

# Product and labour market regulations and patenting activity

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## Abstract

A large literature has focused on labour market institutions as a reason for slow growth in Europe. How important have product market regulations been? Recent work has shown that less regulation encourages investment, increases employment and leads to faster productivity growth. Empirical work at the firm level, within individual countries, suggests that the impact may differ in important ways - e.g. on entrants and incumbents. In this paper we use individual level data on patenting activity across countries to look at what impact product market deregulation has had on patenting activity, and how this varies depending on the level of employment protection legislation. The findings suggest that tougher competition increases innovation by incumbents, but discourages entrants. Employment protection legislation dampens the impact of competition.

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# 1 Introduction

The growth of value-added per capita in EU countries has lagged behind the US and this is widely believed to be due, in large part, to lower levels of innovation and lower rates of adoption of the latest technologies. This is despite widespread reforms to product markets across EU countries aimed at increasing productivity, employment and growth. With this in mind, the European Council adopted the Lisbon Agenda, calling for the EU to become “the most competitive and dynamic knowledge-based economy in the world” by the end of the current decade through reforms to product, labour and capital markets. It implemented a target in Barcelona to raise research and development (R&D) investment to 3% of the EU’s GDP, as well as objectives to increase the employment rate, the level of labour productivity and the rate of output growth. Yet there is only limited empirical evidence on what impact the widespread regulatory reforms in product and labour markets over the past few decades have had on the innovation activities of firms.

This paper looks at how regulatory reforms to product and labour markets have affected the patenting behaviour of firms across ten OECD countries.<sup>1</sup> We start by looking at the impact of increased product market competition on innovation. In aggregate tougher competition encourages innovation, but the effect is markedly different for new and incumbent innovators. We see increased innovation by incumbents when competition is tougher, but evidence to suggest that tough competition discourages innovation by entrants. This accords without our theoretical expectations, increased competition reduces the rewards to entry into a market, however, many models predict that increased competition will encourage incumbent firms to innovate, in order to escape competition.<sup>2</sup>

We also show that employment protection legislation dampens firms’ incentives to innovate. Our main interest is how the impact of competition in the product market varies with rigidities in the labour market - does employment protection legislation dampens the

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<sup>1</sup>Australia, Belgium, Canada, Denmark, France, Great Britain, Italy, Netherlands, Norway, USA

<sup>2</sup>See, *inter alia*, Gilbert and Newbury (1982) and Aghion et al (2005).

responsiveness of firms in an economy.<sup>3</sup>

This paper relates to several literatures. First, there is a literature on the impact of product market competition on innovation. Three effects are emphasised in the literature. The replacement of low productivity plants with high productivity entrants increases productivity through a reallocation of inputs and output. This effect has been emphasised in work by Caves (1998) and Melitz (2003), Olley and Pakes (1996), Pavcnik (2000). Competition may also induce incumbent firms to organize work more effectively, trim fat and reduce slack, and to learn through imitation from new entrants who are utilizing superior technology or organizational structures, effects that are emphasised in Hart (1983), Schmidt (1997), Nickell (1996), Nickell and Nicolitsas (1999), Nickell, Nicolitsas and Dryden (1997), Nickell, Nicolitsas and Patterson (2001) and Aggerwal and Sandwick (1999). In addition, competition may increase innovative effort by incumbents, as emphasised in Blundell, Griffith and Van Reenen (1999) and Aghion et al (2004, 2005a,b). Nicoletti and Scarpetta (2004) provide some cross-country evidence that more competition is associated with faster growth.

Second, there is a literature on the impact of labour market institutions on investment and R&D. Institutions that give workers greater bargaining power affect firms' incentive to investment. The basic mechanism is that reduce the rents that firms can appropriate from innovation (but increase what workers can) - depends on who is more important for innovation or owners of capital or workers. (see, inter alia, Machin, S. and Wadhvani, S. (1991), Menezes-Filmo, Ulph, and Van Reenen (1998), Ulph and Ulph (1994, 1998, 2001). Recently, Caballero, Cowan, Engel and Micco (2004) consider the impact of employment protection legislation on growth through increasing adjustment costs and Blanchard and Giavazzi (2003) considers the impact of worker bargaining power. Nicoletti, Aghion, Burgess, Redding and Zilibotti (2005) and Scarpetta and Boylaud (2000) provide some preliminary evidence on the interactions between product and labour market institutions.

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<sup>3</sup>As emphasised in a recent paper by Caballero, Engel, Cowan and Micco (2004), employment protection legislation may play an important role in increasing adjustment costs and thus slowing the process of creative-destruction. It is also possible that this form of legislation has the opposite effect if more secure and longer job tenure leads to more training and investment by workers (Acemoglu, 1997).

The structure of the paper is as follows. Section 2 discusses the data and sketches an empirical framework for investigating these questions. Section 3 presents the results. Section 4 concludes.

## 2 Theoretical motivation

Traditional models of imperfect competition based on price competition and product differentiation, e.g. the Hotelling linear model, the circular version of that model by Salop (1977), or the symmetric model of monopolistic competition by Dixit and Stiglitz (1977), all deliver the prediction that more intense product market competition reduces the rents of those firms that successfully enter the market, and therefore it discourages firms from entering, or innovating, in the first place. This is what is often called the "Schumpeterian effect" of product market competition on innovation.

An alternative approach considers how competition affects an incumbent firm engaged in a race with a potential entrant for a new innovation that will reduce costs. Who will invest more R&D resources in the race, the incumbent or the potential entrant? The answer turns out to be ambiguous, and relies on the trade-off between two opposite effects: a rent dissipation effect and a replacement effect. The replacement effect (Arrow, 1962) refers to the fact that, by innovating, the incumbent monopolist replaces her own rents, whereas the potential entrant has no pre-existing rents to replace. Everything else remaining equal, this effect will induce the entrant to invest more in the race than the incumbent firm. On the other hand, the rent dissipation effect refers to the fact that the incumbent may lose more by letting the entrant win the race (she dissipates the difference between her current monopoly rents and the duopoly rents if the entrant innovates) than the potential entrant does by letting the incumbent win the race (he loses the difference between what may be at best duopoly rents if he had won the race and zero if the incumbent wins). The rent dissipation effect may or may not counteract the replacement effect. If it does, then the incumbent ends up investing more in the race than the potential entrant.

The Industrial Organisation literature emphasizes the comparison between monopoly and duopoly profits, and the fact that when competition generates enough rent dissipation (reduces duopoly profits sufficiently), then the difference between monopoly and duopoly profits is much greater than duopoly profits themselves, so that the incumbent is more likely to win the race and thereby persist as monopoly.

The prediction that product market competition has an unambiguously negative effect on entry or innovation is shared by the models of endogenous technical change in Growth Theory. In all of these models, an increase in product market competition has a negative effect on productivity growth by reducing the monopoly rents that reward new innovation. An increase in the ability of other firms in the industry to imitate has a similar effect. This discourages firms from engaging in R&D activities, thereby lowering the innovation rate and therefore also the rate of long-run growth, which in these models is proportional to the innovation rate. In the product variety framework of Romer (1990) this property is directly inherited from the Dixit-Stiglitz model upon which this model is built. But the same effect is also at work in the Schumpeterian (or quality-ladder) models of Aghion-Howitt (1992) and Grossman-Helpman (1991), which both predict that competition policy is unambiguously detrimental to growth, increased product market competition discourage innovation and growth by reducing the payoff incumbent innovators can obtain.

Recent endogenous growth models extend the basic Schumpeterian model by allowing incumbent firms to innovate (e.g. Aghion, Harris, Howitt and Vickers, 1997, 2001)). In these models, innovation incentives depend on the difference between post-innovation and pre-innovation rents (the latter were equal to zero in the basic model where all innovations were made by outsiders). In this case, more product market competition may end up fostering innovation and growth, as it may reduce a firm's pre-innovation rents by more than it reduces its post-innovation rents. In other words, competition may increase the incremental profits from innovating, and thereby encourage R&D investments aimed at "escaping competition". Aghion, Bloom, Blundell, Griffith and Howitt (200s), henceforth ABBGH, provide empirical

support for this model.

Standard endogenous growth models (e.g., Aghion and Howitt (1992)) show that the incentive for firms to invest in innovation depends on the surplus share appropriated by firms. Regulations increasing the workers' bargaining power reduce, therefore, the incentive to innovate. Caballero et al (2004) and Alesina et al (2005) emphasise the impact of deregulation in reducing adjustment costs. These may be particularly important when firms are considering introducing a new product or process which may involve substantial adjustment, for example, through demand for new skills and old skills becoming obsolete. If adjustment is more costly this will reduce value of any given invention, and therefore we will see less investment in innovation. The impact of increased competition will be damped, because firms are not able to respond to shocks (Caballero et al).

## 2.1 A model

This model closely follows ABBGH, which models the impact of competition on incumbents' incentives to invest in innovation.<sup>4</sup> Here we add entry and employment protection legislation. In their model competition may increase the incremental profit from innovating, labelled the "escape-competition effect", but may also reduce innovation incentives for entrants, the "Schumpeterian effect". EPL is an additional adjustment cost that affects incumbents more than entrants.

Consider a domestic economy which takes as given the rate of innovation in the rest of the world.<sup>5</sup> Thus the world technology frontier is also moving at a constant rate, with productivity  $\bar{A}_t$  at the end of period  $t$ , satisfying:

$$\bar{A}_t = \gamma \bar{A}_{t-1},$$

where  $\gamma > 1$ .

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<sup>4</sup>See also Aghion and Griffith (2005), Chapter 3.

<sup>5</sup>This section borrows unrestrainedly from Aghion-Howitt (2004), which itself builds on Aghion-Harris-Vickers (1997), Aghion-Harris-Howitt-Vickers (2001), and the discrete time version of the Schumpeterian growth model (see Acemoglu et al. (2002)) used in the previous chapters.

In each country, a final good  $y$  is produced using constant returns to scale production technology, with a continuum of intermediate inputs  $i \in [0, 1]$ , time is discrete and indexed  $t = 1, 2, \dots, T$ , and we normalize the labor supply at  $L = 1$ , so that:

$$y_t = \int_0^1 A_{it}^{1-\alpha} x_{it}^\alpha di,$$

where, in each sector  $i$ , only one firm produces intermediate input  $i$  using final good as capital according to a one-for-one technology.

In each sector, the producing firm faces a competitive fringe of firms that can produce the same kind of intermediate good, although at a higher unit cost. We assume that at the end of period  $t$  a competitive fringe of firms can produce one unit of intermediate input  $i$  of a quality equal to  $\min(A_{it}, \bar{A}_{t-1})$ , where  $A_{it}$  is the productivity level achieved in sector  $i$  after innovation has had the opportunity to occur in sector  $i$  within period  $t$ . They sell at unit cost  $\chi$ , where we assume  $1 < \chi < 1/\alpha < \gamma\chi$ .

In each period  $t$ , there are three types of sectors, which we refer to as type- $j$  sectors, with  $j \in \{0, 1, 2\}$ . A type- $j$  sector starts up at the beginning of period  $t$  with productivity  $A_{it-1} = \bar{A}_{t-1-j}$ , that is,  $j$  steps behind the current frontier  $\bar{A}_{t-1}$ . The profit flow of a firm in any sector at the end of period  $t$ , will depend upon the technological position of that firm with regard to the technological frontier at the end of the period.

Between the beginning and the end of the current period  $t$ , the incumbent firm and a potential entrant in any sector  $i$  have the possibility of innovating with positive probability. Innovations occur step-by-step: in any sector an innovation moves productivity upward by the same factor  $\gamma$ . Firms can affect the probability of an innovation by investing more in R&D at the beginning of the period.

Namely, by investing R&D effort  $\frac{1}{2}\gamma A_{it-1}\mu^2 + \phi f\mu$  a firm  $i$  in a type-0 or type-1 sector, innovates with probability  $\mu$ . The final term  $\phi f$  is a firing/hiring costs that the firm has to incur (which will be a function of labour market institutions), it is increasing in the size of the firm's R&D effort (the more R&D effort the more different skills are needed) and the parameter  $\alpha$  reflects the fact that as firms approach the technological frontier these costs

may rise, e.g.  $\phi = 1$  if  $\bar{A}_t$ , but  $\phi \ll 1$  if  $\bar{A}_{t-1}$ . Innovation is assumed to be automatic in type-2 sectors, which in turn reflects a knowledge externality from more advanced sectors which limits the maximum distance of any sector to the technological frontier.

Now, consider the R&D incentives of firms in the different types of sectors at the beginning of period  $t$ . Firms in type-2 sectors have no incentive to invest in R&D since innovation is automatic in such sectors. Thus

$$\mu_2 = 0,$$

where  $\mu_j$  is the equilibrium R&D choice in sector  $j$ .

Firms (entrants) that start one step behind the current frontier at  $A_{it-1} = \bar{A}_{t-2}$  at the beginning of period  $t$ , if they successfully innovate, they achieve productivity  $A_t = \bar{A}_{t-1}$  (if they do not innovate they end up with productivity  $A_t = \bar{A}_{t-2}$  so do not enter). The competitive fringe can produce intermediate goods of the same quality but at cost  $\chi$  instead of 1. Equilibrium profit is equal to

$$\pi_t = A_t \delta(\chi),$$

with

$$\delta(\chi) = (\chi - 1) (\chi/\alpha)^{\frac{1}{\alpha-1}}.$$

<sup>6</sup>. Thus the net rent from innovating for a type-1 firm is equal to

$$(\bar{A}_{t-1} - \bar{A}_{t-2}) \delta(\chi)$$

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<sup>6</sup>This, in turn, follows immediately from the fact that

$$\frac{\partial y_t}{\partial x_{it}} = \chi = p_{it},$$

which in turn implies that in equilibrium

$$x_{it} = \left(\frac{\chi}{\alpha}\right)^{\frac{1}{\alpha-1}} A_{it}.$$

We then simply substitute for  $x_{it}$  in the expression for profit  $\pi_t$ , namely

$$\pi_t = (p_{it} - 1)x_{it} = (\chi - 1) \left(\frac{\chi}{\alpha}\right)^{\frac{1}{\alpha-1}} A_{it}.$$

and therefore a type-1 firm will choose its R&D effort to solve:

$$\max_{\mu} \{(\bar{A}_{t-1} - \bar{A}_{t-2})\delta(\chi)\mu - \frac{1}{2}\gamma\bar{A}_{t-2}\mu^2 - \phi f\mu\},$$

which yields

$$\mu_1 = \left(1 - \frac{1}{\gamma}\right)\delta(\chi) - \frac{1}{\gamma\bar{A}_{t-2}}\phi f.$$

In particular an increase in product market competition, measured as an reduction in the unit cost  $\chi$  of the competitive fringe, will reduce the innovation incentives of these firms. This we refer to as the *Schumpeterian effect* of product market competition: competition reduces innovation incentives and therefore productivity growth by reducing the rents from innovations of firms that initially start behind the frontier (type-1 firms in ABBGH). This is the dominant effect, both in IO models of product differentiation and entry, and in basic endogenous growth models. Note that type-1 firms cannot escape the fringe by innovating: whether they innovate or not, these firms face competitors that can produce the same quality as theirs at cost  $\chi$ . More restrictive labour market institutions (higher  $f$ ) will reduce innovation incentives.

Firms that start at the current frontier, end up with productivity  $\bar{A}_t$  if they innovate, and stay with their initial productivity  $\bar{A}_{t-1}$  if they do not. But the competitive fringe can never get beyond producing quality  $\bar{A}_{t-1}$ . Thus, by innovating, a leading firm produces an intermediate good which is  $\gamma$  times better than the competing good the fringe could produce, and at unit cost 1 instead of  $\chi$  for the fringe. Our assumption  $\frac{1}{\alpha} < \gamma\chi$  then implies that competition by the fringe is no longer a binding constraint, so that its equilibrium profit post-innovation, will simply be the profit of an unconstrained monopolist, namely:

$$\pi_t = \bar{A}_t\delta(1/\alpha).$$

On the other hand, a leading firm that does not innovate, will keep its productivity equal to  $\bar{A}_{t-1}$ . Since the competitive fringe can produce up to this quality level at cost  $\chi$ , the equilibrium profit if it does not innovate, is equal to

$$\pi_t = \bar{A}_{t-1}\delta(\chi).$$

The firm will then choose its R&D effort to:

$$\max_{\mu} \{ [\bar{A}_t \delta(1/\alpha) - \bar{A}_{t-1} \delta(\chi)] \mu - \frac{1}{2} \gamma \bar{A}_{t-1} \mu^2 - \phi f \mu \},$$

so that in equilibrium

$$\mu_0 = \delta(1/\alpha) - \frac{1}{\gamma} \delta(\chi) - \frac{1}{\gamma \bar{A}_{t-1}} \phi f.$$

In particular an increase in product market competition, i.e a reduction in  $\chi$ , will now have a fostering effect on R&D and innovation. This, we refer to as the *escape competition effect*: competition reduces pre-innovation rents of type-0 incumbent firms, but not their post-innovation rents since by innovating these firms have escaped the fringe. This, in turn, induces those firms to innovate in order to escape competition with the fringe.<sup>7</sup>

### 3 Empirical strategy and data

We consider the relationship

$$P_{ijt} = \alpha + \beta RNT_{ijt} + X'_{ijt} \gamma + \eta_i + \lambda_j + \tau_t + e_{ijt}$$

where  $i$  indexes countries,  $j$  indexed technology class,  $t$  indexes years,  $P$  the number of patents,  $RNT$  is the level of rents available,  $X$  are other control variables,  $\eta_i$  capture country specific unobservables,  $\lambda_j$  captures technology specific unobservables,  $\tau_t$  capture common macro shocks, and  $e_{ijt}$  captures idiosyncratic shocks. We estimate this in aggregate, and also consider the process separately for entrants and incumbents,  $P_{ijt}^E$  and  $P_{ijt}^I$ , respectively.

A concern about OLS estimates of this relationship is that rents are potentially endogenous, due to shocks that affect rents and technology opportunities simultaneously, or to reverse causality. We instrument rents with product market reforms, discussed below.

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<sup>7</sup>A recent paper by Vives (2004) points to an effect which is quite similar to our escape competition effect. In that paper, higher product market competition in the form of higher demand elasticity, encourages firms to invest more in cost reduction in order to steal more demand from other firms by charging lower prices. So what competition does, is to reduce the residual demand for firms that do not innovate, while increasing the demand for firms that achieved lower costs.

As discussed above, we are interested in how the impact of competition may be muted by employment protection legislation. To look at this we estimate

$$P_{it} = \alpha + \beta^R RNT_{it} + \beta^E EPL_{it} + \beta^{RE} RNT_{it} * EPL_{it} + X'_{it}\gamma + \eta_i + \tau_t + e_{it}$$

where  $EPL$  indicates the level of employment protection legislation.

## 3.1 Data

### 3.1.1 Innovation

We use data on individual patents taken out at the European Patent Office (EPO). Patents indicate the country of the assignee (the owner of the patent) and the country of residence of all inventors. We use the country of the inventor(s) to allocate patent to locations. Where there is more than one inventor the share of each inventor is allocated to respective countries (if there are three inventors then each inventor is allocated a third). We use the priority date.<sup>8</sup> We distinguish patents taken out by incumbents from those taken out by entrants. An incumbent is defined as an assignee that took out at least one patent more than 12 months ago, entrants are those assignees which did not have any patents prior to 12 months ago.

We use the count of patents scaled by the population of the country. Table 1 shows descriptive statistics.

[Table 1 here]

### 3.1.2 Product markets

#### Measuring competition

As discussed above, the main channel through which product market reforms are expected to affect innovation outcomes is the level of rents, or economic profits, in the market, following Nickell (1996) and Aghion et al (2005a). To capture this we construct a measure of the level of rents (profitability or the markup) at the whole economy level, and for sub-sectors of the

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<sup>8</sup>If that is not available we use the application date, and where that is not available we use the grant date (and assume that the application was made three years earlier than it was granted).

economy including manufacturing and business service sector industries. Boone (2000) shows that this measure of competition is preferred to most other commonly used measures. It is more theoretically robust, particularly than those based on market concentration and market shares. In addition, it is the only commonly-used measure of competition that is available across countries without firm-level data. Factors other than competition may affect our measure of rents, in particular cost and demand shocks, but also the strength of labour’s bargaining position (what we measure is rents accruing to capital, if labour captures a larger share of rents then these will be smaller). The strategy here is to use indicators of product market regulations as instruments for rents in order to isolate variation in the markup that is associated with changes in competition.

Our measure of rents is defined as value-added as a share of labour and capital costs

$$\mu_{it} = \frac{\text{value added}}{\text{labour costs} + \text{capital costs}}$$

where all variables are in nominal prices. This is equivalent to the measure proposed by Roeger (1995), and contains an implicit assumption of constant returns to scale, such that marginal cost is equal to average cost. To the extent that there are increasing (decreasing) returns to scale this measure will be biased downwards (upwards) compared to the true markup.<sup>9</sup>

A measurement difficulty is the calculation of capital and capital costs. We construct a perpetual inventory measure of the capital stock using data on investment, and use cross-country averages of available capital deflators for countries where these are not available. We calculate the cost of capital assuming that capital flows freely across borders so that all countries face a world interest rate, which we model as the US interest rate.<sup>10</sup>

[Table 2 here]

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<sup>9</sup>We use a perpetual inventory measure of the capital stock. We use a common interest rates, rates of depreciation and capital deflators to calculate the cost of capital. Boulhol (2005) points out, to the extent that capital is fixed, the best measure of variation over time in the true markup may simply be the ratio of output over variable costs – this is equivalent to our measure with capital costs set to zero.

<sup>10</sup>Boulhol (2005) points out, to the extent that capital is fixed, the best measure of variation over time in the true markup may simply be the ratio of output over variable costs – this is equivalent to our measure with capital costs set to zero.

Table 2 shows the mean of the rents variable and the product market reform variables (discussed below). We calculate rents for the whole economy, and for manufacturing separately. As we show below, the measure for manufacturing seems more relevant for patenting. This could be because patents are more relevant in manufacturing industries, or because there are substantial measurement problems when considering the whole economy (such as the public sector).

There is wide and sometimes surprising variation in the average level of rents across countries. For example, the US has one of the highest rents, which runs counter to our intuition about the degree of competition in the US and Europe. There are various data incompatibilities in the measurement of capital and value added across countries that affect the cross-section variation in the average level of rents, and for this reason we include country dummies in our preferred specifications to control for any such factors that are constant over time. This is one of the main reasons why it is important to have indicators of product market reforms that vary over time, since cross-sectional variation in reforms cannot be separately identified from country dummies, which are important to control for these important sources of measurement error. Our results will be based on time-series variation in rents within countries and/or industries.

The second surprising feature of measured rents is that it appears to trend upwards over time for most countries. At first this may seem to conflict with most preconceptions about changes to competition associated with product market reforms, globalisation and opening to trade. One explanation, discussed by Nickell (1996), Blanchard and Giavazzi (2003) and Boulhol (2004), is that upwards trending measured rents could be a short term response to reductions in the bargaining power of workers. The intuition is that declining bargaining power reduces the share of rents captured by workers as higher wages, and increases the share that are measured in firms' profits. In the long term, the increase in profitability associated with declining workers' bargaining power would be expected to lead to entry and a reduction of rents to its previous level, but to the extent that these effects occur with lags

it is possible for the rent transfer effect to dominate the entry effect during the transition period. To control for this type of effect we will include proxies for workers' bargaining power in our regressions, such as union density, bargaining coverage, benefit replacement rates and employment protection legislation.

### **Product market reforms**

The actual level of rents is likely to be endogenous. We use policy reforms as instruments. These include the EU Single Market Programme (SMP), as well as two survey based indicators of the product market environment.

### **The Single Market Programme**

The SMP was a body of reforms designed to create a common market for manufacturing and services in the European Union. The measures undertaken as part of the SMP were targetted at reducing cross-country differences that inhibited trade, such as differences in product and service standards, administrative and regulatory barriers, VAT and capital controls. We exploit the facts that some, but not all, of the countries in our sample were part of the SMP, and that they implemented it at different rates.

Before the programme a survey was carried out by Cecchini et al (1986) on 11,000 firms in different industries. Respondents were asked to rate the current level of various barriers to trade. Based on this survey Buiges et al (1990) considered 120 industrial sectors and chose the 40 deemed to be most sensitive to the programme, ex-ante. They passed these 40 to individual country experts for modification, after which they listed the percentage of industry (specifically percentage of employment) sensitive to the programme for each country. Although the implementation date was 1st January 1992, and although the countries did nominally implement the reforms on this date, they came into actual effect at different rates for different countries. >From 1997 onwards the EU recorded the percentage of each reforms actually transposed into law for each country. We combine these two sources of variation to construct a variable that indicates the percentage of industry liberalized over time. Figure 1 shows the variable for countries that were part of the SMP: the most sensitive economy

being that of Portugal with 68.1% of industry ultimately affected, and the least sensitive being that of the Netherlands with 44.9% of industry ultimately affected.

### **Administrative Burden on Business**

As a further indicator of product market reform we use an index of “Time senior management spends with government bureaucracy” constructed by the Fraser Institute. This is based on survey responses to the question “How much time does your firm’s senior management spend dealing/negotiating with government officials?”. A large amount of time spent with government bureaucracy may constitute a barrier to entry, hinder firms’ expansion, or may indicate a significant amount of government involvement in business decision-making, all of which can inhibit competition. The index ranges from 1 to 10, with 1 indicating the highest level of regulation and 10 indicating the lowest level of regulation. These data are published in the World Economic Forum’s “Global Competitiveness Report 2001-2002”.

### **Ease of starting a new business**

We also use an index of “How easy it is to start a new business” constructed by the Fraser Institute. This is based on survey responses and it is available for the years 1995 and 2000. The index ranges from 1 to 10, with 1 indicating the highest level of regulation and 10 indicating the lowest level of regulation. These data are published in the World Economic Forum’s “Global Competitiveness Report 2001-2002”.

### **3.1.3 Labour markets**

Our main interest in this paper is on employment protection legislation (EPL) and the idea that it hampering firm entry, exit and adjustment, and thus the creative-destruction process, as recently emphasises in Cabellero et al (2005). We also include the benefits replacement rate and the tax wedge on labour.<sup>11</sup> Table 3 shows the means of the labour market variables.

[Table 3 here]

### **Employment protection legislation**

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<sup>11</sup>We also looked a number of other labour market variables including union coverage, union density and a coordination index. Results not reported here.

This is from Nicoletti, Scarpetta and Boylaud (2000). This is 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). The variable ranges from 0 to 4, with 0 indicating no regulation and 4 indicating the most restrictive regulation.

### **Tax wedge on labour**

The tax wedge is calculated as the sum of the employment tax rate (employers' social security contributions as % of wages and salaries), the direct tax rate (amount of direct taxes as % of households' current receipts) and the indirect tax rate (total indirect taxes as % private final expenditures). The data come from the OECD-CEP database and was updated by Nickell and Nunziata.

### **Benefits replacement rate**

The data refers to the first year of unemployment benefits, averaged over family types of recipients. The benefits are expressed as a percentage of average earnings before tax. The OECD provides observations every two years. Nickell and Nunziata interpolated the remaining years. From Nickell (2003), originally obtained from OECD Jobs Study 1994.

### **Coordination index**

This index refers to mechanisms where externalities to the aggregate economy of wage bargaining are internalised. This may be achieved through state centralization of bargaining or through institutions such as employers federations. We use coordination index 2 from Nickell(2003), originally obtained from Wolfgang Ochel.

### **Union coverage**

Percentage of employees covered by collective bargaining, whether they are union members or not. Nickell (2003), originally obtained from Wolfgang Ochel.

### **Union density**

Actual union members as percentage of employees. OECD Labour Force Statistics.

## 4 Results

### 4.1 Impact of competition on patenting

Table 4 considers the impact of product market competition on innovative activity. The dependent variable in columns (1), (2) and (3) is the count of all patent applications made in each year in each country-technology class. Column 1 shows that the level of rents in the whole economy is not informative in explaining variation in patenting activity within country-technology classes. Country and technology class effects control for a host of other non-time varying factors including other institutions and differences in national measurement systems. Year effects control for common macro economic trends. Output gap captures country specific cyclical effects and is measured as deviation from trend growth.

[Table 4 here]

Most economic activity is in services, while most patenting activity is in manufacturing. This means that there may be a mismatch in using the level of rents in the whole economy to proxy competitive conditions. In addition, it may be more difficult to measure prices, and thus rents, in many non-traded sectors. In column 2 we use the measure of rents in the manufacturing sector. This is more informative, and suggests that more competition (lower markup) is associated with more patenting activity.

A major concern with the OLS estimates shown in columns (1) and (2) is that the level of rents is endogeneous - firms will be more likely to implement new ideas in markets that are profitable and growing. This could lead to spurious correlation between patenting and the level of rents. We use the policy reforms undertaken by different countries at different times over the past two decades to give us exogenous variation in the extent of competition, and use these as instruments. In columns (3), (4) and (6) the first stage regression of rents on the policy reforms we use three excluded - single market programme, administrative burden on business and ease of starting a new business. The partial  $R^2$  of the excluded instruments is 0.2485 and an F-test of the joint significance has P-value of 0.000. In column (5) ease of

starting a new business is not used as an instrument, since in column (4) the Hansen J-test rejects the exclusion restrictions. In this case the partial  $R^2$  is 0.2475, and the P-value of the F-test is 0.000. These indicate that the instruments have some power in explaining variation in rents.

Returning to Table 1, in column (3) we use a GMM estimator, with the first stage regression as discussed above. The coefficient on rents increases in absolute magnitude, from -1.5 to -2.1, suggesting that there is upward bias in the OLS regressions. This makes sense, both from an economic point of view and possibly reflecting measurement error (which would lead to attenuation bias towards zero).<sup>12</sup>

In columns (4), (5) and (6) we use different dependent variables. We split the micro patents data into patents taken out by new entrants (assignees that have patented for the first time in the past 12 months) and incumbents (assignees that have patented more than a 12 months ago), and aggregate these separately to the country-year-technology class level.<sup>13</sup> We see that the impact of increased competition is negligible for entrants, but substantially for incumbent patenters. This is not surprising, and is line with the theoretical ideas discussed above, that increased competition leads incumbents to innovate to escape competition, but may deter entrants.

## 4.2 Impact of labour market institutions on patenting

Table 5 considers the impact of controlling for labour market institutions, and in particular employment protection legislation, on patenting. The EPL variable ranges from 0-4 with higher numbers indicating more regulation (see data section). In column (1) we see that less regulation in the labour market (lower value of EPL) is associated with more patenting. In column (2) we control for a number of other labour market characteristics including the

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<sup>12</sup>If we include the control function (the residual from the first stage) in the regressions in Table 1 (not shown) this suggests that endogeneity is a concern (see Wooldridge (2002)). Controlling for endogeneity has an effect on the estimates and suggests substantial positive bias.

<sup>13</sup>Some assignees might be co-owned, so we may be considering some assignees to be entrants when actually they are incumbents. We are in the process of matching the patents data to firm level data to control for this. We have also tried using 24 and 36 months as a definition of entry and the results were substantially similar.

benefits replacement rate, the tax wedge on labour, the extent of worker bargaining power as reflected by coordination, union coverage and union density. Higher benefit replacement rates or taxes increase the cost of labour, and thus have a dampening effect on patenting activity, particularly for incumbent (larger) firms. Greater coordination also dampen innovation, while union coverage and density seem if anything to increase innovation. The main point for this paper is that the coefficient on employment protection legislation remains largely unchanged. In columns (3) and (4) we repeat these regressions looking just at patenting by new patenters and in columns (5) and (6) for incumbent patenters. We see that EPL effects both new and incumbent patenters, but effects incumbents more.

When we add labour market institutions we see that the impact of increased competition (reduced mark-up) for entrants is to decrease innovation. This accords with theory - entrants incentives are driven by the level of rents available (they are comparing no rents with positive rents from entering the market), when competition increases, these rents decrease. In contrast, controlling for labour market institutions does not have the same impact on the markup coefficient for incumbents. Again, this accords with theory - incumbents already operate in the market, increased competition drives down both their pre and post innovation rents. Whether this provides incentives to innovate will depend on which is effected more. The estimates in Table 5 suggest that the net effect is to encourage innovation.

[Table 5 here]

### **4.3 Interaction of product and labour market institutions on patenting**

We are also interested in whether employment protection legislation dampens the responsiveness of firms in an economy, and in particular their responsiveness to greater product market competition. In Table 6 we explore this by interacting rents with the employment protection indicator. In column (1) we report OLS estimators using the total number of patents as the dependent variable. As above we see that greater competition (lower rents) is

associated with more patenting activity. The positive coefficient on the interaction indicates that in markets where employment protection is high the impact of increased product market is muted. In column (2) we add an additional regressor, the share of government in Gross Domestic Product; this enters with a negative sign and is significant. In columns (3), (5) and (7) we present GMM estimates of this relationship using policy variables as instruments. Identifying interaction effects with instrumental variables methods is well known to be difficult. Finding independent variation to instrument the interaction term can be hard. The excluded instruments used here are SMP, administrative burden on business, ease of entry and  $EPL \cdot SMP$ . There are two reduced form equations, one for rents and one for  $rents \cdot EPL$ . The partial R-squared and F-test of the significance of the excluded variables for the rents equation are 0.2548 and 0.000 respectively, and for the  $rents \cdot EPL$  equation are 0.0399 and 0.000. These show that the levels instruments have power to predict variation in both the level and the interaction term. The Hansen J statistic (shown at the bottom of the table) suggests that the exclusion restrictions are not rejected.

[Table 6 here]

Instrumenting in column (3) substantially increases the coefficient on the interaction term, though it is also now much less precisely identified (the standard error increases). Columns (4) and (5) show the OLS and GMM results for patenting by entrants and columns (6) and (7) show the results for patenting by incumbents. For entrants we see (column (5)) that increasing competition actually reduces innovation, as discussed above, this is not surprising. If new entrants anticipate tough competition they will be more likely not to enter the market. For incumbents we see that the impact of competition (reduced rents) is to increase patenting. However, high employment protection legislation dampens this effect. For the levels of employment protection seen in Australia, Canada, Great Britain or the US (all less than 1) the impact of increasing competition is to encourage patenting. For example, for the US, which has the lowest level of employment protection at 0.2, the impact is -1.0326 (-1.312

+ 0.902\*0.2). However, for countries with an employment protection index over 1.35 the impact of increasing competition will be to reduce patenting by incumbent firms.

One important caveat to these findings are that the results are quite sensitive to the precise instruments chosen. Further investigation is needed to fully understand these processes.

## 5 Summary and conclusions

A large literature has focused on labour market institutions as a reason for slow growth in Europe. This paper consider how important product market regulations have been for innovation. Recent work has shown that less regulation encourages investment, increases employment and leads to faster productivity growth. Empirical work at the firm level, within individual countries, suggests that the impact may differ in important ways - e.g. on entrants and incumbents. In this paper we use individual level data on patenting activity across countries to look at what impact product market deregulation has had on patenting activity, and how this varies depending on the level of employment protection legislation. The findings suggest that tougher competition increases innovation by incumbents, but discourages entrants. Employment protection legislation dampens the impact of competition.

Further work is needed on the robustness of these results in a number of important ways.

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**Table 1: Mean and (standard deviation) of dependent variables**

Country	Patents per 1000	Entrant patents per 1000	Incumbent patents per 1000
Australia	0.60 (0.76)	0.36 (0.42)	0.24 (0.41)
Belgium	1.46 (1.83)	0.40 (0.45)	1.06 (1.60)
Canada	0.48 (0.69)	0.23 (0.33)	0.24 (0.41)
Denmark	2.38 (3.17)	1.01 (1.10)	1.37 (2.37)
France	0.94 (1.53)	0.30 (0.44)	0.64 (1.16)
Great Britain	0.78 (1.32)	0.26 (0.37)	0.53 (1.01)
Italy	0.48 (0.72)	0.22 (0.29)	0.26 (0.46)
Netherlands	1.66 (2.34)	0.41 (0.55)	1.25 (2.04)
Norway	1.84 (1.50)	1.08 (0.87)	0.75 (0.87)
USA	0.75 (1.59)	0.19 (0.38)	0.56 (1.24)
Total	0.95 (1.65)	0.33 (0.51)	0.63 (1.29)

Notes: Sample includes information on 115 technology classes (IPCs) in ten countries.

**Table 2: Mean of product market variables**

	Rents (whole economy)	Rents (manufacturing)	SMP	Administrative Burden on Business 1=high, 10=low	Ease of entry 1=high, 10=low
Australia	1.208	1.296	0.000	7.099	6.860
Belgium	1.194	1.161	12.929	6.743	4.782
Canada	1.282	1.236	0.000	7.110	7.780
Denmark	1.087	1.123	13.392	8.829	6.320
France	1.183	1.223	13.043	6.480	3.580
Great Britain	1.261	1.124	13.364	7.820	8.060
Italy	1.314	1.257	13.537	4.841	4.201
Netherlands	1.165	1.189	11.869	7.571	7.510
Norway	1.149	1.060	0.000	8.159	7.161
USA	1.384	1.240	0.000	7.570	8.400

**Table 3: Mean of labour market variables**

	Employment protection legislation	Benefits replacement rate	Tax wedge on labour
Australia	0.900	0.247	18.712
Belgium	2.898	0.486	44.666
Canada	0.600	0.567	22.115
Denmark	1.917	0.654	39.221
France	2.760	0.593	44.300
Great Britain	0.500	0.231	30.450
Italy	3.938	0.165	45.729
Netherlands	2.579	0.688	43.209
Norway	2.920	0.596	34.465
USA	0.200	0.279	28.506
	Coordination index	Union coverage	Union density
Australia	1.866	82.480	39.758
Belgium	2.220	90.000	53.663
Canada	1.032	38.135	33.203
Denmark	2.362	70.991	77.165
France	1.847	91.256	12.160
Great Britain	1.032	56.269	40.567
Italy	2.034	83.687	40.683
Netherlands	2.752	81.006	27.310
Norway	2.582	70.000	57.258
USA	1.000	19.200	16.448

**Table 4: Impact of competition on patenting per 1000 population**

	(1) All	(2) All	(3) All GMM	(4) Entrants GMM	(5) Entrants GMM	(6) Incumbents GMM
Rents (whole economy)	-0.352 (0.274)					
Rents (manufacturing)		-1.480 (0.291)	-2.149 (0.514)	-0.096 (0.144)	-0.064 (0.145)	-2.117 (0.430)
Hansen J test (p-value)			1.726 (0.422)	8.781 (0.012)	1.589 (0.207)	1.210 (0.546)
Observations	13781	13781	13781	13781	13781	13781

Notes: output gap, country, year, 115 technology dummies included in all regressions; standard errors are robust; instruments in columns (3) (4) and (6) are single market programme, administrative burden on business and ease of starting a new business; in column (5) ease of starting a new business is not used as an instrument.

**Table 5: Impact of employment protection legislation on patenting per 1000 population**

	(1) All	(2) All GMM	(3) Entrants	(4) Entrants GMM	(5) Incumbents	(6) Incumbents GMM
Markup (manufacturing)	-0.466 (0.254)	-0.396 (0.532)	-0.062 (0.074)	0.755 (0.165)	-0.404 (0.214)	-1.368 (0.478)
Employment protection legislation	-0.540 (0.090)	-0.444 (0.082)	-0.118 (0.024)	-0.121 (0.019)	-0.422 (0.078)	3.166 (2.200)
Benefits replacement rate	-0.503 (0.181)	-0.583 (0.191)	0.046 (0.058)	0.103 (0.062)	-0.549 (0.147)	0.160 (0.567)
Tax wedge on labour	-0.020 (0.008)	-0.014 (0.007)	-0.008 (0.002)	-0.006 (0.002)	-0.012 (0.007)	-0.037 (0.019)
Coordination index	-0.123 (0.062)	-0.049 (0.056)	0.008 (0.020)	0.032 (0.017)	-0.130 (0.052)	-0.204 (0.091)
Bargaining coverage	0.002 (0.002)	0.003 (0.002)	-0.001 (0.001)	-0.001 (0.000)	0.004 (0.002)	0.012 (0.005)
Union density	0.038 (0.005)	0.035 (0.005)	0.013 (0.002)	0.012 (0.001)	0.025 (0.004)	0.030 (0.006)
Country effects	yes	yes	yes	yes	yes	yes
Year effects	yes	yes	yes	yes	yes	yes
Technology effects	yes	yes	yes	yes	yes	yes
Observations	13781	13781	13781	13781	13781	13781

*Notes: output gap, country, year, 115 technology dummies included in all regressions; standard errors are robust; instruments in columns (2) and (6) are single market programme, administrative burden on business and ease of starting a new business; in column (4) ease of starting a new business is not used as an instrument*

**Table 6: Impact of competition and employment protection legislation on patenting per 1000 population**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	All	All	All	Entrants	Entrants	Incumbents	Incumbents
	OLS	OLS	GMM	OLS	GMM	OLS	GMM
Rents							
(manufacturing)	-1.048 (0.303)	-0.902 (0.296)	-0.525 (0.525)	-0.110 (0.085)	0.671 (0.158)	-0.793 (0.249)	-1.213 (0.430)
EPL*Rents	0.286 (0.084)	0.189 (0.083)	0.771 (0.375)	0.019 (0.023)	-0.114 (0.107)	0.170 (0.067)	0.902 (0.323)
Employment protection legislation	-0.871 (0.139)	-0.637 (0.135)	-1.330 (0.507)	-0.120 (0.036)	0.038 (0.137)	-0.516 (0.113)	-1.391 (0.443)
Benefits replacement rate	-0.660 (0.191)	-1.763 (0.257)	-1.858 (0.285)	-0.152 (0.086)	-0.062 (0.094)	-1.611 (0.210)	-1.818 (0.235)
Tax wedge on labour	-0.017 (0.008)	-0.018 (0.008)	-0.010 (0.008)	-0.008 (0.002)	-0.007 (0.003)	-0.011 (0.007)	-0.002 (0.007)
Coordination index	-0.109 (0.062)	-0.140 (0.062)	-0.067 (0.058)	0.004 (0.020)	0.018 (0.019)	-0.144 (0.052)	-0.083 (0.050)
Union coverage	0.001 (0.002)	-0.000 (0.002)	-0.001 (0.002)	-0.002 (0.001)	-0.001 (0.001)	0.002 (0.002)	0.000 (0.002)
Union density	0.036 (0.005)	0.047 (0.005)	0.044 (0.005)	0.014 (0.002)	0.014 (0.002)	0.033 (0.004)	0.029 (0.004)
Government Share of GDP		-0.047 (0.006)	-0.043 (0.006)	-0.008 (0.002)	-0.008 (0.002)	-0.039 (0.005)	-0.035 (0.005)
Hansen J test (p-value)			3.892 (0.143)		4.433 (0.109)		2.481 (0.289)
Observations	13781	13781	13781	13781	13781	13781	13781

Notes: output gap, country, year, 115 technology dummies included in all regressions; standard errors are robust; instruments are: SMP, administrative burden on business, ease of entry and EPL\*SMP.

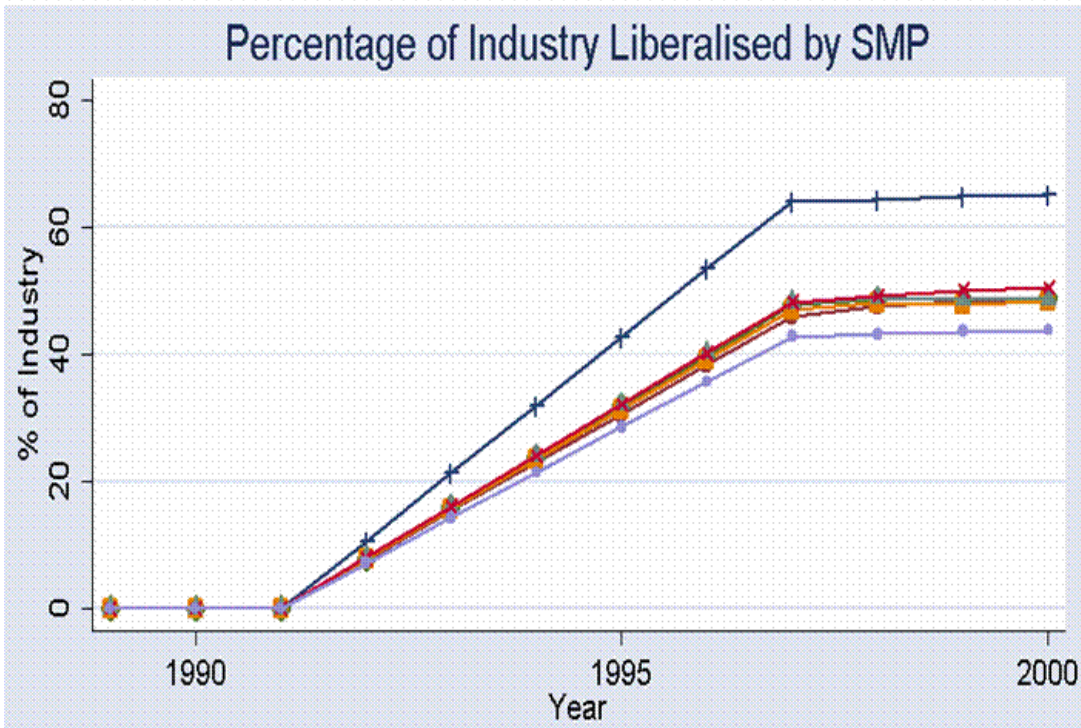


Figure 1 Percentage of employment (value added in the case of Belgium due to lack of data availability) in industry “liberalized” by the SMP. The variable from 1997 onwards is calculated as % of industry identified ex-ante to be sensitive to SMP \* the EU’s transposition index measuring % of reforms actually implemented. The variable is linearly extrapolated back to the programme start date, and is everywhere zero for those countries not in the programme. Key: Portugal (+); Belgium (O); Denmark (◆); France (□); United Kingdom (Δ); Italy (X); the Netherlands (o).