University of Cyprus
Department of Economics

Working Paper 06-2014

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Abstract

This paper examines the relationship between firm-specific training and product market competition. A canonical Cournot competition model shows that the profitability of training investments increases as the number of competitors decreases. Empirical evidence from British establishments in 1998, 2004 and 2011 confirms that a critical form of specific training, cross-training, is far more extensive in less competitive product markets. This persists within all three separate cross-sections and in two separate panel estimates and suggests that a dominant product market position increases the incentives to invest in specific human capital.

Acknowledgments: We acknowledge the Department of Trade and Industry, the Economic and Social Research Council, the Advisory, Conciliation and Arbitration Service and the Policy Studies Institute as the originators of the Workplace Employee Relations Survey data, and the Data Archive at the University of Essex as the distributor of the data. None of these organizations bears any responsibility for our analysis and interpretations of the data. We thank Stephanie Freeth for data advice.

1. Introduction

Workplace training by employers creates an important component of human capital (Acemoglu 1997) that directly matches the needs of firms and so becomes immediately valuable (Booth and Snower 1996). This training increases worker productivity and has been identified as reducing the marginal cost of production (Dearden *et al*. 2006; Moretti 2004; Zwick 2006), increasing wages and profitability (Jones *et al*. 2012; Lynch 1994) and generating positive externalities for the entire economy (Blundell *et al*. 1999). Understanding the determinants of such training is of clear importance. This paper concentrates on product market competition as an understudied determinant. We argue that employers' incentive to invest in training decreases with the extent of product market competition and provide survey evidence from Britain that supports this prediction.

In contrast to the relatively clear-cut prediction on labor market competition (described in the next section), the relationship between product market competition and employer training appears highly dependent upon assumptions (see Wolter and Ryan, 2011 pages 533-534). While we argue that more competition reduces potential rents from training, competition may influence innovation (Aghion *et al*. 2005) and so the need for training and influence union bargaining power and so negotiations over training (Boheim and Booth 2004). Indeed, the three theoretical contributions to date differ in their conclusions, predicting a positive, negative and ambiguous relationship between training and product market competition (Bassanini and Brunello 2011; Gersbach 2012; Lai and Ng 2014). The existing empirical evidence remains similarly mixed, with some finding no effect of product competition on firm sponsored training (Picchio and Van Ours 2011; Görlitz and Stiebale 2011) and others finding a positive effect of competition (Lai and Ng 2014) and of product market deregulation (Bassanini *et al*. 2007; Bassanini and Brunello 2011) on training.

We return to the issue, using a canonical model of Cournot competition to consider the effect of an exogenous change in the number of firms on the profitability of training investments. Decreasing the number of competitors generates off-setting influences but the dominant influence is a scale effect which increases per firm output and so the profitability of a cost reducing investment in training. Dominant firms do more training.

We then use British establishment data to test the relationship between product market competition and training. Britain provides an interesting setting due to its relatively competitive product market and the view that it has increased the extent of employer provided training relative to other European countries. For example contrast the relatively low estimates by Finegold and Soskice (1988) with more recent estimates by Arulampalam *et al*. (2004), Bassanini *et al*. (2007) and Boeri and van Ours (2013). Moreover, interest in training remains high in the UK because government programmes to increase employer provided training appear to have had only modest success in doing so (Abramovsky *et al*. 2011).

The form of training we focus on is ‘cross training’ which has been identified as particularly effective in lowering the cost of production as it uniquely reduces the cost associated with absence and turnover (Cappelli and Rogovsky 1994; Inman *et al*. 1995; Morita 2005). Critically for our purposes, cross-training reflects the particular tasks and processes of a given firm and is almost exclusively firm provided and firm specific (Cappelli and Rogovsky 1994). Thus, we estimate the determinants of cross-training as a firm provided, cost reducing investment in specific human capital. We demonstrate a robust negative relationship between product market competition and this form of training. Dominant firms do more training.

The remainder of the paper is organized as follows. Section 2 reviews the theoretical and the empirical literature with an eye toward motivating our contribution. Section 3 presents the theoretical model while Section 4 describes the data and the empirical methodology. Estimation results are presented in Section 5. Finally, Section 6 concludes and discusses possible directions for future research.

2. Reviewing Literature and Providing Motivation

In describing the potential role for product market competition it is valuable to contrast it with the role of labor market competition. The starting point is Becker's (1964) prediction that employers will not invest in general training in competitive labor markets. The evidence that firms do provide general training (Katz and Ziderman 1990; Krueger 1993; Stevens 1994; Acemoglu and Pischke 1998; Booth and Bryan 2005) is explained by the presence of labor market frictions and wage compression (associated with less than competitive markets) that lead to skills becoming *de facto* firm specific (Acemoglu and Pischke 1998; 1999). At an extreme, all industry specific skills move from fully general to fully firm specific as the market moves from perfectly competitive to monopsonistic (Manning 2003). In this view, increased labor market competitiveness reduces employers' overall incentives to invest in training. Indeed, Brunello and Gambarotto (2007) confirm empirically that employer provided training is smaller in more competitive labor markets.

As indicated in the introduction, the approaches to product market competition vary. Bassanini and Brunello (2011) assume monopolistic competition and explore an increase in product market competition resulting from deregulation that reduces barriers to entering the market. In their setting, deregulation increases training. While it has a negative impact (or a ‘rent effect’) by decreasing profits per unit of output associated with training, this is more than offset by a positive ‘business stealing effect’. The increased number of firms increases the price elasticity of demand increasing the positive impact of training on a firm’s individual demand and output.

Gersbach and Schmutzler (2012) model oligopolistic competition with two firms producing a differentiated good and suggest that increased competition decreases training. Here, competition in the product market is defined to be intense (weak) if a firm’s marginal profit from attracting an additional trained worker is higher (lower) than the marginal profit from being in a symmetric training equilibrium rather than in a no-training equilibrium. Training is assumed to be industry-specific: it increases productivity not only with the current employer but also with other firms operating in the same industry. If competition is weak, an equilibrium with training exists provided training costs are not too high and a wage compression condition holds in the labor market. On the other hand, an equilibrium without training exists if competition in the product market is intense. Intuitively, weak competition reduces the probability of a worker leaving her current employer and thus strengthens the latter’s incentives to invest in human capital. In essence, the increase in competition makes the industry specific capital increasingly general. In this way, it mimics some of the logic from the discussion on labor market competition.

A different approach has been followed by Lai and Ng (2014), who assume that each firm has private information about product quality and that training serves as a signal of high quality. An increase in product market competition reduces the probability of survival for all firms but disproportionately so for firms of bad quality.

This lowers the expected return of investment and tends to reduce training. At the same time, however, it increases good firms' incentives to use training as a signal of their quality in order to differentiate themselves from bad firms. Therefore, the overall impact of product market competition on training is ambiguous and depends on the relative strength of these two opposing effects.

While these three papers make predictions of a positive, negative and ambiguous association between training and product market competition, they employ starkly different models and emphasize different points. Indeed, the very definition of product market competition differs. It is seen as exogenous reductions in barriers to entry, as increased substitutability of differentiated products or as an increased probability of failure in a signaling model.

We examine canonical Cournot competition and consider an exogenous increase in the number of firms. Arguably this fits more clearly, or at least more traditionally, with the notion of increased competition. We emphasize that such a model is dominated by the scale effect in which increased competition reduces per firm output and so the profitability of a cost reducing investment in training.

Perhaps in line with the existing theoretical predictions, the empirical evidence remains mixed. To our knowledge there are six papers that examine the effect of product market competition on training. Two papers find no effect of product market competition on training, one using Dutch worker-manufacturing firm data on firm sponsored training (Picchio and van Ours 2011), the other using German establishment data (Görlitz and Stiebale 2011). In contrast Lai and Ng (2014) find a strong and positive effect of competition on training using Canadian longitudinal matched employer-employee data. Similarly, Bassanini *et al*. (2007) and Bassanini and Brunello (2011) demonstrate a positive relationship between training and product market deregulation in Europe. Finally, Autor (2001) provides evidence that temporary help service firms that face more competition for supplying their product, agency workers, provide more computer training. These studies use a variety of definitions of training (several seem clearly not firm specific) and, as in most applications, the exact measure of training is likely to be consequential (Barron *et al*. 1997). They also differ dramatically in the measures of product market competition and in their institutional settings.

We provide the first empirical test that focuses attention on the relationship between product market competition and specific training for Britain. We use establishment data to examine a unique question that measures the share of workers who are cross-trained. These are workers trained to perform one or more jobs other than their own. Cross-training has been identified as particularly effective in lowering the cost of production by uniquely reducing the cost associated with absence and turnover (Cappelli and Rogovsky 1994; Inman *et al*. 1995; Morita 2005). Cross-training also creates a more flexible workforce that can more readily respond to changes in technology and to peak loads of demand (Heywood *et al*. 2008). Moreover, Carmichael and MacLeod (1993) show how such training makes employment security pledges more credible generating the likelihood of compensating wage reductions. Hopp *et al*. (2004) identify empirically the substantial cost reductions from cross-training in labor intensive industries while Slomp and Molleman (2002) show such training improves the effectiveness and cohesion of work teams.

Critical for our purposes, cross-training reflects the particular tasks and processes of a given firm and is almost exclusively firm provided and firm specific (Cappelli and Rogovsky 1994). It becomes firm specific not only because training for an additional job will have additional specific components but because, as Lazear (2009) emphasizes, unique mixtures of even general training become increasingly firm specific. Cross-training then generates a particular "skill-weighting" that is often highly firm specific. As such, it is likely to increase the expected tenure of workers and so lower recruiting and other training costs that are quasi-fixed (Munasinghe and O'Flaherty 2005). After our theoretical presentation, we estimate the determinants of cross-training as a cost reducing investment in specific human capital focusing on the role of product market competition. We demonstrate a robust relationship suggesting that product market dominance is associated with increased cross-training.

3. Theoretical Model

We assume the cost of training increases with both the proportion of workers trained within the firm and with firm output. Increasing the proportion of trained workers reduces per unit production cost and ultimately generates more total profit when a firm has greater output. As a consequence, a more competitive market structure has more firms each producing less and so facing weaker incentives to train.

3.1 Setup

Consider $n \geq 2$ identical firms (indexed $j = 1,...,n$) producing a homogeneous good. The quantity produced by firm *j* is q_j and $q = \sum_{i=1}^{n} q_i$. The price is given by the inverse demand function $p(q) = a - q$, where $\alpha > 0$. Each firm trains a proportion $I_j \in [0,1]$ of its workforce. We assume that each firm is a monopsonist vis-à-vis its workforce implying that at least this type of training is firm-specific. The cost of training for firm *j* is given by the convex function $g(I_j) = \theta I_j^2 / 2 + \gamma I_j q_j$, where $\theta, \gamma \geq 0$. The cost of training is not assumed to be a fixed cost but to increase with output (i.e. with the level of employment).[1] In particular, the parameter γ represents the additional cost of training one more percentage point of the workforce when the firm produces one more unit of output: $\partial^2 g / \partial I_j \partial q_j = \gamma \geq 0$. Training improves worker productivity and thus reduces the marginal cost of production. We capture this in the simple unit cost function $c(q_j, I_j) = c_j q_j = c(1 - I_j) q_j$ which implies the marginal cost of production $c(1 - I_j)$ decreases with training. Thus, firm *j*'s overall cost function is:

$$\begin{aligned} C(q_j, I_j) &= g(I_j) + c(q_j) = \theta I_j^2 / 2 + \gamma I_j q_j + c(1 - I_j) q_j = \theta I_j^2 / 2 + [c - (c - \gamma) I_j] \cdot q_j = \\ &= F(I_j) + h(I_j) q_j \quad \text{, where } \gamma < c < a. \end{aligned} \tag{1}$$

Note that $F(I_j) \equiv \theta I_j^2 / 2$ is the fixed cost component of a training investment and $h(I_j) \equiv c - (c - \gamma) I_j$ is the overall effective marginal cost of production which decreases with I_j.

In order to focus on the effect of product market competition, we suppress the labor market by normalizing the wage to zero. This is arbitrary but assumes that the firm captures all benefits associated with specific training. The worker's outside option is not improved with training. Each firm *j*'s profit is:

$$\Pi_j = p q_j - c(q_j, I_j) - g(I_j) = [p - c(1 - I_j)] q_j - \theta I_j^2 / 2 - \gamma I_j q_j \tag{2}$$

In what follows, we assume $\theta \geq 2n(a - \gamma)(c - \gamma)/(n+1)^2$ – i.e. that the training cost parameter is large enough to guarantee an interior level of investment.

[1] In the special case where $\gamma = 0$, the cost of training is a fixed cost for the employer as in Bassanini and Brunello (2011).

3.2. Subgame Perfect Equilibrium

We assume that in stage 1, firms *j=1,…,n* simultaneously choose training $\boldsymbol{I_j}$ and in stage 2, firms *j=1,…,n* simultaneously choose quantity $\boldsymbol{q_j}$ (*Cournot* quantity competition). In this setting, the extent of competition in the product market increases with the number (*n*) of firms. The equilibrium is identified by backwards induction.

In stage 2, each firm chooses q_j so as to maximize profits taking as given the quantities of other firms and the investment levels from the first stage. Therefore,

$$\max_{\{q_j\}} \Pi_j = pq_j - c(1-I_j)q_j - g(I_j) = \left[a - \gamma I_j - c(1-I_j) - \sum_{i=1}^{n} q_i\right] \cdot q_j - \theta I_j^2/2 \quad s.t.\ q_j \geq 0$$

Solving the associated first-order conditions generates firm *j*'s best-response function:

$$q_j(q_{-j}) = \frac{1}{2} \cdot \left[a - \gamma I_j - c(1-I_j) - \sum_{i \neq j} q_i\right] \text{, where } q_{-j} = (q_1, ..., q_{j-1}, q_{j+1}, ..., q_n) \tag{3}$$

If we add by parts the above expression for all firms except firm *j*, we get:

$$\sum_{i \neq j} q_i = \frac{1}{n}\left[(n-1)(a - c - q_j) + (c - \gamma) \cdot \sum_{i \neq j} I_i\right] \tag{4}$$

Substituting (4) into (3) yields Cournot-Nash equilibrium quantity for firm *j*:

$$q_j^C(I_j, I_{-j}) = \frac{1}{n+1}\left[a - c + (c-\gamma) \cdot (nI_j - \sum_{i \neq j} I_i)\right] \text{, where } I_{-j} = (I_1, ..., I_{j-1}, I_{j+1}, ..., I_n) \tag{5}$$

The associated second-stage equilibrium price is:

$$p^C(I_j, I_{-j}) = \frac{1}{n+1}\left[a + nc - (c-\gamma) \cdot \sum_{i=1}^{n} I_i\right] \tag{6}$$

Substituting (5) and (6) into (2) yields firm *j*'s second-stage equilibrium profits:

$$\Pi_j(I_j, I_{-j}) = \left[p^C(I_j, I_{-j}) - c(1-I_i)\right] \cdot q_j^c(I_j, I_{-j}) - g(I_j) = \left[q_j^c(I_j, I_{-j})\right]^2 - \theta I_j^2/2 \tag{7}$$

In stage 1, firms simultaneously choose the training levels taking as given the levels of other firms and anticipating the second-stage outcomes derived above. The profit maximization problem for firm *j* is:

$$\max_{\{I_j\}} \Pi_j(I_j, I_{-j}) = \left[p^C(I_j, I_{-j}) - c(1-I_i) \right] \cdot q_j^c(I_j, I_{-j}) - g(I_j) = \left[q_j^c(I_j, I_{-j}) \right]^2 - g(I_j)$$

$$s.t.\ \ 0 \le I_j \le 1$$

Assuming that $I_j < 1$, the Kuhn-Tucker first-order conditions are:

$$\frac{\partial \Pi_j}{\partial I_j} = \left[\frac{\partial p^C}{\partial I_j} + c - \gamma \right] \cdot q_j^C + \left[p^C - c(1-I_j) - \gamma I_j \right] \cdot \frac{\partial q_j^C}{\partial I_j} - \theta I_j \le 0 \text{ (with equality if } I_j > 0\text{)} \quad (8)$$

An increase in firm *j*'s investment level reduces price by $\left| \partial p^C / \partial I_j \right| = (c-\gamma)/(n+1)$ but, at the same time, decreases firm *j*'s effective marginal cost by $\left| \partial h / \partial I_j \right| = c - \gamma$. Since the marginal cost reduction exceeds (in absolute terms) the price reduction, the price-cost margin increases. The term $[(\partial p^C / \partial I_j) + c - \gamma] \cdot q_j^C$ represents the marginal benefit of investment associated with this increase of the price-cost margin. At the same time, an increase in I_j also increases firm *j*'s quantity q_j. The term $[p^C - c(1-I_j) - \gamma I_j] \cdot (\partial q_j^C / \partial I_j)$ is the marginal benefit associated with this increase in sales. Finally, the term θI_j is the marginal cost of investment in training.

It is useful to write the first order condition in the following form:

$$\frac{\partial \Pi_j}{\partial I_j} = 2 q_j^C \cdot \frac{\partial q_j^C}{\partial I_j} - \theta I_j \le 0 \quad \text{(with equality if } I_j > 0\text{)} \qquad (9)$$

After imposing symmetry, $I_i = I_j$, this yields the equilibrium level of training:

$$I_j^* = \frac{2n(c-\gamma)(a-c)}{\theta(n+1)^2 - 2n(c-\gamma)^2} \in (0,1) \text{ for } \theta \ge 2n(a-\gamma)(c-\gamma)/(n+1)^2 \qquad (10)$$

Finally, we can substitute (10) into (5), (6) and (7) to get the subgame perfect equilibrium quantities, price and profits:

$$\left.\begin{aligned}
I_j^* &= \frac{2n(c-\gamma)(a-c)}{\theta(n+1)^2 - 2n(c-\gamma)^2} \quad , \; j=1,\ldots,n \\
q_j^* &= \frac{\theta(n+1)(a-c)}{(n+1)^2\theta - 2n(c-\gamma)^2} \quad , \; j=1,\ldots,n \\
p^* &= \frac{\theta(n+1)(a+nc) - 2an(c-\gamma)^2}{(n+1)^2\theta - 2n(c-\gamma)^2} \\
\Pi_j^* &= \frac{\theta(a-c)^2 \cdot \left[\theta(n+1)^2 - 2n^2(c-\gamma)^2\right]}{\left[\theta(n+1)^2 - 2n(c-\gamma)^2\right]^2}
\end{aligned}\right\} \qquad (11)$$

3.3 The Impact of Product Market Competition on Training Intensity

The equilibrium above allows some initial comparative statics.

Proposition 1: The equilibrium level of training:

(i) Increases with market size, $\partial I_j^* / \partial a > 0$.

(ii) Either increases or decreases with the base marginal cost of production. In particular:

· If $\dfrac{2n(a-\gamma)(c-\gamma)}{(n+1)^2} \leq \theta \leq \dfrac{2n(a-\gamma)^2}{(n+1)^2}$, then $\dfrac{\partial I_j^*}{\partial c} > 0$ for all $c \in (\gamma, a)$.

· If $\theta \geq \dfrac{2n(a-\gamma)^2}{(n+1)^2}$, then $\dfrac{\partial I_j^*}{\partial c} > 0$ for $c \in (\gamma, c_0)$ and $\dfrac{\partial I_j^*}{\partial c} < 0$ for $c \in (c_0, a)$, where:

$$c_0 = \frac{\theta(n+1)^2 + 2n\gamma(a-\gamma) - (n+1)\sqrt{\theta[\theta(n+1)^2 - 2n(a-\gamma)^2]}}{2n(a-\gamma)}$$

(iii) Decreases with the training cost parameters, i.e. $\partial I_j^* / \partial \theta < 0$, $\partial I_j^* / \partial \gamma < 0$.

Yet, we are primarily interested in the effect of product market competition on the equilibrium level of training.

Proposition 2. Increasing product market competition, *n*, reduces training.

$$\frac{\partial I_j^*}{\partial n} = \frac{2(c-\gamma)(a-c)\theta(1-n^2)}{[\theta(n+1)^2 - 2n(c-\gamma)^2]^2} < 0 \text{ for all } n > 1 \qquad (12)$$

In the Appendix we present a series of numerical calculations illustrating the relationship between I_j^*, n and either α, θ or c. These illustrate the comparative static isolated in (12). As an example, if γ=1, c=2 and α=3, then θ=2 yields an interior solution. As Case 2 shows, if *n*=6, the share trained is 0.140 which more than doubles to 0.333 when *n*=1.

Proposition 2 can be further understood with the marginal profit expression in (8):

$$\frac{\partial \Pi_j}{\partial I_j} = 2q_j^C \cdot \frac{\partial q_j^C}{\partial I_j} - \frac{\partial g}{\partial I_j} = 2\cdot\frac{a-c+n(c-\gamma)I_j - (c-\gamma)\cdot\sum_{i\neq j} I_i}{n+1}\cdot\frac{n(c-\gamma)}{n+1} - \theta I_j \qquad (13)$$

Imposing symmetry $I_i = I_j$, this is written as:

$$\frac{\partial \Pi_j}{\partial I_j} = 2\cdot\frac{a-c+(c-\gamma)I_j}{n+1}\cdot\frac{n(c-\gamma)}{n+1} - \theta I_j = 2q_j^{CS}\cdot\frac{\partial q_j^C}{\partial I_j} - \theta I_j \qquad (14)$$

where $q_j^{CS} = \left[a-c+(c-\gamma)I_j\right]/(n+1)$ is the Cournot equilibrium quantity under symmetry. Then, from Varian (1992, pp.490-1) we know that:

$sign\,\frac{\partial I_j^*}{\partial n} = sign\,\frac{\partial^2 \Pi_j^C}{\partial I_j \partial n}$, where:

$$\frac{\partial^2 \Pi_j^C}{\partial I_j \partial n} = 2\cdot\left[\frac{\partial q_j^{CS}}{\partial n}\cdot\frac{\partial q_j^C}{\partial I_j} + q_j^{CS}\cdot\frac{\partial^2 q_j^C}{\partial I_j \partial n}\right] = 2\cdot\left[-\frac{a-c+(c-\gamma)I_j^*}{(n+1)^2}\cdot\frac{n(c-\gamma)}{n+1} + \frac{a-c+(c-\gamma)I_j^*}{n+1}\cdot\frac{c-\gamma}{(n+1)^2}\right] =$$

$$= \frac{2c(a - c + cI_j^*)(1-n)}{(n+1)^3} < 0 \text{ for all } n>1 \quad (15)$$

The term $(\partial q_j^{CS} / \partial n) \cdot (\partial q_j^C / \partial I_j)$ shows that increasing *n* reduces each firm's sales and, thereby, reduces the marginal profit of investment in training. This negative "rent effect" dominates the positive "business-stealing effect" captured by the term $q_j^{CS} \cdot (\partial^2 q_j^C / \partial I_j \partial n)$. The result that in a classic Cournot model greater competition decreases the incentive to invest in training motivates our testing.

4. Data and Empirical Methodology

We draw data from the 1998, 2004 and 2011 cross-sections of the Workplace Employment Relations Survey (WERS). Associated with these three cross sections are two smaller panel surveys, one for 1998 to 2004 and one for 2004 to 2011. We examine our fundamental hypothesis in all five data sources with the second two allowing us to control for establishment specific fixed effects.[2]

4.1 WERS Data

The 1998, 2004 and 2011 cross-sections are the fourth, fifth and sixth instalments of a Government funded survey series of British workplaces. In each year the sample of workplaces was randomly drawn from the Interdepartmental Business Register, considered to be the highest quality sampling frame available in the United Kingdom. The surveys are stratified by workplace size and industry with larger workplaces and some industries overrepresented (Chaplin *et al*. 2005). As a consequence, all estimates are weighted to be representative of the sampling population. The survey comprises three main sections; the 'Management Questionnaire' (a face-to-face

[2] Workplaces are followed up only once and 1998 observations cannot be followed into 2011.

interview with the most senior manager with day-to-day responsibility for personnel matters), the 'Worker Representative Questionnaire' and the 'Employee Questionnaire'. We rely exclusively on the Management Questionnaire as it provides information on cross-training and product market competition. The survey population is all British workplaces except private households and those in primary industries.

The response rates for 1998, 2004 and 2011 were 80%, 64% and 46% yielding 2,191, 2,295 and 2,680 establishments respectively. Response rates are decreasing through time reflecting prevailing trends in business surveys (see van Wanrooy *et al*. 2013). The 1998 WERS interviewed workplaces with 10 or more employees, while the 2004 and 2011 WERS surveys interviewed workplaces with 5 or more employees. To ensure comparable estimates across years we limit attention to establishments with ten or more employees. We also exclude establishments not in the trading sector (government and non-profit offices) and those missing data on the critical dependent variable measuring training. The resulting sample sizes are 1,532, 1,263, and 1,338 for the 1998, 2004 and 2011 respectively.

The 1998-2004 Panel Survey returned to a random selection of workplaces in the 1998 cross-section. The follow-up survey, with a response rate of 77 per cent, yielded a sample of 956 continuing establishments. Our sample restrictions result in 195 establishments (390 observations) observed in both 1998 and in 2004. The 2011 WERS followed 989 workplaces that also participated in the 2004 which, after our sample restrictions, yielded 162 establishments (324 observations) observed in both 2004 and 2011. Both panels are balanced.

The surveys are extremely attractive for our purpose as they identify cross-training and product market competition while providing a wide range of relevant employer characteristics that should serve as important controls. The cross-sections allow us to follow the hypothesized relationship over time and the panel element allows us to remove unobserved firm heterogeneity. To our knowledge this is the first paper that studies the effect of product market competition on a specific training measure (cross training) for the UK.

Managers provide information about the share of employees formally cross-trained. The specific question asks "*Approximately, what proportion of employees in the largest non-managerial occupational group are formally trained to be able to do jobs other than their own*?" While no survey question may be perfect, this one seems well suited for our purpose. The question asks explicitly about cross-training (training to do the task of another) which, as we indicated, has been closely tied to reduced costs and specific skills. Moreover, as it identifies formal training, it seems likely to be employer provided as well as specific. It clearly is not identifying mere helping effort on the job or learning by doing. Nonetheless, we recognize that the question does not identify whether or not the training takes place on site or during normal working hours. In addition, while we contend that cross-training is less likely to transfer to another firm than training for a single job (especially in circumstance of team work), we have no direct evidence on that from the wording of the question.

Managers provide one of seven answers: None (0%), Just a few (1-19%), Some (20-39%), Around half (40-59%), Most (60-79%), Almost all (80-99%) and All (100%). Table 1 provides the distribution of responses and suggests a reasonable stable pattern over time. Approximately, 1 out of 3 managers answered that 'None' of the employees were formally trained to do jobs other than their own, about 1 out of 4 managers said 'Just a few: 1-19%' and about 1 out of 10 managers said 'All'.

Managers identify the number of competitors they face by responding to the following question: "*If trading sector and trading externally*[3]*, how many competitors do you have for your (main) product or service*? (Prompt: 'few' equal 5 or less)" to which mangers could respond *1. 'None/Organisation dominates market'; 2. 'Few competitors' or 3. 'Many competitors'.* This question does not provide a quantitative measure such as a concentration index but provides other advantages as it allows the manager to identify the product and geographic market in which they compete. This may well be more important than a measure constructed along standardized industry classifications as it allows managers to include relevant competitors even if they are outside the standard industry or geographic boundaries.[4] As a robustness check, we will show that an alternative measure that focuses on the extent of price competition returns very similar results.

Table 2 provides the distribution of responses and again shows reasonable stability. In all three cross sections about sixty percent of the managers said that they had many competitors, between thirty and forty percent said that they had less than five competitors, and between eight and two percent said that their product or service dominated the market.

In examining the relationship between market structure and competitors we will 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] 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.

[4] Emphasizing this point is not unique to us and the number of self-identified competitors has been use by Blanchflower and Machin (1996) and Bloom *et al*. (2010) among others.

4.2 Empirical methodology

The primary empirical objective is to estimate ordered probits in which the categorical measure of the extent of cross-training is a function of the extent of competition and suitable controls. We begin with cross-sectional estimates for each of the three years and build up to an increasingly complete set of covariates that reflect general establishment characteristics, workforce composition, and technology.

In a baseline estimate we recognize that there may be substantial fixed costs in establishing a formal cross-training program, and that large establishments can spread out that cost across many workers. Moreover, more complex operations may require greater cross-training. Thus, we control for log number of employees, the number of years the establishment has been in operation (in logs), if the establishment produces multiple products or services, and whether the establishment is part of a larger organization (multi-establishment). 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 workforce that is disabled. As a first cut at controlling for technology in the baseline, we include the share of the workforce in each of eight occupational groups, dummies for the largest non-managerial occupational group in the establishment, regional and industry dummies, whether or not there has been an introduction or upgrading of new technology, and the introduction of a technologically new product or service in the last two years.

We next add further controls to the baseline. Cross-training could potentially substitute for the use of temporary agency and fixed term employees when providing short-term cover for absent workers (Inman *et al*. 2005). Hence, 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 employee sickness or absence. Finally, to capture labor mobility in the establishment we control if there have been any vacancies in the last year, as well as we construct two variables that capture the percent of employees who got separated from the establishment in the previous year as well as the percent of employees who quitted.

In a second estimate we retain all of the controls from the baseline and add indicators of human resource management practices including whether or not the establishment conducts personality/attitude and performance/competency tests when filling vacancies, the presence of quality circles, the presence of joint consultative committees, and whether or not there is a just in time inventory system. In the end, we recognize that bundles of human resource management practices may come together for strategic reasons and want to control for as many as we can in an effort to isolate the influence of product market position.

A final estimate includes indicators of performance related pay. There variables capture whether or not employees are paid by results, receive merit pay, or receive profit related payments or bonuses. We estimate all three specifications for all three cross-sections. There are also potentially important covariates that are not available for all three cross-sections and experiment with these when available.

We emphasize that parsimonious and complete estimates present the same picture. When firms hold a more dominate position in their product market they engage in more cross-training. We show this in each cross-section across every specification. We then move on to the two panels. Here we experiment with several specifications but the estimate most inherently similar to our cross-sections is the fixed-effect ordered probit (we estimate alternatives). The concern is that despite our long list of controls, unmeasured but time-invariant heterogeneity influences both market position and the extent of cross-training. Thus, in the next set of estimates we hold constant time invariant characteristics of the establishment and continue to show that increases in market dominance are reflected in greater cross-training. Finally, we present robustness exercises that change the measure of dominance to those establishments least influenced by their rival's prices and confirm that those least influenced do the most cross-training.

5. Empirical Results

In the first column of Table 3 we present the baseline ordered probit estimate of the extent of cross-training using the most recent 2011 cross section. While establishment size, establishment age and being a multi-establishment appear irrelevant, establishments that produce multiple products or services cross-train a larger share of their workers. Higher percentages of female and fixed term workers are associated with higher training probabilities while higher percentages of employees older than 50 and higher quit rates are associated with lower training probabilities (see Dearden *et al*. 1997; Booth and Zoega 1999; Munasinghe and O'Flaherty 2005). Critically, both more competitive market structures do significantly less cross-training when compared to firms that dominate their market.

Column 2 reports estimates from a model where HRM practice indicators are included. Cross-training is more prevalent when the establishment conducts personality/attitude tests when filling vacancies. This result is in line with Altonji and Spletzer (1991) who find that the receipt of on the job training is correlated with measures of ability as captured by aptitude tests. Column 3 adds indicators of performance related pay. The estimates suggest that establishments with profit related pay do more cross-training. While a number of the controls added in columns 2 and 3 are correlated with training, their inclusion does not substantively alter the estimates of the influence of product market competition on training. These suggest that dominant firms engage in more cross-training, and this does not merely reflect overall differences in HRM practices (column 2) or offering performance related pay (column 3) in these firms. Thus, the estimates across the 2011 cross-section appear robust and we now turn to the earlier cross-sections.

In Table 4 we reproduce the same series of three estimates using the establishments that comprise the 1998 (columns 1 to 3) and the 2004 (columns 4 to 6) cross-sections. The pattern of significant controls is very similar and the full estimations are available upon request. The Table highlights the critical results on market competition and indicates not only that the 2011 estimate is robust across specifications but that it closely mimics estimates from both of the earlier years. The critical coefficients for the number of competitors remain negative and statistically significant confirming that dominate firms engage in more cross-training in all years.

Critically, both those firms with a few competitors and those with many competitors engage in less cross-training than do firms dominant in their market. The coefficients are not statistically significantly different from each other, but together with the cutoff points can be used to estimate the marginal influence relative to those establishments that are dominant. In Table 5 we report the marginal effects for the two competition variables and for each category of the dependent variable. The marginal effects are obtained from the most complete specification for all three cross sections. In columns 1 (WERS 1998), 3 (WERS 2004) and 5 (WERS 2011) the marginal effects suggest that moving from a dominant firm to one with a few competitors are associated with an increase of 0.072, 0.139, and 0.210 in the probability of cross training none of the workforce and reduction of 0.027, 0.037 and

0.088 in the probability of cross training all of the workforce. Thus, the marginal effects in the tails of the cross-training distribution seem to be increasingly sensitive to the presence of dominant firms.

In columns 2 (WERS 1998), 4 (WERS 2004) and 6 (WERS 2011) the marginal effects suggest that moving from a dominant firm to one with many competitors is associated with an increase of 0.074, 0.164, and 0.193 in the probability of cross training none of the workforce and a reduction of 0.032, 0.053 and 0.099 in the probability of cross training all of the workforce. These marginal effects are remarkably similar to the first set and again suggest that the major difference in cross-training is driven by dominant firms. They again show the heightened sensitivity over time to the presence of dominant firms. As a check on the pattern over time, we compute the statistical difference between years for the marginal effects. Between 1998 and 2004 the marginal effect of being in the many competitors category on the probability of reporting "none of the workers train" increases 0.090 (0.164 - 0.074) with t-statistic of 44.45. The corresponding increase between 2004 and 2011 is 0.029 (0.193 - 0.164) with a t-statistic of 10.48. Similarly, between 1998 and 2004 the negative marginal effect of being in the many competitors category on the probability of reporting "all the workers train" grows 0.21 (0.053 - 0.032) with a t-statistics of 11.93. The corresponding increase in the magnitude of the marginal effect between 2011 and 2004 is 0.046 (0.099 - 0.053) with a t-test of 27.92. There exist similar significant differences in the marginal effects across for establishments with few competitors as well.

We mentioned that some potential covariates are not available in all years. We undertook extensive robustness checks when this is the case. Thus, we thought teams could be relevant to the extent of cross-training and we add a series of dummy variables that measure the prevalence of teams in the workplace. This risks over-controlling as teams and cross-training often go together mechanically under some bundles of HRM practices but it provides a further test. We also include a measure of the percent of workers who use computers in their job to further control for technology. These two sets of variables are available for 2004 and 2011 but not for 1998. The team variables are typically positive statistical determinants but neither they nor computer usage change in any meaningful way the pattern of results we have identified across all three years. In 1998 and 2004, we have access to the unemployment rate which we add to vacancy rates by local area to capture the tightness of the local labour market. These estimates return the same pattern. Finally, we use the financial performance questionnaire available in 2004 but for a smaller sample of establishments to include as determinants the log of sales (turnover) and the log of assets. These measures of size also do not change the central finding. In all these robustness checks, dominant firms engage in significantly more cross-training.

5.1 Panel Estimates

Table 6 moves to the panel data where we now observe a sample of 195 establishments that change market structure category between 1998 and 2004 and 162 establishments that change market structure category between 2004 and 2011. In the fixed effect estimates it is these "movers" that identify the influence of market structure on training. We start by presenting a pooled estimate without establishment fixed effects on the panel samples of establishments that changed market structure. These results are in columns 1 (1998-2004) and 4 (2004-2011) and reveal the familiar pattern that establishments with a dominant position engage in more cross-training. The point estimates of the two competition variables in the two panel samples are roughly comparable to earlier cross section estimates suggesting the movers are not an unusually selected sample. As an example, the 2004-2011 marginal effects indicate that an establishment with a few competitors has an increased probability of training no workers of 0.199 and a reduced probability of training all workers of 0.049. While, moving from a dominant firm to one with many competitors increases the probability of cross-training none of the workers by 0.189 and decreases the probability of cross-training all the workers by 0.043. The full set of marginal effects is available upon request.

Columns 2 and 4 present the results from a fixed effects ordered probit model. This model allows holding constant time invariant characteristics that might influence both the extent of cross-training and the market position of the firm. The point estimates in such fixed effect estimates are generated by the within establishment variation in market position and present the closest analogue to the ordered probits presented for the 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). The point estimates suggest that as firms move from more competitive market structures into positions of market dominance the extent of cross-training they provide increases. The point estimates are substantially *larger* (more negative) than those in the pooled estimates on exactly the same sample. Thus, to the extent that unmeasured time invariant characteristics influence the cross-section estimates, they seem to generate a downward bias.

As a robustness test, we alter the functional form of our fixed effect estimate. We imagine the ordered categories that measure the extent of cross training represent a count variable from zero to six. 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 columns 3 and 6. The estimated coefficients retain the signs and statistical significance we have shown throughout and efforts to investigate magnitude suggest they are broadly similar to those associated with fixed-effect ordered probit.

It is reassuring that essentially the same pattern of negative coefficients for both competition variables emerge in both panels and under two alternative fixed-effect specifications. At minimum, we find no indication that the cross-sectional finding that dominant firms engage in more cross-training is the result of invariant establishment specific effects. Those effects, if anything, appear to obscure the very large role played by dominant market position.

5.2 *An Alternative Measure of Dominance*

In the theoretical discussion we emphasized that competition bids away rents that might be earned on cost-reducing training investments and that as a consequence dominant firms do more training, all else equal. The measure of dominance in the estimations to this point has been the number of competitors but we now examine an alternative. It is well recognized that the relationship between earning rents and market structure is influenced by a variety of factors. Products with high demand elasticity will generate lower rents. Moreover, when entry barriers are low, potential competition will limit rents regardless of demand elasticity (Gilbert 1989). Finally, competitors may produce imperfect substitutes that dull price competition. Thus, as a robustness test, we replace the number of competitors with a measure of the importance that price relative to competitors' price plays in determining an establishment's product demand. While this measure of the ability to raise price should be associated with fewer competitors, it may also reflect underlying elasticity, the degree of differentiation in the industry and the extent of potential competition. Thus, it provides an alternative measure of the ability to earn rents from training investments.

The 2004 and 2011 WERS asked managers “to what extent would you say that the demand for your (main) product or service depends upon offering lower prices than your competitors?” The managers responded from 1, "does not depend at all on price" to 5, "depends heavily on offering lower prices". We generate four dummy variables with the category 1 as the base. We take establishments in this base category to be dominant and anticipate that as price becomes increasingly important, the ability to earn rents is reduced relative to these dominant establishments. We re-estimate the determinants of cross-training in the two cross-sections and in the panel. Our specification remains as before and the sample of establishments is trading sector companies[5] offering goods to the public.

Table 7 summarizes the results with the cross-section estimates in the first two columns. All four dummies in both cross-sections take negative signs suggesting dominant firms do more training. Three of the dummies take statistically significant coefficients. The pattern is more dramatic in the panel with the pooled estimate in column 3 and the fixed effect estimates in column 4. Again, all four dummies in both estimates take negative signs but here there are six statistically significant coefficients. Thus, the pattern of results confirms that found with the number of competitors, the establishment with greater control over price does more cross-training. The full estimates and marginal effects are available from the authors but the agreement of the two measures of dominance is reassuring.

[5] Trading sector companies include public limited companies, private limited companies and companies limited by guarantee.

6. Conclusion

Specific training represents an investment in an establishment's workforce and provides a return by lowering the cost of production. We emphasize in our formal model that scale effects imply the incentive for such investment is larger for more monopolistic firms. This motivated our empirical investigation. Using British establishment data from three cross-sections, we found dominant establishments cross-train a substantially larger share of their workforce. This remains true throughout a large variety of specifications. We focused on cross-training as it seems most likely to be both firm provided and firm specific. When we move to two separate panels, we found the same role for dominant firms and confirmed that role even when controlling for time invariant fixed effects.

We raise a number of caveats and suggestions in closing. First, product market structure itself may determine whether a given skill is general or specific. Thus, all skills unique to an industry are general in a competitive market and completely specific in a monopoly. If specific skills are provided by the firm, we should anticipate the extent of firm provided skills to be greater in a monopoly. We have no easy way to distinguish this from the scale effect we model but emphasize that it would move in the same direction. Second, we consciously examined cross-training as it has been emphasized to lower costs and be firm specific. The data source includes other less suitable measures of training and, as might be anticipated, it was difficult to confirm a robust role for product market structure. Relatedly, we note our measure represents the share of trained workers rather than the intensity of that training. Additional study of alternative types of training, measured in different ways is certainly called for.

Third, there remains an issue of the direction of causation. Could cross-training be such a powerful competitive weapon that those that cross-train more move to a position of market dominance? This would result in strong positive relationships between training and dominance such as we have shown and we cannot completely rule it out. It does, however, seem to us unlikely. Innovation, product market advantages and unique assets seem more likely to generate market dominance. Moreover, if cross-training was such a strong competitive weapon, one would anticipate that all firms would engage in it. Thus, like many prisoners' dilemmas one should observe extensive cross-training even in cases without dominance which is not the case. In the end, we think it remains a valuable contribution to have demonstrated that one of the most familiar models of competition predicts larger investments in training by more monopolistic firms and to follow this with robust evidence that dominant establishments in the UK do more of a critical form of training, cross-training.

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Table 1. Distribution of Cross Training (dependent variable)

	1998	2004	2011	Panel 1998-2004	Panel 2004-2011
None (0%)	0.322	0.335	0.285	0.272	0.286
	(0.467)	(0.472)	(0.451)	(0.446)	(0.452)
	[351]	[300]	[283]	[80]	[82]
Just a few (1-19%)	0.231	0.227	0.248	0.304	0.286
	(0.422)	(0.419)	(0.432)	(0.461)	(0.452)
	[432]	[383]	[398]	[108]	[103]
Some (20-39%)	0.105	0.150	0.133	0.183	0.147
	(0.307)	(0.357)	(0.339)	(0.387)	(0.354)
	[250]	[226]	[225]	[81]	[47]
Around half (40-59%)	0.075	0.092	0.089	0.077	0.066
	(0.262)	(0.289)	(0.286)	(0.267)	(0.247)
	[145]	[138]	[139]	[38]	[25]
Most (60-79%)	0.063	0.065	0.061	0.044	0.080
	(0.241)	(0.247)	(0.239)	(0.205)	(0.272)
	[135]	[91]	[93]	[35]	[28]
Almost all (80-99%)	0.076	0.055	0.077	0.072	0.049
	(0.265)	(0.227)	(0.267)	(0.259)	(0.216)
	[104]	[61]	[90]	[28]	[17]
All (100%)	0.128	0.076	0.107	0.048	0.086
	(0.334)	(0.262)	(0.309)	(0.212)	(0.281)
	[115]	[64]	[110]	[20]	[22]
Total observations	1,532	1,263	1,338	390	324

Notes: The samples for the three cross sections consist of trading sector 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 where the largest occupational group is managers or senior officials as the dependent variable does not apply to this group. For the two panel datasets we apply the same restrictions as in the cross sections but for establishments that have changed competition status and we observe twice. Thus, in the 1998-2004 (2004-2011) balanced panel we have 195 (162) establishments generating 390 (324) observations. Means sum to 100 percent and are estimated on non-missing observations. Standard deviations are in parentheses and numbers of observations are in square brackets. Estimates are weighted.

Table 2. Distribution of the Number of Competitors Variables

	1998	2004	2011	Panel 1998-2004	Panel 2004-2011
None/dominates market	0.089	0.059	0.028	0.029	0.079
	(0.278)	(0.226)	(0.153)	(0.169)	(0.269)
	[173]	[76]	[57]	[28]	[26]
Few competitors	0.320	0.365	0.401	0.483	0.472
	(0.463)	(0.481)	(0.490)	(0.500)	(0.499)
	[513]	[475]	[502]	[178]	[150]
Many competitors	0.591	0.576	0.571	0.488	0.449
	(0.491)	(0.494)	(0.495)	(0.500)	(0.498)
	[846]	[712]	[779]	[184]	[148]
Total observations	1,532	1,263	1,338	390	324

Note: For information on the sample, see Notes in Table 1. Means sum to 100 percent and are estimated on non-missing observations. Standard deviations are in parentheses and numbers of observations are in square brackets. 'Few competitors' equals to five or less competitors. Estimates are weighted.

Table 3. Cross Training and Product Market Competition: WERS 2011

	(1)	(2)	(3)
Few competitors	-0.571**	-0.550**	-0.630**
	(0.259)	(0.254)	(0.254)
Many competitors	-0.558**	-0.538**	-0.616**
	(0.256)	(0.253)	(0.254)
Log number of employees	0.074	0.055	0.053
	(0.051)	(0.055)	(0.056)
Log number of years establishment has been in operation	0.036	0.036	0.030
	(0.023)	(0.023)	(0.023)
Establishment produces different products or services	0.372***	0.358***	0.354***
	(0.101)	(0.100)	(0.100)
Multi-establishment (part of a larger organization)	0.127	0.097	0.080
	(0.114)	(0.118)	(0.119)
Percent female employees	0.444*	0.493*	0.546**
	(0.260)	(0.254)	(0.262)
Percent part time employees	0.032	0.014	0.043
	(0.223)	(0.222)	(0.222)
Percent disable employees	0.776	0.809	0.878
	(0.750)	(0.764)	(0.721)
Percentage workdays lost through employee sickness/absence	-0.015	-0.050	-0.022
	(0.709)	(0.712)	(0.718)
Percent of employees who belong to a union	0.352	0.259	0.218
	(0.365)	(0.363)	(0.344)
Percent fixed term employees	0.521**	0.558**	0.603***
	(0.228)	(0.229)	(0.227)
Percent temporary agency employees	0.240	0.258	0.346
	(0.425)	(0.433)	(0.460)
Percent of workers who separated last year	0.352	0.318	0.260
	(0.463)	(0.460)	(0.458)
Percent of workers who quitted last year	-0.923***	-0.835**	-0.765**
	(0.322)	(0.326)	(0.323)
Percent of employees more than 50 years old	-1.038***	-0.954***	-0.979***
	(0.331)	(0.338)	(0.335)
Percent of employees between 18 and 21 years old	0.488	0.440	0.360
	(0.484)	(0.483)	(0.493)
Vacancies available in the last 12 months	-0.105	-0.141	-0.176
	(0.130)	(0.130)	(0.130)
Introduction/upgrading of new technology in the last 2 years	0.056	0.053	0.027
	(0.104)	(0.103)	(0.104)
Introduction of technologically new product/service in the last 2 years	-0.056	-0.074	-0.103
	(0.104)	(0.105)	(0.105)
Personality/attitude test when filling vacancies		-0.066	-0.069
		(0.111)	(0.110)
Performance/competency test when filling vacancies		0.192*	0.175*
		(0.103)	(0.103)
Problem solving groups/quality circles		0.083	0.082
		(0.110)	(0.111)
System designed to minimize inventories, supplies, work in progress		0.118	0.120
		(0.113)	(0.112)
Joint consultative committees/work councils		-0.001	0.042
		(0.113)	(0.112)
Payment by result			0.129
			(0.118)
Merit pay			0.211
			(0.142)
Profit related pay			0.236**
			(0.100)
Cutoff 1	-0.900	-0.879	-0.932
	(0.484)	(0.479)	(0.477)

Cutoff 2	-0.171	-0.148	-0.191
	(0.483)	(0.477)	(0.475)
Cutoff 3	0.217	0.243	0.204
	(0.481)	(0.476)	(0.474)
Cutoff 4	0.510	0.538	0.502
	(0.481)	(0.476)	(0.474)
Cutoff 5	0.740	0.770	0.735
	(0.481)	(0.476)	(0.473)
Cutoff 6	1.113	1.144	1.111
	(0.482)	(0.476)	(0.474)
Industry dummies	Yes	Yes	Yes
Region dummies	Yes	Yes	Yes
Occupational composition	Yes	Yes	Yes
Largest occupational group dummies	Yes	Yes	Yes
Log pseudolikelihood	-2275.99	-2271.67	-2259.23
Observations	1,338	1,338	1,338

Notes: For information on the sample, see Notes in Table 1. The estimation method is an ordered probit model. Entries are coefficients and robust errors are in parentheses. The dependent variable reads as follows "*Approximately, what proportion of employees in the largest non-managerial occupational group are formally trained to be able to do jobs other than their own*?" 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). 'Few competitors' equals to five or less competitors. The omitted category is 'No Competitors'. Other controls not reported but their estimates are available upon request are: eleven industry dummies (omitted category *other community services*), 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 few and many competitors are not significantly different from each other. Levels of significance: *** p<0.01, ** p<0.05, * p<0.1.

Table 4. Cross Training and Product Market Competition: WERS 1998 and WERS 2004

	WERS 1998			WERS 2004		
	(1)	(2)	(3)	(4)	(5)	(6)
Few competitors	-0.247**	-0.259**	-0.258**	-0.333*	-0.376*	-0.387**
	(0.120)	(0.121)	(0.121)	(0.195)	(0.193)	(0.192)
Many competitors	-0.250**	-0.276**	-0.275**	-0.450**	-0.473**	-0.475**
	(0.127)	(0.128)	(0.128)	(0.196)	(0.195)	(0.195)
Cutoff 1	-0.371	-0.564	-0.545	-0.343	-0.480	-0.468
	(0.375)	(0.378)	(0.378)	(0.457)	(0.467)	(0.469)
Cutoff 2	0.497	0.318	0.339	0.320	0.200	0.216
	(0.377)	(0.380)	(0.380)	(0.457)	(0.467)	(0.470)
Cutoff 3	1.043	0.873	0.897	0.777	0.664	0.682
	(0.376)	(0.378)	(0.378)	(0.459)	(0.469)	(0.472)
Cutoff 4	1.327	1.160	1.186	1.105	0.993	1.013
	(0.376)	(0.379)	(0.379)	(0.460)	(0.471)	(0.474)
Cutoff 5	1.675	1.511	1.538	1.395	1.286	1.307
	(0.379)	(0.381)	(0.381)	(0.460)	(0.470)	(0.474)
Cutoff 6	2.058	1.897	1.925	1.737	1.633	1.655
	(0.384)	(0.386)	(0.386)	(0.460)	(0.470)	(0.475)
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes
Region dummies	Yes	Yes	Yes	Yes	Yes	Yes
Occupational composition	Yes	Yes	Yes	Yes	Yes	Yes
Largest occupational group	Yes	Yes	Yes	Yes	Yes	Yes
Log pseudolikelihood	-2613.32	-2594.93	-2590.53	-2066.99	-2046.71	-2041.39
Observations		1,532			1,263	

Notes: For information on the sample, see Notes in Table 1. The estimation method is an ordered probit model. Entries are coefficients and robust errors are in parentheses. 'Few competitors' equals to five or less competitors. The omitted category is 'No Competitors'. For reasons of brevity we only report estimates for the two competition variables. The rest of controls are the same as those reported in column 3 of Table 3 and their estimates are available upon request. Estimated coefficients of few and many competitors are not significantly different from each other. Levels of significance: *** p<0.01, ** p<0.05, * p<0.1.

Table 5. Marginal Effects

	1998		2004		2011	
	Few competitors	Many competitors	Few competitors	Many competitors	Few competitors	Many Competitors
	(1)	(2)	(3)	(4)	(5)	(6)
Cutoff 1: None	0.072**	0.074**	0.139**	0.164**	0.210**	0.193**
	(0.035)	(0.034)	(0.070)	(0.065)	(0.086)	(0.076)
Cutoff 2: Just a few	0.030**	0.036**	0.009*	0.021*	0.034***	0.048**
	(0.013)	(0.016)	(0.005)	(0.011)	(0.012)	(0.023)
Cutoff 3: Some	-0.017*	-0.015**	-0.030*	-0.031**	-0.031**	-0.022**
	(0.009)	(0.007)	(0.016)	(0.012)	(0.014)	(0.008)
Cutoff 4:Around half	-0.017**	-0.017**	-0.030*	-0.035**	-0.039**	-0.035**
	(0.008)	(0.007)	(0.015)	(0.014)	(0.016)	(0.013)
Cutoff 5: Most	-0.022**	-0.023**	-0.026**	-0.033**	-0.034**	-0.033**
	(0.010)	(0.010)	(0.013)	(0.014)	(0.014)	(0.013)
Cutoff 6: Almost all	-0.020**	-0.022**	-0.026**	-0.033**	-0.052**	-0.053**
	(0.009)	(0.010)	(0.012)	(0.015)	(0.021)	(0.022)
Cutoff 7: All	-0.027**	-0.032**	-0.037**	-0.053**	-0.088**	-0.099**
	(0.012)	(0.015)	(0.017)	(0.023)	(0.034)	(0.044)

Notes: Entries are marginal effects obtained from an ordered probit model based on the complete estimates model (i.e. column 3 of Table 3) across all three cross sections. Standard errors are in parentheses. We only report the marginal effects of the two variables of interest. Marginal effects for the rest of the covariates are available upon request. ‘Few competitors’ equals to 5 or less competitors. The marginal effect is the discrete change going from 0 to 1. Levels of significance: *** p<0.01, ** p<0.05, * p<0.1.

Table 6. Cross Training and Product Market Competition: Panel data 1998-2004 and 2004-2011

	Panel 1998-2004			Panel 2004-2011		
	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Ordered Probit Without FE	Ordered Probit With FE	Poisson Fixed Effects	Ordered Probit Without FE	Ordered Probit With FE	Poisson Fixed Effects
Few competitors	-0.696**	-1.215***	-0.515**	-0.706**	-1.504***	-0.779***
	(0.286)	(0.372)	(0.235)	(0.285)	(0.455)	(0.255)
Many competitors	-0.727**	-1.403***	-0.566**	-0.657**	-1.203***	-0.543**
	(0.290)	(0.375)	(0.236)	(0.292)	(0.469)	(0.257)
Log-likelihood	-628.79	-454.76	-233.60	-492.83	-339.61	-154.32
Observations	390	390	390	324	324	324

Notes: The sample consists of a balanced panel of trading sector establishments with 10 or more employees. In the 1998-2004 panel we observe 195 establishments generating 390 observations. In the 2004-2011 panel we observe 162 establishments generating 324 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 competition status. Robust standard errors are in parentheses. 'Few competitors' equals to five or less competitors. The omitted category is 'No Competitors'. For reasons of brevity, we only present coefficients of the two competition variables. Other controls are those shown in column 3 of Table 3 and their estimates are available upon request. Estimated coefficients of few and many competitors are not significantly different from each other. Levels of significance: *** p<0.01, ** p<0.05, * p<0.1.

Table 7: Cross Training and the Extent of Price Competition (relative to no price competition)

	WERS 2004	WERS 2011	WERS Panel 2004-2011	WERS Panel 2004-2011, with FE
	(1)	(2)	(3)	(4)
2 Light Price Competition	-0.003	-0.606*	-0.583*	-0.927*
	(0.185)	(0.319)	(0.332)	(0.534)
3 Moderate Price Competition	-0.035	-0.214	-0.581**	-0.362
	(0.168)	(0.280)	(0.295)	(0.489)
4 Hard Price Competition	-0.354**	-0.685**	-1.158***	-1.045**
	(0.176)	(0.306)	(0.307)	(0.486)
5 Heavy Price Competition	-0.108	-0.262	-0.856***	-0.646
	(0.186)	(0.286)	(0.305)	(0.497)
Observations	659	688	310	310

Notes: The sample consists of a balanced panel of companies that offer their main product or service to the general public. The estimation method is an ordered probit model. Entries are coefficients and robust errors are in parentheses. The variables of interest 2 to 5 are generated from the following question available only in the 2004 and 2011 cross sections: "To what extent would you say that the demand for your (main) product or service depends upon offering lower prices than your competitors?" Managers responded from 1, "does not depend at all on price" to 5, "depends heavily on offering lower prices". The omitted category is 1. The controls are the same as those reported in column 3 of Table 3 and the full estimates are available upon request. Coefficients in columns 3 and 4 are estimated on 155 establishments that are observed twice, thus generating 310 observations. Levels of significance: *** p<0.01, ** p<0.05, * p<0.1.

Appendix: Illustrating the Model

▪ <u>Case 1</u>. The relationship between n, α and I_j^*

If we set γ=1, c=2 and θ=2 the necessary condition for an interior equilibrium outcome becomes: $\theta \geq \frac{2n(a-\gamma)(c-\gamma)}{(n+1)^2} \Leftrightarrow n^2 + (3-a)n + 1 \geq 0$. The last inequality is satisfied when $a \in [1,5]$. Since we must also have $a \geq c = 2$, we consider values of α in the interval [2,5]. Then, we have: $I_j^*(a,n) = \frac{n(a-2)}{n^2+n+1}$. This is depicted in Table A1, where training decreases with the number of competitors (n) and increases with the market size (α).

n \ a	3	3.5	4	4.5	5
1	0.333	0.5	0.667	0.833	1
2	0.286	0.429	0.571	0.714	0.857
4	0.190	0.286	0.381	0.476	0.571
6	0.140	0.209	0.279	0.349	0.419
8	0.110	0.164	0.219	0.274	0.329

Table A1. The proportion of trained workers (I_j^*) for different combinations of n and a

▪ <u>Case 2</u>. The relationship between n, θ and I_j^*

If we set γ=1, c=2 and α=3 the necessary condition for an interior equilibrium outcome becomes: $\theta \geq \frac{2n(a-\gamma)(c-\gamma)}{(n+1)^2} \Leftrightarrow \theta n^2 + 2(\theta-2)n + \theta \geq 0$. The last inequality is always satisfied when $\theta \geq 1$. Then, we have: $I_j^*(\theta,n) = \frac{2n}{\theta(n+1)^2 - 2n}$.

This is depicted in Table A2. Clearly, the level of training decreases with both the number of firms (n) and with the training cost parameter (θ).

θ

		1	1.5	2	2.5	3
	1	1	0.5	0.333	0.250	0.200
	2	0.800	0.421	0.286	0.216	0.174
n	**4**	0.471	0.271	0.190	0.147	0.119
	6	0.324	0.195	0.140	0.109	0.089
	8	0.246	0.152	0.110	0.086	0.070

Table A2. The proportion of trained workers (I_j^*) for different combinations of n and θ

▪ <u>Case 3</u>. The relationship between *n*, *c* and I_j^*

If we set γ=1, α=3 and θ=2 the necessary condition for an interior equilibrium outcome becomes: $\theta \geq \frac{2n(a-\gamma)(c-\gamma)}{(n+1)^2} \Leftrightarrow n^2+2(2-c)n+1 \geq 0$. The last inequality is always satisfied when $c \in [1,3]$. Then, we have: $I_j^*(\theta,n) = \frac{n(c-1)(3-c)}{(n+1)^2 - n(c-1)^2}$. Note that I_j^* increases with c for $c \in [1,c_0)$ and decreases with c for $c \in (c_0,3]$, where $c_0 = 2+1/n$. This is depicted in Table A3 below. The level of training initially increases and eventually decreases in the base marginal cost of production (*c*).

c

		2	2+1/8	2+1/6	2+1/4	2+1/2	2.8
	1	0.333	0.360	0.368	0.385	0.429	0.474
	2	0.286	0.304	0.310	0.319	0.333*	0.286
n	**4**	0.190	0.197	0.199	0.200*	0.188	0.120
	6	0.140	0.1426	0.1429*	0.1420	0.127	0.073
	8	0.1096	0.1111*	0.1109	0.1095	0.095	0.052

Table A3. The proportion of trained workers (I_j^*) for different combinations of n and c

**Starred entries represent maximum proportions of training for various values of n*