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BARRIERS TO ENTRY, DEREGULATION AND WORKPLACE TRAINING

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Barriers to Entry, Deregulation and Workplace Training[*]:

A Theoretical Model with Evidence from Europe

by

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Abstract

We study the impact of regulatory barriers to entry on workplace training. We develop a model of training in imperfectly competitive product and labour markets. The model indicates that there are two contrasting effects of deregulation on training. As stressed in the literature, with a given number of firms, deregulation reduces the size of rents per unit of output that firms can reap by training their employees. Yet, the number of firms increases following deregulation, thereby raising output and profit gains from training and improving investment incentives. The latter effect prevails. In line with the predictions of the theoretical model, we find that the substantial deregulation in the 1990s of heavily regulated European industries (energy, transport and communication) increased training incidence.

Key words: training, product market competition, regulatory reform, Europe

JEL codes: J24, L11, O43

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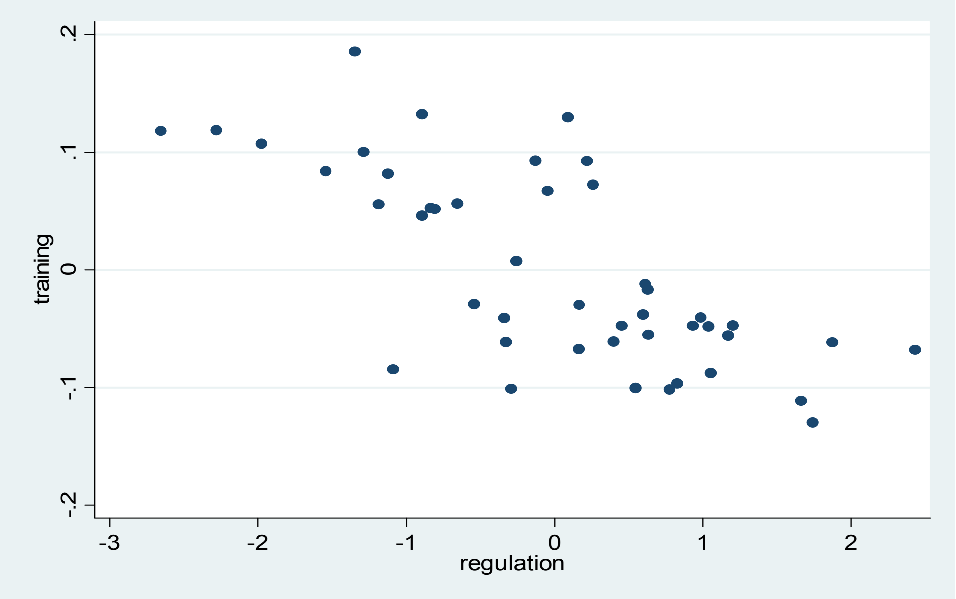
Introduction

This paper develops a theoretical and empirical analysis of the relationship between product market regulation and workplace training in the European context. We believe that looking at training is important because of its effects on productivity. For example, OECD (2007) surveys the literature on training and productivity and reports that the elasticity of the latter to the former is between 0.05 and 0.15 for European countries.

A casual look at available industry-level cross-country data reveals that the degree of stringency of anti-competitive product market regulation and the training participation rate are negatively correlated. Using data from the European Labour Force Survey and the OECD regulatory database which cover the years 1995-2002, Figure 1 illustrates this for 15 European countries and 3 non-manufacturing industries (energy, transport and communication), for which regulation data are available.

Figure 1. The correlation between training and anti-competitive regulation



Note: Data refer to averages for 1995-2002, three 2-digit (letter) industries (energy, transport and communications) and 15 countries (Norway and pre-enlargement EU excluding Luxembourg). The training participation rate refers to training taken in the 4 weeks preceding the survey by full-time employees aged between 25 and 54 years and with at least 4 weeks of tenure. The regulation indicator is a simple average of sub-indicators concerning industry-specific entry barriers, the market share of the dominant player(s), vertical integration in network industries and price controls (see Section 3 of the paper for details). The industry average of each variable has been subtracted to make comparable in a single chart figures from different industries. *Sources*: OECD regulatory database and Eurostat, European Labour Force Surveys.

Yet labour economists typically expect that product market competition depresses training, because additional competition compresses the size of the rents that can be appropriated by firms, which invest in human capital and pay for most of job-related training (see e.g. Acemoglu and Pischke, 1999, Gersbach and Schmutzler, 2001, 2006). This view apparently overlooks a standard finding in the theory of industrial organization: a firm's incentives to reduce unit costs - for instance by training more workers - do not depend on the size of rents *per se* but on the sensitivity of rents to unit cost reductions (see e.g. Boone, 2000, and Aghion et al., 1997). In the case of price competition (that is when firms set prices rather than quantities), if firms have similar production costs and there is endogenous entry, it is well known that greater competition increases incentives to reduce unit costs even if rents – defined in terms of profits per unit of output – fall (see e.g. Aghion et al., 2001). This occurs because reducing costs allows reducing prices and the sensitivity of product demand to relative prices is greater, the greater the degree of competition.

In this paper we argue that a similar mechanism applies to the investment in human capital by firms, insofar as firms pay for training as a mean to reduce unit costs (see e.g. Stevens, 1996, Acemoglu and Pischke, 1999). We develop a model which casts the training decision in an economy characterized by imperfectly competitive product and labour markets, where firms and workers are ex-ante identical and firms compete in the product market by setting prices, as in Blanchard and Giavazzi (2003). We show that in equilibrium deregulation has two contrasting effects on training. On the one hand, a reduction in the barriers to entry for a given number of firms compresses profits per unit of output, and therefore tends to depress training (we will call this "rent effect" hereafter). On the other hand, there is an "elasticity" or "business stealing" effect: conditional on profits per unit of output, additional firm entry due to deregulation increases the output (and therefore profit) gains from training and raises the employer's incentive to invest in human capital. Output gains increase because additional training reduces the relative product price and the response of output to prices is greater, the greater the degree of competition in the product market[1]. In our model the latter effect prevails on the former, and therefore deregulation increases training intensity.

We first derive the equilibrium and describe the comparative statics when: a) training is firm – specific and paid by firms; and b) wages are the outcome of the bargain between employers and workers. We focus on training paid and organized by firms because this is the bulk of workplace training (see Bassanini et al., 2007, and the references therein), and on bargaining in line with the

[1] A similar effect is also stressed by Vives (2008), who investigates the relationship between competition and innovation, and Raith (2003), who looks at how competition affects managerial incentives.

importance of collective wage determination in Europe, to which our empirical analysis applies. Our emphasis on firm – specific training is also motivated by the European perspective. In his comparative analysis of labour markets, Wasmer (2006) argues that in Europe high employment protection facilitates the investment in firm - specific skills and reduces labour mobility. By contrast, in the United States, limited protection favours both the accumulation of more general skills and higher mobility of workers.

Next, we show that our key results apply also when training is general and the marginal cost of training is lower than the marginal cost of hiring, because labour market frictions substantially reduce the transferability of general skills, making them *de facto* specific, as discussed by Acemoglu and Pischke (1999). Moreover, we show that the positive relationship between deregulation and training holds also when training is fully general, hiring costs are low, the employee invests and bears the training costs and there is no wage bargaining. The reason is that, with additional firm entry due to deregulation, the output gains from employing trained workers increase, thus the demand for training improves, and so does its supply. Our findings are also robust to an extension of the basic setup which allows for heterogeneity of workers and training costs.

The only other model focusing on competition and training we are aware of is the one by Gersbach and Schmutzler (2001, 2006).[2] They consider a setting with a frictionless labour market and an imperfectly competitive product market with a fixed number of firms. They assume that workers cannot pay for their general training and show that, if an equilibrium with nonzero firm-sponsored training exists, this type of training and competition are inversely related in equilibrium. While our model differs from theirs in several respects, the most important difference is that we allow for entry and market contestability, as in Blanchard and Giavazzi (2003). We believe that assuming some degree of market contestability is essential when analysing the effect of deregulation of entry barriers.

The findings of our theoretical model are a useful guide to empirical research. Previous work in the area is relatively scarce. Autor (2001) finds that the Herfindhal index and training are negatively correlated in US temporary help firms, which suggests that less competition reduces training. Schone (2007) finds that training is greater in Norwegian manufacturing firms that declare to be more exposed to foreign competition. Goerlitz and Stiebale (2008) and Picchio and van Ours (2010) find – for

[2] Autor (2001) builds a model to explain why Temporary Help Service (THS) firms train and finds that local competition in that industry increases firm-sponsored training. However, in his model training is essentially used by THS firms as a screening and selection device. Greater product market competition increases the pressure on THS firms to secure high-ability workers and to use training as a way to attract and select them. His model, therefore, appears to be specific to the THS industry.

Germany and the Netherlands, respectively - no statistically significant relationship between training and measures of product market competition, such as the elasticity of profits to marginal costs, firm concentration and mark-ups, Bassanini et al (2007) use a large panel of European countries, thereby exploiting the cross – country variation of product market regulation, and find evidence of a negative and statistically significant correlation between the OECD aggregate index of product market regulation and training intensity.

One potential drawback of multi-country aggregate studies is that, by exploiting only the country and time dimensions, they do not allow controlling for many confounding factors that might affect training and vary across country and over time. One way to overcome this limit is to add at least one additional dimension to the data, the industry, as we do in this paper. With data which vary by country, year and industry, we can compare the behaviour of industries differently affected by deregulation, while at the same time controlling for country and country by time specific effects.

Heavily regulated European industries (energy, transport and communication) underwent a substantial deregulation during the 1990s. Because of this, they provide an interesting laboratory to study the relationship between product market deregulation and training. We use the OECD database on product market regulation, which has been designed to pick up regulatory reforms in traditionally heavily regulated industries, and the fact that, after the implementation of the European Single Market Programme (SMP hereafter) in the early 1990s, there has been essentially no country / industry-specific regulatory reform affecting the manufacturing sector. By comparing training incidence in both manufacturing and non-manufacturing, we can disentangle the effects of deregulation on training from other confounding factors, which affect both groups of industries. To this purpose we match regulation data with training data from the European Labour Force Survey (ELFS) as well as several other databases and obtain a rich industry-level database of training covariates.

Our econometric analysis shows that reducing product market regulation in heavily regulated European industries has increased training incidence, in line with the predictions of the theoretical model. The estimated effects are not small: depending on the empirical specification, a 10 percent reduction of regulation increases training incidence in the exposed industries by 2.8 to 5 percent. Whether these sizeable effects can be extended to a broader sample of industries remains however an open question that cannot be addressed with the data at hand.

The paper is organized as follows. In the first section we develop the theoretical model. The subsequent sections introduce the empirical strategy and the data and present our estimates of the relationship between training and product market regulation. Conclusions follow.

1. The Model

The presentation of the model is organized in two subsections: subsection 1.1 deals with the case of firm-specific training, and subsection 1.2 considers the case of general training.

1.1 Firm-specific training and wage bargaining

Following Blanchard and Giavazzi (2003) and Stevens (1996), we consider a three–stage model where each firm produces a differentiated product using labour. The number of firms m is determined by an entry condition, which is affected by product market regulation. The logical sequence of the model is as follows: first, firms decide entry (let us call this stage zero); second, each firm hires a number of (unskilled) workers and provides them with a given amount of firm-specific training, paying the related training costs (call this first stage); third, and conditional on training, firms and workers bargain over wages and employment – or over wages only if the employer commits to employ all trainees in final production – (call it second or final stage) [3]. Conditional on the amount of training, prices are set when employment is determined. Production occurs at the end of the sequence.

As standard in the training literature (see e.g. Acemoglu and Pischke, 1999, Stevens, 1996, or Bassanini et al., 2007), we assume that no training can occur after bargaining.[4] In both the decision to enter and in the choice of how many workers to train, each employer has full information and can perfectly foresee the wages she will pay, the level of employment and the prices at which she will be able to sell her goods.

Firms share the same production and training technology, and the same elasticity of product demand. Risk neutral homogeneous workers have the same reservation wage, and there are no exogenous separations of workers from firms[5]. Each firm operates the technology $Y_i = AL^e{}_i$, where Y_i is output of firm i, A is a productivity parameter and $L^e{}_i$ is employment in efficiency units, which depends on the amount of training given to each employee $\tau_i \geq 0$. Hereafter, we shall call this amount

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[3] A model with wage bargaining is a plausible characterization of European labour markets, where wages are often set by collective bargaining between employers and trade unions (see Nickell, Nunziata and Ochel, 2005).

[4] When firms invest in firm–specific training, the hold up problem implies that workers can re-negotiate their wage after the training investment has taken place (Malcomson, 1997). Therefore, if workers were trained after the bargaining, a new bargaining stage would occur after the training and only the latter would determine the wage.

[5] We consider the cases of workers with heterogeneous skills and of heterogenous production and training technologies in Appendix B and show that the main results hold true, although with some qualifications.

“training intensity”. The (real) cost of training per employee c is assumed to be a convex function of training intensity τ, given by $c(\tau_i) = \mu\tau_i^2 / 2$, where μ is a scale parameter. This assumption captures decreasing returns in the production of human capital. Training affects productivity and labour in efficiency units is given by $L^e{}_i = (1+\tau_i)L_i$ where L is employment. Hence, the production function can be written as $Y_i = A(1+\tau_i)L_i$. Since training is firm-specific, firms cannot hire trained workers from the market. Therefore, the number of trained employees cannot be greater than the number of workers recruited and trained in the first stage T_i ($L_i \leq T_i$).[6]

Following Blanchard and Giavazzi (2003), we assume that each firm faces the following product demand function: $Y_i = (Y/m)(P_i/P)^{-\theta}$, where Y is aggregate output, P_i and P are the price set by firm i and the average price, respectively, and $1 < \theta = \sigma g(m) < +\infty$ is the absolute value of the elasticity of demand with respect to the relative price, which we assume to increase in the number of firms ($\partial g / \partial m > 0$), with σ being a suitable constant. This assumption – which implies that the price mark-up is decreasing in m – is standard in models of monopolistic competition (see *e.g.* Perloff and Salop, 1985) and is supported by a number of empirical studies (see *e.g.* Barron, Taylor and Umbeck, 2004, and Pinske and Slade, 2004).[7] Also, as standard in this type of models, we assume that the individual decisions of the firm do not affect aggregate variables. In Appendix B we relax this assumption and show that our main results are unaffected.

Define net and gross profits as net and gross of training costs. The characterization of the equilibrium proceeds by backward induction and starts with the bargain in the second and final stage. In the event of settlement, employed workers earn $W \geq V$, where V is the reservation wage. We characterize the bargaining as a cooperative Nash game, and define the Nash maximand as

$$\Omega_i = \delta \ln\left[(W_i - V)L_i\right] + (1-\delta)\ln\left[P_i Y_i - L_i W_i\right] \qquad [1]$$

where $\delta \leq 1$ is the relative bargaining power of labour and the second element on the right hand side of

[6] Yet, in principle, firms might gain by hiring additional unskilled workers in the second stage. This possibility is excluded by assumption in our baseline model. However, we can show that, even if employers were allowed to hire unskilled workers in the second stage, they would refrain from doing so in equilibrium (see Appendix B).

[7] Barron, Taylor and Umbeck (2004), use firm – level data from the US retail gasoline industry and find that in markets with a higher number of sellers there is a statistically significant decrease in mean prices. Given marginal costs, this result is consistent with a lower price mark-up, and a higher price elasticity of product demand. Pinske and Slade (2004), and Kim and Singal (1993), study the effect of mergers, which reduce the number of firms, in the UK brewing industry and in the US airline industry and find evidence of price increases and lower price elasticity. Oliveira Martins, Scarpetta and Pilat (1996), examine OECD data and show that entry rates of new firms are negatively correlated with the price mark-up - and positively correlated with the price elasticity of demand. Finally, Weiher, Sickless and Perloff (2002) show that the price mark-up in the US airline industry decreases with the number of airlines operating in the same route.

[1] is the gross nominal profit from a positive settlement accruing to the employer[8].

Consider now two alternative settings: in one setting, each firm either can commit to employ in the second stage all the workers who were trained in the first stage or is forced to do so by strict dismissal regulations. In these circumstances, second–stage employment is fixed and the parties bargain only over wages. In the other setting, the employer does not commit to employ all trainees. As a consequence, in the second stage both wages and employment are bargained over, subject to the constraint that the number of employees cannot exceed the number of trainees set in the first stage[9]. We start by describing the equilibrium under the former setting (call it the "commitment equilibrium"). We do so for expositional reasons, since the derivation of the equilibrium is more intuitive in this case. We then show that the same equilibrium also holds in the absence of commitment.

1.1.1 The commitment case

With employment equal to the number of trainees, the parties in the second stage bargain over wages to maximise equation [1]. The outcome of the bargain in firm *i* is

$$W_i = \delta P_i \frac{Y_i}{L_i} + (1-\delta)V = V + \delta(P_i A(1+\tau_i) - V) \qquad [2]$$

Each employee is paid the outside option plus a share of total rents per worker, a standard result. Employer i in the first stage internalises the wage rule [2] and chooses training intensity and the number of trainees (and therefore employment and prices) to maximize her net real profits[10]

$$\Pi_i = \left\{(1-\delta)\frac{P_i}{P} - (1-\delta)\frac{V}{PA(1+\tau_i)} - \frac{\mu\tau_i^{\,2}}{2A(1+\tau_i)}\right\}\frac{Y}{m}\left(\frac{P_i}{P}\right)^{-\theta} \qquad [3]$$

The terms within and outside the braces on the right-hand side are net real profits per unit of output π_i and output Y_i respectively. Since $L_i = T_i$ under commitment, profit maximisation with respect to the number of trainees yields

$$\frac{P_i}{P} = \frac{\theta}{(\theta-1)}\left(\frac{V}{PA(1+\tau_i)} + \frac{\mu\tau_i^{\,2}}{2(1-\delta)A(1+\tau_i)}\right) \qquad [4]$$

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[8] Profits are gross because training costs in the second stage are bygones.

[9] We assume that in this case the parties are involved in efficient bargaining. An alternative characterization would be the "right to manage" model, where the employer retains authority over employment determination. Our main results still hold in a "right-to-manage" setup (see Appendix B).

[10] That is, nominal profits divided by the average price.

The maximisation of profits with respect to training intensity τ_i yields instead

$$(1-\delta)\frac{V}{P}-\mu\tau_i(1+\tau_i)+\frac{\mu\tau_i^{\ 2}}{2}=0 \qquad [5]$$

which can be used in [4] to obtain

$$\left(1-\frac{1}{\theta}\right)(1-\delta)\frac{P_i}{P}A=\mu\tau_i \qquad [6]$$

Solving [5] with respect to training intensity yields

$$\tau_i=-1\pm\sqrt{1+2\frac{1-\delta}{\mu}\frac{V}{P}}>0$$

as the unique non-negative solution. Since both V and the parameters μ and δ do not vary across firms, it must be that $\tau_i=\tau$, implying that all firms select the same training intensity for their employees. It follows from this and equation [4] that, at the optimal level of training, relative prices are the same across firms. Since in general equilibrium we cannot have that all firms have a relative price above or below 1, it must be that $\frac{P_i}{P}$ is equal to 1. Using this result into [6] we obtain the key expression

$$\tau=\frac{A}{\mu}(1-\delta)\frac{(\theta-1)}{\theta} \qquad [7]$$

which shows that training intensity in equilibrium is an increasing function of the elasticity of demand θ and, therefore, the number of firms *m*. To better explain this result, we use equation [4] and the fact that relative prices in equilibrium are equal to 1 in the definition of profits per unit of output π to obtain $\pi=(1-\delta)/\theta$, which plugged into [7] yields

$$\tau=\frac{A}{\mu}\pi(\theta-1) \qquad [8]$$

Training intensity is increasing in net real profits per unit of output π and, conditional on π, is increasing in the elasticity θ. The relationship between training intensity and θ reflects both a "rent" and a "business stealing" effect. The former effect has negative sign and occurs because an increase in θ reduces profits per unit of output π and the benefits of training. The latter effect has positive sign and comes from the fact that the output (and profit) gains from training are increasing in θ: training increases productivity, relative prices are decreasing in productivity and the response of output to relative prices is greater, the higher is θ. Our model suggests that the latter effect always dominates the former.

In the long-run, the equilibrium number of firms is determined by the condition that net profits per unit of output π must be equal to the cost of entry per unit of output ρ, which we assume to be an increasing function of the stringency of regulatory barriers R:

$$\pi = \frac{1-\delta}{\theta} = \rho = f(R) \qquad [9]$$

where $\partial f / \partial R > 0$. The assumption that ρ is proportional to output is convenient and used also by Blanchard and Giavazzi (2003).[11] Equation [9] implies that a fall in the costs of entry, brought about by a relaxation of regulatory barriers, increases the number of firms and θ. As a consequence, profits per unit of output are reduced until the arbitrage condition [9] is satisfied.

Plugging [9] into [8] we obtain

$$\tau = \frac{A}{\mu}(\theta - 1) f(R) \qquad [10]$$

which, taking into account the relationship between θ and R described by equation [9], yields:

$$\tau = \frac{A}{\mu}(1 - \delta - f(R)) \qquad [11]$$

We summarise our results in the following proposition:

Proposition 1. In the commitment case, the long run equilibrium in the presence of positive entry costs ρ exists and is unique. A reduction in regulatory barriers to entry R increases training intensity[12].

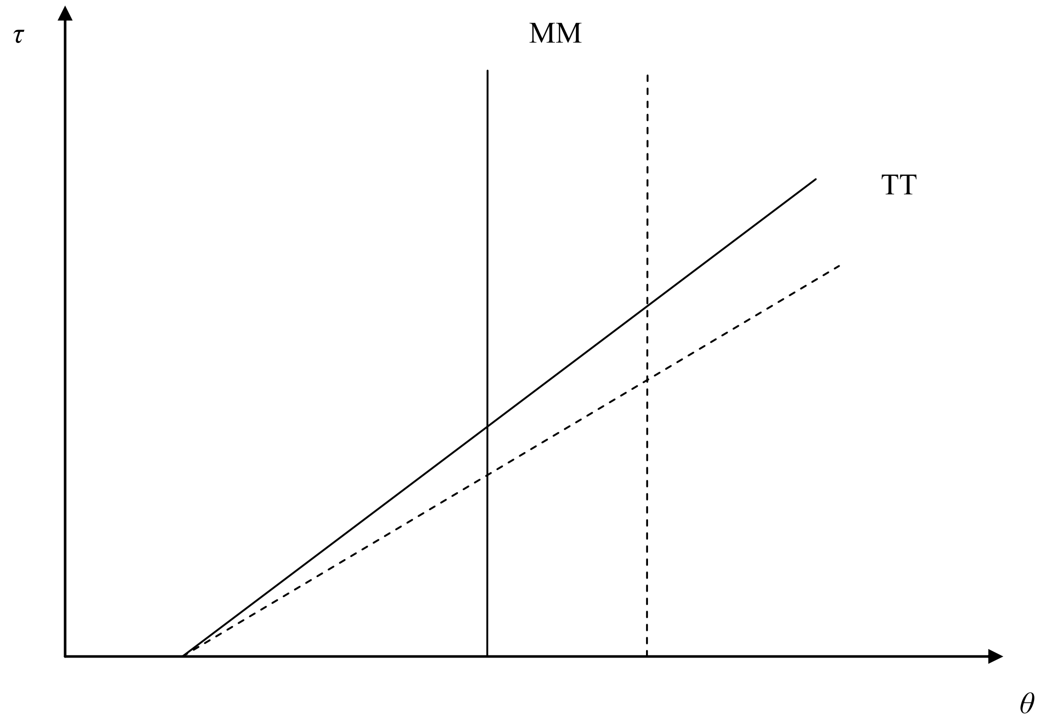
In comparative statics terms, the effect of product market deregulation on training intensity is illustrated in Figure 2, where continuous lines in the (θ, τ) plane refer to the initial equilibrium and dashed lines to the new equilibrium. Training intensity along the schedule TT – associated with

[11] Our findings still hold when we model entry costs more conventionally as fixed costs (see Bassanini and Brunello, 2010).

[12] If we adopt the more general production function $Y_i = A[(1+\tau)L_i]^{\alpha}$, with $\alpha \le 1$, which includes the linear specification used in the text as a special case, the optimal training intensity is given by $\tau = \frac{\alpha}{\mu}[(1-\delta)(2-\alpha) - f(R))]A^{\frac{1}{\alpha}}\left(\frac{Y}{m}\right)^{1-\frac{1}{\alpha}}$, which is still a decreasing function of regulatory barriers.

equation [10] – tends to zero when $\theta \to 1$ and increases with θ and the number of firms[13]. The schedule MM associated with equation [9] is a vertical line, which simply describes the relationship between entry costs and the number of firms. This line cuts the horizontal axis at $\theta = (1-\delta)/\rho > 1$. Therefore, the two schedules certainly intersect (existence of equilibrium) and do so only once in the relevant domain (uniqueness).

Figure 2: The effect of reducing barriers to entry in the commitment case



A product market deregulation which reduces entry barriers and the value of ρ shifts the MM curve outwards and the TT curve downwards. The overall effect is to increase the number of firms unambiguously. There are two effects on training intensity: first, and for a given number of firms, lower entry barriers rotate the TT schedule downwards, because they imply lower net profits per unit of output, thereby dampening training intensity. This is the "rent" effect usually stressed in the literature. Second, the number of firms in equilibrium is higher and the MM curve shifts outwards. Training increases along the new TT schedule, because the output gains from training are greater (the "business

[13] Recall that $\frac{\partial \theta}{\partial m} = \sigma \frac{\partial g}{\partial m} > 0$.

stealing" effect). Since the latter effect is larger than the former, equilibrium training intensity increases.

1.1.2 The no-commitment case

In this sub-section we argue that the commitment equilibrium described above is an equilibrium even in the absence of commitment. Our argument here is only verbal, but the formal proofs are available in Appendix A. We proceed in two steps, which correspond to the two lemmas presented in the appendix. First we show that, starting from the commitment equilibrium, bargaining outcomes involving any employer and her workers cannot produce a level of employment L_i that differs from the equilibrium number of trainees T_i. On the one hand, $L_i < T_i$ is not a profitable deviation from the equilibrium: if the bargaining pair were free to deviate, it would bargain for $L_i > T_i$. The intuitive reason is that, in the second stage, the employer and her workers bargain over employment without internalising training costs, which are bygones and do not affect the Nash maximand (cf. equation [1]). By contrast, as shown in the previous subsection, T_i is set in the first stage by taking into account those costs – that are increasing in T_i. On the other hand, $L_i > T_i$ is not feasible because training is only possible in the first stage and, since skills are firm-specific, there is no available skilled worker who can be hired in the labour market.[14] Therefore, training in the first stage acts as an effective commitment device.

Second, let us define an "accommodating strategy" as a strategy that selects in the first stage a training intensity τ_i and a number of trainees T_i which accommodates the level of employment that each firm *i* expects to be chosen by the bargaining parties in the second stage if they could bargain over wages and employment without any constraint. We show that this strategy is always less profitable than a non accommodating strategy, which sets a relatively low number of trainees in the first stage and by so doing binds employment in the second stage to the constraint $L_i = T_i$. The intuition here is that, in the absence of commitment, the level of employment set by bargaining parties in the second stage tends to be "too high" because, as discussed above, the employer and her workers bargain over employment in the second stage without internalising training costs. By accommodating this employment level in the first stage, the employer is forced to bear the associated training costs. A natural way to reduce these costs is to tie her hands and train a smaller number of workers in the first stage, thereby

[14] As remarked in footnote 6, employers in equilibrium do not hire unskilled workers in the second stage (see Appendix B).

constraining employment in the second stage.

Since the bargaining parties cannot profitably deviate in the second stage from the commitment equilibrium, and no single firm can profitably pursue an accommodating strategy that allows employment to be freely chosen in the second stage, employment is effectively constrained to be equal to the ex-ante number of trainees even in the absence of commitment, and the following proposition holds:

Proposition 2. In the presence of positive entry costs ρ, and given the workers' bargaining power δ, the cost parameter μ and the productivity parameter A, a combination of training intensity τ, number of trainees T, wages W and employment L that is an equilibrium in the commitment case is also the unique equilibrium in the no-commitment case.

Proof: see Appendix A.

In the extreme case when $\rho = 0$ and the number of firms goes to infinity, there are no rents, which implies no scope for business stealing effects because firms cannot trade off lower profits per unit of output for greater output. Therefore, equilibrium training is zero. The case of no entry costs looks, however, implausible and, at best, applies to a relatively small number of specific markets. Hence, we can establish the following corollary, which yields a testable implication and provides an explanation for the empirical pattern shown in Figure 1:

Corollary 1. A reduction in entry barriers *R* that does not lead to perfect competition in the product markets increases firm-specific training incidence.

1.2 General training

In the economy described so far, each firm invests in firm – specific training and is willing to pay the necessary training costs. In this sub-section, we consider an alternative specification of the model where firm-specific training is replaced by general training and we show that, also in this case, Corollary 1 holds but training will be paid by either workers or the firm, depending on hiring costs. Assume that skills are general and that firms have the option of hiring skilled labour from the labour market or from other firms (*poaching*). If training is general workers can be trained by one firm and switch employer in the second-stage if there are employers willing to offer them a higher wage. If hiring were costless and hired workers were as productive as workers trained in-house, no firm would be willing to train and bear the training costs. However, hiring skilled labour in an imperfectly competitive labour market is costly, either because skills are not fully transferable or because of the presence of frictions and information asymmetries. For example, the recruitment of skilled labour requires a costly screening activity to distinguish between skilled and unskilled applicants and to measure the skills of potential hires. Since the cost of screening is likely to rise with the level of skills, we make the convenient assumption that hiring costs h per employee are given by $h(\tau_i) = \eta\tau_i^2/2$, where η is a non-negative scale parameter.

When the marginal cost of training is lower than the marginal cost of hiring, the analysis in Section 1.1 applies. Consider next the case when hiring is less costly than training. With no heterogeneity in the technology and in the costs of hiring and training, all firms prefer to hire skilled labour than train unskilled labour. But with no training by firms there can be no hiring of skilled labour, unless workers themselves are willing to bear the training costs. For each worker, let the cost of training be $\xi\tau^2/2$ and assume that wages are a function of training intensity, $W = W(\tau)$. Then homogeneous workers will invest until the marginal benefit of the investment is equal to the marginal cost, that is, $W'(\tau) = \xi\tau$, where the prime is for the first derivative.

The demand for training intensity by firms is obtained by maximising profits. The first order condition with respect to τ is $\left(1-\frac{1}{\theta}\right)A = W'(\tau) + \eta\tau$, where we have imposed the equilibrium condition that relative prices are equal to 1. Using the condition $W'(\tau) = \xi\tau$, we obtain that training is given by:

$$\tau = \left(1 - \frac{1}{\theta(\rho)}\right)\frac{A}{\xi+\eta} \qquad [12]$$

where θ is a negative function of entry costs per unit of output ρ. Proceeding as in Section 1.1 – that is, taking into account the entry condition, the first-order conditions with respect to employment and the symmetry of prices – we obtain that $\theta = (1/\rho) = (1/f(R))$, which when used in [12] yields:

$$\tau = \frac{A}{\xi+\eta}(1 - f(R)) \qquad [13]$$

The above equations indicate that, when workers invest in general skills, a deregulation of the product market which raises the number of firms and the elasticity of product demand θ generates higher training intensity because it increases the marginal benefits of training per worker $\left(1-\frac{1}{\theta(\rho)}\right)A$

accruing to firms and, therefore, the demand for better trained workers.[15] We conclude from this that Corollary 1 holds independently of the fact that training is specific or general.

2. The Empirical Model

In the empirical application, we investigate whether changes in regulation affect training, measured in our data as the proportion *TP* of workers receiving training during a defined period of time. This measure gives us an indication of the proportion of time an average worker spends being trained. If workers are homogeneous, the measure *TP* is proportional to the amount of training received by each worker, the variable used in the theoretical model. Equations [11] in the case of firm specific training and [13] in the case of general training generate a map from regulatory barriers to entry *R* to training intensity τ , and therefore *TP*, which we can estimate.

Our regulatory indicators vary by industry, country and over time. Therefore, we collapse our data on training and additional controls at the same level of aggregation and consider the following empirical counterpart of the theoretical model:

$$TP_{ipt} = \lambda_0 + \lambda_1 X_{ipt} + \lambda_2 Y_{ipt} + \varepsilon_{ipt} \qquad [14]$$

where X is a vector of controls, which includes average age, education and firm size, Y is the selected measure of regulation, the subscript i is for the industry, p is for the country and t is for time. The error term can be decomposed as $\varepsilon_{ipt} = \xi_{ip} + \xi_{it} + \xi_{pt} + \omega_{ipt}$, where ξ_{ip} is a country by industry effect, ξ_{it} is an industry by time effect, ξ_{pt} is a country by time effect, and ω_{ipt} is a standard disturbance. We control for these unobserved effects by including in the specification country by industry, country by year, and industry by year dummies. The country by industry dummies capture cross country differences in the structure of each industry, including differences in the parameters σ, δ and A; the industry by year effects capture the time varying differences in trend growth between industries; the country by year dummies absorb country-specific macroeconomic effects, country-wide changes in policy (notably training policy and nation-wide regulation, on which we have no data - see below) as well as changes in the routing of the questionnaire and/or the exact formulation of the training question. Our key interest lies in estimating the coefficient λ_2, which measures the relationship between product

[15] As in the previous subsection, this occurs because more training reduces relative prices and the sensitivity of output (and profits) to prices is greater, the greater the elasticity of product demand. Higher demand for training generates in turn higher wages for trained labour, and a higher supply of skills.

market regulation and training. A negative estimate of λ_2 would suggest that a negative relationship between regulation and training prevails, consistent with our theoretical model.[16]

The linear specification in [14] can be problematic when the dependent variable is fractional (see Wooldridge, 2001). Therefore, following Papke and Wooldridge (1996), we assume in an alternative specification that the conditional mean is an inverse logit function *G* of the independent variables and estimate the following transformed generalized linear model (GLM):

$$TP_{ipt} = G(\lambda_0 + \lambda_1 X_{ipt} + \lambda_2 Y_{ipt} + \xi_{ip} + \xi_{it} + \xi_{pt}) + \omega_{ipt} \quad [15]$$

using a quasi-maximum likelihood estimator (QMLE), where the quasi-likelihood function is the binary choice log likelihood.[17]

In estimating [14] or [15], we assume that regulation is exogenous, a standard assumption in the recent literature on competition and performance (see for example Alesina et al.,2005, Aghion et al.,2005, 2009, and Guadalupe, 2007). Nevertheless, one might argue that deregulation is more likely to occur where productivity growth or innovation are greater (see e.g. Duso and Röller, 2003). If these variables are also correlated with training, their exclusion from the regression may bias our estimates. To check whether this is a serious problem in our context, we add to some of our specifications of [14] and [15], as additional covariates, R&D intensity, productivity levels and growth and the investment rate. If these variables were correlated with regulation, we should obtain that the estimated effect of regulation on training is significantly altered. Yet we find that this is not the case, and conclude that the issue of endogeneity of regulation is likely to be of secondary importance in our empirical setup.[18]

Specifications [14] and [15] assume that, conditional on the vector *X*, product market regulation variables are the only institutional variables that can vary by country, year and sector, and that

[16] One might argue, however, that the training concept developed in the model corresponds to steady state training stocks, while we have specified our empirical model in terms of training flows. In a sensitivity analysis, we construct training stocks from training flows – by following the methodology suggested by Conti (2005) and Dearden et al. (2006) – and re-estimate our model obtaining similar results. The results are available from the authors upon request.

[17] Papke and Wooldridge (1996) show that QMLE estimators of this kind yield consistent estimates of equation [15] independently of any assumption on the error term, for which a robust variance estimator can be easily devised. In addition, in contrast to the more classical WLS estimation of a linear model with log-odds transformation of the dependent variable, the GLM specification does not require adjustment for boundary values (such as zeros) and can be estimated when fractional data are obtained by sample averages in samples of unknown size that cannot therefore be used to construct weights, as is our case.

[18] Another potential source of endogeneity is that firms anticipating policy reform can switch industry of activity. However, given the costs of switching sector, we believe that this source is of second order of relevance. Nevertheless, one could argue that the cost of switching industry is smaller for workers. Yet, this is unlikely to be of major concern for European countries where workers do not often separate from their employers and two-thirds of job-to-job transitions occur within the same industry, even if the latter is defined at the 2-digit level (see OECD, 2010). We also find that lagged values of regulation have a stronger impact on training than forward values, as one would expect in the absence of endogeneity (see Appendix C).

institutional confounding factors are fully accounted for by the combination of country by year, country by sector and sector by year dummies. While this is plausible, we cannot rule out the possibility that variables measuring labour market institutions at the same level of detail as regulation variables do affect training. If this is so, failure to account for these effects could erroneously attribute them to changes in product market regulation. Therefore, we also experiment with specifications that augment the vector X with available measures of labour market institutions.

The relationship between deregulation and training predicted by our model consists of two components: the effect of product market regulation on entry costs and the effect of entry costs on training. Equation [11] implies that training intensity τ and therefore *TP* are inversely related to entry costs. Since in the long-run equilibrium entry costs are equal to (net) real profits per unit of output, we can use a measure of profitability, such as the Lerner index *LE*, to proxy entry costs, and estimate the relationship between *LE* and *TP,* which is negative in our model. Insofar as training is used by firms to increase profits, profitability measures are clearly endogenous. However, to the extent that entry regulation can be assumed to be exogenous, as discussed above, we can use it as an instrument for the measure of profitability. In so doing, we break down in practice the relationship between regulation and training into the relationship between regulation and entry costs and the relationship between entry costs and training.

3. Data

We use three main sources of data: a) an OECD database on training and other labour market variables; b) OECD regulatory indicators for seven non-manufacturing industries (electricity, gas, air transport, road transport, railways, post and telecommunications); c) additional sector-level information on output, physical capital and other controls available in the OECD STAN Family databases and the companion 60-industry database of the Groningen Growth and Development Centre.

The OECD database on training is drawn from the EU Labour Force Surveys. It contains information on training and other labour market variables for employed workers in 23 European countries from 1995 to 2002 (with many missing values, corresponding to countries and years where questions on training were not administered or data on training are unreliable). Data have been collected in the second quarter of each year (March in most countries). Individual data are not available to us, but we have access to data aggregated into cells, where a cell corresponds to a combination of categories. Available cells cover all non-empty combinations with one category for each variable. Population weights (but not the effective number of individual observations) are available for each cell.

Training data refer to participation in any education or training course in the 4 weeks preceding the interview (1 week for France). Information on the type of training and its length is available but often missing. For this reason, we do not use it. In order to avoid that initial and close-to-retirement education confound the information on workplace training, we limit our analysis to full-time employees with at least 1 month of tenure, aged between 25 and 54 years, and working in their country of residence. We collapse our data on training and selected other labour market variables (education, age, gender and firm size) at the level of industries. Descriptive statistics as well as the list of industries are available in Appendix D.

We have access to detailed OECD indicators of anti-competitive product market regulation in seven 2 or 3-digit non-manufacturing industries. Data are available for 21 OECD countries on an annual basis. These indicators refer to industry-specific entry barriers, public ownership, the market share of the dominant player(s), vertical integration in network industries and price controls. They are obtained from sub-indicators of each specific policy, usually giving equal weight to each sub-policy.[19] For example, in the case of the electricity industry, the indicator of industry-specific entry barriers is the simple average of three sub-indicators concerning third-party access (free, regulated, no access), existence of a wholesale pool and minimum consumption threshold that consumers must exceed in order to be able to choose their electricity supplier. Available indicators vary between 0 and 6 from the least to the most regulated. For example, in the case of entry barriers, a value of 0 corresponds to free entry (defined as a situation with three or more competitors and with complete ownership separation of the natural monopoly, if any, and the competitive segment of the industry). By contrast, a value of 6 applies when entry is severely restricted (defined as a situation with legal monopoly and full vertical integration in network industries or restrictive licensing in other industries). All other indicators are similarly defined.

Following Alesina et al. (2005) we use the available information to construct time-series indicators of regulatory barriers for three aggregate industries (energy, transport, and communication services), for which training data are available. This method involves two steps. First, we take simple averages of separate indicators of barriers to entry, public ownership, market structure, vertical integration and price controls for each of the seven industries and obtain two coarser (and partially

[19] One issue with these indicators is the potential arbitrariness of the use of equal weights for different components of regulation. However, Woelfl et al. (2009) provide evidence that aggregated indicators are not sensitive to different reasonable choices of weights. Thoroughly disaggregated information contained in the OECD regulatory database and more details on the aggregation procedure followed by the OECD are available at http://www.oecd.org/document/1/0,3343,en_2649_34323_2367297_1_1_1_1,00.html .

alternative) indicators: BEVI, which summarizes barriers to entry (comprising legal restrictions and vertical integration) and REGNO, which includes all dimensions of regulation except public ownership. We expect both of them to be correlated with training insofar as the presence of price controls and the absence of barriers to concentration can, to a certain extent, be seen as additional barriers to start-ups. Second, REGNO and BEVI for the three most aggregated industries are obtained by simple averaging the values of the corresponding sub-industries.

One key issue is the extent to which the OECD indicators effectively capture regulatory barriers to competition. One would expect that if this is the case, they should be positively associated with mark-ups and negatively associated with entry and exit rates. Empirical evidence suggests that they are negatively associated with entry rates (Scarpetta et al., 2002). Furthermore, in the next section of this paper we provide evidence that a profitability measure such as the observed Lerner index tends to be greater when REGNO and BEVI are higher. Finally, these indicators have been found to capture well the extent of competition in several industry-specific studies (see, for example, Steiner, 2004, Azmat, Manning and van Reenen, 2007, and Fiorio and Florio, 2011).

Once the two indicators of regulation are matched to our training data, we obtain 309 country by industry by time non-missing observations, concerning three non-manufacturing industries for 15 European countries and a maximum of 8 years.[20] While these industries account for a small share of total employment, they were substantially deregulated during the period for which we undertake our empirical analysis, as shown by our regulation indicators, which slumped by almost 50%. Therefore, European energy, transport and communication industries provide an interesting and useful laboratory for the study of the relationship between deregulation and training.

In the event that reforms in these three industries have occurred almost simultaneously, the effect of the variation in regulation on training incidence risks to be swept away once country per year dummies are included in the empirical analysis. To circumvent this potential problem, we also add manufacturing industries to our dataset. For these industries, regulation concerns essentially administrative burdens as well as barriers to trade, at least in European countries. Now, only the last type of barriers can be considered to be industry-specific. But for them, due to the coming into action of the Single Market Programme (SMP) in 1992, it can be assumed that their time profile is flat since at least 1994 for the 12 countries that were EU members in 1992 (see e.g. Bottasso and Sembenelli,

[20] Since the exact month of each regulatory reform is not known and might well be subsequent to the second quarter of the corresponding year, each regulatory indicator is lagged one year.

2001).[21] The same argument can be applied to Austria, Finland, Norway and Sweden from 1995 (see e.g. Baldwin et al., 1996, and Gullstrand and Johansson, 2005). This is equivalent to assume that – since 1994 for the majority of countries and since 1995 for a few countries - regulation in manufacturing has been equal to an arbitrary constant, which we capture in the empirical analysis with country by industry dummies.[22] We end up with a sample composed of 15 countries and 12 industries for a maximum of 8 years for each country-industry pair, which contains 1236 observations once observations with missing information on training are excluded.

Turning to the Lerner index *LE,* this is defined as the difference between the value of output and total intermediate, labour and capital costs, normalised by the value of output. See Appendix D for data construction and sources. The other additional relevant covariates are mainly taken from the OECD STAN and related databases. Exact variable definitions, sources and sample statistics are provided in Appendix D. Since ELFS data are collected early in the calendar year, all non-ELFS data, which usually refer to yearly averages or unknown months, are lagged one year.

4. Empirical results

We start our analysis by examining the association between regulation and training participation at the industry level. Using the sample of manufacturing and non-manufacturing industries, we estimate linear specifications (eq. [14]) by OLS (Table 1, Panel A) and the corresponding GLM specifications (eq. [15]) by QMLE (Table 1, Panel B), with the dependent variable expressed in terms of training flows and using REGNO as the measure of regulation[23]. Each panel in the table is organized in five columns: the first column includes only the product market regulation indicator and (bi-dimensional) fixed effects, which appear in all the columns; column (2) also includes gender, education, the log worked hours gap and the import weighted real exchange rate;[24] column (3) adds age, firm size, and

[21] Bottasso and Sembenelli (2001) report that, on average, 75% of the measures implied by the SMP agreement were already transposed into national legal systems at the time when the SMP came into action, and that virtually all measures were transposed shortly after.

[22] To some extent, our empirical approach is equivalent to using a difference in difference estimator, where the three non - manufacturing industries are the treated group and manufacturing industries are the control group.

[23] Results based only on the sub-sample of non-manufacturing industries and estimates with BEVI instead of REGNO are reported in Appendix C. All the estimates presented in Table 1 are robust to the inclusion of productivity levels and growth and the investment rate. These additional covariates, however, are always statistically insignificant. See Appendix C for details.

[24] To control for sector-specific business cycles we construct log worked hours gaps by subtracting to hours the trend obtained using the Hodrick-Prescott filter with standard parameters. We also include a measure of import-weighted industry-specific exchange rates since one might expect that, particularly in certain manufacturing industries, globalisation is increasing the competitive pressure on businesses, particularly to improve product quality, independently of regulation.

employment growth;[25] column (4) the logarithm of R&D intensity; and column (5) labour market institutions. The impact of nation-wide labour market institutions, when homogeneous across industries, is controlled for by country per year dummies. However, certain labour market institutions might not have the same impact on training in all industries. In particular, union power might also vary along these three dimensions, and we capture it by including industry-specific union density. Moreover, the literature suggests that the impact of lay-off regulations on job turnover varies according to the natural propensity of industries to adjust their labour input (see e.g. Haltiwanger et al., 2006). Following this literature, we interact US industry-level job turnover rates (TURN) with the OECD aggregate indicator of employment protection legislation (EPL), so as to obtain an effect of EPL that varies by country, industry and time.[26]

We find that the association between regulation and training is always negative and statistically significant. Evaluating elasticities at the sample means in the exposed industries, we find that a 10% decrease in REGNO would increase training incidence by 2.8% to 5.0% percent – depending on the specification used.[27] These are economically significant effects.[28]

As regards controls, training incidence is significantly lower when the share of low educated individuals – with ISCED less than 3 – is higher, a standard result in the training literature (see Bassanini et al, 2007). Consistently with the finding of Sepulveda (2002) that on-the-job training is counter-cyclical in data from the US National Longitudinal Survey of Youth, we also find that training incidence is countercyclical. Furthermore, the import-weighted real exchange rate is negatively related to training in a (weakly) significant way, yielding some support to the idea that, for the tradeable sector, globalisation can have an additional effect on training independently of deregulation. There is also

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As short- and long-run effects of the exchange rate on trade usually differ, import-weighted real exchange rates are lagged one extra time. We also experimented with a 3-year moving average with virtually the same results.

[25] Employment growth controls for the fact that growing businesses are likely to have a greater propensity to train than downsizing businesses, for instance because of the higher expected length of the employment relationship.

[26] This interaction does not take into account that regulation for temporary workers affects industries differently depending on the extent to which the use of temporary workers is allowed in each industry, which varies across countries. In countries where no reform for this type of regulation was implemented during 1995-2002, this effect is controlled for by country-by-industry dummies. According to OECD (2004), however, significant reforms occurred in six countries (Germany, Greece, Ireland, Italy, Portugal and Spain). Therefore, we re-estimate our preferred specification (Table 1, Panel B, Column 2) by excluding simultaneously all these six countries and obtain a coefficient of product market regulation equal to -0.146, with standard error equal to 0.041. This estimate remains significant at the 1% level.

[27] If $E(y \mid x) = G(z)$, with $z = xb$, is the logistic specification, the marginal effect is $E(y \mid x) = \frac{\partial G}{\partial z} b$.

[28] Since there are only 15 countries in our sample, we check that our results are not driven by one specific country, by eliminating countries one by one and re-estimating our preferred specification (Table 1, Panel B, Column 2). Estimates of the effect of deregulation on training appear to be relatively stable and always significant at the 1% level. Our qualitative findings also hold when we limit our sample to non-manufacturing industries (see Appendix C).

some evidence that training incidence is higher in industries employing more women, a result in line with the literature as regards to Europe (see Bassanini et al., 2007 for a survey), and no evidence that age, the industry's firm size distribution and employment growth matter for training. When log R&D intensity is included to control for investment in intangibles, regulation remains significant, while log R&D intensity appear to attract a negative coefficient, although only weakly significant. Finally, union density is unrelated to training while EPL does not appear to have a significantly greater effect in high turnover industries.

Table 1. *Estimates of training as function of the index of product market regulation REGNO, which excludes public ownership.*

Panel A: Linear specification estimated by OLS

	(1)	(2)	(3)	(4)	(5)
Regulation, excluding public own. (REGNO)	-0.014 [3.24]***	-0.015 [3.29]***	-0.014 [3.00]***	-0.017 [3.47]***	-0.015 [3.29]***
Percentage with low education		-0.141 [3.11]***	-0.129 [2.73]***	-0.147 [3.06]***	-0.141 [3.10]***
Percentage with intermediate education		-0.065 [1.51]	-0.069 [1.37]	-0.073 [1.64]	-0.064 [1.48]
Percentage females		0.070 [1.82]*	0.068 [1.71]*	0.076 [1.82]*	0.075 [1.90]*
Import-weighted real exchange rate		-0.025 [1.02]	-0.021 [0.82]	-0.025 [1.03]	-0.025 [1.03]
Log worked hours gap		-0.207 [1.94]*	-0.268 [2.42]**	-0.213 [1.81]*	-0.208 [1.94]*
Percentage large firms			0.005 [0.29]		
Age			-0.000 [0.12]		
Employment growth			0.012 [0.41]		
Logarithm of R&D intensity				-0.004 [1.33]	
Union density					0.000 [0.55]
EPL times US job turnover					-0.007 [0.11]
Estimated elasticity of training wrt regulation	-0.472	-0.494	-0.490	-0.500	-0.492
Country by sector dummies	*yes*	*yes*	*yes*	*yes*	*yes*
Country by year dummies	*yes*	*yes*	*yes*	*yes*	*yes*
Sector by year dummies	*yes*	*yes*	*yes*	*yes*	*yes*
R squared	0.93	0.93	0.93	0.93	0.93
Bayesian Information Criterion (BIC)	-6335.9	-6213.5	-5932.5	-5148.1	-6199.3
Number of observations	1236	1224	1188	1061	1224

Table 1 (continued).
Panel B: GLM specification estimated by QMLE

	(1)	(2)	(3)	(4)	(5)
Regulation, excluding public own. (REGNO)	-0.141 [3.84]***	-0.161 [4.40]***	-0.175 [4.22]***	-0.151 [4.25]***	-0.167 [4.51]***
Percentage with low education		-2.005 [4.38]***	-1.938 [4.03]***	-2.045 [4.38]***	-1.988 [4.36]***
Percentage with intermediate education		-0.679 [1.93]*	-0.646 [1.76]*	-0.737 [2.12]*	-0.638 [1.80]*
Percentage females		0.737 [1.91]*	0.672 [1.71]*	0.643 [1.69]*	0.713 [1.84]*
Import-weighted real exchange rate		-0.275 [1.78]*	-0.263 [1.67]*	-0.382 [2.44]**	-0.276 [1.80]*
Log worked hours gap		-2.269 [2.13]***	-3.186 [2.79]***	-1.939 [1.85]*	-2.229 [2.09]**
Percentage large firms			0.203 [0.66]		
Age			0.012 [0.64]		
Employment growth			0.364 [0.95]		
Logarithm of R&D intensity				-0.069 [1.83]*	
Union density					0.001 [0.18]
EPL times US job turnover					-1.828 [1.57]
Estimated elasticity of training wrt regulation	-0.279	-0.316	-0.345	-0.319	-0.329
Country by sector dummies	*yes*	*yes*	*yes*	*yes*	*Yes*
Country by year dummies	*yes*	*yes*	*yes*	*yes*	*Yes*
Sector by year dummies	*yes*	*yes*	*yes*	*yes*	*Yes*
Pseudo R squared	0.17	0.17	0.17	0.15	0.17
Bayesian Information Criterion (BIC)	-6330.2	-6208.1	-5927.3	-5143.5	-6193.8
Number of observations	1236	1224	1188	1061	1224

Notes: Dependent variable: training participation rates. Elasticities are estimated at the sample means computed only for exposed industries. Robust t-or z-values within brackets. *, **, ***: significant at the 10%, 5% and 1% level, respectively.

An alternative to the direct estimation of the relationship between regulation and training is to estimate how training is affected by profitability, measured by the observed Lerner index, and to instrument the latter with a measure of product market regulation. The advantage of this approach is that it allows us to disentangle the effect of regulation on profitability from the effect of profitability on training. The disadvantages are greater measurement errors and the fact that profitability needs to be treated as endogenous in training regressions. We estimate the linear model by two-stage least squares and the GLM model with the control function approach suggested by Smith and Blundell (1986), using regulatory indicators as instruments. The latter approach consists of two steps: in the first step, we regress the Lerner index on regulation and other controls; in the second step, we augment the GLM specification with the residual from the first stage regression, and obtain confidence intervals by bootstrapping (see Efron, 1987). The results from this exercise are concisely presented in Table 2. As expected, we find that regulation has a statistically significant positive effect on the Lerner index, and that an increase in the Lerner index reduces training incidence.[29]

Table 2. *Estimates of training as function of the Lerner index, instrumented with REGNO. Dependent variable: training participation rates.*

Panel A: Linear model, 2SLS

	(1)	(2)	(3)	(4)	(5)
Lerner Index	-1.323 [1.90]*	-1.419 [2.00]**	-1.391 [1.82] *	-1.187 [2.27]**	-1.456 [1.92]*
Durbin-Wu-Hausman exogeneity test ($\chi^2(1)$)	23.75***	24.70***	27.86***	25.89***	27.64***
Coeff. of REGNO in the first-stage regression	0.013 [2.67]***	0.013 [2.71]***	0.013 [2.56]**	0.016 [3.20]***	0.013 [2.58]***
Elasticity of training to the Lerner Index	-1.613	-1.749	-1.744	-1.381	-1.789
Derivative of training wrt REGNO	-0.017	-0.018	-0.019	-0.019	-0.019
Elasticity of training wrt REGNO	-0.445	-0.486	-0.488	-0.497	-0.488
Country by sector dummies	*yes*	*yes*	*yes*	*yes*	*yes*
Country by year dummies	*yes*	*yes*	*yes*	*yes*	*yes*
Sector by year dummies	*yes*	*yes*	*yes*	*yes*	*yes*
Number of observations	1120	1108	1084	985	1108

Panel B: GLM, Two-step IV estimates

	(1)	(2)	(3)	(4)	(5)
Lerner Index	-11.08** [-69.09,-0.05]	-12.44** [-71.03,-0.87]	-13.62* [-130.0,0.04]	-9.36** [-44.74,-0.96]	-13.59** [-87.96,-1.41]
Residual first stage	11.41* [-0.48,66.48]	12.49** [0.59,69.65]	13.64* [-0.56,130.0]	9.14** [0.56,38.04]	13.68** [1.45,89.30]
Coeff. of REGNO in the first-stage regression	0.013** [0.008, 0.017]	0.013** [0.008, 0.017]	0.013** [0.008, 0.018]	0.016** [0.011, 0.021]	0.013** [0.008, 0.018]
Elasticity of training to the Lerner Index	-0.651	-0.795	-0.729	-0.589	-0.795
Elasticity of training wrt REGNO	-0.289	-0.359	-0.329	-0.317	-0.350
Country by sector dummies	*yes*	*yes*	*yes*	*yes*	*yes*
Country by year dummies	*yes*	*yes*	*yes*	*yes*	*yes*
Sector by year dummies	*yes*	*yes*	*yes*	*yes*	*yes*
Number of observations	1120	1108	1084	985	1108

Notes: Dependent variable: training participation rates. No additional controls are included in Column 1. Controls in Columns 2-5 are as in the corresponding columns of Table 1. Elasticities with respect to the Lerner index are estimated at the global sample mean; elasticities with respect to regulation, excluding public ownership (REGNO), are estimated at sample means computed only for exposed industries. Robust t-values within brackets in Panel A. Bias-corrected bootstrapped confidence intervals at the 5% statistical level, obtained with 1000 replications, within brackets in Panel B. In Panel A: *, ** and *** means significant at the 10%, 5% and 1% level, respectively. In Panel B, * and ** means that the bias-corrected bootstrapped confidence intervals at the 10% and 5% confidence level, respectively, do not include 0.

[29] In addition, the statistical significance of the first stage residuals in the second stage regression (for the non-linear model) and the exogeneity tests (for the linear model) suggest that the Lerner index is endogenous.

In our preferred specification, we find that a 1% increase in profitability reduces training by about 0.8% percent, a large effect. Yet, in assessing the economic importance of this effect, one needs to take into account that the cross-country/cross-industry average range of percentage variation of the Lerner index over the sample period is about 7%, while regulatory indicators have varied in our sample by much more (almost 50% on average in the exposed industries). Interestingly, the estimated compounded effect of a deregulation – that is the derived estimated effect of deregulation on training via the effect of the former on the Lerner index – is very close to the estimate we obtain from reduced-form models.

Conclusions

Does product market deregulation affect workplace training, and if yes, in what direction? This paper has addressed this question both from an empirical and from a theoretical viewpoint. In our empirical analysis we have used repeated cross section data extracted from the European Labour Force Survey, and a sample of 15 European countries and 12 industrial sectors, which we have followed for about 8 years. We have shown that the massive regulatory reforms undergone by European countries in certain service and utility industries, as quantified by changes in the OECD indicators of regulatory barriers, have raised competition, which, in turn, has increased investment in workplace training.

Our empirical results are robust to several sensitivity exercises. They highlight that an important link in the relationship between deregulation and productivity growth is the investment in human capital which takes place in firms. Our preferred estimate suggests that a 10% reduction in the indicator of product market regulation is associated with a 3.2% increase in training incidence. Assuming an elasticity of productivity to training of 0.1, as suggested by the literature for Europe (see OECD, 2007), this translates into an impact on productivity growth of about 0.3 percentage points in the affected industries (energy, transport and communication). Whether these quantitative effects can be extended to a broader set of industries is an open question that cannot be answered with the data at hand. Needless to say, this is left to future research and to better data.

In order to provide an explanation for our findings, which seem to be at odd with the standard view in labour economics, we have built a theoretical model of workplace training with imperfect competition in the product and labour market and ex-ante homogeneous firms, that is sufficiently general to allow for both general and specific training and for wages being either set by bargaining or determined by the interaction between supply and demand.

We have identified two contrasting effects at work: on the one hand, a reduction in the barriers to entry for a given number of firms compresses profits per unit of output, and thereby reduces training. On the other hand, and conditional on profits per unit of output, additional entry increases the output (and profit) gains from training, which facilitates investment. These output gains occur because additional training reduces the relative product price and the sensitivity of product demand to prices is larger, the greater the degree of competition in the product market. We have shown that the balance of these effects implies that a deregulation increases training.

Although we believe that the mechanism suggested by our theoretical model is a key determinant of the observed empirical patterns, we do not claim that this model provides the only possible explanation. For example, if firms are heterogeneous, a negative relationship between the degree of stringency of anti-competitive regulation and training can also emerge through alternative routes. In fact, if more efficient firms have also lower training costs and train more, one can expect that increasing competition will increase the market share of these firms and therefore average training.[30] To disentangle the market-share story from ours, one would need sufficiently rich firm-level panel data that include information on training and enough regulatory variation. Unfortunately, firm-level panel data on training are scarce and we are unaware of a dataset with the above-mentioned characteristics. Clearly, this issue must be left to future research.

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[30] Still, an extension of our model predicts that, even in the case of heterogeneous firms, greater competition increases each firm's training provided that it reduces average prices (see Appendix B), as suggested by the empirical evidence (see Section 1.1, footnote 7).

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Appendix A: Proof of Proposition 2

We start by establishing

Lemma A2.1. Consider the commitment equilibrium where each firm sets τ and T in the first stage:

$$\tau = \frac{A}{\mu}(1-\delta)\frac{\theta-1}{\theta} \quad [A.1]$$

$$T = \frac{Y}{mA(1+\tau)} \quad [A.2]$$

in the expectation that ex-post employment L will be equal to the number of hired trainees T. In the absence of commitment, the employer and workers of an arbitrarily-chosen firm i cannot increase the value of the Nash maximand by choosing unilaterally $L_i < T$, if the bargaining parties of all other firms set $L = T$ in the second stage.

Proof. In this combination of strategies, the symmetry of prices ($P_i = P$) implies that (see equation [4])

$$\frac{V}{P} = \frac{\theta-1}{\theta}A(1+\tau) - \frac{\mu\tau^2}{2(1-\delta)} \quad [A.3]$$

In the absence of commitment and with ex-post bargaining over employment, we ask whether it would be profitable for a single bargaining pair, consisting of the employer and her workers, to set $L_i < T$, in contrast with first stage expectations. Unconstrained maximisation of the Nash maximand [1] yield equation [2] and

$$\frac{P_i}{P} = \frac{\theta}{\theta-1}\frac{V}{PA(1+\tau)} \quad [A.4]$$

Using [A.3] into [A.4] and rearranging gives

$$\frac{P_i}{P} = 1 - \frac{\tau}{2(1+\tau)} \quad [A.5]$$

The product demand schedule and the production technology imply that ex-post employment is given by

$$L_i = \frac{Y}{mA(1+\tau)}\left(1 - \frac{\tau}{2(1+\tau)}\right)^{-\theta} > T \quad [A.6]$$

Since $L_i < T$ is not chosen and $L_i > T$ is not feasible, because training in the second period is ruled out, the only feasible solution is $L_i = T$, in line with first-stage expectations. QED.

Next we establish

Lemma A2.2. Consider the first stage strategies of an employer *i*, who chooses training intensity τ_i and the number of trainees T_i, and assume that, in the absence of commitment, wages W_i and employment L_i are bargained over in the second stage to maximise the Nash maximand. Then, for any combination of strategies chosen by other firms and workers, an accommodating strategy, which consists in choosing T_i such that $L_i \leq T_i$ is not binding in the second stage, is less profitable than a non accommodating strategy, which selects a value of T_i low enough that in the second stage the equality $L_i = T_i$ holds.

Proof. Suppose that the firm chooses in the first stage a training intensity τ_i and a number of trainees T_i sufficiently large that, given τ_i, the constraint $L_i \leq T_i$ is not binding in the second stage. In the second stage, employment will be set by bargaining at:

$$L_i = \frac{Y}{mA(1+\tau_i)}\left(\frac{P_i}{P}\right)^{-\theta} \qquad \text{[A.7]}$$

where P_i / P is given by [A.4], except that τ must be replaced with τ_i. There can be two cases: either $T_i = L_i$ or $T_i > L_i$. Since the employer can anticipate the result of the bargaining, her net profits will be always higher if she sets $T_i = L_i$, where L_i is defined as in [A.7]. With no loss of generality we can therefore concentrate on this type of strategy (call it "A-strategy" hereafter, with A standing for accommodating, since with this strategy the firm accommodates the employment resulting from the unconstrained bargaining).

Consider now an alternative strategy in which the firm chooses in the first stage the same τ_i but a lower value of T_i, denoted with T_i^*:

$$T_i^* = \frac{Y}{mA(1+\tau_i)}\left(\frac{P_i}{P} + \frac{\theta}{(1-\theta)(1-\delta)}\frac{\mu\tau_i^2}{2A(1+\tau_i)}\right)^{-\theta} < L_i = T_i$$

where $\frac{P_i^*}{P} = \frac{P_i}{P} + \frac{\theta}{(1-\theta)(1-\delta)}\frac{\mu\tau_i^2}{2A(1+\tau_i)}$ and the star * indicates the new strategy (called "S-strategy", hereafter, where S stands for "low", since it implies a smaller number of trainees). Since $T_i^* < L_i$ and L_i is the result of the unconstrained maximisation of the Nash maximand given τ_i, the S-strategy implies that the employment constraint $L_i^* = T_i^*$ is binding in the second-stage.

Net profits in the A-strategy are given by:

$$\Pi_A = \left\{ (1-\delta)\frac{P_i}{P} - (1-\delta)\frac{V}{PA(1+\tau_i)} - \frac{\mu\tau_i^{\ 2}}{2A(1+\tau_i)} \right\} \frac{Y}{m} \left(\frac{P_i}{P} \right)^{-\theta} \qquad \text{[A.8]}$$

and in the S-strategy they are equal to

$$\Pi_S = \left\{ (1-\delta)\frac{P_i^*}{P} - (1-\delta)\frac{V}{PA(1+\tau_i)} - \frac{\mu\tau_i^{\ 2}}{2A(1+\tau_i)} \right\} \frac{Y}{m} \left(\frac{P_i^*}{P} \right)^{-\theta} \qquad \text{[A.9]}$$

The right-hand side terms of equations [A.8] and [A.9] are identical, except for the value of relative prices. Therefore, the function

$$\Pi(p) = \left[(1-\delta)p - (1-\delta)\frac{V}{PA(1+\tau_i)} - \frac{\mu\tau_i^{\ 2}}{2A(1+\tau_i)} \right] \frac{Y}{m} p^{-\theta}$$

will be such that $\Pi(p) = \Pi_A$, when $p = P_i / P$, and $\Pi(p) = \Pi_S$ when $p = P_i^* / P$. Define $p_{\max} = \arg\max_p \{\Pi(p)\}$. The first-order conditions for a maximum imply

$$(1-\delta)(1-\theta)p_{\max} + \theta \left[(1-\delta)\frac{V}{PA(1+\tau_i)} + \frac{\mu\tau_i^{\ 2}}{2A(1+\tau_i)} \right] = 0$$

while the second-order condition is always verified since $\partial^2\Pi / \partial p^2 = (1-\delta)(1-\theta) < 0$. Using [A.4] and some simple manipulations we obtain:

$$p_{\max} = \frac{P_i^*}{P} = \frac{P_i}{P} + \frac{\theta}{(1-\theta)(1-\delta)} \frac{\mu\tau_i^2}{2A(1+\tau_i)} > \frac{P_i}{P}$$

Therefore $\Pi_S > \Pi_A$, which implies that the A-strategy is dominated by the S-strategy. QED.

We are now ready to prove Proposition 2. Consider the commitment equilibrium where each firm sets τ and T in the first stage as in equations [A.1] and [A.2] and in the second stage the bargaining parties set W according to equation [2] and $L = T$. In order to show that this is an equilibrium we need to show that no agent can deviate unilaterally from it and earn a greater pay-off if the others do not deviate. From Lemma A2.1, it follows immediately that no bargaining party can deviate unilaterally in the second stage and earn a greater pay-off by choosing $L \neq T$ in the second stage. Then, consider first-stage deviating strategies $(\tau_i^{\ *}, T_i^*)$. Let us call again A-strategy any strategy such that the constraint $L_i \leq T_i^*$ is not binding in the second stage (as above A for "accommodating"). Similarly, let us call NA-strategies, first-stage strategies such that $L_i \leq T_i^*$ is binding in the second stage (NA for "non accommodating"). Lemma A2.2 shows that for any A-strategy there exists at least one NA-strategy (the corresponding S-strategy) that yields higher profits. Therefore, if there existed a deviating

A-strategy that is profit-improving with respect to the equilibrium, there would also be a deviating NA-strategy that is profit-improving. But, by construction, the commitment equilibrium consists of the combination of NA-strategies that yields the highest profit among all NA-strategies, which excludes the possibility of profit-improving NA-strategies. Therefore there cannot exist profit-improving *A* strategies. As first-stage strategies are either A-strategies or NA-strategies, there are no deviations in the first-stage that yield higher profits.

It remains to prove that the equilibrium is unique. Lemma A2.2 shows that strategies A are dominated, therefore no equilibrium can contain all or a fraction of firms playing A-strategies. But subsection 1.1.1 has already shown that there cannot be any other equilibrium in which all firms in the first stage play NA-strategies, except the commitment equilibrium, which is therefore unique. QED

Appendix B: Extensions

B.1. Right-to-manage model

In a right-to-manage model of the labour market, firms retain the potential right to set employment in a third stage after the bargaining. This has clearly no consequences in the commitment case, since the bargaining is already confined to wages only and no additional trainee can be hired after the bargaining. Therefore, Proposition 1 holds. Using the same steps as in Appendix A for the proof of Proposition 2, it can be shown that, even if the firm can set employment in the third stage, it will never employ fewer workers than it trains and the constraint that employment cannot be larger than the number of trainees (hired in the first stage) is binding, insofar as training costs are bygones in the third stage. Therefore, both Proposition 2 and Corollary 1 hold.

B.2. The equilibrium when unskilled workers can be hired after the bargaining

In our model, if untrained employees U can be hired in the final stage, production in the last stage is equal to $Y_i = A((1+\tau_i)L_i + U_i)$, where L is employment of trained workers. With commitment on trained workers, this is equal to $Y_i = A((1+\tau_i)T_i + U_i)$. Given that newly-hired unskilled workers have no hold-up power, we assume that unskilled workers have no bargaining power and are paid their reservation wage.[31] Let us call CNU (Commitment No Unskilled) strategies the strategies played by firms in the commitment equilibrium of Section 1.1 with no unskilled workers. We show that these strategies are deviation-proof. Hence, their combination is also an equilibrium in this extended set-up. It seems natural that skilled workers bargain on wages and not on the number of unskilled workers who are hired in the final stage, which would then be set by the firm as in a right-to-manage model. Therefore, we only consider this case, although we can show that results hold also in the case where the number of untrained workers is set by bargaining (proof available from authors upon request).

[31] This is consistent with evidence provided by Cahuc et al. (2006).

In practice, the model in Section 1.1 assumes that $U_i = 0$. Once we allow firms to hire a non-negative amount of unskilled workers in the final stage, this constraint is relaxed and becomes a simple feasibility constraint $U_i \geq 0$. Since we have shown in Section 1.1 that a CNU strategy is the optimal response within the set of strategies with $U_i = 0$, it must be that payoff-improving deviations from the commitment equilibrium are such that $U_i > 0$. We show that this is impossible in each stage of the game.

Final stage. Consider as a deviation a strategy that has τ_i and T_i as in the CNU strategy but with $U_i > 0$. As all other firms play CNU, it follows from equation [6] and [7] and some manipulations that:

$$\frac{V}{P} = \frac{A^2}{2\mu}(1-\delta)\left(\frac{\theta-1}{\theta}\right)^2 + A\left(\frac{\theta-1}{\theta}\right) \qquad [B.1]$$

The firm chooses *U* in order to maximise ex-post profits. Given that, if a payoff-improving deviation exists, it must be such that $U_i > 0$, first-order conditions must imply:

$$\frac{\partial \Pi_i}{\partial U_i} = \left(1-\frac{1}{\theta}\right)\left(\frac{m}{Y}\right)^{-\frac{1}{\theta}} A^{1-\frac{1}{\theta}}((1+\tau_i)T_i + U_i)^{-\frac{1}{\theta}} - \frac{V}{P} = 0$$

Setting $K = \left(1-\frac{1}{\theta}\right)\left(\frac{m}{Y}\right)^{-\frac{1}{\theta}} A^{-\frac{1}{\theta}}$, we obtain after few manipulations:

$$U_i = \left(\frac{V}{AKP}\right)^{-\theta} - (1+\tau_i)T_i \qquad [B.2]$$

and

$$\frac{P_i}{P} = \left(\frac{m}{Y}\right)^{-\frac{1}{\theta}}\left(\frac{Y_i}{A}\right)^{-\frac{1}{\theta}} A^{-\frac{1}{\theta}} = \frac{\theta}{\theta-1}\frac{1}{A}\frac{V}{P} \qquad [B.3]$$

Plugging [B.1] into [B.3] yields

$$\frac{P_i}{P} = \frac{A}{2\mu}(1-\delta)\left(\frac{\theta-1}{\theta}\right) + 1 > 1.$$

Since all other firms play the CNU strategy, if the firm also plays the CNU strategy, we will have $P_i / P = 1$. This means that if τ_i and T_i are set as in the CNU strategy, with commitment on trained workers, $P_i / P = 1$ if $U_i = 0$. Thus, the only way for firm *i* to reduce output in order to obtain $P_i / P > 1$ is to reduce U_i below zero, which is impossible given that $U_i \geq 0$. Therefore no payoff-improving deviation can occur in the final stage.

Bargaining stage. The proof given above concerning a possible deviation in the final stage is independent of the value of W_i chosen in the bargaining stage, provided that τ_i and T_i are chosen as in the CNU strategy. As a consequence any deviation at the bargaining stage that does not lead to $U_i = 0$ as the optimal response of firms in the final stage is not possible. Since we have shown that setting W_i as in the commitment equilibrium is the best response when τ_i and T_i are as in the CNU strategy and $U_i = 0$, it follows that no payoff-improving deviation is possible at this stage.

First stage. Recall that we are looking for deviations such that $U_i > 0$ in the final stage. This implies that [B.2] holds. Taking this into account, maximisation of the Nash maximand with respect to wages yields:

$$\frac{W_i}{P} = \frac{V}{P}\left[1 + \frac{1}{T_i}\left(\frac{\theta}{\theta - 1} - 1\right)\left(\frac{V}{AKP}\right)^{-\theta} + (1 + \tau_i)\right] \qquad \text{[B.4]}$$

Plugging [B.2] and [B.4] into ex-ante profits we obtain, after few manipulations:

$$\Pi_i = (1 - \delta)\frac{V}{P}\left[\left(\frac{\theta}{\theta - 1} - 1\right)\left(\frac{V}{AKP}\right)^{-\theta} + \tau_i T_i\right] - \frac{\mu\tau_i^2}{2}T_i \qquad \text{[B.5]}$$

First-order conditions with respect to τ_i yields:

$$\tau_i = \frac{1 - \delta}{\mu}\frac{V}{P} \qquad \text{[B.6]}$$

The partial derivative of [B.5] with respect to T_i yields:

$$\frac{\partial \Pi_i}{\partial T_i} = (1 - \delta)\frac{V}{P}\tau_i - \frac{\mu\tau_i^2}{2} \qquad \text{[B.7]}$$

which, taking into account [B.1] and [B.6], yields:

$$\frac{\partial \Pi_i}{\partial T_i} = \frac{(1 - \delta)^2}{2\mu}\left[\frac{A^2}{2\mu}(1 - \delta)\left(\frac{\theta - 1}{\theta}\right)^2 + A\left(\frac{\theta - 1}{\theta}\right)\right]^2 > 0$$

This implies that the firm would always prefer the largest possible value of T_i. But, because of [B.2], this would imply $U_i \le 0$. Therefore no payoff-improving deviation with $U_i > 0$ can occur in the final stage.

In the same way as in Appendix A it can be shown that this result also holds in the no-commitment case: since training expenditure is bygone in the final stage, in that stage players desire more trainees than those trained in the first period. Finally, using the same equations as above, it can be shown that no alternative equilibrium with $U_i > 0$ for at least one firm can exist. Indeed, if $U_i > 0$ one can show that maximising ex-ante profits with respect to τ_i leads to [B.6] and the partial derivative of ex-ante profits with respect to T_i yields

[B.7]. Moreover, [B.3] implies that $V/P > 0$ for $\theta > 1$. Plugging [B.6] into [B.7] one obtains:

$$\frac{\partial \Pi_i}{\partial T_i} = \frac{(1-\delta)^2}{2\mu}\left[\frac{V}{P}\right]^2$$

which is positive. Again this result implies that the firm would always prefer the largest possible value of T_i, which would imply $U_i \leq 0$. Therefore no alternative equilibrium with $U_i > 0$ can occur in the final stage.

B.3. The equilibrium when a single firm can affect average demand

In this subsection we illustrate the implications of assuming that each firm in our model is large enough with respect to the market to be able to affect aggregate variables *P*, *Y* and *V/P*. We start by assuming that aggregate output *Y* is a linear function of real money balances, as in Blanchard and Kiyotaki (1987), that is $Y = aM/P$, where *M* is the money stock, and by positing that the real reservation wage *V/P* is a linear function of real output, that is $V/P = bY$. When a firm is large relative to the market, its price decisions affect aggregate output and prices. Aggregate prices in our setup are given by[32]

$$P = \left(\frac{1}{m}\sum_m P_i^{1-\theta}\right)^{\frac{1}{1-\theta}}$$

Therefore, the elasticity of the aggregate price to the individual price is

$$\frac{\partial \ln P}{\partial \ln P_i} = \frac{1}{m}\frac{P_i^{1-\theta}}{\frac{1}{m}\sum_m P_i^{1-\theta}} = \phi$$

The effect of individual prices on aggregate output is $\frac{\partial Y}{\partial P_i} = \frac{\partial Y}{\partial P}\frac{\partial P}{\partial P_i}$. Since $\frac{\partial Y}{\partial Y_i} = \frac{\partial Y}{\partial P_i}\frac{\partial P_i}{\partial Y_i}$, we also have that $\frac{\partial Y}{\partial Y_i} = \frac{\partial Y}{\partial P}\frac{\partial P}{\partial P_i}\frac{\partial P_i}{\partial Y_i}$. Similarly, $\frac{\partial V/P}{\partial Y_i} = \frac{\partial V/P}{\partial P}\frac{\partial P}{\partial P_i}\frac{\partial P_i}{\partial Y_i}$. Define as $\eta_Y = \frac{\partial \ln Y}{\partial \ln P}\frac{\partial \ln P}{\partial \ln P_i}\frac{\partial \ln P_i}{\partial \ln Y_i} = -\frac{\partial \ln P}{\partial \ln P_i}\frac{\partial \ln P_i}{\partial \ln Y_i}$, the aggregate output elasticity with respect to individual output. It follows that $\eta_{\frac{V}{P}} = \eta_Y$. The demand curve of the individual firm implies that $\partial \ln Y_i = -\theta\partial \ln P_i + (\theta - 1)\partial \ln P$, which yields $\frac{\partial \ln Y_i}{\partial \ln P_i} = -\theta + (\theta-1)\phi$. Then $\eta_Y = \eta_{\frac{V}{P}} = \frac{\phi}{\theta - (\theta-1)\phi}$. Notice that this elasticity is equal to zero when firms ignore the effect of their own price on the average price ($\phi = 0$). Next consider the ex-ante profits of each single firm:

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[32] See Blanchard and Giavazzi (2003).

$$\Pi_i = (1-\delta)m^{-\frac{1}{\theta}} Y^{\frac{1}{\theta}} Y_i^{1-\frac{1}{\theta}} - (1-\delta)bYT_i - \frac{\mu\tau_i^2}{2} T_i$$

When a firm decides the optimal number of trainees, it considers also the fact that aggregate output and the real reservation wage depend on individual output. Therefore, the first order conditions with respect to T and τ are given by

$$(1-\delta)(1-1/\theta)m^{-\frac{1}{\theta}} Y^{\frac{1}{\theta}} Y_i^{-\frac{1}{\theta}} + (1-\delta)(1/\theta)m^{-\frac{1}{\theta}} Y^{\frac{1}{\theta}-1} Y_i^{1-\frac{1}{\theta}} \frac{\partial Y}{\partial Y_i} - (1-\delta)bT_i \frac{\partial Y}{\partial Y_i}$$

$$= (1-\delta)\frac{V}{PA(1+\tau_i)} + \frac{\mu\tau_i^2}{2A(1+\tau_i)}$$

and

$$(1-\delta)(1-1/\theta)m^{-\frac{1}{\theta}} Y^{\frac{1}{\theta}} Y_i^{-\frac{1}{\theta}} + (1-\delta)(1/\theta)m^{-\frac{1}{\theta}} Y^{\frac{1}{\theta}-1} Y_i^{1-\frac{1}{\theta}} \frac{\partial Y}{\partial Y_i} - (1-\delta)bT_i \frac{\partial Y}{\partial Y_i} = \frac{\mu\tau_i}{A}$$

These conditions can be written as

$$\frac{(1-\delta)}{\theta}\frac{P_i}{P}\left[(\theta-1)+\eta_Y\right] = (1-\delta)\frac{1}{A(1+\tau_i)}\frac{V}{P}\eta_Y + (1-\delta)\frac{V}{PA(1+\tau_i)} + \frac{\mu\tau_i^2}{2A(1+\tau_i)}$$

$$\frac{(1-\delta)}{\theta}\frac{P_i}{P}\left[(\theta-1)+\eta_Y\right] = (1-\delta)\frac{1}{A(1+\tau_i)}\frac{V}{P}\eta_Y + \frac{\mu\tau_i}{A} \qquad \text{[B.8]}$$

Following the same reasoning as in Section 1.1, we can show that the equilibrium is symmetric. With symmetry we obtain that optimal training intensity is

$$\tau = \frac{(1-\delta)}{\theta}\frac{A}{\mu}\left[(\theta-1)+\eta_Y\right] - \frac{(1-\delta)}{\mu(1+\tau)}\frac{V}{P}\eta_Y \qquad \text{[B.9]}$$

which corresponds to [7] when $\eta_Y = 0$. From [3] and [B.8], profits per unit of output are given by

$$\pi = \frac{(1-\delta)}{\theta}\left[1-\eta_Y\right] + (1-\delta)\frac{1}{A(1+\tau)}\frac{V}{P}\eta_Y = \rho \qquad \text{[B.10]}$$

Using [B.10] in [B.9] and rearranging yields

$$\tau = \frac{A}{\mu}\left[1-\delta-\rho\right]$$

which corresponds to Eq. [11]. We conclude that allowing for the possibility that individual firms affect average prices does not change the key conclusions of the model.

B.4. The case of heterogeneous workers

In this subsection we extend our model by allowing that workers can differ in their skills. There are two types of worker, H (high education) and U (low education). H workers are more productive and are also less costly to train than U workers. While the marginal cost of training an H worker is finite and equal to $\mu\frac{\tau^2}{2}$, where τ is training intensity, the cost of training a U worker is infinite. This is clearly extreme but simplifies the algebra considerably and is not inconsistent with our empirical results.[33] There is commitment on the employment of H workers, who are hired before the wage bargain. U workers are not trainable and are hired in the last stage of the game. Training is firm specific and the (nominal) reservation wage is V_H for H workers and V_L for U workers. In particular, $V_H = (1+\lambda)V_L$ and $\lambda \geq 0$: we allow for the possibility that educated workers, who are more productive than less educated workers, have a higher reservation wage. The production technology is

$$Y_i = A\left[(1+\tau_i)T_i\right]^{\beta} U_i^{1-\beta} \qquad \text{[B.11]}$$

where $\beta > 1/2$ and T is the number of trained H workers. In the last stage of the game, the employer chooses U to maximise profits $\Pi_i = \frac{P_i}{P}Y_i - \frac{W_i}{P}T_i - \frac{V_L}{P}U_i$, which yields

$$U_i = \left(1-\frac{1}{\theta}\right)\frac{P_i}{P}(1-\beta)\frac{Y_i}{V_L/P} \qquad \text{[B.12]}$$

Replacing [B.12] in [B.11] we obtain

$$\Pi_i = \frac{P_i}{P}Y_i\left[1-(1-\beta)\left(1-\frac{1}{\theta}\right)\right] - \frac{W_i}{P}T_i \qquad \text{[B.13]}$$

Next consider the wage bargain. The standard Nash solution is

$$T_i\frac{W_i}{P} = \frac{V_S}{P}(1-\delta)T_i + \delta\frac{P_i}{P}Y_i\left[1-(1-\beta)\left(1-\frac{1}{\theta}\right)\right] \qquad \text{[B.14]}$$

Use [B.14] in ex-ante profits to obtain

$$\Pi_i^e = (1-\delta)\frac{P_i}{P}Y_i\left[1-(1-\beta)\left(1-\frac{1}{\theta}\right)\right] - \frac{V_S}{P}(1-\delta)T_i - \frac{\mu\tau_i^2}{2}T_i \qquad \text{[B.15]}$$

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[33] Taken at face value, estimates in Table 1 predict that the training participation rate would fall to 0 if the share of the low-educated increases from the sample average (0.37) to 1.

In the first stage, profit maximization with respect to T and τ yields

$$\beta\left[1-(1-\beta)\left(1-\frac{1}{\theta}\right)\right](1-\delta)\left(1-\frac{1}{\theta}\right)\frac{P_i}{P}\frac{Y_i}{T_i}=\frac{V_S}{P}(1-\delta)+\frac{\mu\tau_i^2}{2} \qquad [B.16]$$

$$\beta\left[1-(1-\beta)\left(1-\frac{1}{\theta}\right)\right](1-\delta)\left(1-\frac{1}{\theta}\right)\frac{P_i}{P}\frac{Y_i}{1+\tau_i}=\mu\tau_i T_i \qquad [B.17]$$

By combining [B.16] and [B.17] we obtain

$$\frac{\mu\tau_i^2}{2}+\mu\tau_i=\frac{V_S}{P}(1-\delta)=\frac{V_L}{P}(1-\delta)(1+\lambda) \qquad [B.18]$$

As in Section 1.1, it is straightforward to prove that the equilibrium is symmetric. Symmetry and some rearrangement yields

$$Y=A^{\frac{1}{\beta}}(1+\tau)T\left(1-\frac{1}{\theta}\right)^{\frac{1-\beta}{\beta}}(1-\beta)^{\frac{1-\beta}{\beta}}\frac{V_L}{P}^{\frac{\beta-1}{\beta}}$$

Using this into [B.17] and [B.18] to eliminate the reservation wage yields

$$(\mu\tau)(1+\frac{\tau}{2})^{1-\beta}=F(\tau)=A\left(1-\frac{1}{\theta}\right)(1+\lambda)^{1-\beta}\beta^{\beta}(1-\beta)^{1-\beta}\left[1-(1-\beta)\left(1-\frac{1}{\theta}\right)\right]^{\beta}(1-\delta)$$

Let $(1+\lambda)^{1-\beta}\beta^{\beta}(1-\beta)^{1-\beta}(1-\delta)A=\Phi$, and $F(\tau)=(\mu\tau)(1+\frac{\tau}{2})^{1-\beta}$. Then

$$F(\tau)=\left(1-\frac{1}{\theta}\right)\Phi\left[1-(1-\beta)\left(1-\frac{1}{\theta}\right)\right]^{\beta}=\Lambda(\theta)$$

We are interested in the sign of $\frac{\partial\tau}{\partial\theta}=\frac{\Lambda'(\theta)}{F'(\tau)}$. We know that $F'(\tau)>0$. Furthermore we have that

$$\Lambda'(\theta)=\Phi\left[1-(1-\beta)\left(1-\frac{1}{\theta}\right)\right]^{\beta-1}\frac{1}{\theta^2}\left[1-(1-\beta^2)\left(1-\frac{1}{\theta}\right)\right]>0$$

Hence $\frac{\partial\tau}{\partial\theta}>0$. From [B.15] and [B.16] we have that

$$\pi=(1-\delta)\left[1-(1-\beta)\left(1-\frac{1}{\theta}\right)\right]\left[1-\beta\left(1-\frac{1}{\theta}\right)\right]=\rho$$

which implies $\frac{\partial\theta}{\partial\rho}<0$ and $\frac{\partial\tau}{\partial\rho}=\frac{\partial\tau}{\partial\theta}\frac{\partial\theta}{\partial\rho}<0$. Therefore, in this model, as in the model with homogeneous workers, training intensity increases with the number of firms (and deregulation), in spite of the fact that workers are heterogeneous.

From an empirical viewpoint, using the same argument as in Section 2 we can argue that τ is proportional to training participation for H workers. However, it is not proportional to training participation for all workers, which is the measure used in the empirical analysis. To the extent that the model predicts that U workers do not receive training, training participation of all workers will be proportional to $\tau \frac{T}{T+U}$, the product of training intensity by the share of H workers in total employment. Two remarks follows from this observation. First, define $\frac{T}{T+U} = \frac{1}{1+z}$. Then the model predicts that $\frac{\tau}{1+z}$ is increasing in θ if $\eta_\tau > \eta_z \frac{z}{1+z}$, where η_τ and η_z are the elasticities of training intensity and z with respect to θ. After some manipulation, we derive the following sufficient condition

$$\tau(\theta) < \frac{2\beta^2}{2+2\beta^2-3\beta}$$

Numerical computations (available from the authors upon request) clearly indicate that this condition is satisfied when the cost of training H workers is not too low. Second, we can obtain an empirical equivalent of τ by dividing the training participation rate by the share of educated workers (which is the empirical equivalent of the share of H workers). Table B1 replicates Table 1 (Panel A) using this ratio as dependent variable. [34] Estimated results are consistent with the predictions of the model.

Table B1. *Estimates of the ratio of training to the share of the educated as function of REGNO, non-manufacturing sample, linear specification estimated by OLS*

	(1)	(2)	(3)	(4)	(5)
Regulation, excluding public own. (REGNO)	-0.020 [3.27]***	-0.022 [3.60]***	-0.022 [3.35]***	-0.024 [3.46]***	-0.023 [3.71]***
Country by sector dummies	*yes*	*yes*	*yes*	*yes*	*Yes*
Country by year dummies	*yes*	*yes*	*yes*	*yes*	*Yes*
Sector by year dummies	*yes*	*yes*	*yes*	*yes*	*Yes*
Number of observations	1236	1224	1188	1061	1224

Notes: Dependent variable: training participation rates divided by the share of high- and medium-educated workers. For each column, controls are as in Table 1. Robust t-values within brackets. ***: significant at the 1% level.

B.5. The case of heterogeneous production and training technology

In this subsection we extend our model by allowing production technologies and training costs to be firm-specific, that is by assuming that, for each firm *i*, the production function is given by $Y_i = A_i(1+\tau_i)L_i$ and

[34] Given the nature of the dependent variable, GLM specifications cannot be estimated.

the training costs are equal to $\mu_i \frac{\tau_i^2}{2}$. Following the same steps as in Section 1 we can show that equations [3]-[6] still hold, albeit with μ and A indexed by i. Moreover, plugging [4] into [3] and re-arranging yields the following expression for profits per unit of output:

$$\pi_i = \frac{1-\delta}{\theta}\frac{P_i}{P} \qquad \text{[B.19]}$$

From equation [6] and [B.19] we obtain:

$$\tau_i = \frac{A_i}{\mu_i}\pi_i(\theta - 1)$$

which shows that the main finding of the model still holds: training intensity within each firm is increasing in net real profits per unit of output π and, conditional on π, is increasing in the elasticity θ. In other words, the relationship between training intensity of firm i and competition still depends on the balance between the "rent" and "business stealing" effects. However, which effect prevails is ambiguous in the case of heterogeneous firms and a matter of empirical assessment. Nonetheless, we can characterise this relationship a bit further by noticing that the only non-negative solution of [5] implies that training intensity is given by

$$\tau_i = -1 + \sqrt{1 + 2\frac{1-\delta}{\mu_i}\frac{V}{P}} \qquad \text{[B.20]}$$

which, by making the same assumption on the reservation wage V as in Appendix B.3, implies that each firm's training increases in the elasticity θ (the business-stealing effect prevails) if average prices decrease in θ, and in the number of firms m, as in the case of homogeneous firms. Insofar as available empirical evidence suggests that average prices tend to decrease as the number of firms and competition increase (see Section 1.1, footnote 7), one would expect a positive relationship between the latter and each firm's training – and a negative relationship between regulation and training – in most realistic applications. By contrast, the aggregate amount of training will depend also on firms' market shares. Insofar as each firm's market share will depend also on its own productivity parameter A_i – while its training intensity does not, as shown by equation [B.20] – aggregate training will depend on the correlation between A and μ: the more negative this correlation, the greater the market share of firms that train more and the greater the aggregate amount of training.

Appendix C: Additional Empirical Results

Table C1 replicates Table 1 using only non-manufacturing industries. Table C2 replicates Table 1 using BEVI, the indicator that is perhaps the closest to a strict definition of barriers to entry. The similarity of the results with those of Table 1 is remarkable. As expected, the relevant estimates in Table C1 are less precise than those presented in the text.

In order to check that our results are not driven by the fact that training is higher when the level and growth of productivity are higher and/or investment in capital stock is higher, Table C3 replicates our preferred specification (Table 1, Panel B, Column 2) by including these covariates. The estimates are robust to this sensitivity exercise, suggesting that our results are unlikely to be biased by the relationship between productivity, regulation and training. We also find that, when we increase the lag of regulation, we still find a significant impact on training. For example, we find that regulation lagged two periods attracts a coefficient equal to -0.066 (with a t-value of 2.11). By contrast, if we use future values of regulation, we always obtain insignificant coefficients. For example, regulation one-year after training attracts a coefficient equal to -0.056 (with t-value of 1.50). We find this re-assuring with respect to the potential endogeneity of regulation in the training equations.

Table C1. *Estimates of training as function of REGNO, non-manufacturing sample*

Panel A: Linear specification estimated by OLS

	(1)	(2)	(3)	(4)	(5)
Regulation, excluding public own. (REGNO)	-0.014 [2.15]**	-0.015 [2.10]**	-0.013 [1.83]*	-0.014 [1.71]*	-0.016 [2.18]**
Country by sector dummies	*yes*	*yes*	*yes*	*yes*	*Yes*
Country by year dummies	*yes*	*yes*	*yes*	*yes*	*Yes*
Sector by year dummies	*yes*	*yes*	*yes*	*yes*	*Yes*
Number of observations	309	306	297	242	306

Panel B: GLM specification estimated by QMLE

	(1)	(2)	(3)	(4)	(5)
Regulation, excluding public own. (REGNO)	-0.142 [3.16]***	-0.158 [3.43]***	-0.150 [3.11]***	-0.145 [3.27]***	-0.170 [3.66]***
Country by sector dummies	*yes*	*yes*	*yes*	*yes*	*Yes*
Country by year dummies	*yes*	*yes*	*yes*	*yes*	*Yes*
Sector by year dummies	*yes*	*yes*	*yes*	*yes*	*Yes*
Number of observations	309	306	297	242	306

Notes: Dependent variable: training participation rates. No additional controls are included in Column 1, Columns 2-5 include the shares of those with low and intermediate education, the share of women and the log worked hours gap. Column 3 includes also the employment growth rate, average age and the share of large firms. Column 4 include the log of R&D intensity and Column 5 labour market institutions reported in Table 1. Robust t-or z-values within brackets. *, **, ***: significant at the 10%, 5% and 1% level, respectively.

Table C2. *Estimates of training as function of BEVI, the index of barriers to entry and vertical integration.*

Panel A: Linear specification estimated by OLS

	(1)	(2)	(3)	(4)	(5)
Barriers to entry and vertical integration (BEVI)	-0.011 [3.10]***	-0.011 [3.17]***	-0.011 [2.85]***	-0.013 [3.43]***	-0.011 [3.17]***
Country by sector dummies	*yes*	*yes*	*yes*	*yes*	*Yes*
Country by year dummies	*yes*	*yes*	*yes*	*yes*	*Yes*
Sector by year dummies	*yes*	*yes*	*yes*	*yes*	*Yes*
Number of observations	1236	1224	1188	1061	1224

Panel B: GLM specification estimated by QMLE

	(1)	(2)	(3)	(4)	(5)
Barriers to entry and vertical integration (BEVI)	-0.114 [4.16]***	-0.129 [4.82]***	-0.135 [4.51]***	-0.125 [4.68]***	-0.134 [4.93]***
Country by sector dummies	*yes*	*yes*	*yes*	*yes*	*Yes*
Country by year dummies	*yes*	*yes*	*yes*	*yes*	*Yes*
Sector by year dummies	*yes*	*yes*	*yes*	*yes*	*Yes*
Number of observations	1236	1224	1188	1061	1224

Notes: Dependent variable: training participation rates. See Table C1 for the list of controls. In addition, Columns 2 to 5 include the import-weighted real exchange rate. Robust t-or z-values within brackets. ***: significant at the 1% level.

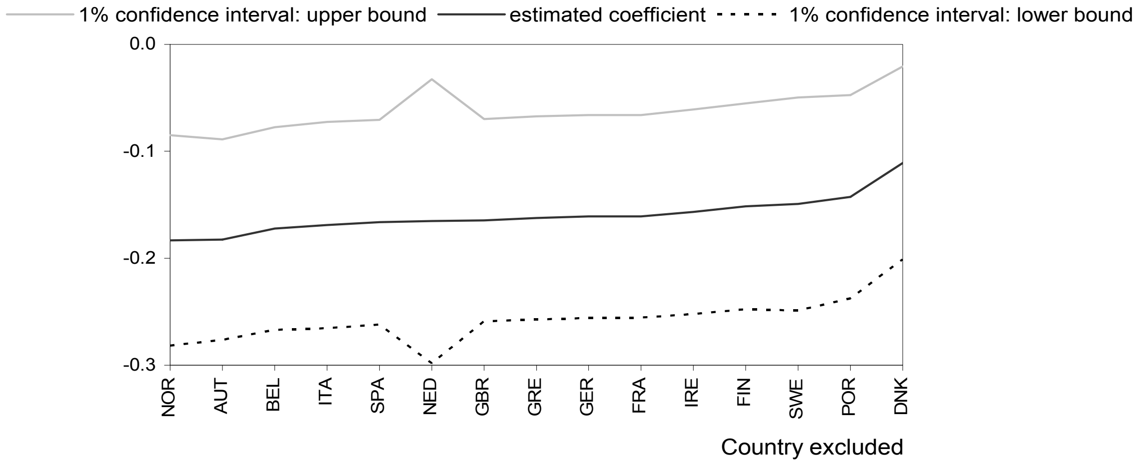
Table C3. *Estimates of training as function of REGNO, including productivity level and growth and the investment rate; GLM specification estimated by QMLE.*

	(1)	(2)	(3)	(4)
Regulation, excluding public own. (REGNO)	-0.156 [3.79]***	-0.144 [3.63]***	-0.160 [3.83]***	-0.139 [3.54]***
Country by sector dummies	*yes*	*yes*	*yes*	*yes*
Country by year dummies	*yes*	*yes*	*yes*	*yes*
Sector by year dummies	*yes*	*yes*	*yes*	*yes*
Number of observations	1116	1080	1116	1080

Notes: Dependent variable: training participation rates. Column 1 controls for the log productivity level, Column 2 for the log investment rate, Column 3 for productivity growth and Column 4 for all the three variables simultaneously. For the list of other controls, see Table 1, Panel B, Column 2. Robust z-values within brackets. ***: significant at the 1% level.

Finally, Figure C1 plots the estimates of the parameter of interest, which captures the impact of REGNO on training, obtained by excluding one country at a time for our preferred specification. Estimates appear to be relatively stable and always significant at the 1% level. In particular, it is reassuring that our results are not driven by the presence of Norway in the sample. It can be argued that, although intra-European trade barriers were lifted by the implementation of the SMP, trade barriers still exist with respect to non-European countries and these barriers are not captured by real industry-specific exchange rates. A further refinement of our strategy consists therefore in restricting the sample to EU members only (thus excluding Norway). Since EU trade policy is common to all EU member countries, there is no cross-country variation in industry-specific tariff and non-tariff barriers, which are therefore entirely controlled for by industry-by-time dummies.

Figure C1. *Sensitivity to country coverage*



Note: The figure shows central estimates and confidence intervals obtained by re-estimating the model of Column 2 in Panel B of Table 1 excluding one country at a time.

Appendix D: Definition of variables, sources and descriptive statistics

D.1. Data from the OECD Database on Training

All variables refer to employees aged between 25 and 54 years working at least 30 hours per week and with at least one month of tenure. Data are derived from Eurostat, European Labour Force Surveys.

Training participation rate

Definition: Share of employees that took training in the 4 weeks preceding the survey.

Share of males

Definition: ratio of men employees to total wage and salary employment.

Average age

Definition: average age of employees. Data are available by 5-year classes in the micro-data. Data are aggregated assuming that each individual's age corresponds to the average of each class.

Share low education

Definition: Share of employees with educational attainment corresponding to ISCED 0-2.

Share medium education

Definition: Share of employees with educational attainment corresponding to ISCED 3.

Share firms with more than 50 employees

Definition: Ratio of the number employees of firms with more than 50 employees to total wage and salary employment. Since in the micro-data respondents may simply say that firm size is greater than 10 employees, with no distinction between more or less than 50 employees, the share is obtained as the product of the ratio of the number of employees in firms with more than 50 employees to the number of employees in firms with more than 10 employees and the complement to one of the ratio of the number of employees in firms with less than 11 employees to total wage and salary employment.

D.2. Data on product market regulation

Indicators of sector-specific product market regulation

Definition: Indicators of entry barriers, public ownership, market share of the dominant player(s), vertical integration in network industries and price controls. They cover seven industries (electricity, gas, rail, road freight, air transport, post and telecommunications). All indicators vary from 0 to 6 from the least to the most restrictive. Source: OECD Regulatory Database.

D.3. Other data

Labour productivity

Definition: value added per hour, in volume. Source: Groningen Growth and Development Centre 60-Industry Database.

Investment rate

Definition: ratio of gross fixed capital formation to value added. Source: OECD STAN Database.

Employment

Definition: total persons engaged. Source: Groningen Growth and Development Centre 60-Industry Database.

Hours worked

Definition: average hours worked per persons engaged. The hours worked gap is defined as the difference between log hours worked and its filtered time-series obtained applying a Hodrick-Prescott filter with standard parameters. Source: Groningen Growth and Development Centre 60-Industry Database.

Import weighted real exchange rate

Definition:

$$x_{ikt} = \sum_{i=1}^{I} \sum_{l=1}^{L} m_{iklt_0} e_{klt} p_{lt} / p_{kt}$$

where x stands for the import-weighted real exchange rate, m is to the import share from country l in industry i of country k at a fixed time period t_0 (early 1980s in these data) - the import weights thus vary across industries and countries but are constant in time - e is to the nominal bilateral exchange rate between countries k and l at time t - which varies across partner countries and time, but not across industries - the p variables refer to price levels, as approximated by the GDP deflator, in countries l and k respectively. Within a country in a given year, the variation in industry-specific real exchange rates derives entirely from differences in the import pattern across industries. An increase in the industry-specific exchange rate represents a real depreciation in the price of output produced in industry i of country k relative to its trading partners (weighted by import shares). Put differently, an increase in the industry-specific exchange rate represents an improvement in the terms of trade in industry i for country k. Source: OECD Employment Outlook 2007.

R&D intensity

Definition: ratio of Business Enterprise Expenditures in R&D to value added. Source: OECD STAN, ANBERD and R&D Databases.

Observed Lerner index

Definition:

$$LE_{ijt} = \frac{Y_{ijt} - CV_{ijt}}{Y_{ijt}}$$

where LE is the observed Lerner index in country i, industry j and time t, CV are variable costs in nominal terms and Y is the value of output (see e.g. Klette, 1999). In practice, CV is the sum of intermediate inputs costs, labour costs and the estimated cost of capital. Capital stock is constructed by perpetual inventory method for countries where it is not provided in national accounts at a sufficiently disaggregated level. However, since reconstructed capital stocks are available only in volume terms, in practice nominal capital stocks are obtained by dividing them by value added in volume terms and pre-multiplying them by nominal value added. In the calculation of the cost of capital, we follow Griffith et al. (2006) and assume that capital flows freely across borders so that all countries face a world interest rate, for which we use the US long-term interest rate. This computed index is equivalent to the price-cost margin under the assumption of perfect competition and constant returns to scale (see Klette, 1999, for a discussion). In principle, violation of these assumptions might induce biases, and estimations from production or cost functions would be desirable. Yet, estimated mark-up cannot vary simultaneously by country, industry and year. In addition, our Lerner index is treated as an endogenous variable and instrumental variables deal with the possibility of systematic measurement error. For these reasons we prefer to follow Aghion et al. (2005) and use a computed Lerner index. Sources: OECD STAN and EO databases.

Index of Employment Protection Legislation

Definition: OECD aggregate summary indicator of the stringency of employment protection legislation incorporating both regular contracts and temporary work. Source: OECD, Employment Outlook 2004.

Union density

Definition: Share of workers affiliated to a trade union (in %). Disaggregated data are available only for two macro-sectors Transport and Industry (Manufacturing plus Energy) in Austria, Germany, Italy, the Netherlands, Norway, Spain and Sweden. The macro-sector average is assigned to all subsectors. For the other countries, the same value is assigned to all sectors. Source: Ebbinghaus and Visser (2000).

Job creation and destruction rates

Definition: US average gross job creation and destruction rates aggregated from establishment level data (assuming, for continuous firms, that net employment changes are equal to gross employment changes). Data refer to 1990-1996. Gross job turnover is defined as the sum of job creation and job destruction. Source: Haltiwanger, Scarpetta and Schweiger (2006).

D.4. List of countries and industries

Countries are Austria, Belgium, Germany, Denmark, Spain, Finland, France, UK, Greece, Ireland, Italy, the Netherlands, Norway, Portugal, and Sweden. Industries are available at the 2-digit level of the NACE rev.1 classification for most countries and years in manufacturing. In non-manufacturing, they are available at a slightly more disaggregated level than 1 digit of NACE rev. 1. However, since only NACE 1970 is available for certain country-year pairs, we are obliged to aggregate a few industries in order to construct our industry-level database. Table D1 reports the full list.

Table D1. *List of industries.*

NACE Rev. 1	Description
15-16	Food products, beverages and tobacco manufacturing
17-19	Textiles, textile products, leather and footwear manufacturing
20	Wood and wood products manufacturing
21-22	Pulp, paper and related products manufacturing, printing and publishing
23-25	Chemical and fuel products manufacturing, rubber and plastics
26	Other non-metallic mineral products manufacturing
27-28	Basic metals and fabricated metal products manufacturing
34-35	Transport equipment manufacturing
29-33	Other machinery and equipment manufacturing
40-41	Electricity, gas and water supply
60+62	Land and air transport
64	Communications services

D.5. Descriptive statistics

Table D2. *Descriptive statistics.*

Variable	Observations	Mean	Standard deviation
Training participation rate	1236	0.078	0.075
Training stock	1236	0.476	0.457
REGNO	1236	0.820	1.593
BEVI	1236	0.790	1.584
Share males	1236	0.756	0.143
Average age	1236	38.86	1.465
Share firms with > 50 employees	1200	0.561	0.223
Share low education	1224	0.373	0.209
Share medium education	1224	0.463	0.177
Import weighted real exchange rate	1236	1.297	1.914
Hours gap	1236	0.002	0.012
Employment growth	1236	-0.002	0.037
Union density	1236	44.526	24.69
EPL*TURN	1236	0.411	0.168
Investment rate	1116	0.222	0.109
Labour productivity growth	1080	0.035	0.085
Lerner index	1120	0.100	0.062