theta}\\ &\qquad p_i,I_i\geq 0\end{aligned} \tag{13}$$

Equivalently, the above problem can be written as:

$$\max_{p_i, I_i} \pi_i(p_i, I_i) = (p_i - c) y p_i^{-\alpha} I_i^{\beta\theta} - \gamma I_i$$
$$s.t. \quad p_i, I_i \geq 0 \tag{14}$$

To ensure the concavity of the objective function, we assume $\beta\theta \leq 1$ henceforth. The first-order conditions of this problem imply:

$$p_i^* = \left(\frac{\alpha}{\alpha - 1}\right) c = \rho^{-1} c \tag{15}$$

and:

$$I_i^* = \left(\frac{\beta\theta y p_i^{*1-\alpha}}{\alpha\gamma}\right)^{\frac{1}{1-\beta\theta}} \tag{16}$$

The associated equilibrium level of profits for each firm is then:

$$\pi_i^* = \pi_i(p_i^*, I_i^*) = \left(\tfrac{1-\beta\theta}{\alpha}\right) y p_i^{*1-\alpha} I_i^{\beta\theta} \tag{17}$$

To consider the impact of demand elasticity with respect to quality, β, on training intensity, we define $\tilde{\beta} \in \left(0, 1/\theta\right)$ and $\tilde{\gamma} = \alpha^{-1} y p_j^{*1-\alpha}$ and state the following proposition.

Proposition: *The impact of demand elasticity with respect to quality on training intensity can be either positive or negative. In particular:*

(i) *If* $\gamma < \tilde{\gamma}$ *then* $\partial I_i^* / \partial\beta > 0$ *for all* $\beta \in \left(0, 1/\theta\right)$.

(ii) *If* $\gamma \geq \tilde{\gamma}$, *then* $\partial I_i^* / \partial\beta > 0$ *for all* $\beta \in \left(0, \tilde{\beta}\right)$ *and* $\partial I_i^* / \partial\beta < 0$ *for all* $\beta \in \left(\tilde{\beta}, 1/\theta\right)$.

Proof: *See Appendix A*

In words, if the marginal cost of training is relatively small (i.e. does not exceed a critical level, $\tilde{\gamma}$), any increase in the demand elasticity with respect to quality, β, increases the equilibrium level of training, I_i^*. On the other hand, if the marginal cost of training is

relatively large (i.e. exceeds a critical level, $\tilde{\gamma}$), then an increase in the elasticity of demand with respect to quality initially increases but eventually decreases the equilibrium level of training.

While this proposition identifies the conditions under which increasing sensitivity to quality would increase training, it also makes clear that theoretical ambiguity remains. This motivates our desire to identify the dominant empirical patterns.

3. Data and Empirical Methodology

We draw data from the Workplace Employment Relations Surveys (WERS). These surveys provide large scale statistically reliable information about a broad range of employment practices across almost every sector of the British economy. We use the 2004 and 2011 cross-sections and a smaller panel survey across those years. We also exploit the matched employer-employee data to take questions from the worker surveys in each of the two years.

3.1 *WERS Data*

The 2004 and 2011 cross-sections are the fifth and sixth instalments of a Government funded survey series of British workplaces. In each year the sample of workplaces represents a random draw from the Interdepartmental Business Register, which is generally considered to be the highest quality UK sampling frame. The surveys are stratified by workplace size and industry with larger workplaces and some industries overrepresented [Chaplin *et al*. (2005)]. As a consequence, we weight all estimates to be representative of the sampling population. The 'Management Questionnaire' reflects a face-to-face interview with the most senior manager with day-to-day responsibility for personnel matters. The survey population is all British workplaces except private households and those in primary industries.

The response rates for 2004 and 2011 were 64% and 46%, yielding 2295 and 2680 establishments respectively. The decline in response rates reflects prevailing trends in

business surveys [see van Wanrooy *et al*. (2013)]. We limit attention to establishments with ten or more employees and exclude establishments and industries not in the trading sector (government and non-profit offices) as well as those with missing data measuring training and demand competition with respect to product quality. The resulting sample sizes are 1028 and 1072 establishments for the 2004 and 2011 cross sections respectively. The 2011 WERS followed a subset of workplaces that also participated in the 2004 survey. After our sample restrictions, we retained 142 establishments (284 observations) observed in both 2004 and 2011.

The surveys are attractive for our purpose as they identify training intensity and the nature of competition with respect to product quality while also providing a wide range of relevant employer characteristics. The two cross-sections allow us to follow the hypothesized relationship over time and the panel element allows us to remove time invariant unobserved firm heterogeneity. We also check for robustness by using an alternative measure of training intensity from the matched Employee Questionnaire addressed to a random subset of establishment employees.

The core measure of training intensity asks managers if experienced employees in the largest occupational group were given time off from their normal daily work duties to undertake training over the past 12 months. If they answer yes, then managers were subsequently asked: '*If any training*, *on average, how many days of training did experienced employees in the largest occupational group undertake over the past 12 months?*' The responses include one of six answers: 'No time', 'Less than one day', '1 to less than 2 days', '2 to less than 5 days', '5 to less than 10 days', and '10 days or more'. All establishments that responded that they did not provide training were recoded as 'No time'. Table 1 provides the distribution of responses and shows the variation of training intensity across establishments, a pattern that is reasonably stable over time. Around ten percent of establishments provided

'No time' and another ten percent provided '10 days or more'. The heart of the distribution is the middle two categories.[3]

Managers identify the importance of product quality by responding to the following question: '*If in the trading sector and trading externally, to what extent would you say that the demand for your (main) product or service depends upon offering better quality than your competitors*?'[4] Managers provide an ordered categorical response from *1. 'Demand does not depend at all on quality' to 5 'Demand depends heavily on superior quality'*. At best, the responses should proxy the elasticity of demand that the establishment faces with respect to product quality with the larger numbers reflecting a greater elasticity of demand with respect to product quality.

Table 2 provides the distribution of responses again showing variation across establishments but a stable pattern between surveys. While 5 percent or less of the managers responded that '*Demand does not depend at all on quality*', approximately forty percent said that '*Demand depends heavily on offering superior quality*'. In what follows we identify these five categories as *Quality Importance 1* through *Quality Importance 5*.

In examining the relationship between training intensity and the importance of product quality we control for an extensive set of other covariates. We describe this process in the next subsection but emphasize that the descriptive statistics for all covariates are available upon request.

3.2 *Empirical Methodology*

We estimate a series of ordered probit models in which the categorical measure of training intensity depends on the extent of the importance of product quality and suitable controls. We

[3] All the tables of statistics and results are set out in Appendix B.
[4] Establishments trading externally provide goods and services to the general public and/or to other organisations rather than exclusively supplying other parts of their own organisation.

begin with cross-sectional estimates for each of the two years using an increasingly complete set of covariates.

In a baseline estimate we recognize that fixed costs in establishing formal training imply that larger organizations can provide additional training more efficiently. Moreover, such formal training programs may take time to develop and may reflect the permanence and scope of the establishment. Thus, we control for the (log) number of employees, the number of years the establishment has been operating, whether the establishment is part of a larger organization (i.e. multi-establishment), and if so, the size of the organization in which the establishment is a part, whether the establishment is listed on the stock exchange, and whether it is a part of a franchise operation. Also in the baseline, we capture workforce composition with the percentage of female employees, the percentage of young (18 to 21 years of age) and older employees (above 50 years of age), the presence of trade union members and the share of the workforce that is disabled. We also control for the share of the workforce in each of eight occupational groups, for dummies identifying the largest non-managerial occupational group in the establishment, for region and for industry. We control for the use of temporary agency and fixed-term employees, the share of the establishment's workforce that is part-time and the percentage of workdays lost due to sickness or absence. Since we recognize the connection between the incentive to train and the extent of labour mobility, we control for whether there have been any vacancies in the last year, for the percent of employees separated from the establishment in the previous year and for the percent of employees who quitted. We also include indicators of human resource management practices such as the presence of quality circles, the presence of joint consultative committees, the presence of just-in-time inventory, meetings taking place between line managers or supervisors and employees, a formal strategic plan and an internal investment plan. Finally, we also include indicators for shift work, the use of

personality/attitude and performance/competency tests when filling vacancies, the use of merit pay, profit sharing, bonuses, employee schemes and piece rates (i.e. payment by results).

In a second estimate we retain all of the controls from the baseline and add two dummy variables capturing the number of competitors that the establishment is facing. This reflects previous empirical work suggesting that product market structure may influence the profitability of investments in training [Lai and Ng (2014), Bassanini and Brunello (2011)].

A final estimate includes indicators of the current state of the market in which the establishment operates. Managers were asked to declare whether the current state of the market is 'growing', 'mature', 'declining' or 'turbulent'. In the empirical analysis we treat the last category as the omitted category.

We estimate all three specifications for both cross-sections. Using the panel, we estimate an analogous fixed-effect ordered probit [Green and Henscher (2010)]. The concern is that despite our long list of controls, unmeasured but time-invariant heterogeneity influences both the importance of quality and the extent of training. The fixed-effect ordered probit holds constant time invariant characteristics of the establishment. We recognize that the fixed-effect ordered probit brings with it an incidental parameters problem and so provide a variety of alternative estimation techniques that confirm its results.

4. Empirical Results

4.1 *Ordered Probit Analysis*

The first column of Table 3 presents the baseline estimate of the determinant of training intensity in 2004. Many of the controls behave as anticipated. Larger establishments, multi-establishments and establishments with higher percentages of union members and young employees all provide more training. Training intensity is greater in establishments that have

problem solving groups, joint consultative committees, hold meetings between supervisors and employees, have a formal strategic plan, and payment by result schemes. In contrast, higher percentages of part time employees and employees who quit in the previous year are associated with lower training intensities.

The critical result for our hypothesis is shown in the coefficients associated with the importance of product quality. While not monotonically increasing, all coefficients are positive suggesting that as quality becomes important, establishments engage in more training. Moreover, the two categories that indicate the greatest importance for quality have the largest coefficients and these two are significantly greater than zero indicating that training intensity is above that in establishments with no importance for quality.

Column 2 reports estimates that add the number of competitors and indicates that training intensity is higher when the number of competitors is low. Yet, this suggestion that more monopolistic establishments do more training [see Bilanakos *et al*. (2014)] does not substantially change the role of competition on product quality. The two categories for which quality is most important retain the largest coefficients and now the three categories for which quality is most important all take significant coefficients. Column 3 adds indicators of the current state of the product market demand and indicates that mature product markets are associated with more training. Again, recognizing this new relationship proves only modest changes to the apparent role of product quality. All four coefficients are positive and now significantly different from zero suggesting that when product market quality is not important, there is less training. The two categories for which product market quality is the most important retain the two largest coefficients.

In Table 4 we reproduce the series of estimates using the 2011 cross-section. The pattern of significant controls remains very similar. Critically, the role of product quality closely mimics that in the 2004 survey. The coefficients for the two categories indicating the

greatest importance for product quality again take the largest values, all coefficients are positive and those for the three categories indicating greater importance of quality are all significantly different from zero (no importance of quality is the excluded category).

In Table 5 we report the marginal effects of product quality from the most complete specification. Columns 1 to 4 present the marginal effects for 2004 and columns 5 to 8 present the marginal effects for 2011. Columns 3 and 4 as well as columns 7 and 8 suggest that moving from an establishment where product quality has no importance to either of the two highest categories of importance greatly influences the probability of offering training of '10 days or more.' For example, in column 4, the probability increases .081, or slightly more than 8 percentage points. As only around 10 percent of workplaces provide this much training, this is a very large effect. There is also evidence of large influences on the lower tail of the training distribution. Thus, moving from an establishment where product quality has no importance to one with greater importance can reduce the probability that either no or less than one day of training will be provided. Again, take column 4 as an example. Here, the probability of providing no training is reduced by nearly 10 percentage points and that of providing less than one day of training is reduced by nearly 3 percentage points. The marginal effects are broadly similar across the two years and suggest that the magnitudes of the statistical relationship are also economically meaningful.

4.2 *Panel Estimates*

Table 6 moves to the panel data where we now observe 142 establishments that change categories in the importance of quality for demand between 2004 and 2011. These 'movers' identify the influence of demand competition with respect to product quality on training intensity in fixed effect estimates. As always, there can be concern that the movers which identify the fixed effect estimate are an unusually selected sample. The first column of Table 6 limits the sample to the movers but merely pools the observations from the two years

without controlling for fixed effects. The point estimates on the associated ordered probit continues to suggest, as did the full cross sections, that greater training intensity is associated with quality being important in competition. This provides initial assurance that the movers do not appear as an unusually selected sample.

Column 2 presents the results from a fixed effects ordered probit model. This holds constant time invariant characteristics that might influence both the extent of training intensity and the importance of product quality. The point estimates in such fixed effect estimates are generated by the within establishment variation in demand competition and present the closest analogue to the ordered probits presented for the two cross-sections. The relevance of the incidental parameter problem and the advantages and limitations of the fixed-effect ordered probit are discussed in Greene (2001) and Greene and Henscher (2010). The point estimates suggest that as establishments move from less importance on quality to more importance on quality, they provide more training. The point estimates change modestly as a result of the fixed effect estimates (compared to the pooled estimate on the same sample) with some of them becoming larger and others becoming smaller. Thus, to the extent that unmeasured time invariant characteristics influence the cross-section estimates, they do not seem to generate a routinely upward bias. It is also of interest that the pattern of coefficients monotonically increases with the importance of quality.

As a robustness test, we alter the functional form of our fixed effect estimate. We imagine the ordered categories that measure training intensity represent a count variable from zero to five. While not as accurate as simply recognizing they represent ordered categories, it allows estimation of the fixed-effect Poisson regression, one of the few non-linear fixed effect estimators without incidental parameter concerns [Hilbe and Greene (2008)]. The results from this exercise are presented in column 3. The estimated coefficients largely retain the signs and statistical significance we have shown throughout.

It is reassuring that essentially the same pattern of positive coefficients for the product quality variables emerge in the pooled panel and in two separate fixed-effect specifications. At minimum, we find no indication that the cross-sectional finding that establishments with greater importance on quality engage in more training results from invariant establishment specific effects.

4.3 *Employee Level Analysis*

In this sub-section we provide further robustness exercises by using the WERS Employee Questionnaire.[5] The WERS follows establishments and not employees and so we can only treat the matched employer-employee data as cross sections. Thus, we match the management data to the employee data and retain the employee as the unit of measure.

Employees identify training intensity from the following question: '*Apart from health and safety training how much training have you had during the last 12 months, either paid for or organised by your employer. Please only include training where you have been given time off from your normal daily work duties to undertake training*.' Employees provide one of six answers: 1. '*None*', 2. '*Less than 1 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*'. These categories match those from the management questionnaire and we now use the worker responses as the dependent variable. Table 9 presents the distribution of responses revealing that a larger share of workers than establishments report no training. These workers may not be part of the largest occupational group (the focus of the establishment question) and/or the reported intensity by the establishment is an average that may include many workers with zero training. Nonetheless, there remains substantial representation of workers across all the intensity categories.

[5] At those workplaces responding to the management questionnaire, a questionnaire was presented to 25 randomly selected employees in workplaces with more than 25 employees, or to all employees in workplaces with fewer than 25 employees. The employee response rate in the 2004 (2011) employee questionnaire was 61% (54%). The employee questionnaire used a self-completion format without direct interviewer involvement.

After dropping observations due to missing data on variables at the employee level, our final sample comprises of 7660 employees clustered in 774 establishments in 2004 and 7764 employees clustered in 777 establishments in 2011. The employee data allows us to add a wide variety of relevant employee characteristics that contribute significantly to explaining training. Table 7 summarizes the ordered probits on the employee data clustering all standard errors at the establishment level. Suppressed are the significant coefficients on gender, age, education and other individual characteristics. The role of these additional variables may be partially responsible for the product quality variables taking smaller coefficients than those reported in column 3 of Tables 3 and 4. Nonetheless, the prevailing pattern remains clear. All coefficients in both years are positive. Workers in those establishments which identify either of the two categories where quality is most important emerge as significantly more likely to be trained. This conforms with the establishment level results but here it is true holding both measured establishment and personal characteristics constant.

Table 8 reports the marginal effects. Columns 1 to 4 present the marginal effects for 2004 and columns 5 to 8 present the marginal effects for 2011. Columns 3 and 4 as well as columns 7 and 8 suggest that moving from an establishment where demand competition does not depend on product quality to an establishment higher in the ranking can generate an increased probability of greater training intensity. Thus, in all of the columns mentioned above, the probability of being in the two lowest categories of intensity significantly decreases while that of being in the four highest categories of intensity significantly increases. Again, relative to the means many of these marginal effects are substantial even if smaller than some of those implied by the establishment analysis.

The employee estimates are reassuring as they suggest that the basic observations on training by managers and employees are roughly consistent.[6] In addition, they suggest that limitations of the management survey to the largest occupational group or to providing only an average do not obscure the actual pattern of which workers are trained. When product quality is critical for retaining product demand, the establishment more intensely trains its workers.

5. Final Comments

Firms making higher quality products and using that quality to compete with rivals are likely to use higher quality inputs including higher quality labour. As a consequence, we hypothesize that such firms provide more training to their workers. Training is, of course, not the only element of worker quality. Establishments could simply hire more able or better educated workers. Yet, these other elements seem imperfect substitutes. Each establishment has a particular production process, particular non-labour inputs and, often, particular customers. Learning how to produce quality products in these circumstances seems likely to require very specific skills typically taught through training.

While the distinction between general and specific training was not explicit in our theoretical model we showed that when training investments improve quality, it is possible that increased demand sensitivity to quality will increase training. This emphasis in the model on demand sensitivity dovetails nicely with the WERS questions which asks specifically how important is product quality in competing with rivals. We used this question to investigate our hypothesis.

We routinely found that establishments with demand that is more sensitive to quality train more intensively. This is true in two establishment level cross-sections when including a

[6] This has not always been the case in the WERS. Budd and Mumford (2006) show an enormous divergence between the availability of family friendly practices as reported by managers and as reported by employees.

very extensive set of sensible controls. It is true in several variants of panel fixed effect estimates designed to hold constant time invariant establishment effects. It is true when we changed the measure of training intensity from an aggregate establishment level indicator to an individual employee indicator. Those workers in establishments making products with more quality sensitivity were likely to receive more training holding constant both establishment and personal controls.

We recognize that additional examination may be appropriate. We have not been able to hold constant individual worker fixed effects. The measure of demand sensitivity to quality remains a subjective view of the establishment manager. We have used a temporal measure of training intensity that may not fully capture the value of what is learned. It certainly does not include informal training. Despite these imperfections, it seems sensible that product market characteristics are crucial determinants of training investments and that the quality of the product itself should be among those determinants. Our confirming evidence represents an initial contribution on which further work can build.

References

Abowd, J. M., Kramarz, F. and Moreau, A. (1996) 'Product Quality and Worker Quality' *Annales d'Économie et de Statistique* No. 41/42, 299-322.

Bacchiega. E and Minnitiy, A. (2013) 'Training and Product Quality in Unionized Oligopolies' *Working Paper DSE No. 871, Department of Economics, University of Bologna.*

Banker, R. D., Khosla, I. and Sinha, K. K. (1988) 'Quality and Competition' *Management Science* **44**, pp. 1179-1192.

Bassanini, A. and Brunello, G. (2011) 'Barriers to Entry, Deregulation and Workplace Training' *European Economic Review* **55**, pp. 1152-1176.

Bilanakos, C., Green, C. P., Heywood, J. S. and Theodoropoulos, N. (2014) 'Do Dominant Firms Provide More Training?' *Working Paper 06-14, Department of Economics, University of Cyprus*.

Brakman, R. E., Forslid, R. P. Marti, G. I . Ottaviano, P. and Robert-Nicoud, F. (2005). *Economic Geography and Public Policy*. Princeton, New Jersey: Princeton University Press.

Budd, J. and Mumford, K. (2006) 'Family-friendly Work Practices in Britain: Availability and Perceived Accessibility' *Human Resource Management Journal* **45**, pp. 23–42.

Chaplin, J., Mangla, J., Purdon, S. and Airey, C. (2005) 'The Workplace Employment Relations Survey 2004 (WERS 2004) Technical Report (Cross Section and Panel Surveys)', London: National Centre for Social Research.

China Labor Watch (2012) '3000 to 4000 workers strike at Foxconn's China factory' October 12, 2012, http://www.chinalaborwatch.org/news/new-433.html

Chioveanu, I. (2012) 'Price and Quality Competition' *Journal of Economics* **107**, pp. 23- 44.

Courakis, A. S. (1991) 'Labour Skills and Human Capital in the Explanation of Trade Patterns' *Oxford Economic Papers* **43**, pp. 443-462.

Dixit, A. K. and Stiglitz, J. E. (1977) 'Monopolistic Competition and Optimum Product Diversity' *American Economic Review* **67**, pp. 297-308.

Gabszewicz, J. J. and Turrini, A. (1999) 'Workers' Skills and Product Selection' *Revue Economique* **50**, pp. 383-391.

Gabszewicz, J. J. and Turrini, A. (2000) 'Workers' Skills, Product Quality and Industry Equilibrium' *International Journal of Industrial Organization* **18**, pp. 575-593.

Gonzalex, X. and Pazo, C. (2004) 'Firms' R&D Dilemma: To Undertake or not to Undertake R&D' *Applied Economics Letters* **11**, pp. 55-59.

Greene, W. H. (2001) 'Estimating Econometric Models with Fixed Effects' *Discussion Paper*, Department of Economics, Stern School of Business, New York University.

Greene, W. H. and Henscher, D. A. (2010) *Modeling Ordered Choices: A Primer***,** Cambridge: Cambridge University Press.

Greenaway, D. and Torstensson, J. (2000) 'Economic Geography, Comparative Advantage and Trade within Industries: Evidence from the OECD' *Journal of Economic Integration* **15**, pp. 260-280.

Gilbert. R. J. (1989) 'The Role of Potential Competition in Industrial Organization' *Journal of Economic Perspectives* **3**, pp. 107–127.

Hilbe, J.M. and Greene, W.H. (2008) 'Count Regression Models', Chapter 7 in *Handbook of Statistics (Epidemiology and Medical Statistics)* **27**, 210-252, edited by C.R. Rao, J.P. Miller and D.C. Rao.

Kranton, R. E. (2003) 'Competition and the Incentive to Produce High Quality' *Economica* **70**, pp. 385–404.

Kugler, M. and Verhoogen, E.A. (2012) 'Prices, Plant Size, and Product Quality' *Review of Economic Studies* **79**, pp. 307-339.

Lai, Tat-Kei. and Ng, T. (2014) 'The Impact of Product Market Competition on Training Provision: Evidence from Canada' *Canadian Journal of Economics* forthcoming.

Levin, R. and P. Reiss. (1988). 'Cost Reducing and Demand Creating R&D with Spillovers' *Rand Journal of Economics* **19**, pp. 538-556

Martin-Montaner, J. and Rios, V. (2002) 'Vertical Specialization and Intra-Industry Trade: The Role of Factor Endowments' *Review of World Economics* **138**, pp. 340-365.

Maskus, K., Sveikauskas, C. and Webster, A. (1994) 'The Composition of the Human Capital Stock and its Relation to International Trade: Evidence from the US and Britain' *Review of World Economics* **130**, pp. 50-76.

Matsa, D. A. (2011) 'Competition and Product Quality in the Supermarket Industry' *Quarterly Journal of Economics* **126**, pp. 1539–1591.

Motta, M. (1992) 'Cooperative R&D and Vertical Product Differentiation' *International Journal of Industrial Organization* **10**, pp. 643-661.

Nike, Inc. (2014) 'Corporate Responsibility Report – Workers and Factories' http://www.nikebiz.com/crreport/content/workers-and-factories/3-9-1-our-approach.php?cat=hr

Oulton, N. (1996) *Work Force Skills and Export Competitiveness* In A. L. Booth and D. Snower (Eds.), *Acquiring Skills*. Cambridge University Press.

Schott, P. K. (2004) 'Across-Product Versus Within-Product Specialization in International Trade' *Quarterly Journal of Economics* **119**, pp. 647-678.

Sutton, J. (1998). *Technology and Market Structure*. MIT Press.

Van Wanrooy, B., Bewley, H., Bryson, A., Forth, J., Freeth, S., Stokes, L. and Wood, S. (2013) The 2011 Workplace Employment Relations Survey: First Findings. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/210103/13-1010-WERS-first-findings-report-third-edition-may-2013.pdf

Webster, A. (1993) 'The Skill and Higher Educational Content of UK Net Exports' *Oxford Bulletin of Economics and Statistics* **55**, pp. 141-169.

Appendix A

Proof of Proposition

Taking the natural logarithm of (16) yields:

$$\ln I_i^* = \frac{1}{1-\beta\theta} \cdot \ln\left(\frac{\beta\theta y p_i^{*1-\alpha}}{\alpha\gamma}\right) \tag{A1}$$

The partial derivative of the above expression implies:

$$\frac{\partial \ln I_i^*}{\partial \beta} = \frac{1}{1-\beta\theta} \cdot \left[\frac{\theta}{1-\beta\theta} \cdot \ln\left(\frac{\beta\theta y p_i^{*1-\alpha}}{\alpha\gamma}\right) + \frac{1}{\beta}\right] \tag{A2}$$

Focusing on the term in square brackets in expression (A2), the relationship between the elasticity of demand with respect to product quality, β, and the level of investment in firm specific training may be determined from the following function:

$$f(\beta) = \ln\left(\frac{y p_i^{*1-\alpha}}{\alpha\gamma}\right) + g(\beta) \tag{A3}$$

where $g(\beta) = \ln\beta\theta + (1/\beta\theta) - 1 \geq 0$. Defining a critical level of training $\tilde{\gamma} \equiv \alpha^{-1} y p_i^{*1-\alpha}$ suggests two cases:

Case 1: $\gamma \leq \tilde{\gamma} \Rightarrow f(\beta) \geq 0 \Rightarrow \partial I_i^* / \partial \beta \geq 0, \ \forall \beta \in (0, 1/\theta)$

Case 2: $\gamma > \tilde{\gamma} \Rightarrow \begin{cases} f(\beta) \geq 0 \Rightarrow \partial I_i^* / \partial \beta \geq 0, \ \forall \beta \in (0, \tilde{\beta}) \\ f(\beta) < 0 \Rightarrow \partial I_i^* / \partial \beta < 0, \ \forall \beta \in (\tilde{\beta}, 1/\theta) \end{cases}$

Appendix B

Table 1. Distribution of Training Intensity

	2004			2011			Panel 2004-2011		
	Mean	*Std. D*	*Observations*	*Mean*	*Std. D*	*Observations*	*Mean*	*Std. D*	*Observations*
No time	0.114	0.317	117	0.082	0.275	88	0.102	0.303	29
Less than one day	0.058	0.234	60	0.054	0.226	58	0.039	0.193	11
1 to less than 2 days	0.219	0.413	225	0.242	0.428	259	0.285	0.452	81
2 to less than 5 days	0.340	0.474	350	0.348	0.476	373	0.313	0.465	89
5 to less than 10 days	0.155	0.361	159	0.167	0.373	179	0.141	0.348	40
10 days or more	0.114	0.318	117	0.107	0.309	115	0.120	0.325	34
Total Observations		1028			1072			284	

Notes: The samples for the two cross sections consist of private sector trading establishments with 10 or more employees. 'Trading' implies that establishments provide goods and services to the general public or to other organisations. We also exclude establishments with missing data on training and on product quality. We exclude establishments where the largest occupational group is managers or senior officials as the dependent variable does not apply to this group. For the panel dataset we apply the same restrictions as in the cross sections but for establishments that have changed product quality competition status and we observe twice. Thus, the panel is balanced and we observe 142 establishments which generate 284 observations. Means sum to 100 percent.

Table 2. Distribution of Demand Dependence on Product Quality

	2004			2011			Panel 2004-2011		
	Mean	*Std. D*	*Obs*	*Mean*	*Std. D*	*Obs*	*Mean*	*Std. D*	*Obs*
1: Demand does not depend at all on quality	0.046	0.208	47	0.029	0.167	31	0.063	0.244	18
2:	0.033	0.178	34	0.034	0.180	36	0.081	0.273	23
3:	0.138	0.345	142	0.138	0.345	148	0.208	0.406	59
4:	0.351	0.477	361	0.372	0.484	399	0.349	0.477	99
5: Demands depends heavily on superior quality	0.432	0.495	444	0.427	0.495	458	0.299	0.459	85
Total Observations		1028			1072			254	

Note: For information on the sample, see Notes in Table 1. Means sum to 100 percent.

Table 3: Training Intensity and Competition on Product Quality - WERS 2004

Ordered Probit

	(1)		(2)		(3)	
	Coef.	*Std. E*	*Coef.*	*Std. E*	*Coef.*	*Std.E*
Quality Importance 2	0.315	0.256	0.420	0.259	0.429*	0.259
Quality Importance 3	0.302	0.186	0.387**	0.189	0.435**	0.189
Quality Importance 4	0.459***	0.175	0.577***	0.179	0.598***	0.179
Quality Importance 5	0.396**	0.174	0.495***	0.177	0.513***	0.178
Few Competitors			-0.552***	0.189	-0.505***	0.190
Many Competitors			-0.570***	0.185	-0.542***	0.186
Market is growing					0.112	0.109
Market is mature					0.212*	0.115
Market is declining					-0.182	0.151
Log number of employees	0.095*	0.055	0.092*	0.055	0.096*	0.055
Log firm age	0.006	0.026	0.005	0.026	0.001	0.026
Multi-establishment (part of a larger organization)	1.171***	0.351	1.191***	0.351	1.333***	0.354
Single independent establishment	0.827***	0.289	0.832***	0.288	0.917***	0.289
Organisation size> 150 employees	0.251*	0.139	0.260*	0.139	0.216	0.140
Stock exchange	0.050	0.197	0.058	0.197	0.067	0.198
Part of a franchise operation	0.553***	0.206	0.573***	0.206	0.612***	0.208
% employees using computers	0.003**	0.001	0.003**	0.001	0.002*	0.001
% female employees	0.285	0.214	0.263	0.214	0.210	0.215
% part time employees	-1.288***	0.204	-1.297***	0.205	-1.303***	0.206
% of employees who belong to a union	0.407*	0.245	0.339	0.247	0.423*	0.249
% of employees who set their pay through trade unions	0.189	0.134	0.182	0.134	0.193	0.135
% disabled employees	0.641	1.053	0.623	1.052	0.681	1.052
% workdays lost through employee sickness/absence	0.456	0.760	0.413	0.771	0.453	0.774
% fixed term employees	-0.082	0.208	-0.080	0.209	-0.124	0.209
% temporary agency employees	-0.842	0.557	-0.796	0.557	-0.884	0.560
% of employees more than 50 years old	-0.176	0.250	-0.227	0.251	-0.263	0.252
% of employees age 18-21 years old	1.681***	0.394	1.812***	0.397	1.749***	0.402
% of employees who quitted last year	-0.382	0.236	-0.374	0.236	-0.414*	0.237
% of employees who separated last year	-0.254	0.325	-0.355	0.326	-0.385	0.327
Vacancies available in the last year	0.271**	0.109	0.284***	0.110	0.277**	0.110
Problem solving groups/quality circles	0.298***	0.097	0.311***	0.098	0.303***	0.098
System designed to minimize inventories supplies	-0.121	0.093	-0.102	0.094	-0.087	0.094
Joint consultative committees/work council councils	0.310**	0.130	0.299**	0.130	0.326**	0.131
Meetings between line managers and employees	0.172*	0.088	0.183**	0.088	0.167*	0.088
Formal strategic plan	0.286***	0.090	0.271***	0.090	0.253***	0.091
Investors in people accredited	0.291***	0.098	0.282***	0.098	0.257***	0.099
Internal investment plan	0.005	0.078	0.005	0.079	0.026	0.079
Work time arrangement: Shift working	0.238***	0.090	0.239***	0.090	0.238***	0.091
Personality or attitude test prior to hiring	0.040	0.099	0.025	0.099	0.013	0.100
Performance or competency test prior to hiring	0.128*	0.077	0.112	0.078	0.112	0.078
Payment by result	0.153*	0.085	0.167*	0.086	0.172**	0.087
Merit pay	0.203	0.131	0.202	0.131	0.199	0.132
Profit related pay	-0.071	0.082	-0.077	0.082	-0.088	0.083
Employee share schemes	-0.447***	0.124	-0.432***	0.124	-0.462***	0.125
Cutoff 1	1.773***	0.590	1.372**	0.602	1.443**	0.618
Cutoff 2	2.007***	0.590	1.607***	0.602	1.678***	0.618
Cutoff 3	2.792***	0.591	2.399***	0.603	2.473***	0.619)
Cutoff 4	3.749***	0.595	3.363***	0.607	3.447***	0.623
Cutoff 5	4.321***	0.597	3.938***	0.609	4.030***	0.625

Log likelihood	-1499.69	-1493.73	-1486.97
Observations		1028	

Notes: For information on the sample, see Notes in Table 1. The dependent variable reads as follows "On average, how many days of training did experienced employees in the largest occupational group undertake over the past 12 months?" Since the dependent variable excludes establishments where the largest occupational group is managers/senior officials, we drop establishments where the largest occupational group is managers/senior officials and include seven dummies for the largest occupational group in the establishment (omitted category routine/unskilled). The omitted category of product quality competition is 'Demand does not depend at all on product quality'. Other controls (which are not reported but whose estimates are available upon request) are: eleven industry dummies (omitted category *health*), ten region dummies (omitted category *Yorkshire and Humberside*), and percentages of eight occupational groups (managerial, professional, technical, sales, operative/assembly, clerical/secretarial, craft/skilled manual, personal services, omitted category *percentage of routine/unskilled staff*). In addition, dummy variables for missing values on each covariate (if the covariate has missing values) are included in the estimation. Estimated coefficients of the demand competition variables are not significantly different from each other but they are jointly significant different from zero. Robust standard errors are reported. Levels of significance: *** p<0.01, ** p<0.05, * p<0.1.

Table 4: Training Intensity and Competition on Product Quality - WERS 2011

Ordered Probit

	(1)		(2)		(3)	
	Coef.	*Std. E*	*Coef.*	*Std. E*	*Coef.*	*Std. E*
Quality Importance 2	0.351	0.302	0.410	0.309	0.393	0.310
Quality Importance 3	0.420*	0.243	0.489**	0.247	0.500**	0.249
Quality Importance 4	0.589**	0.232	0.660***	0.239	0.667***	0.240
Quality Importance 5	0.440*	0.233	0.512**	0.239	0.517**	0.240
Few Competitors			-0.361*	0.214	-0.389	0.237
Many Competitors			-0.293**	0.136	-0.302	0.239
Market is growing					0.024	0.087
Market is mature					0.222**	0.099
Market is declining					-0.072	0.121
Log number of employees	0.051**	0.023	0.051**	0.023	0.062*	0.034
Log firm age	0.067***	0.022	0.064***	0.022	0.063***	0.023
Multi-establishment (part of a larger organization)	0.846**	0.329	0.863***	0.331	0.869***	0.332
Single independent establishment	0.286	0.233	0.277	0.233	0.289	0.234
Organisation size> 150 employees	0.224*	0.120	0.226*	0.120	0.225*	0.120
Stock exchange	0.306	0.188	0.342*	0.189	0.350*	0.190
Part of a franchise operation	0.565***	0.212	0.569***	0.212	0.576***	0.213
% employees using computers	0.004***	0.001	0.004***	0.001	0.004***	0.001
% female employees	0.655***	0.197	0.688***	0.199	0.680***	0.199
% % part time employees	-0.238	0.171	-0.253	0.172	-0.291*	0.173
% of employees who belong to a union	0.128	0.259	0.124	0.259	0.108	0.262
% of employees who set their pay through trade unions	0.057	0.132	0.066	0.132	0.067	0.133
% disabled employees	1.669**	0.816	1.755**	0.818	1.598*	0.821
% workdays lost through employee sickness/absence	1.493**	0.582	1.534***	0.583	1.516***	0.583
% fixed term employees	-0.133	0.175	-0.133	0.175	-0.133	0.176
% temporary agency employees	-0.130	0.408	-0.165	0.408	-0.075	0.413
% of employees more than 50 years old	-0.562**	0.244	-0.594**	0.245	-0.612**	0.245
% of employees age 18-21 years old	0.656*	0.393	0.692*	0.394	0.715*	0.397
% of employees who quitted last year	-0.871***	0.331	-0.920***	0.336	-0.954***	0.337
% of employees who separated last year	-0.405	0.387	-0.367	0.388	-0.381	0.389
Vacancies available in the last year	0.325***	0.104	0.331***	0.104	0.310***	0.105
Problem solving groups/quality circles	0.377***	0.097	0.381***	0.097	0.362***	0.098
System designed to minimize inventories supplies	-0.094	0.086	-0.089	0.086	-0.076	0.086
Joint consultative committees/work council councils	0.207*	0.120	0.197	0.120	0.202*	0.121
Meetings between line managers and employees	0.166*	0.090	0.173*	0.091	0.183**	0.091
Formal strategic plan	-0.058	0.093	-0.059	0.093	-0.050	0.094
Investors in people accredited	0.174*	0.096	0.161*	0.096	0.159*	0.096
Internal investment plan	0.054	0.079	0.052	0.079	0.063	0.079
Work time arrangement: Shift working	0.212**	0.086	0.217**	0.086	0.217**	0.086
Personality or attitude test prior to hiring	0.189**	0.092	0.180*	0.093	0.181*	0.093
Performance or competency test prior to hiring	0.007	0.080	0.011	0.080	0.016	0.080
Payment by result	0.185**	0.094	0.183*	0.094	0.182*	0.094
Merit pay	0.206**	0.102	0.223**	0.103	0.223**	0.103
Profit related pay	-0.049	0.079	-0.045	0.079	-0.048	0.079
Employee share schemes	-0.055	0.130	-0.053	0.130	-0.047	0.131
Cutoff 1	-0.127	0.559	-0.392	0.581	-0.403	0.588
Cutoff 2	0.164	0.558	-0.100	0.581	-0.110	0.588
Cutoff 3	1.027*	0.559	0.764	0.581	0.759	0.588
Cutoff 4	2.138***	0.561	1.877***	0.584	1.877***	0.591
Cutoff 5	2.801***	0.563	2.541***	0.585	2.542***	0.592

Log likelihood	-1563.07	-1561.07	-1557.51
Observations		1072	

Notes: For information on the sample, see Notes in Table 1. The dependent variable reads as follows "On average, how many days of training did experienced employees in the largest occupational group undertake over the past 12 months?" Since the dependent variable excludes establishments where the largest occupational group is managers/senior officials, we drop establishments where the largest occupational group is managers/senior officials and include seven dummies for the largest occupational group in the establishment (omitted category routine/unskilled). The omitted category of product quality competition is 'Demand does not depend at all on product quality'. Other controls (which are not reported but whose estimates are available upon request) are: seven industry dummies (omitted category *health*), ten region dummies (omitted category *Yorkshire and Humberside*), and percentages of eight occupational groups (managerial, professional, technical, sales, operative/assembly, clerical/secretarial, craft/skilled manual, personal services, omitted category *percentage of routine/unskilled staff*). In addition, dummy variables for missing values on each covariate (if the covariate has missing values) are included in the estimation. Estimated coefficients of the demand competition variables are not significantly different from each other but they are jointly significant different from zero. Robust standard errors are reported. Levels of significance: *** p<0.01, ** p<0.05, * p<0.1.

Table 5: Marginal Effects of Quality Importance on Training based on Tables 3 and 4

	2004								*2011*							
	Quality Importance 2		*Quality Importance 3*		*Quality Importance 4*		*Quality Importance 5*		*Quality Importance 2*		*Quality Importance 3*		*Quality Importance 4*		*Quality Importance 5*	
	(1)		(2)		(3)		(4)		(5)		(6)		(7)		(8)	
Training	*Coef.*	*Std. E.*	*Coef.*	*Std. E.*	*Coef.*	*Std. E.*	*Coef.*	*Std. E.*	*Coef.*	*Std. E.*	*Coef.*	*Std. E.*	*Coef.*	*Std. E.*	*Coef.*	*Std. E.*
$x = 0$	-0.066	0.051	-0.072	0.051	-0.106**	0.045	-0.097***	0.038	-0.047*	0.027	-0.061***	0.023	-0.095***	0.032	-0.075**	0.034
$0 < x < 1$	-0.022	0.013	-0.023**	0.010	-0.032***	0.010	-0.028***	0.010	-0.023	0.016	-0.030**	0.013	-0.042***	0.014	-0.033**	0.015
$1 \leq x < 2$	-0.071	0.051	-0.070*	0.041	-0.090*	0.048	-0.072	0.047	-0.073	0.061	-0.092*	0.048	-0.114***	0.041	-0.086**	0.040
$2 \leq x < 5$	0.019	0.066	0.026	0.065	0.045	0.085	0.049	0.071	0.024***	0.006	0.031***	0.007	0.064***	0.017	0.056**	0.022
$5 \leq x < 10$	0.057*	0.032	0.059**	0.024	0.080***	0.023	0.069***	0.023	0.060	0.047	0.076**	0.037	0.098***	0.034	0.075**	0.035
$x \geq 10$	0.083	0.077	0.080	0.061	0.103**	0.038	0.081**	0.030	0.060	0.060	0.076	0.047	0.089**	0.037	0.063**	0.030

Notes: 1. x denotes number of days devoted to training; 2. Entries are marginal effects obtained from an ordered probit model based on the complete estimates model (i.e. column 3 of Table 3) across the two cross sections; 3. We only report the marginal effects of the four variables of interest. Marginal effects for the rest of the covariates are available upon request; 4. The marginal effect is the discrete change going from 0 to 1; 5. Levels of significance: *** p<0.01, ** p<0.05, * p<0.1.

Table 6. Training Intensity and the Importance of Quality

Panel Data Analysis 2004-2011

	Ordered Probit Without FE		*Ordered Probit With FE*		*Poisson with FE*	
	(1)		*(2)*		*(3)*	
Demand Competition	*Coef.*	*Std. E.*	*Coef.*	*Std. E.*	*Coef.*	*Std. E.*
Quality Importance 2	0.661	0.531	0.385	0.908	0.406	0.258
Quality Importance 3	0.756*	0.398	0.536	0.764	0.225	0.212
Quality Importance 4	0.895**	0.444	0.642*	0.368	0.435*	0.232
Quality Importance 5	0.919**	0.443	1.450**	0.738	0.466**	0.213
Fixed Effects	No		Yes		Yes	
Log-likelihood	-316.47		-193.14		-174.50	
Observations	284		284		284	

Notes: The sample consists of a balanced panel of trading sector establishments with 10 or more employees. In the 2004-2011 panel we observe 142 establishments generating 284 observations. 'Trading' implies that establishments provide goods and services to the general public or to other organisations. Identification of the fixed effect estimates comes from establishments that have changed product quality competition status and we observe twice. The omitted category is 'Demand does not depend at all on product quality'. For reasons of brevity, we only present coefficients of the four variables of interest. Other controls are those shown in column 3 of Table 3 as well as a year dummy. The estimates are available upon request. Robust standard errors are reported. Levels of significance: *** p<0.01, * *p<0.05, * p<0.1.

Table 7. Training Intensity and Importance of Quality

Employee Level Analysis

	2004		*2011*	
Demand Competition	*Coef.*	*Std. E.*	*Coef.*	*Std. E.*
Quality Importance 2	0.061	0.101	0.052	0.124
Quality Importance 3	0.028	0.077	0.172*	0.089
Quality Importance 4	0.214***	0.071	0.271***	0.086
Quality Importance 5	0.147**	0.069	0.228***	0.087
Log-likelihood	-11151.98		-12050.11	
Observations	7660		7764	

Notes: The 2004 (2011) sample consists of 7660 (7764) employees clustered in 774 (777) establishments. Standard errors are clustered at the establishment level. The estimation method is an ordered probit model. Employees were asked: "*Apart from health and safety training how much training have you had during the last 12 months, either paid for or organised by your employer. Please only include training where you have been given time off from your normal daily work duties to undertake training*". Employees provide one of six answers: 1. '*None*', 2. '*Less than 1 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*'. The distribution of responses is provided in Table 9 in Appendix C. The omitted category of competition on product quality is 'Demand does not depend at all on product quality'. For reasons of brevity, we only present coefficients of the four variables of interest. Other controls are those shown in column 3 of Table 3 plus the following individual level controls: age, age squared/100, female, six educational dummies, one vocational qualification dummy, tenure, tenure squared/100, temporary job, fixed term job, long term illness/health problem, union member, married/cohabited, a dummy for dependent children, and a dummy if the individual is a supervisor or line manager. Levels of significance: *** p<0.01, ** p<0.05, * p<0.1.

Table 8: Marginal Effects Obtained from Table 7

Employee Level Analysis

	2004								*2011*							
	Quality Importance 2		*Quality Importance 3*		*Quality Importance 4*		*Quality Importance 5*		*Quality Importance 2*		*Quality Importance 3*		*Quality Importance 4*		*Quality Importance 5*	
	(1)		(2)		(3)		(4)		(5)		(6)		(7)		(8)	
Cutoff	*Coef.*	*Std. E.*	*Coef.*	*Std. E.*	*Coef.*	*Std. E.*	*Coef.*	*Std. E.*	*Coef.*	*Std. E.*	*Coef.*	*Std. E.*	*Coef.*	*Std. E.*	*Coef.*	*Std. E.*
$x = 0$	-0.023	0.038	-0.011	0.029	-0.082***	0.026	-0.056**	0.026	-0.018	0.043	-0.059	0.029	-0.095***	0.030	-0.080***	0.030
$0 < x < 1$	-0.001	0.002	-0.001	0.001	-0.003***	0.001	-0.002*	0.001	-0.022	0.006	-0.008*	0.005	-0.012***	0.004	-0.010**	0.004
$1 \leq x < 2$	0.002	0.003	0.001	0.002	0.006***	0.001	0.005**	0.002	0.001	0.003	0.003***	0.001	0.007***	0.002	0.006***	0.001
$2 \leq x < 5$	0.010	0.016	0.004	0.012	0.034***	0.010	0.023**	0.010	0.008	0.019	0.026**	0.013	0.042***	0.013	0.035***	0.013
$5 \leq x < 10$	0.006	0.010	0.003	0.008	0.021***	0.007	0.015**	0.007	0.006	0.016	0.022*	0.011	0.034***	0.010	0.028***	0.010
$x \geq 10$	0.007	0.011	0.003	0.008	0.023***	0.008	0.016**	0.007	0.005	0.011	0.017*	0.009	0.025***	0.008	0.020**	0.008

Notes: 1. x denotes number of days devoted to training; 2. Entries are marginal effects obtained from the estimates reported in Table 7; 3. We only report the marginal effects of the four variables of interest. Marginal effects for the rest of the covariates are available upon request; 4. The marginal effect is the discrete change going from 0 to 1; 5. Levels of significance: *** p < 0.01, ** p < 0.05, * p < 0.1.

Table 9: Training Intensity

Employee Level Analysis

	2004		*2011*	
	Mean	*Std. D*	*Mean*	*Std. D*
None	0.373	0.484	0.316	0.465
Less than 1 day	0.092	0.287	0.130	0.336
1 to less than 2 days	0.145	0.352	0.167	0.373
2 to less than 5 days	0.208	0.406	0.217	0.412
5 to less than 10 days	0.095	0.293	0.100	0.300
10 days or more	0.086	0.280	0.070	0.255
Total Observations	7660		7764	

Notes: The 2004 (2011) sample consists of 7660 (7764) employees clustered in 774 (777) establishments. The distribution of responses are generated from the following question: "*Apart from health and safety training how much training have you had during the last 12 months, either paid for or organised by your employer. Please only include training where you have been given time off from your normal daily work duties to undertake training*". Employees provide one of six answers: 1. '*None*', 2. '*Less than 1 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*'.