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Employment Protection Legislation, Multinational Firms and Innovation

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Abstract

The theoretical effects of labour regulations such as employment protection legislation (EPL) on innovation is ambiguous, and empirical evidence has thus far been inconclusive. EPL increases job security and the greater enforceability of job contracts may increase worker investment in innovative activity. On the other hand EPL increases adjustment costs faced by firms, and this may lead to under-investment in activities that are likely to require adjustment, including technologically advanced innovation. In this paper we find empirical evidence that both effects are at work - multinational enterprises locate more innovative activity in countries with high EPL, however they locate more technologically advanced innovation in countries with low EPL.

JEL codes: D21, F23, O31, J24

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1 Introduction

Employment protection legislation has been a focus of policy concern in the European Union. There is now considerable evidence that this type of labour market rigidity is associated with higher unemployment.[1] More recently attention has focused on the impact of labour regulations on the incentives for firms to invest in productivity enhancing innovation and growth. Here the relationship is less clear. When making its innovation decision a firm considers two effects of employment protection legislation (EPL). First, EPL introduces a firing cost to any adjustment to employment made by the firm. Second, this adjustment cost increases job security for existing workers as it reduces the probability of being fired in response to small fluctuations in demand. Efficiency wage arguments suggest that this increases the value of employment for the worker and increases their (unobservable) effort, which in turn can increase the return to innovation for the firm.[2] On the other hand, where innovation is radically new and requires new skills, and thus a drastic adjustment to employment, EPL may increase the cost of such innovation. Existing models of radical innovation suggest that countries with low EPL have a comparative advantage in radical innovation.[3]

The main contribution of this paper is empirical. To motivate our empirical strategy we describe a model that incorporates both positive and negative effects of EPL on innovation incentives for firms. We distinguish between incremental innovation and radical innovation: radical innovation is potentially more profitable than incremental innovation, but requires a large and drastic employment adjustment, because workers with new skills are needed to implement the innovation (as in Chapter 8 of Aghion-Howitt 1998). EPL increases this cost of adjustment, but it also has positive effects on both types of innovation by increasing workers' effort to further increase the

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[1] See, inter alia, Lazear (1990), Blanchard and Wolfers (2000), Nickell, Nunziata and Ochel (2005), and Griffith, Harrison and Macartney (2007).

[2] See Shapiro and Stiglitz (1984) for the efficiency wage set-up and Boeri and Jimeno (2005) for an application to EPL. Although not its central point, workers invest more in general training in the presence of search frictions in the labour market when they are less likely to be fired by their present employer in Acemoglu (1997). See also Akerloff (1982), Agell (1999) and Chapter 10 of Saint-Paul (1996) for the positive effects of EPL.

[3] See Saint-Paul (1997, 2002) and Samaniego (2006). Also Cunat and Melitz (2007) provide theoretical and empirical evidence that countries with flexible labour markets have a comparative advantage in industries with high demand volatility. Caballero et al. (2004) provide theoretical and empirical evidence that countries with strong EPL are slow to adjust employment, and that this is associated with low productivity growth. Also, Bartelsman et al. (2008).

productivity of innovations. The model suggest that, for plausible parameter values, the optimal level of investment in radical innovation decreases with EPL but that the optimal level of investment in incremental innovation increases with EPL.

The paper is related to several literatures. It is directly related to the growing literature on the effects of labour market regulations on productivity and by extension to the papers on cross-country patterns of specialization and national institutions.[4] There is a related literature on the product life-cycle that distinguishes between new product innovation and mature product innovation, where demand is more certain for the latter.[5] It also relates to the endogenous growth literature and the model presented builds heavily on the framework of Aghion-Howitt, where the distinction between radical and incremental innovation is through the employment adjustment that is required to implement radical innovation.[6] Our paper is also related to the literature on the location of activity by multinational firms. [7]

There is an existing empirical literature on the relationship between labour regulations and productivity and innovation, based mainly on cross-country evidence, which remains inconclusive, with studies finding divergent results.[8] Such studies struggle to deal with two key identification problems. One is that the effect of EPL may depend on the *nature* of innovation, and in most data it is difficult to distinguish between incremental and radical innovation. The other is that in the cross-section labour

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[4] See, inter alia, Nunn (2007), Carlin (2003).

[5] See, inter alia, Klepper (1996) and Breschi et al. (2000), Audretsch (1995), Puga and Trefler (2005), and Saint-Paul (1997, 2002).

[6] This is in contrast to the distinction that radical innovation is less likely to succeed than incremental innovation that is made in Saint-Paul (1997, 2002) and Bartelsman et al. (2008). We argue that modelling radical innovation as requiring adjustment to employment is appropriate for our sample of large incumbent firms, whereas modelling radical innovation as more risky with high firing costs arising in the event of failure seemed more appropriate for small firms and considerations of firm entry and exit. If radical innovation were more risky and the cost of failure (exit) increased with EPL then this would enhance our predictions.

[7] See, inter alia, Dunning (1977), Caves(1996), Ekholm and Hakkala (2007), Devereux and Griffith (1998). Haaland and Wooton (2003) show that multi-national enterprises will locate high risk projects in countries with low redundancy costs in the presence of industry or economy wide wage bargaining, and when the risk profile of the MNE is different to that of domestic firms.

[8] Both Storm and Nastepaad (2007) and Buchele and Christiansen (1999) find that high EPL is associated with greater productivity growth. Bassanini and Ernst (2002) find that EPL has a negative effect in less coordinated countries, in higher coordinated countries workers and firms can align their interests better**.** Similarly, Scarpetta and Tressel (2004) find a significant impact of EPL on multi-factor productivity growth when interacted with bargaining coordination, but no linear result. Hall and Soskice (2001) argue that differences in specialisation between Germany and the US are due to the more market orientated financial and labour market institutions in the US. Acharya et al. (2009) find that strong labor laws encourage innovation. Akkermans et al. (2005) support the view that liberal market economies specialize in radical innovation.

regulations may be correlated with unobservable characteristics of countries, industries and firms that determine innovation. We deal with the first challenge by using an intuitively appealing measure of radical innovation: the proportion of citations on a patent application made to scientific journals (as opposed to other patents). We show that patents that are closer to the scientific literature are associated with more variability in output and employment. We tackle the second challenge by basing our results on an identification strategy that uses variation *within* multinational firms from 12 countries on where they locate different innovative activities, and therefore controls for unobservable characteristics of the home country, industry and firm that affect the innovation decision. We find that multinational firms perform more overall innovation in high EPL countries, but that the same multinational firms perform more radical innovation in low EPL countries.

We see these basic relationships in the cross-country association between EPL and innovation activity. Figure 1 shows the average proportion of citations to the scientific literature plotted against EPL, using data on all firms that applied for patents at the European Patent Office.[9] The downward sloping relationship suggests that there is less radical innovation performed in countries with high EPL. In this paper we focus on multinational firms.[10] Figure 2 shows the same negative association between EPL and radical innovation across these firms. In Figure 3, however, we see a positive effect of EPL on overall innovation. These aggregate pictures may be masking many different effects. We show below that these results are robust to controlling for firm fixed effects and for many country level regulatory and factor endowment characteristics.

This paper proceeds as follows: section 2 presents a simple model of incremental and radical innovation; section 3 discusses our identification strategy; section 4 describes our empirical specification and data, explaining our measure of radical innovation; section 5 presents our results; and a final section concludes.

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[9] This graph is based on patent applications made to the European Patent Office by 37,350 listed and unlisted firms in the private sector, see Macartney (2009). These firms were responsible for the filing of 230,322 patents in the period 1997 to 2003. The country is the country of registration of the applicant firm.

[10] This is a sample of 1,378 subsidiaries of multinational firms, see Section 4 for details of the data used.

2 Theoretical Background

The current literature on the effect of EPL on productivity suggests that the nature of innovation has a role to play. The endogenous growth literature (Aghion-Howitt, 1998) emphasize the difference between radical and incremental innovation. Where successful, radical innovation requires a drastic adjustment of employment as the human capital of existing workers is rendered obsolete. EPL increases this cost by way of firing costs. Radical innovation is more valuable than incremental innovation and more costly. If there is uncertainty in future demand then EPL also has a positive effect on the returns to both types of innovation, in that it increases worker commitment and their efforts in making the new technology more productive through learning by doing. EPL will increase incremental innovation effort, but at sufficiently high levels it will decrease radical innovation effort. Thus firms will be more likely to choose to perform radical innovation in low EPL regimes and incremental innovation in high EPL regimes, which is the central prediction tested in this paper.

The underpinnings of this model are based on Aghion-Howitt (1998). Innovation improves the productivity of intermediate goods supplied by a firm for use in the production of a final good. A further improvement on this productivity gain comes via the effort (or learning by doing) of production workers. This effort is higher in the presence of employment protection legislation (EPL), which takes the form of higher firing costs per worker, as production workers are less likely to be fired and therefore more likely to share in the surplus from increased productivity.

However, EPL can also have negative effects on innovation, depending on whether innovation is radical or incremental. Radical innovation is more productive, but makes existing human capital obsolete. The implementation of a radical innovation requires that all production workers are replaced, at a per worker firing cost. Incremental innovation increases productivity, but to a lesser extent than radical innovation, and existing production workers are retained. EPL's effect on worker effort will have an increasing effect on the returns to both types of innovation, but due to the firing costs it will also have a negative effect on the returns to radical innovation.

In this paper our main interest is in the impact of EPL on innovation incentives, where the main impact of EPL is on costs, and therefore to focus on this effect we assume away any strategic impact of innovation in the product market.

2.1 Model

A final good is produced using a continuum of intermediate goods produced by firms, each one of which is a monopolist in its market, using the technology,

$$y = \int_0^1 \left(Z\left(e_i^j\right)A_i^j\right)^{1-\alpha} x_i^{\alpha}\,di\,, \qquad (1)$$

where y is final output, i indexes firms (and intermediate industries, since each firm is a monopolist in its industry), $j= 0, I, R$ indexes innovation type, $Z\left(e_i^j\right)$ is the level of investment in unobservable effort made by production workers, A_i^j is the intermediate producers productivity level, and x is other inputs to production.

Profits of the intermediate firm are given by,

$$\pi_i^j = \delta Z\left(e_i^j\right)A_i^j\,, \qquad (2)$$

where π_i^j is profits and δ reflects the extent of competition in the intermediate goods market.

We consider the following timing of events:

Intermediate producers draw an initial productivity level A_i^0. Firms decide whether to invest in radical or incremental innovation, and how much to invest (which determines the probability of success μ_i^R, μ_i^I). If successful, incremental innovation leads to a productivity increase of $\gamma > 1$ and, if radical innovation is successful productivity increases by a factor of γ^2. Innovation incurs a fixed cost.

Productivity is enhanced by the efforts of workers. However, in the case of radical innovation existing workers do not have the required skills to work with the new technology and must be fired and replaced by more skilled workers.[11] Production workers decide the level of investment in unobservable effort e_i^j, which increases productivity by a factor $Z(e_i^j)$. A demand shock occurs which leads to the possibility of the worker being fired. We assume that the future uncertainty in demand is small enough to be trivial to the firm, although of importance to the workers.

Intermediate production occurs, if the firm chooses incremental innovation then they use existing workers. If the firm chooses radical innovation then existing production workers are fired at cost φ per worker. They are replaced at zero hiring costs by production workers with more appropriate skills. Output is sold and the surplus shared between the firm and its workers, depending in part on (exogenous) worker

[11] This implies that innovation and production are co-located, so the effect EPL has on worker incentives affects the firm's innovation incentives. Such a co-location is more likely when technology transfer costs are high relative to product transport costs (see Ekholm and Hakkala 2007). This is consistent with a model where location is endogenous and determined by the effect EPL has on the benefits to innovation. That is, if transport costs are low so that production can be located anywhere, firms may choose to locate innovation and production in countries where the labour market environment is conducive to their intended type of innovation.

bargaining power β. We are interested in the innovation incentives for the intermediate producers.

To solve for the impact of firing costs on firms' incentives to innovate we solve the problem by backward induction:

Output generates surplus for the firm. These are given for each *j* technology by,

$$V_i^0 = (1-\beta)\pi_i^0 \tag{3}$$

$$V_i^I = \mu_i^I(1-\beta)\pi_i^I + (1-\mu_i^I)(1-\beta)\pi_i^0 - c_i^I - F^I \tag{4}$$

$$V_i^R = (\mu_i^R(1-\beta)\pi_i^R - f_i) + (1-\mu_i^R)(1-\beta)\pi_i^0 - c_i^R - F^R \tag{5}$$

where V_i^j is firm *i*'s surplus using technology *j*, μ_i^j is the level of innovation effort by the firm, c_i^j is variable costs of innovation for *j* technology, f_i is firing cost incurred if radical innovation is successful, and F^j is fixed costs of innovation for *j* technology.

Variable costs take the form,

$$c_i^j = \frac{1}{2}A_i^j\left(\mu_i^j\right)^2. \tag{6}$$

Intermediate production occurs. Output of the intermediate firm is given by equation (2).

If the firm has chosen not to innovate or chosen incremental innovation then it uses existing workers. If the firm chose radical innovation then existing production workers do not have the skills to work with the new technology and are fired by the firm. EPL is modeled as a firing cost of φ per worker (a bureaucratic cost, not a transfer to the worker), that makes employment adjustment costly.[12] These firing costs take the form,

$$f_i = \varphi k Z\left(e_i^0\right)A_i^0 \quad (7)$$

where $kZ\left(e_i^0\right)A_i^0$ is the number of existing workers employed by the firm.[13] New workers are hired at zero hiring costs.

Demand shock occurs. There are shocks to demand which mean that the worker will be fired with probability $s(\varphi)$. This occurs after the worker has committed to an effort level. We assume that the future uncertainty in demand is small enough to be trivial to the firm, although of importance to the workers (see Acemoglu 1997, and Boeri and Jimeno 2005). The firing cost of φ per worker makes it more likely that employment adjustment in the face of demand shocks is unprofitable to the firm and, therefore, $s = s(\varphi), s'(\varphi) < 0$. In this way EPL increases workers' job security, and therefore increases their effort.

[12] There are conditions where EPL will be irrelevant to firm location, specifically when EPL takes the form of a redundancy payment rather than a bureaucratic cost to the firm. Pissarides (2001) and Lazear (1990) show that redundancy costs are irrelevant to the firm location decision if wages are determined endogenously. The worker takes into account both the probability of firm bankruptcy and the size of the redundancy payment when bargaining over wages. We have assumed this situation away by interpreting EPL as regulation that results only in a (bureaucratic) firing cost to the firm and not a transfer to the worker. However, EPL as redundancy will affect location decisions if wage bargaining is conducted at the industry level rather than at the firm level and the probability of bankruptcy is private information to the firm and is different to the industry average (Haaland and Wooton 2003). The worker, taking into account the probability of receiving a redundancy payment, accepts a low (high) wage if the industry average riskiness is high (low). Therefore a firm that is more risky than the average is worse off, as it still has to pay the same wage as other firms but has a higher probability of paying a redundancy payment. Therefore risky firms (or firms more likely to make employment adjustments) have an incentive to locate their activities in a low EPL country.

[13] Let $k = \left(\frac{1}{\alpha^2}\right)^{\frac{1}{\alpha-1}}$. The number of existing workers comes from simple profit maximisation.

Production workers decide level of effort. This increases productivity by a factor $Z(e_i^j)$ (where $Z(0)=1, Z'(e_i^j)>0, Z''(e_i^j)<0$). Workers will choose effort to maximise their expected return,

$$\max_{e_i^j}\left[(1-s(\varphi))\beta\pi_i^j + s(\varphi)\cdot 0 - e_i^j\right] \tag{8}$$

We assume Z takes the form $Z(e_i^j)=\sqrt{e_i^j+1}$, so that Z displays diminishing returns to workers effort and is equal to one if workers make zero effort. Using this, substituting equation (2) into (8) and performing the maximization we obtain an expression for the worker's optimal effort, e_i^{j*}:

$$Z(e_i^{j*})=\frac{(1-s(\varphi))\beta\delta}{2}A_i^j\,. \tag{9}$$

Worker effort for target innovation type j is increasing in the productivity of that innovation, and increasing in EPL,

$$\frac{\partial Z(e_i^{j*})}{\partial\varphi}=-\frac{\partial s(\varphi)}{\partial\varphi}\frac{1}{2}\beta\delta A_i^j>0\,, \tag{10}$$

since $s'(\varphi)<0$, i.e. the probability of being fired decreases with EPL.

Firm decides level of innovation. The problem facing the firm is to choose the optimal level of innovation effort, conditional on the type of innovation and on worker effort. For incremental innovation the firm chooses innovation effort, μ_i^I, such that (from substitution of equation (2) into equation (4)):

$$\max_{\mu_i^I}\left[\mu_i^I(1-\beta)\delta Z(e_i^{I*})A_i^I + (1-\mu_i^I)(1-\beta)\delta Z(e_i^{0*})A_i^0 - c_i^I - F^I\right]. \tag{11}$$

Using equation (6), the fact that $A_i^I = \gamma A_i^0$ and $Z(e_i^{I*}) = \gamma Z(e_i^{0*})$ the firm's optimal innovation effort will be:[14]

$$\mu_i^{I*} = (1-\beta)\left(\gamma - \frac{1}{\gamma}\right)\delta Z\left(e_i^{0*}\right). \tag{12}$$

This effort is increasing in EPL, since learning-by-doing is increasing in firing costs, as stated in equation (10), and $\gamma > 1$.

To investigate how radical innovation varies with firing costs we substitute equations (2), (6) and (7) into equation (5) and, using the fact that $A_i^R = \gamma^2 A_i^0$, we obtain:[15]

$$\max_{\mu_i^R} \mu_i^R \left[(1-\beta)\delta Z\left(e_i^{R*}\right)\gamma^2 A_i^0 - \varphi k Z\left(e_i^{0*}\right)A_i^0\right] + \left(1-\mu_i^R\right)(1-\beta)\delta Z\left(e_i^{0*}\right)A_i^0 - \frac{1}{2}\gamma^2 A_i^0\left(\mu_i^R\right)^2 - F^R . \tag{13}$$

Solving as before, the firm's optimal radical innovation effort will be:

$$\mu_i^{R*} = \left[(1-\beta)\left(\delta\gamma^2 - \frac{\delta}{\gamma^2}\right) - \frac{\varphi k}{\gamma^2}\right] Z\left(e_i^{0*}\right). \tag{14}$$

Innovation incentives are increasing in workers learning-by-doing effort and therefore EPL has an increasing effect for both types of innovation. Due to the large employment adjustment required in the case of radical innovation, firing costs also have a decreasing effect on the incentives for radical innovation.

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[14] Maximisation of equation (11) gives $(1-\beta)\left(\delta Z\left(e_i^{0*}\right)\gamma^2 A_i^0 - \delta Z\left(e_i^{0*}\right)A_i^0\right) - \gamma A_i^0 \mu_i^{I*} = 0$, which after rearrangement results in equation (12).

[15] Maximisation of equation (13) gives $(1-\beta)\left(\delta Z\left(e_i^{0*}\right)\gamma^4 A_i^0 - \delta Z\left(e_i^{0*}\right)A_i^0\right) - \varphi k Z\left(e_i^{0*}\right)A_i^0 - \gamma^2 A_i^0 \mu^{R*} = 0$, which after rearrangement gives equation (14).

2.2 Robustness to assumptions

The idea that EPL increases worker effort in making innovation more productive is robust to changing a number of the assumptions of the model. For instance, we have assumed that the workers' return to learning-by-doing effort is entirely tied to the firm, i.e. their efforts enhance the productivity of the firm's capital but do not enhance their own productivity. However, say the worker gained from their efforts by way of acquiring general skills. Becker (1964) predicts an under-investment in general skills, as workers are credit constrained and firms are reluctant to fund skills that the worker may use elsewhere. As described by Acemoglu (1997) it is likely that a contract could be written to mitigate such a problem (penalties for workers who train and quit) and, for our purposes, it is not initially clear what role EPL has to play: EPL will not stop workers leaving once trained and offered a job elsewhere. Acemoglu (1997) considers a model of training and innovation with job market search frictions, where workers can exogenously lose their job with probability s.[16] Costly job search means that when a worker and firm are matched they bargain over the surplus of the match, and therefore over any increased productivity that the worker has achieved through learning-by-doing effort. This leads to an under-investment in training by workers, as there is a probability of being fired and then, after search, receiving only a part return to their training efforts. Where EPL reduces this probability of being fired, it will mitigate this problem of under-investment, which would be qualitatively consistent with our model.

We have also assumed that the worker's effort is unobservable, otherwise the firm and worker could write a contract specifying e in return for a guaranteed wage in each

[16] Our equation (9) is inspired by equation (2) in Acemoglu (1997).

period. We could relax this assumption and assume that such a contract can be written and that there is a monitoring technology available to the firm so that a worker can be caught shirking with some probability. The efficiency wage paid to the worker so that they do not shirk is increasing in the exogenous probability of spontaneous dismissal in the future ("economic dismissal"), increasing in the exogenous probability of once dismissed getting another job ("flow into employment") and decreasing in the probability of getting caught shirking and subsequently being dismissed ("disciplinary dismissal"), as in Shapiro and Stiglitz (1984). EPL can then have two effects: it will decrease the probability of economic dismissal, but it will also decrease the probability of disciplinary dismissal. Boeri and Jimeno (2005), argue that for large firms (which is what we consider in our empirical application), where monitoring is very difficult, the dominant effect of EPL is that it decreases the probability of economic dismissal and therefore increases the value of employment to the worker and reduces the efficiency wage that the firm must pay. As in our model, EPL will increase the firm's innovative effort, since the lower efficiency wage will increase the return to the firm from innovation.

2.3 Relevant ranges for firing costs to affect innovation effort

Specifying a functional form for $s(\varphi)$ allows us to infer how optimal innovation effort varies over reasonable ranges of firing costs. Specifically, consider the case where there is a probability *p* of a drop in demand from θ^h to θ^l then (see Appendix A.1):

$$s(\varphi) = p.\left(1 - \left(\frac{\theta^h}{\theta^l}\right)^{\frac{1}{\alpha-1}} (1-\varphi)^{\frac{1}{\alpha-1}}\right). \tag{15}$$

This function is decreasing in φ at an increasing rate: $s'(\varphi)<0, s''(\varphi)<0$. Using a linear approximation for equation (15) (see Appendix A.1) and, along with equation (9), we note that the expression for radical innovation effort, equation (14), is quadratic in firing costs. Furthermore, radical innovation effort initially increases with φ and then decreases with φ. This functional form for $s(\varphi)$ is not necessary for the qualitative predictions of our model, but it will help in discussing the dominant effect of EPL on radical innovation effort for realistic values of φ.

In Appendix A.2 we show that, using our approximation for $s(\varphi)$:

$$\frac{\partial \mu_i^{I*}}{\partial \varphi} = (1-\beta)\left(\gamma - \frac{1}{\gamma}\right)\delta \frac{1}{2} pb\beta\delta A_i^0 \tag{16}$$

$$\frac{\partial \mu_i^{R*}}{\partial \varphi} = (1-\beta)\left(\gamma^2 - \frac{1}{\gamma^2}\right)\delta \frac{1}{2} pb\beta\delta A_i^0 - \frac{\varphi k}{\gamma^2}\frac{1}{2} pb\beta\delta A_i^0 - \frac{k}{\gamma^2}\frac{1}{2}\left((1-p+p(1-\alpha)b)+pb\varphi\right)\beta\delta A_i^0 \tag{17}$$

Equation (16) is strictly positive: higher EPL, modeled as higher firing costs, unambiguously increases optimal incremental innovation effort. In equation (17) the first term is positive for $\gamma > 1$, and the second two terms are negative and increasingly so in φ. To find the point at which firing costs start to have a negative effect on radical innovation, $\hat{\varphi}^R$, set equation (17) equal to zero and solve to obtain:[17]

$$2\hat{\varphi}^R = (1-\beta)(\gamma^4 - 1)\left(\frac{1}{\alpha} - 1\right) - \frac{(1-p)}{pb} - (1-\alpha). \tag{18}$$

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[17] We obtain $2\hat{\varphi}^R = \frac{1}{kpb}\left[(1-\beta)(\gamma^4 - 1)\delta pb - k(1-p+p(1-\alpha)b)\right]$, which using $\frac{\delta}{k} = \left(\frac{1}{\alpha} - 1\right)$ becomes equation (18) after some rearrangement.

Therefore, $\hat{\varphi}^R$ is lower when the productivity gains from innovation are low (when γ is smaller), and when the firms gets a low proportion of the return to innovation (worker bargaining power, β, is high). Also, $\hat{\varphi}^R$ is lower when the extent to which φ increases learning-by-doing is lower: that is, when the probability of a negative demand shock, *p*, is low and therefore the relevance of EPL in making workers feel secure in their jobs is lower; and when the elasticity of final good output with respect to intermediate good input is low (i.e. $-(1-\alpha)$ is small) as this reduces the intermediate good adjustment required in the face of a small demand shock and therefore the possibility of getting fired and the relevance of EPL to job security (see Appendix A.1).

We can show that for reasonable values of the parameters in our model we always expect to be in the range where EPL has a negative impact on incentives for radical innovation, that is $\hat{\varphi}^R$ is less than the lower limit of the likely range of φ. The firing cost φ, which is a bureaucratic cost of dismissing a worker, is likely to be no greater than the worker's reservation wage which is normalized at one. Therefore, it is realistic to assume that φ is between zero and one. Setting $\alpha = 1/2, b = 2, p = 0.1, \beta = 1/2$ we can calculate that $\hat{\varphi}^R < 0$ for $\gamma \le 1.821$ and that for $1.821 < \gamma \le 1.968$, $0 < \hat{\varphi}^R < 1$.[18] In this second range of γ values, EPL increases the value of radical innovation initially, but will start to decrease it again as the radical firing cost effect starts to outweigh the learning-by-doing effect. Remembering that in

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[18] By inserting values into the following expression and solving for γ:

$$(\gamma^4 - 1) = \frac{1}{(1-\beta)}\left[\left(\frac{1}{\alpha} - 1\right) + \frac{(1-p)}{pb} + (1-\alpha) + 2\hat{\varphi}^{RI}\right].$$

this model the productivity gain from an incremental innovation is γ and that for a radical innovation is γ^2, the values just mentioned are very large: $\gamma = 1.821$ corresponds to a productivity gain from incremental innovation of 82.1 percent and from radical innovation of 231.6 percent. Therefore, in this model it is likely that $\hat{\varphi}^R < 0$ and, therefore, firing costs have a strictly decreasing effect on radical innovation incentives. Also, the model predicts that firing costs have a strictly increasing effect on incremental innovation.

2.4 Empirical predictions

The theoretical discussion suggests two empirical predictions that we can take to the data:

Prediction 1: Firm innovation activity is higher in regimes with higher EPL.

Prediction 2: The proportion of innovation performed by firms that is "radical" (and will likely require significant adjustments in employment) is higher in regimes with low EPL.

3 Empirical strategy

In order to investigate the two empirical predictions outlined above we consider the decisions of multinational firms over where to locate innovative activities across twelve OECD countries. As emphasised above, our identification strategy is to use variation *within* multinational firms, which allows us to control for a large range of potentially unobservable characteristics at the firm, industry and home country level. We use data on multinationals from 12 countries. We consider both the total level of innovative activity, and the level of activity on the most technologically new projects, which we interpret as being those most associated with employment adjustment and volatility (we show evidence to support this interpretation).

Our main measure of the level of innovative activity is a count of patents. We follow the literature (Hausman et al (1984), Pakes (1986), Blundell et al (1999)) and model the count of patents with a linear exponential model.

Consider a multinational firm (*m*), with a number of subsidiaries (*s*) each of which operates in (a potentially different) industry (*i*) and is located in country (*c*). We model the level of inventive activity, measured by patent applications (*P*), in each location as a function of EPL, a range of other covariates (X), multinational effects (η) and an idiosyncratic error (*u*):

$$P_{ms} = \exp\left(\beta_1 EPL_c + X_{ci} + \eta_m + u_{ms}\right) \tag{19}$$

Our interest is in the sign and magnitude of β_1. Recall from the discussion above that the theoretical literature is ambiguous about what we expect the sign to be - a positive sign would suggest that the dominant effect of EPL is to increase both firms investment in workers and worker commitment, while a negative sign would support the idea that higher EPL makes employment adjustments more costly.

While the theoretical literature is ambiguous about the impact of EPL on the overall level of innovative activity, it clearly points to a detrimental effect of EPL on more technologically advanced or risky investments. To empirically investigate this prediction we estimate

$$NPL_{ms} = \exp\left(\beta_2 EPL_c + \gamma \ln CITWP_{ms} + X_{ci} + \eta_m + \nu_{ms}\right) \tag{20}$$

where *NPL* is a weighted count of patents that gives a greater weight to patents that are more technologically advanced. More specifically, *NPL* is a count of patents weighted by the number of citations made to non-patent literature, mainly scientific journals (the specific definition is discussed further in the next section). *CITWP* is the count of all patents weighted by all citations made, to control for differences across patents in the amount of citations made. Again, our interest is the sign and magnitude of β_2 - a negative sign would indicate that higher technologically advanced patenting, as a proportion of overall patenting, is associated with lower EPL.

One concern we might have with estimating equations (19) and (20) is that EPL is correlated with other institutional variables that also affect innovation incentives. We control for country level measures of other labour market regulations, a measure of product market regulation, concentration in the banking sector and a measure of the efficiency of the courts, all of which may affect the value of holding a patent.[19] Full definitions of all variable and sources are in Table A1.

Some of these variables are highly correlated with EPL, as we can see from the correlation matrix in Table 1, and it is therefore challenging to separately identify the effect of EPL, as with all studies using cross-country variation in this way. EPL is particularly highly correlated with collective bargaining coverage and bargaining coordination, which have been found to be determinants of worker bargaining power,[20] and with the OECD overall measure of product market conditions. Nevertheless, our results are robust to controlling for these institutional variables.

A further concern we might have is that differences in country-industry specialization may influence our results. The trade literature emphasises that countries with a large endowment of capital or skills have an advantage in industries that are capital or skill intensive, which may include high-tech industries. We follow Nunn (2007) and use capital abundance and investment in skills at the country level, interacted with estimates of industry capital and skill intensity. Another concern is that country size may be correlated with EPL, and production activity locates in large countries to access the product market, and where this production is highly skilled it drives up

[19] See Aghion et al. (2005) for the effect of product market regulations that determine competition on innovation. See Carlin (2003) for the effect of banking concentration on specialisation in high tech innovative sectors.

[20] See Calmfors and Driffil (1988), Flanagan (1999) and Griffith, Harrison and Macartney (2007) for further discussion and evidence that coordination increases worker bargaining power.

wages for high skilled workers in those countries (e.g. see Ekholm and Hakkala, 2007). As market access is less important for R&D this may crowd out highly skilled innovation to smaller countries. To control for country size we include population.

These considerations lead to the following structure for X_{ci}:

$$X_{ci} = \alpha_1 k_i + \alpha_2 k_i K_c + \alpha_3 K_c + h_i + \alpha_4 h_i H_c + \alpha_5 H_c + \alpha_6 Pop_c, \qquad (21)$$

where k_i is the capital per unit output in industry *i* based on US data (the US is not in the sample), K_c is the natural log of the capital per worker in country *c*, h_i is the skill intensity of industry *i*, H_c is the natural log of the proportion of GDP spent on higher education in country *c*, and Pop_c is the working population of country *c* averaged over the sample period.

4 Data

In order to estimate equations (19) and (20) we need information on the geographic location and level of technological sophistication of multinational firms' innovative activity, along with information on EPL and other country and industry characteristics.

4.1 Measuring the innovative activity of multinational firms

The data on patents come from the European Patent Office PATSTAT dataset, which we have matched to information on corporate ownership structure and financial accounts from BVD Amadeus (see Macartney 2009). Patent applications filed at the European Patent Office (EPO) are an attractive measure of innovative activity for a number of reasons. The advantage of this measure is that it is administrative in nature with well defined rules that are independent of the location of the patent applicant. Furthermore, it is measured at the firm-location level (in contrast to data on firm level

R&D expenditure, which is not widely available for firms in many European countries, and where it is reported it is almost always at the world-wide level). Patents data has been widely used and found to be closely related to R&D expenditure measures (see Griliches et al. 1984 and 1990), and this is also true for our data at the industry level (see Macartney 2009). There are of course also drawbacks to using patents as a measure of innovative activity, including that firms in different industries and countries have different propensities to patent, and that the value of a patent is heterogenous across firms. Our identification strategy, of looking *within* the firm, helps to control for many of these potential drawbacks.

Our main sample contains 1,378 subsidiaries of 343 multinational firms.[21] These subsidiaries file at least one patent that makes at least one citation. Conditioning on only patents that make a citation is convenient for estimating the functional form of equation (20), which includes as a regressor the log of the total number of citations made by patent held by a subsidiary. In the results section we show that the results we find for equation (19) are similar for the larger sample that also includes subsidiaries that file patents that make no citations.

Table 2 shows how the firms and patent applications are distributed across countries. Column (1) shows the total number of firms (including domestic and foreign subsidiaries) in each country, and column (2) shows the total number of patents filed by corporations. Column (3) shows how the 1,378 subsidiaries of multinational firms that make up our baseline sample are distributed across countries and column (4) gives the count of their patent applications. The baseline sample includes all patent

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[21] Voith AG was removed form the sample due to concerns about the data.

applications whether or not they have been granted (we show the results are robust to considering only granted patents).

To estimate equation (19) we measure innovative activity as a simple count of patents (*P*). We use simple counts rather than weighting patents by citations *received* as many of the patents are relatively new and therefore citations are severely truncated. However, our results are robust to using citations weighted patents, suggesting that the effect is significant for economically valuable patents. To estimate equation (20) we measure *radical* innovation activity (NPL_{ms}) as a count of non-patent literature (NPL) citations *made* by patents filed by subsidiary *s* in multinational firm *m* over the sample time period, and we control for the total number of citations *made* by the same patents. This measure is an indicator of the newness of the innovation, since NPL citations are typically citations to scientific journals. Table 3 shows how the proportion of all citations made that are to NPL varies across industries. We can see that industries which we might expect to require highly scientific innovation, such as food production, transport and communications, finance and chemical (including pharmaceuticals) have the highest proportion of NPL citations, and industries which we might expect to involve less scientific innovations, such as light manufactures, have the lowest proportion of NPL citations.

Our interest in this paper is on the effect of labour market regulations that affect job security for workers and adjustment costs for employees. Increased job security increases worker incentives to invest in innovation and therefore increases the return to innovation for employers. However, where innovation is uncertain or significantly new, in that it requires an adjustment in the skill mix of employees which may involve the replacement of existing workers with external workers, regulations that protect existing employment increase the cost of innovation. Our expectation is that the second effect will dominate the first when innovation is significantly technologically advance, as measured by the proportion of citations to the scientific literature (NPL).

In Table 4 we show a number of correlations that supports the appropriateness of this measure. We start in column (1) by showing the positive correlation between high NPL citations and the average number of inventors per patent, a possible indicator of the complex nature of the technology. Column (2) shows that NPL innovation is positively correlated with employment adjustment within firms and column (3) that NPL innovation is correlated with country-industry sales volatility, a measure of uncertainty.

4.2 Employment Protection Legislation

We use an index of EPL from the OECD (OECD Economic Outlook 1999 Chapter 2) and widely used in the literature on the determinants of unemployment (see, inter alia, Nickell et al. 2005, Nicoletti et al 2000). Our preferred measure is the indicator of the legislation relating to regular contracts (covering procedural inconveniences, direct cost of dismissal, notice and trial period). Our results are also robust to using the higher level indicator that also includes legislation for temporary contracts (covering types of work admissible under temporary contracts and maximum cumulative duration allowed). Key for our purposes is that there is real variation in this measure across the countries in our sample, as is evident from Figure 1.

5 Results

To recap, we have derived empirical predictions of an effect of EPL on innovation that is differential across the nature of innovation. On the one hand EPL may increase overall patenting, but on the other hand it may reduce radical innovation. We consider whether there is empirical support for these predictions, controlling for multinational firm fixed effects, country and industry characteristics.

5.1 Main results

The results for total innovation are presented in Table 5. Column (1) shows results for a simple specification with multinational firm fixed effects. The positive coefficient on EPL indicates that, within multinational firms, more innovation is performed by subsidiaries in countries with high employment protection for workers. To ensure that the result is not driven by patterns of industrial specialization in countries with abundant capital, column (2) includes as control variables the capital intensity of the industry in which each subsidiary resides, the capital abundance of the country in which it is registered and the interaction between these two variables. The coefficient on the interaction of capital abundance and capital intensity is positive as we would expect, and the coefficient on EPL remains positive and statistically significant. Also included is the working population of each country to ensure that the result that total patenting occurs more in countries with high EPL is not driven by market size effects that may be correlated with employment regulation. To ensure that our results are not driven by patterns of industrial specialization in countries with abundant skills, column (3) includes as control variables the skill intensity of each industry in which subsidiaries resides, the skill level of the country in which it is registered and the interaction between these two variables. Although the coefficient on this interaction is negative, counter to intuition, column (3) shows that our results are not driven by patterns of comparative advantage with relation to skills.[22] Column (4) ensure that our result is not driven by other national regulations, by including a set of product market,

[22] We do not have data on higher education expenditure in Portugal so two observations drop out.

financial market and legal variables, as well as other labour market regulations. However, as shown in column (1) of Table 1, many of these variables are highly correlated with our measure of EPL. This, and the fact that the coefficient in column (4) increase substantially in magnitude relative to the previous three columns and slightly loses statistical significance, suggests problems of multi-colinearity in this specification.

Table 6 show the results for radical innovation. The dependent variable is the number of citations to the non-patent literature, with the log of the total number of citations as a control, so that we can interpret the results as the effect of EPL on the proportion of citations that are to NPL. In column (1) the negative coefficient on EPL indicates that, within multinational firms, the more technologically advanced innovation is performed by subsidiaries in countries with low employment protection for workers. Column (2) presents the results with controls included for industry capital intensity, national capital abundance and their interaction. The coefficient on the interaction of capital abundance and capital intensity is positive, as we would expect. The coefficient on EPL remains negative and statistically significant at the 10% level. Again, the working population of each country is included as a control for market size effects. Column (3) includes control variables for industry skill intensity, country skill abundance and their interaction. The coefficient on this interaction is positive as expected, but is not statistically significant. Nevertheless, the coefficient on EPL in column (3) remains negative and statistically significant. Column (4) ensures that our key result is robust to the inclusion of regulatory variables in product, financial and labour markets, as well as the efficiency of legal institutions. The coefficient on EPL remains negative and statistically significant at the 10% level.

5.2 Robustness

The specification so far only used data on subsidiaries that file patents that make citations. However, we can use a larger sample that also includes subsidiaries that file patents that make no citations, as well as those that file patents that do make citations, to look at the impact of EPL on total innovative activity. The coefficients (standard errors) for this sample of 2,870 subsidiaries for the equivalent specifications shown in Table 5 are shown in Table 7. The results remain robust.

Weighting patents by the number of citation that they receive captures their economic importance. The sample of patents that we have used in this paper have been filed relatively recently, and therefore citations are truncated. Nevertheless, we re-run the regressions from column (1) in Table 5, weighting the patent count by citations so far *received*. The resulting coefficient (standard error) on the EPL variable is 0.2257 (0.1294). Also, the regression was re-run using the total number of citations *made* as the dependant variables, in which case the coefficient (standard error) on the EPL variable is 0.3224 (0.1233).

The results thus far have relied on patent filings irrespective of whether or not those patents have been granted. The motivation for using all patent filings is again the relative youth of the patents in the sample. Patents may not have been granted yet, although they will be in the future. Furthermore, the length of time it takes for a patent to be granted may be related to the nature of that innovation, i.e. how radical the innovation is, and therefore conditioning on only granted patents may introduce non-classical measurement error into the dependant variable. Nevertheless, our results are broadly robust to conditioning on only patents that have been granted. This reduces the sample to just 820 observations. The coefficient (standard error) for the specification previously presented in column (1) of Table 5 when we use only granted patents is 0.3027 (0.1419) and the coefficient (standard error) for the specification previously presented in column (1) of Table 6 when we use only granted patents is -0.173 (0.0286). It is not possible to identify the effect of EPL on innovation and include skills, capital and other regulatory variables on this reduced sample.

We use a measure of employment protection that concerns only regular full time contract. We can also use a measure that includes the protection afforded to temporary workers as well as regular workers, and includes a measure of protection against collective dismissals. The results that employment protection increase incremental innovation by firms and decreases radical innovation is robust to using this higher level measure of employment protection as shown in columns (1) and columns (4) of Table 8. Columns (2) and columns (5) show the two specifications using the employment protection legislation afforded to temporary workers as the variable of interest and columns (3) and (6) shows the results with both EPL for regular contracts and EPL for temporary contracts included as separate variables. The fact that the coefficient on EPL for regular contracts is in general the larger and more statistically significant suggests that it is the rights of permanent employees that affect firms incentives with regard to innovation, as we would expect given the intuition of the model presented in this paper.

5.3 Economic Significance

What is the economic significance of these estimates? To consider this we look at the impact of moving each country to the mean EPL index of 2.3. Consider countries such as Italy and Germany, which have relatively strong employment protection legislation with an EPL index of 2.8. Reducing their EPL to the mean in our sample of 2.3 would result in approximately a 20% fall in overall patents (using the coefficient estimates in column (2) of Table 5 evaluated at the mean level of patenting), but an increase in radical innovations of around 5%.

On the other hand, consider a country like Denmark with a low amount of employment protection, which has an EPL index of 1.6. Increasing their EPL index to 2.3 would lead to an increase in overall patenting of around 37%, but a fall in radical innovations of around 6%. These are substantial effects.

6 Conclusion

This paper has investigated the relationship between employment protection legislation and innovation activity across twelve European countries. We use new data on the activities of multinational firms operating across different jurisdictions. Our findings suggest that multinational firms do more incremental patenting activity in high EPL countries and more radical patenting activity in low EPL countries. This is consistent with a variant of an Aghion-Howitt style growth model that incorporates the two effects of EPL - increases job security for existing workers, and thus increased effort, and increased firing costs leading to higher adjustment costs for the firm.

As a final caveat, however, we should note that our empirical findings are also consistent with other theoretical models, such as Saint-Paul's model of comparative advantage, and with the ideas put forward in Hall and Soskice. We are not able to empirically distinguish these alternative models. Care must be taken in interpreting these results. While we have attempted to control for a number of other characteristics that vary across countries, and for firm specific characteristics, identification is still from cross-sectional data. We do not observe sufficient time series variation in EPL and our data to identify the effects of changes in labour market regimes. Nonetheless, this evidence is suggestive and appears to be robust to a number of standard concerns put forward in the literature.

Appendix A.1

In a similar vein to Boeri and Jimeno (2005) consider that there is a small probability p that demand for the final good will drop from high, θ^h, to low, θ^l.[23] For a given level of worker effort output is then given by $y = \theta^S \int_0^1 (ZA_i)^{1-\alpha} x_i^\alpha di$, where $S = h,l$.[24] On the realisation of the demand shock the firm will wish to adjust employment from x_i^h to the new optimal level x_i^l by firing workers. The probability of being fired for each worker is then given by:

$$s = p.\left(\frac{x_i^h - x_i^l}{x_i^h}\right). \tag{A1}$$

In the presence of EPL it costs the firm φ per worker to adjust employment downwards. The loss to the firm of a non-optimal level of employment, x_i, is given by:

$$\Delta\pi_i = \left(\theta^l \alpha (ZA_i)^{1-\alpha} x_i^{\alpha-1} - 1\right)x_i - \left(\theta^l \alpha (ZA_i)^{1-\alpha} \left(x_i^l\right)^{\alpha-1} - 1\right)x_i^l, \tag{A2}$$

where the first term is the level of profits given low demand but with employment $x_i > x_i^l$ and the second term is the level of profits given low demand and the optimal level of employment. When $x_i = x_i^l$, $\Delta\pi_i = 0$. The firm faces firing costs given by $\varphi\left(x_i^h - x_i\right)$. The firm will adjust the employment level until the marginal gain from

[23] This is simpler than Boeri and Jimeno (2005) in that we consider that demand is normally high, but there is a small possibility that it drops. The firm initially chooses employment levels assuming demand will be high.

[24] For simplicity the j superscript and the variable for workers effort, e_i^j, are omitted from the discussion in this section.

doing so equals the marginal cost of firing an employee. The optimal level of employment, $\hat{x}_i$, given firing costs is then given by:

$$\theta^l \alpha^2 (ZA_i)^{1-\alpha} \hat{x}_i^{\alpha-1} - 1 = -\varphi \tag{A3}$$

Therefore,

$$\hat{x}_i = \left(\frac{1-\varphi}{\theta^l \alpha^2} \right)^{\frac{1}{\alpha-1}} ZA_i . \tag{A4}$$

This expression is increasing in φ. Note that it reduces to x_i^l in the absence of firing costs ($\varphi = 0$). There will also exist some level of φ where no adjustment occurs. Substituting this into A1 gives the probability of being fired faced by each worker in the presence of firing costs:

$$s = p.\left(\frac{\left(\frac{1}{\theta^h \alpha^2} \right)^{\frac{1}{\alpha-1}} ZA_i - \left(\frac{1-\varphi}{\theta^l \alpha^2} \right)^{\frac{1}{\alpha-1}} ZA_i}{\left(\frac{1}{\theta^h \alpha^2} \right)^{\frac{1}{\alpha-1}} ZA_i} \right) = p.\left(1 - \left(\frac{\theta^h}{\theta^l} \right)^{\frac{1}{\alpha-1}} (1-\varphi)^{\frac{1}{\alpha-1}} \right). \tag{A5}$$

This probability decreases as $\theta^l \to \theta^h$ as we would expect.[25] Writing out $s(\varphi)$ followed by its first and second derivatives, gives:

$$s(\varphi) = p.\left(1 - \left(\frac{\theta^h}{\theta^l} \right)^{\frac{1}{\alpha-1}} (1-\varphi)^{\frac{1}{\alpha-1}} \right), \tag{A6}$$

[25] The probability of being fired is non-positive when $\theta^l = \theta^h$. Note that $\alpha < 1$.

$$s'(\varphi) = p.\frac{1}{(\alpha-1)}\left(\frac{\theta^h}{\theta^l}\right)^{\frac{1}{\alpha-1}}(1-\varphi)^{\frac{2-\alpha}{\alpha-1}}, \tag{A7}$$

$$s''(\varphi) = -p.\frac{(2-\alpha)}{(\alpha-1)^2}\left(\frac{\theta^h}{\theta^l}\right)^{\frac{1}{\alpha-1}}(1-\varphi)^{\frac{3-2\alpha}{\alpha-1}}. \tag{A8}$$

As $\alpha < 1$ and restricting $\varphi \in [0,1)$ we have $s'(\varphi) < 0, s''(\varphi) < 0$, that is the probability of a worker losing their job is decreasing in φ and at an increasing rate.[26]

Using a Taylor expansion around $\varphi = 0$ we can now write A1 as:

$$s = p.\left(1-\left(\frac{\theta^h}{\theta^l}\right)^{\frac{1}{\alpha-1}}\right) - p.\frac{1}{(1-\alpha)}\left(\frac{\theta^h}{\theta^l}\right)^{\frac{1}{\alpha-1}}\varphi - p.\frac{1}{2}\frac{(2-\alpha)}{(\alpha-1)^2}\left(\frac{\theta^h}{\theta^l}\right)^{\frac{1}{\alpha-1}}\varphi^2.... \tag{A9}$$

Appendix A.2

From differentiation of equations (12) and (14) in the main text, incremental innovation and radical innovation effort vary with firing costs as described in A10 and A11.

$$\frac{\partial \mu_i^{I*}}{\partial \varphi} = (1-\beta)\left(\gamma - \frac{1}{\gamma}\right)\delta\frac{\partial Z(e_i^{0*})}{\partial \varphi}, \tag{A10}$$

$$\frac{\partial \mu_i^{R*}}{\partial \varphi} = (1-\beta)\left(\gamma^2 - \frac{1}{\gamma^2}\right)\delta\frac{\partial Z(e_i^{0*})}{\partial \varphi} - \frac{\varphi k}{\gamma^2}\frac{\partial Z(e_i^{0*})}{\partial \varphi} - \frac{k}{\gamma^2}Z(e_i^{0*}). \tag{A11}$$

[26] Restricting firing costs to be between zero and one is natural here as the workers reservation wage is normalised to one and it is likely that firing costs will be some proportion of that. *s* tends to negative infinity as firing costs tend to one, but we just exclude this and say that at some point firing costs are so high that the firm does not adjust employment at all.

For small φ we can write (from equation A9):

$$s(\varphi) = p.\left(1 - \left(\frac{\theta^h}{\theta^l}\right)^{\frac{1}{\alpha-1}}\right) - p.\frac{1}{(1-\alpha)}\left(\frac{\theta^h}{\theta^l}\right)^{\frac{1}{\alpha-1}}\varphi . \qquad \text{(A12)}$$

Inserting this into equation (9) from the main text and letting $b = \frac{1}{(1-\alpha)}\left(\theta^h/\theta^l\right)^{\frac{1}{\alpha-1}}$ we can write:[27]

$$Z(e_i^{0*}) = \frac{1}{2}(1 - p(1-(1-\alpha)b - b\varphi))\beta\delta A_i^0 = \frac{1}{2}((1 - p + p(1-\alpha)b) + pb\varphi)\beta\delta A_i^0 . \qquad \text{(A13)}$$

Insertion of expression (A13) into (A10) and (A11), after trivial manipulation results in equations (16) and (17) in the main text.

[27] Note that *b* is decreasing in the severity of the shock. Its range is between zero and $\frac{1}{1-\alpha}$.

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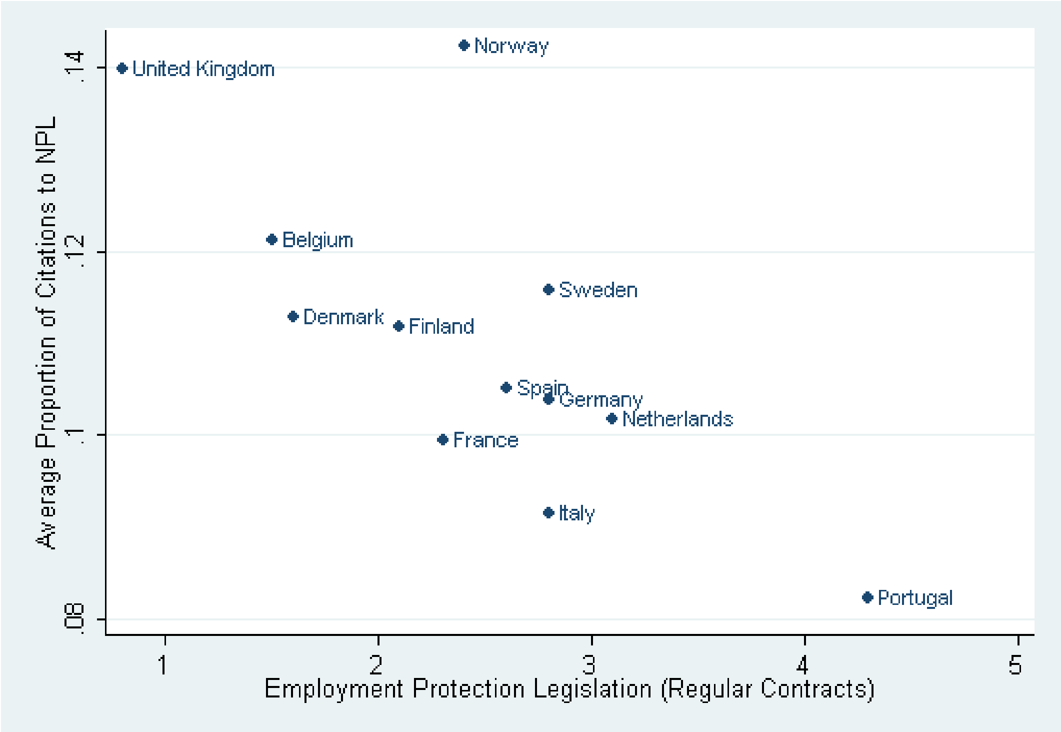
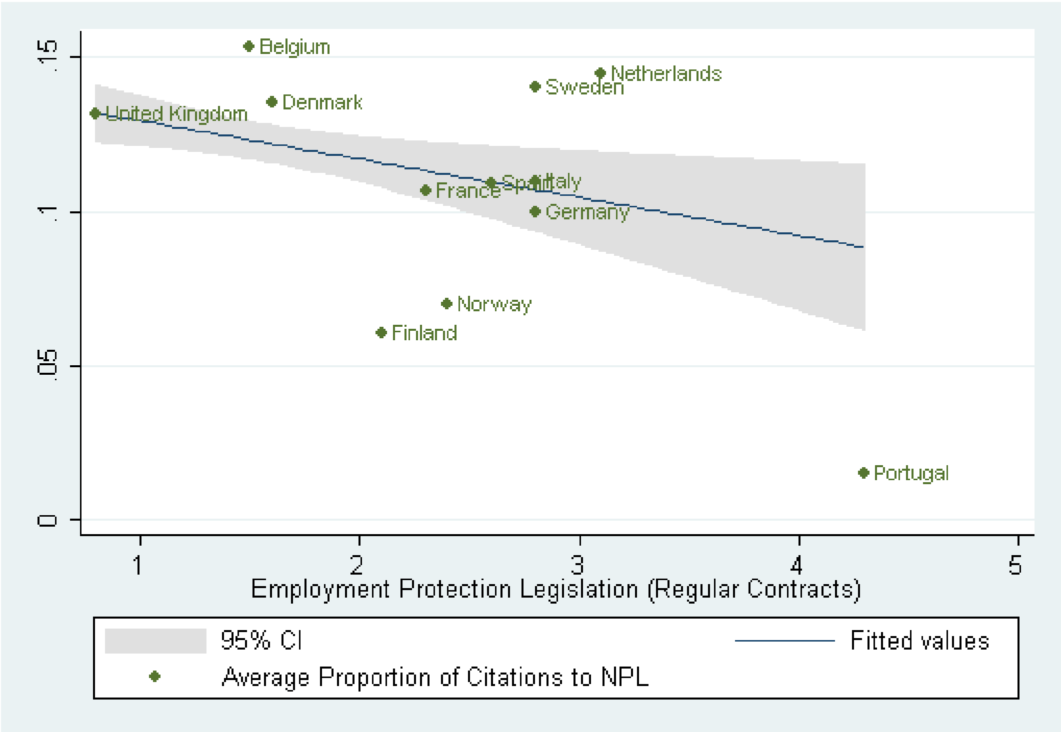
Storm, S. and Naastepad, C. (2007). “Labour Market Regulation and Productivity Growth: Evidence for 20 OECD Countries (1984-1997)”, *ILO, Economic and Labour Market Analysis Department, Working Paper*.

Figure 1: EPL and Radical Innovation (all firms)



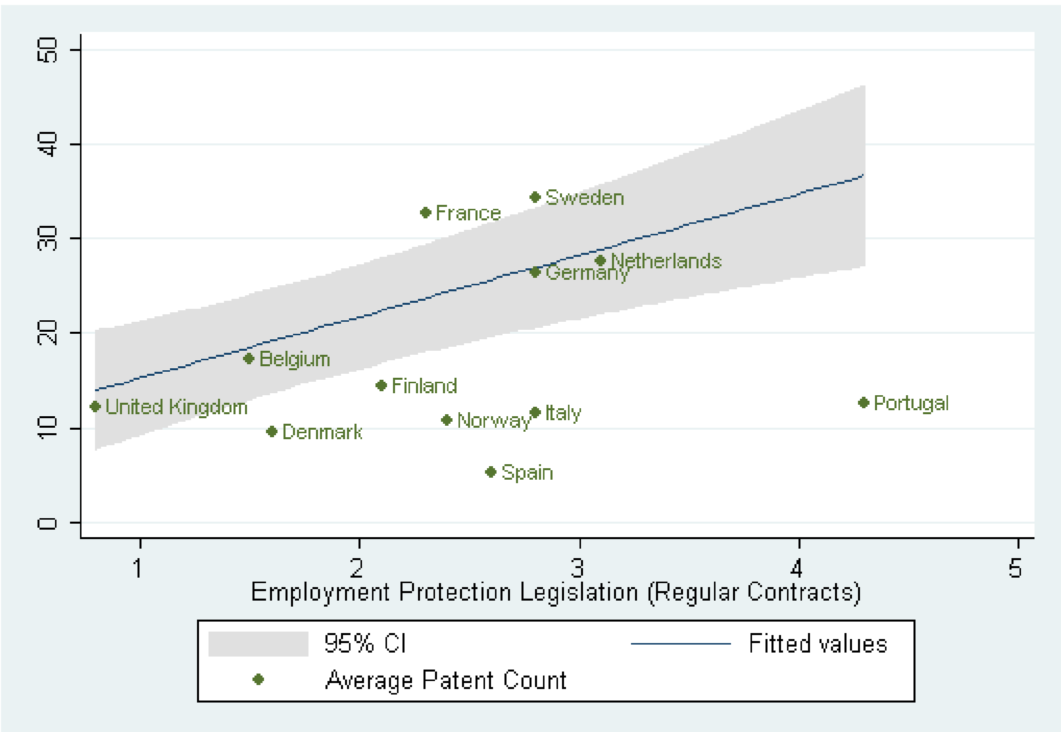
Notes: The graphs shows the relationship between radical innovation and EPL for the 37,350 private sector firms registered in the countries presented that filed patents in the period 1997 to 2003. These firms were responsible gor the filing of 230,322 patents in this period. The x-axis shows the average index for Employment Protection Legislation (Regular Contracts from OECD (XXXX) over the period 1997-2003. The y-axis shows the average proportion of citations made to the scientific literature by subsidiaries located in each country over the period 1997-2003.

Figure 2: EPL and Radical Innovation by Multinational Firms



Notes: Based on a sample of 1,378 subsidiaries of multinational firms, see Section 4 for details of the data used Fitted line weighted by number of subsidiaries. The confidence interval uses standard errors clustered at the country level.

Figure 3: EPL and Innovation by Multinational Firms



Notes: Based on a sample of 1,378 subsidiaries of multinational firms, see Section 4 for details of the data used Fitted line weighted by number of subsidiaries. The confidence interval uses standard errors clustered at the country level.

Table 1: Employment Protection Legislation and Control Variables

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Employment Protection Legislation (Regular Contracts)	(1)	1.00										
Union Density - Average 1997-2003	(2)	-0.22	1.00									
Collective Bargaining Coverage	(3)	0.63	0.05	1.00								
Employment Tax Wedge - Average 1997-2003	(4)	0.33	0.24	0.87	1.00							
Bargaining Coordination	(5)	0.73	0.09	0.59	0.39	1.00						
OECD Product Market Regulations 1998&2003 Average	(6)	0.57	-0.36	0.63	0.53	0.36	1.00					
Credit Institutions per Capita - Average 1997-2002	(7)	0.19	0.52	0.36	0.17	0.52	-0.14	1.00				
Percent of Claim Spent in Court and Attorney Fees (where mandatory)	(8)	0.10	0.07	-0.20	0.05	-0.03	-0.04	-0.40	1.00			
Log of Real Capital per thousand workers, 2000 USD, 1995 prices, in year 1997	(9)	0.42	0.27	0.65	0.46	0.44	0.38	0.36	-0.47	1.00		
Log of Share of GDP Spent on Higher Education	(10)	0.16	0.47	0.28	0.26	0.17	-0.45	0.43	0.16	0.06	1.00	
Average working population (mil.) 1997-2003	(11)	0.09	-0.74	-0.07	-0.06	-0.18	0.25	-0.43	0.01	-0.40	-0.41	1.00

Notes: see table A1 for full descriptions and sources.

Table 2: Firms and Patents

Country	Number of firms (1)	Number of patents filed (2)	Number of subsidiaries of multinational firms (3)	Number of patents filed by subsidiaries of multinational firms (4)
Belgium	853	4,583	36	622
Germany	11,592	108,431	491	12,998
Denmark	1,151	4,160	40	380
Spain	1,149	2,084	34	181
Finland	869	8,032	5	72
France	4,043	31,310	322	10,536
United Kingdom	7,964	23,857	228	2,766
Italy	4,556	11,833	89	1,027
Netherlands	2,103	21,442	64	1,765
Norway	689	1,362	5	54
Portugal	54	96	2	25
Sweden	2,327	13,132	62	2,131
Total	37,350	230,322	1,378	32,557

Notes: Column (1) includes subsidiaries of domestic and multinational firms.

Table 3: Industries and Non-Patent Literature Citations

INDUSTRY	Percent of Citations to Non-Patent Literature
FOOD PRODUCTS, BEVERAGES AND TOBACCO	0.26
TRANSPORT AND STORAGE AND COMMUNICATION	0.22
FINANCE, INSURANCE, REAL ESTATE AND BUSI	0.19
CHEMICALS AND CHEMICAL PRODUCTS	0.17
BASIC METALS	0.15
ELECTRICAL AND OPTICAL EQUIPMENT	0.14
ELECTRICITY, GAS AND WATER SUPPLY	0.13
WHOLESALE AND RETAIL TRADE; RESTAURANTS	0.11
COKE, REFINED PETROLEUM PRODUCTS AND NUC	0.10
MOTOR VEHICLES, TRAILERS AND SEMI-TRAILE	0.10
OTHER TRANSPORT EQUIPMENT	0.10
CONSTRUCTION	0.09
OTHER NON-METALLIC MINERAL PRODUCTS	0.09
MACHINERY AND EQUIPMENT, NEC	0.08
PUBLISHING, PRINTING AND REPRODUCTION OF	0.08
RUBBER AND PLASTICS PRODUCTS	0.08
TEXTILES, TEXTILE PRODUCTS, LEATHER AND	0.07
FABRICATED METAL PRODUCTS, EXCEPT MACHIN	0.06
PAPER AND PAPER PRODUCTS	0.06
WOOD AND PRODUCTS OF WOOD AND CORK	0.06
MANUFACTURING NEC	0.05

Notes: The values are estimated using the years 1997 to 2003.

Table 4: NPL Citations, complexity, adjustment and uncertainty

	Average no of inventors per patent	Within firm employment volatility	Within firm sales volatility
	(1)	(2)	(3)
Proportion of citations to non-patent literature	0.2681	0.1158	0.1919
P-val	0.0000	0.0000	0.0000

Notes: Observations are country-3 digit industries. The values are estimated using the years 1997 to 2003. Column (2): employment volatility is the country-industry average coefficient of variation in employment calculated for each firm over the time period. Column (3): sales volatility is the country-industry average coefficient of variation in sales calculated for each firm over the time period.

Table 5: Employment Protection Legislation and Innovation

Dependent Variable:	All Patent Applications			
	(1)	(2)	(3)	(4)
Employment Protection Legislation (Regular Contracts)	0.4417	0.3414	0.321	0.8479
	[0.1220]***	[0.1619]**	[0.1361]**	[0.4543]*
Average working population (mil.) 1997-2003		-0.0026	0.0028	-0.0047
		[0.0053]	[0.0072]	[0.0092]
Log of Real Capital per thousand workers, 2000 USD, 1995 prices, in year 1997		-0.5967		
		[0.7419]		
Log of Capital per worker at 1997*Industry capital intensity		0.7759		
		[0.4008]*		
Industry Capital Intensity		-3.5953		
		[1.8005]**		
Log of Share of GDP Spent on Higher Education			2.0159	
			[0.4060]***	
Log of Share of GDP Spent on Higher Education*Industry skill intensity			-4.2225	
			[1.0242]***	
Industry Skill Intensity			-2.7873	
			[1.2624]**	
Union Density - Average 1997-2003				-0.0216
				[0.0168]
Collective Bargaining Coverage				-0.0095
				[0.0452]
Employment Tax Wedge - Average 1997-2003				0.1222
				[0.1213]
Bargaining Coordination				-1.0381
				[0.2029]***
OECD Product Market Regulations 1998&2003 Average				-1.3472
				[0.7726]*
Credit Institutions per Capita - Average 1997-2002				16.9807
				[12.1849]
% of Claim Spent in Court and Attorney Fees (where mandatory)				0.0451
				[0.0298]
Constant	0.7452	6.1463	4.6065	0.4226
	[0.0976]***	[3.3970]*	[0.9471]***	[0.7208]
MNE Fixed Effects	Yes	Yes	Yes	Yes
Observations	1378	1378	1376	1378

Notes: All columns show the results of Poisson regression with robust standard errors clustered at the country level.
In column (3) Portugal is excluded due to a lack of data on expenditure on education.

Table 6: Employment Protection Legislation and Radical Innovation

Dependent Variable:	NPL Citations			
	(1)	(2)	(3)	(4)
Employment Protection Legislation (Regular Contracts)	-0.1245	-0.0591	-0.1102	-0.3706
	[0.0414]***	[0.0349]*	[0.0211]***	[0.2099]*
Log of All Citations Made	1.0013	1.0115	1.0111	1.0175
	[0.0194]***	[0.0120]***	[0.0113]***	[0.0096]***
Average working population (mil.) 1997-2003		-0.0092	-0.0087	0.0028
		[0.0019]***	[0.0011]***	[0.0050]
Log of Real Capital per thousand workers, 2000 USD, 1995 prices, in year 1997		-0.6255		
		[0.1794]***		
Log of Capital per worker at 1997*Industry capital intensity		0.3984		
		[0.1114]***		
Industry Capital Intensity		-1.7793		
		[0.5101]***		
Log of Share of GDP Spent on Higher Education			0.0558	
			[0.2950]	
Log of Share of GDP Spent on Higher Education*Industry skill intensity			0.4631	
			[1.2823]	
Industry Skill Intensity			0.9486	
			[1.4105]	
Union Density - Average 1997-2003				0.0083
				[0.0065]
Collective Bargaining Coverage				0.0603
				[0.0265]**
Employment Tax Wedge - Average 1997-2003				-0.0946
				[0.0640]
Bargaining Coordination				0.2466
				[0.1432]*
OECD Product Market Regulations 1998&2003 Average				-0.6723
				[0.1628]***
Credit Institutions per Capita - Average 1997-2002				-20.0452
				[6.6221]***
% of Claim Spent in Court and Attorney Fees (where mandatory)				0.035
				[0.0063]***
Constant	-0.8759	0.6873	-2.4668	-2.9932
	[0.1148]***	[0.7775]	[0.3808]***	[0.2334]***
MNE Fixed Effects	Yes	Yes	Yes	Yes
Observations	1378	1378	1376	1378

Notes: All columns show the results of Poisson regression with robust standard errors clustered at the country level.
In column (3) Portugal is excluded due to a lack of data on expenditure on education.

Table 7: Employment Protection Legislation and Incremental Innovation – Larger Sample

Dependent Variable:	All Patent Applications			
	(1)	(2)	(3)	(4)
Employment Protection Legislation (Regular Contracts)	0.571	0.3214	0.4549	1.1349
	[0.1054]***	[0.1667]*	[0.1541]***	[0.4590]**
Average working population (mil.) 1997-2003		0.0057	0.0103	-0.0161
		[0.0055]	[0.0067]	[0.0102]
Log of Real Capital per thousand workers, 2000 USD, 1995 prices, in year 1997		-0.0031		
		[0.6180]		
Log of Capital per worker at 1997*Industry capital intensity		0.671		
		[0.3341]**		
Industry Capital Intensity		-3.0386		
		[1.5372]**		
Log of Share of GDP Spent on Higher Education			1.678	
			[0.3632]***	
Log of Share of GDP Spent on Higher Education*Industry skill intensity			-3.3317	
			[1.0380]***	
Industry Skill Intensity			-1.6402	
			[1.1057]	
Union Density - Average 1997-2003				-0.0386
				[0.0128]***
Collective Bargaining Coverage				-0.0739
				[0.0481]
Employment Tax Wedge - Average 1997-2003				0.2702
				[0.1096]**
Bargaining Coordination				-1.0398
				[0.2062]***
OECD Product Market Regulations 1998&2003 Average				-1.3049
				[0.4160]***
Credit Institutions per Capita - Average 1997-2002				29.4541
				[9.1999]***
% of Claim Spent in Court and Attorney Fees (where mandatory)				0.0056
				[0.0236]
Constant	0.9295	2.2178	3.4095	0.1854
	[0.0843]***	[2.4865]	[0.6933]***	[0.6170]
MNE Fixed Effects	Yes	Yes	Yes	Yes
Observations	2870	2870	2868	2870

Notes: All columns show the results of Poisson regression with robust standard errors clustered at the country level. In column (3) Portugal is excluded due to a lack of data on expenditure on education.

Table 8: Employment Protection Legislation – Regular and Temporary Contracts

Dependent Variable:	All Patent Applications			NPL Citations		
EPL (All Contracts)	0.4043			-0.1083		
	[0.0988]***			[0.0279]***		
EPL (Temporary Contracts)		0.2346	0.1261		-0.072	-0.0429
		[0.0947]**	[0.0794]		[0.0214]***	[0.0438]
EPL (Regular Contracts)			0.3532			-0.0845
			[0.1039]***			[0.0681]
Log of All Citations Made				1.0055	1.0043	1.0052
				[0.0178]***	[0.0181]***	[0.0173]***
Constant	0.8964	2.3072	-0.8408	-0.9746	-1.9519	-0.9117
	[0.0494]***	[0.3597]***	[0.2994]***	[0.1384]***	[0.1180]***	[0.1443]***
MNE Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1378	1378	1378	1378	1378	1378

Notes: All columns show the results of Poisson regression with robust standard errors clustered at the country level.

Table A1: Data and Sources

Variable	Description and source	Mean s.d.
Employment Protection Legislation (Regular Contracts)	An average of an indicator of legislation for regular contracts (covering procedural inconveniences, direct cost of dismissal, notice and trial period) and an indicator for legislation for temporary contracts (covering types of work admissible under temporary contracts and maximum cumulative duration allowed). Nicoletti et al (2000).	2.425 .89048
Union Density - Average 1997-2003	Actual union members as percentage of employees. OECD Labour Force Statistics.	42.10833 25.38686
Collective Bargaining Coverage	Percentage of employees covered by collective bargaining, whether they are union members or not. Nickell (2003), originally obtained from Wolfgang Ochel.	79.66667 15.69211
Employment Tax Wedge - Average 1997-2003	Average of the tax wedge for one-earner family with two children and single persons without children. OECD, Taxing Wages, 2003.	38.74788 6.950881
Bargaining Coordination	The degree of coordination of bargaining: 1- firm level, 2- industry level, 3- economy level. We use coordination index 2 from Nickell (2003), originally obtained from Wolfgang Ochel.	2.083333 .5149287
OECD Product Market Regulations 1998&2003 Average	Top level indicator capturing extent of state control of product markets, barriers to entrepreneurship and trade and investment. Source: OECD International Regulation Database.	1.700718 .3538945
Credit Institutions per Capita - Average 1997-2002	Credit institutions are defined by the European Central Bank as any institution covered by the definition contained in Article 1(1) of Directive 2000/12/EC, as amended. Accordingly, a credit institution is "(i) an undertaking whose business is to receive deposits or other repayable funds from the public and to grant credits for its own account; or (ii) an undertaking or any other legal person, other than those under (i), which issues means of payment in the form of electronic money." Source: CESIfo Dataset, see http://www.cesifo.de. For Norway, from Eitrheim et al. (2003).	.0404272 .0255226
% of Claim Spent in Court and Attorney Fees (where	The estimated cost of suing for breach of contract in a hypothetical case as a percentage of the claim amount. Source: Doing Business Report. See http://www.doingbusiness.org/ExploreTopics/EnforcingContracts/ for data	19.44167

mandatory)	and exact methodology	7.113554
Average working population (mil.) 1997-2003	Source: OECD.	19.92361
		18.70212
Real Capital per thousand workers, 2000 USD, 1995 prices, in year 1997	For total economy, averaged over sample period. Calculated using a permanent inventory method using gross fixed capital formation. In units of 2000 USD at 1995 prices. Source: OECD Stan.	108.1972
		30.38796
Industry Capital Intensity	Capital divided by output for each industry using US data, average over the sample period. Source: OECD Stan.	1.16211
		.6363175
Share of GDP Spent on Higher Education	As a proportion of GDP. Averaged over 1991-1995, making it pre-sample period. Source: OECD.	.3635136
		.1318802
Industry Skill Intensity	Proportion of workers in each two digit industry in the United Kingdom in 2000 with degree or other higher education. Source: UK Labour Force Survey.	.250483
		.128509