EUROPEAN
ECONOMY
EUROPEAN COMMISSION
DIRECTORATE-GENERAL FOR ECONOMIC
AND FINANCIAL AFFAIRS

ECONOMIC PAPERS

ISSN 1725-3187
http://europa.eu.int/comm/economy_finance

Number 243 February 2006

The link between product market reform, innovation and EU macroeconomic performance

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ECFIN/REP/50672-EN

ISBN 92-79-01184-7

KC-AI-06-243-EN-C

Executive Summary

This report analyses the impact of product market reforms, in the form of the EU Single Market Programme, on the extent of product market competition and the subsequent effects of competition on innovation activity and productivity growth.

The report first summarises the main messages from the existing theoretical and empirical literature on the relationship between competition and innovation and uses this to inform the subsequent empirical analysis. The theoretical literature on competition and growth emphasises the importance of economic profits, or rents, in providing incentives for firms to innovate to compete for market position or in order to enter new markets. Increased competition may increase incentives for firms to increase efficiency or to innovate in order to protect or enhance their market position. However, competition may reduce the rewards to innovation or entry into a market and thus discourage these activities.

The main empirical analysis carried out in the report is centred on the manufacturing sector, as this is where the product market reforms that analysed have the greatest impact and where the majority of research and development expenditure and patenting activity is carried out. The analysis exploits country-industry level information on the expected degree of impact of the Single Market Programme in order to identify effects of changes in the extent of competition on innovation and productivity growth.

We relate information across industries and countries on the product market reforms associated with the Single Market Programme to changes in mark-ups, which are used to measure the degree of product market competition, (the greater the extent of competition, the less able are firms to mark-up prices above costs). To investigate the relationship between competition and innovation, we use country-industry level information on business sector R&D expenditure and data on patenting activity by individual firms across countries. The data on patents enables us to look at whether product market reforms impact differentially on incumbents (defined as firms that are already innovative and actively patenting) compared to new entrants into innovative activity.

Innovation in service sectors is inherently more difficult to measure, and measures of R&D expenditure do not capture the introduction of new services or other quality improvements and cost reductions well in service sectors. However the bulk of economic activity in most EU countries is in services. The report therefore presents some indicative evidence on the relationship between competition and productivity growth in service sectors.

We also present an initial exploration into the ways in which a country's distance to the international technological leader or frontier, (i.e. the scope for technological catch-up), and labour market regulations are related to variation in innovation and productivity growth rates.

The main empirical findings suggest the following:

- The product market reforms that were associated with the Single Market Programme lead to a reduction in the average mark-up, i.e. an increase in product market competition, in affected countries and industries.

- Increased competition (as measured by the mark-up) led to increased R&D investment in manufacturing industries.

- The Single Market Programme may have had an additional direct negative impact on R&D expenditure in some high-tech manufacturing industries. However, it is not clear whether this actually represented a reduction in innovative outputs or an increase in the efficiency of R&D spending in these industries across EU countries.

- Competition increased innovative activity by incumbents, but if anything it decreased incentives for new firms to enter into the innovation process. This is consistent with theory which suggests that increased competition reduces the potential rewards to innovation for entrants, but may increase it for incumbents if it reduces pre-innovation rents by more than post-innovation rents.

- There is some indication that, within an industry, the effect of increasing competition on innovation is larger in countries that are closer to the global technological frontier. However, this result may also reflect the fact that a higher proportion of innovative activity is measured as formal R&D or patents in countries that are more technologically advanced. With existing data (i.e. without information on imitation activity) it is difficult to distinguish between these two effects.

- Increased R&D investment led to faster total factor productivity growth in manufacturing industries.

- There is some indication that competition (as measured by the mark-up) is associated with faster productivity growth in the service sector, but this result should be seen as an association rather than a causal relationship. Given their importance in modern economies, the impact of competition on innovation in service sectors represents an interesting avenue for further research.

- The effect of labour market regulations on innovation and productivity growth is complex and a detailed examination is beyond the scope of this study. However, the above results are robust to controlling for the direct effects of a range of labour market regulations on innovation.

1 Introduction

The growth of value-added per capita in EU countries has lagged behind the US in recent years, 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 set a target in Barcelona to raise 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.[1]

In light of these strategic policy objectives, the purpose of this study is to analyse and measure the impact of product market reforms on innovation activity undertaken in the European Union and the subsequent impact on total factor productivity. Our focus is on the private sector, and we restrict our attention to non-network industries.[2]

The research aims to inform policy that affects both frontier innovation and imitation, or technology transfer. Frontier innovation is the creation of new goods, services or processes, and occurs both in incumbent firms, and through the entry of new firms. Diffusion of new technologies is also an important source of growth, particularly for firms and industries far behind the technological frontier. Diffusion is affected by the actions of incumbent firms, and also by firm entry and exit.

Two important caveats are worth noting. One is that growth is driven by a large number of factors other than product market institutions. Other factors, such as human capital development, infrastructure provision and fiscal stability are likely to be major elements. The other is that the bulk of economic activity in most EU countries is in service sectors.

[1] It is worth noting that some of these objectives may be in conflict with each other. For example, increasing employment may conflict with raising labour productivity if new workers have lower average skill levels than existing workers, or if most new jobs are created in sectors with low average productivity.

[2] Network industries include telecommunications, post, electricity, water, gas, airlines and rail. In most countries these industries are regulated. However, the nature of reforms and the processes driving innovation and technology transfer in these industries differ substantially from the rest of the economy and would require detailed modelling of each industry.

Innovation in service sectors is difficult to measure, and the indicators that we use – R&D expenditure and patents – do not capture well the introduction of new services or other quality improvements and cost reductions in service sectors.

The structure of this report is as follows. In Section 2 we highlight the main themes in the literature that inform our methodology, (a full literature review is contained in Appendix I), and in Section 3 we outline our empirical approach. Section 4 describes the data and provides a discussion of the indicators of product market reforms and other types of regulation that we use in our empirical analysis, focusing on the sources of variation which allow us to identify the relevant economic relationships.[3] In Section 5 we present results on the impact of product market reforms on R&D performed at the national and industry level. We also use data on patenting activity by individual firms across countries to look at whether product market reforms impact differentially on incumbents (firms that are already innovative) and on entrants into innovative activity. We then explore the ways in which distance to the frontier (i.e. the scope for technological catch-up) and labour market regulations are related to variation in innovation and total factor productivity (TFP) growth rates.[4] A final section summarises and concludes.

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[3] Appendix II contains further details of different measures of innovation and imitation and discusses trends in innovative activity across EU countries. Appendix III contains further discussion of product market regulations and reforms, and Appendix IV contains more detail on how we measure the mark-up.

[4] Appendix V provides some additional results.

2 The literature

The theoretical literature on competition and growth emphasises the importance of economic profits, or rents, in providing incentives for firms to innovate to compete for market position or in order to enter new markets. Increased competition may increase incentives for firms to reduce slack[5] or to innovate in order to protect or enhance their market position or to escape competition.[6] However, it also may reduce the rewards to innovation or entry into a market and thus discourage these activities.

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.

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[5] See, inter alia, Hart (1983) and Schmidt (1999).

[6] See, inter alia, Gilbert and Newbury (1982) and Aghion et al (2005).

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".

These models predict that the innovative behaviour of firms (industries or countries) will vary with their distance to the technological frontier. Aghion et al (2005b), henceforth ABGHP, focus on the incentive effects of frontier entry on incumbents incentives to innovate. Other papers consider the ability of firms to benefit from spillovers.

ABGHP consider the impact of entry threat on incumbent innovation effort. The main implication of their model is that a higher threat from technologically advanced entrants should encourage incumbent innovation in sectors that are initially close to the technological frontier (an escape-competition effect), whereas it may discourage incumbent innovation in sectors that are initially further behind the frontier (a discouragement effect of entry). The intuition for these two effects is that, in the former case, incumbent firms that are initially close to the frontier can potentially escape competition by innovating; therefore tougher competition, or a higher threat of entry, will result in more intensive innovation activities aimed at escaping that threat. The latter results relies on the potential entrant being near the technological frontier. In that case incumbents that are further behind the frontier see no hope to win, so do not invest. This yields the prediction that innovation and productivity growth of incumbents in sectors close to the world technological frontier should react more positively to competition and entry (so long as it is at the frontier) than in sectors further below the frontier.[7] In the ABGHP model, if there is no threat of entry then incumbent performance would be greater the further the sector is from the frontier (i.e. the level effect of the distance to the frontier would be positive). Such a positive effect of the initial distance to frontier on expected productivity growth is in fact found in any model with convergence.

The ABGHP model is about incumbent firms' innovation incentives. There is also a literature on knowledge spillovers that makes predictions about how imitation and productivity growth may vary with distance to the frontier. This literature highlights two effects that work in opposite directions. Some models consider the idea that firms and sectors further from the frontier should benefit most from knowledge spillovers, since the scope for learning is highest there.[8] Thus imitation would be highest the further away a firm is from the frontier. Another idea that is prevalent in the literature on knowledge spillovers is that firms in industries closer to the technological frontier have higher absorptive capacity, so may benefit more from spillovers.[9] This literature emphasises the two roles or "faces" of engaging in innovative

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7 ABGHP focus on foreign entry. In their model, if entrants have productivity below the frontier, this gives the prediction that increasing the threat of entry encourages innovation and productivity growth in sectors that are at intermediate distance from the frontier, discourages innovation in sectors that are far below the frontier and has little effect on innovation in sectors close to the frontier.

8 Griffith et al. (2004) find empirical support for such consequences of general spillovers looking across a panel of OECD industries and countries. Griffith et al. (2002) find similar evidence at the establishment level in the UK.

9 See Cohen and Levinthal (1989), Aghion and Howitt (1997), Howitt (2000) and Griffith, Redding and Van Reenen (2004).

activity. The first of these roles is in stimulating innovation, the second role is in facilitating the imitation of others' discoveries. Some knowledge is “tacit”, difficult to codify in manuals and textbooks, and hard to acquire without direct investigation. By actively engaging in R&D in a particular intellectual or technological field, one acquires such tacit knowledge and can more easily understand and assimilate the discoveries of others. Under this model firms, industries or countries that are closer to the technological frontier should have higher outcomes on measures that reflect imitation.

These models make no obvious predictions for innovation outcomes, or for an interaction between competition and the distance to frontier. Nicoletti and Scarpetta (2003) find empirical evidence for such an interaction. They adapt the model from Griffith, Redding and Van Reenen (2004) by substituting the extent of product market regulations for R&D, arguing that competition may induce firms behind the frontier to adopt best practice and up-to-date technologies. However, there is no obvious theoretical reason why the main impact of product market reforms is to encourage adoption of new technologies by firms and/or industries that are further behind the frontier.

3 Empirical approach

From the discussion above we see that the theoretical literature emphasises the importance of economic profits, or rents, in providing incentives for firms to enter markets and to innovate. This has also been emphasised in the empirical literature, for example, Nickell (1996) and Aghion et al (2005a). Thus, to empirically investigate how product market reforms have affected innovation, one of our main interests is to investigate how product market reforms have affected the level of economic rents, and in turn how the level of rents has affected innovation. Product market reforms can affect competition through the intensity with which firms interact in the product market and through lowering the costs of entry. In equilibrium the level of rents reflects both these factors. Competitive intensity between firms will drive prices down, while entry, or the threat of entry, will restrain firms from raising prices. We start from the premise that the primary impact of product market reforms on productivity growth is through the pressure they put on firms to innovate and imitate, and that the main determinant of that is the potential rewards from doing so, as reflected in rents. However, product market reforms themselves may also have a direct effect on innovation and/or productivity growth, for example through the reallocation of resources towards more productive firms or activities. In all of our results we test for the direct effects of our measures of product market reforms as well as the indirect effects through their impact on the level of rents.

Another way to think about the way we relate product market reforms to rents, and then rents to innovation, is to contrast it with other empirical approaches in the literature. Nicoletti and Scarpetta (2003), for example, look at the impact of a large number of product market reforms on TFP growth. They aggregate the product market reforms into a single index. What we are doing is using the impact of various reforms on rents as a way of aggregating the reforms, rather than using ad hoc or subjective weights.

These considerations suggest a general model that related competition to innovation and innovation to TFP growth of the general form:

$$\mu = f(PMR, X)$$

$$innov = f(\mu, PMR, X) \quad (1)$$

$$\Delta LP, \Delta TFP = f(innov, \mu, PMR, X)$$

where μ is the mark-up and captures the extent of competition, PMR stands for product market reforms, *innov* represents various measures of innovation, ΔLP and ΔTFP are measures of labour productivity and total factor productivity growth, and X captures other factors.

Despite our focus on product market competition, it is important to bear in mind that the level of competition is unlikely to be the single major determinant of innovation in a country or industry. Factors such as infrastructure, skills and technological opportunity may play a much more important role. These vary across countries, industries and technology classes and we are unlikely to be able to capture all of that variation. Therefore, we rely on variation within countries, industries and technology classes - this allows us to control for unobservable characteristics that may be correlated with the level of rents. The vector X importantly includes country and time effects (and industry and technology class where relevant) and various other controls.

Without further restrictions it is not possible to estimate all the parameters of this general model. Our strategy is to exclude most or all of our indicators of product market reforms from the *innov*, and *LP / TFP growth* equations, and then to test these exclusion restrictions using suitable econometric methods. In other words, we test for any direct effects of PMRs as well as the indirect effect through their impact on the level of rents. We would expect an immediate impact of PMRs to be to change the degree of product market competition firms face, which we summarise in our measure of the mark-up. This in turn would be the main channel through which product market reforms would affect innovation and imitation incentives. We also exclude the mark-up from the TFP growth equation.

Our baseline model therefore takes the following form:

$$\mu = f(PMR, X)$$

$$innov = f(\mu, X) \qquad (2)$$

$$\Delta LP, \Delta TFP = f(innov, X)$$

We also consider whether the level of rents has a direct effect on productivity growth. In service sector industries, where information on innovative activity is very difficult to obtain, (for example, relatively little R&D expenditure is carried out in this sector), we use productivity growth as a proxy for innovative activity, and explore direct relationships between productivity growth and the mark-up,

$$\Delta LP, \Delta TFP = f(\mu, X). \qquad (3)$$

For manufacturing sectors we argue that it is more reasonable to consider the level of rents as only affecting productivity growth through its impact on the rate of innovation. As before we test the validity of this exclusion restriction. However there may be statistical and economic reasons why we cannot exclude the level of rents from the productivity growth equation. In particular, conventional measures of TFP are biased in the presence of mark-ups. Also, it is possible that product market competition increases productivity directly by forcing firms to increase their productive efficiency. We consider a more general model where we include measures of both innovation and the mark-up in the productivity growth equation and instrument these two variables.

The final consideration is what enters the set of control variables *X*. We include country dummies (and industry and technology class where relevant) to control for unobserved factors that do not change over time. We also include a full set of time dummies to capture aggregate trends across all countries, as well as a control for the business cycle (deviations from trend output). As discussed in the previous section, much of the recent literature emphasizes the idea that the impact of product market competition on innovation and imitation may depend on other characteristics of the industry or country. The main other characteristic that we examine is distance to the technological frontier. We investigate the direct impact of distance to the frontier on innovation and productivity growth, as well as how it interacts with our measures of the mark-up.

A number of other issues are raised in the literature which we have not been able to investigate or where we have not been able to identify clear results. These include non-linear effects of competition, the effects of differences in credit market and labour market institutions, the sequencing of reforms and innovation in service sectors. These are discussed in section 5.5.

4 Data

In order to implement the model discussed above empirically we need measures of innovation activity, the mark-up and product market regulations and reforms. We discuss these in turn. Further details are provided in Appendices II-IV. Appendix VI provides references for the various data sources.

4.1 Innovative activity

We focus on two measures of innovation activity - Business Enterprise R&D (BERD) expenditure and counts of patents taken out at the European Patents Office (we also consider triadic patents). We investigate both because R&D expenditures will capture resources devoted to all private sector innovative activity, not just that that is ultimately successful in producing new products and processes, whereas patents only capture successful innovation. Patents data are also available at the firm level, and we can therefore investigate whether the impact of product market reforms differ across entrants and incumbent firms. There is a strong correlation between our two main measures of innovation inputs and innovation outputs – BERD as a % of GDP and patenting per 1000 population. However the importance of patents as measures of innovation varies considerably across industries. Further discussion of these measures and how they vary across countries is given in Appendix II.

A detailed description of innovative activity in our sample is given in Appendix II.2. Business Enterprise R&D (BERD) as a proportion of GDP, varies dramatically across European countries. Within countries there has also been substantial variation in the path of BERD as a percentage of GDP over time. For example between 1981 and 2001 BERD intensity in Sweden and in Finland increased by over 1.5 percentage points of GDP, whereas in the UK it actually decreased by 0.25 percentage points.

Imitation is harder to measure. We do not have direct measures of the extent to which firms imitate or adopt the latest technological developments in other firms. Therefore, we proxy a country's scope for benefiting from technological diffusion by the distance that it lies behind the technological frontier (the country with the highest productivity). This has the merit that it is easily measurable with available data for a wide range of countries and time periods. We therefore investigate whether product market reforms have different impacts on innovative activity and on macro-performance depending on the extent to which countries lie behind the frontier. If they do, this implies that policy reforms of this type may have differential effects depending on a country's relative technological position. However, as we discuss later on, without better data on imitation activity than exists at present it is very difficult to distinguish whether any differential impact of competition on innovation with distance to the frontier is due to different effects on incentives to innovate, or because of differences in measurement between innovation and imitation activity.

Finally, we measure then growth of total factor productivity growth using a superlative index (Caves et al, 1982). The data comes from the OECD STAN database which provides information at the two-digit industry level on value added, labour and capital stocks. Our TFP growth sample consists of 12 two-digit industries across nine countries over the period 1988-2000.

The growth rate of TFP for a country-industry is defined as

$$\Delta TFP_t = \ln\left(V_t / V_{t-1}\right) - \tilde{\alpha} \ln\left(L_t / L_{t-1}\right) - \left(1 - \tilde{\alpha}\right) \ln\left(K_t / K_{t-1}\right)$$

where V denotes real value-added (converted to US dollars using an economy-wide PPP), $\tilde{\alpha}$ is the average labour share over t and t-1,

$$\tilde{\alpha} = \frac{1}{2}\left(\alpha_t + \alpha_{t-1}\right),$$

L is numbers employed and K is capital stock (converted to US dollars using an economy-wide PPP). One concern that is often expressed in the literature is that the share of labour in value-added can be quite volatile. This is suggestive of measurement error, so we check that our main results are robust to the adjustment suggested by Harrigan (1997). This involves exploiting the properties of the translog production function to smooth the observed labour shares. [10]

[10] Under the assumption of a translog production function and standard market-clearing conditions, the labour share can be expressed as a function of the capital-labour ratio and a country-industry constant. If actual labour shares deviate from their true values by an i.i.d. measurement error term, then the parameters of this equation can be estimated by fixed effects panel data estimation, where we allow the coefficient on the capital-labour ratio to vary across industries *j*. The fitted values from this equation are then used as the labour cost shares in our calculation of TFP growth.

Table 1 shows the means and standard deviations of TFP growth, ln R&D expenditure and R&D intensity in a panel of manufacturing industries. Further discussion of innovative activity and productivity growth is contained in Appendix II.

Table 1: Mean TFP growth and R&D

	Growth in TFP (standard deviation)	ln real R&D expenditure (standard deviation)	R&D intensity (standard deviation)	Number of observations
Belgium	0.012	4.489	0.051	95
	(0.091)	(1.396)	(0.050)	
Canada	0.020	4.892	0.033	166
	(0.051)	(1.409)	(0.049)	
Denmark	0.010	5.331	0.043	91
	(0.065)	(1.853)	(0.058)	
Finland	0.029	3.602	0.051	140
	(0.065)	(1.235)	(0.043)	
France	0.015	5.978	0.105	82
	(0.098)	(1.230)	(0.160)	
Netherlands	0.012	4.126	0.042	136
	(0.066)	(1.686)	(0.050)	
Norway	0.007	5.045	0.041	108
	(0.062)	(1.380)	(0.043)	
United Kingdom	0.020	5.435	0.061	150
	(0.050)	(1.556)	(0.065)	
United States	0.016	7.967	0.078	154
	(0.059)	(1.615)	(0.099)	
Total	0.017	5.229	0.055	1,122
	(0.066)	(1.963)	(0.076)	

The sample consists of an unbalanced panel of 12 two-digit industries over the period 1987-2000.

4.2 The mark-up

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. This is difficult to measure. We construct a measure of the mark-up, or profitability, at the whole economy level, and for sub-sectors of the 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, and it is the only commonly-used measure of competition that is available across countries.

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

$$markup = \frac{ValueAdded}{LabourCosts + CapitalCosts},$$

where all variables are in nominal prices. This simple measure of the mark-up can be shown to be equivalent to that proposed by Roeger (1995),[11] 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 mark-up. While value-added and labour costs are observed in the data, capital costs are not. 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 long term interest rate. In our main results we instrument the mark-up with exogenous changes in competition, which should help to control for classical measurement error.

Assuming that all countries face the same world interest rate might conceivably induce bias in the results if some countries have liberalised their credit markets during the period in a way that is correlated with reforms to product markets. However, none of our main results is sensitive to using an alternative assumption of closed capital markets, or even a constant 10% cost of capital across countries.

Table 2 shows the mean of the rents variable for the whole economy, and for manufacturing separately. More discussion is provided in Appendix IV.

Table 2: Mean of rents

	Rents (whole economy)	Rents (manufacturing)
Australia	1.208	1.296
Belgium	1.194	1.161
Canada	1.282	1.236
Denmark	1.087	1.123
France	1.183	1.223
Great Britain	1.261	1.124
Italy	1.314	1.257
Netherlands	1.165	1.189
Norway	1.149	1.060
USA	1.384	1.240

There is wide and sometimes surprising variation in the average level of rents across countries. For example, the US has one of the highest level of rents, which runs counter to our intuition about the degree of competition in the US and Europe. There are various data

[11] See Klette (1999) for a discussion.

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 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 help to control for these important sources of measurement error. As stressed above, our results are 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 (see Appendix IV). At first this may seem to conflict with most preconceptions about changes to the degree of competition associated with product market reforms, globalisation and opening to trade. One explanation, discussed by 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 their 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. There are a range of other factors that might explain an upwards trending mark-up over time, including increases in returns to scale. However, what is important from our point of view is that *differential* changes in mark-ups across countries and industries can be shown to be related to product market reforms in ways that accord with theory. We discuss this further in the results section. In Appendix V we show that controlling for this type of effect, by including proxies for workers' bargaining power in our regressions, such as union density, bargaining coverage, benefit replacement rates and employment protection legislation, does not substantially affect our results.

Another feature of our measured mark-ups is that they are generally pro-cyclical. We include an OECD country-level measure of the output gap in all regressions (calculated as a deviation from trend growth) to control for this. As discussed in Appendix IV, we might be concerned that this will not remove all of the cyclical variation in the mark-up. However, any excess pro-cyclicality in the mark would induce if anything a positive bias in our OLS estimates. For example, if R&D or productivity growth are pro-cyclical, excess cyclicality in the mark-up could bias the coefficient on the mark-up in a positive direction, which means that the size of our results would be understated (we find negative coefficients on the mark-up). In addition, when we instrument the mark-up with our indicators of product market reforms, the estimated coefficient becomes more negative in almost all cases. This is consistent with the hypothesis that the instrumental variables (IV) estimates control for measurement error in the mark-up that is associated with excess cyclicality.

4.3 Product market regulations and reforms

One of the main challenges in the literature looking at the impact of product market competition on innovation is the endogeneity of competition. Product market reforms can provide useful exogenous variation to enable researchers to identify the causal impact of competition on innovation. In addition, the effect of specific policies may be of direct interest to policy makers.

In order to be able to estimate the impact of a policy reform on outcomes we need to observe data both before and after the reform, and the reform must have affected different countries, industries or firms differently. Without this variation we can not identify the impact of the reform.

An important indicator of product market reform that we use is based on the implementation of the European Single Market Programme (SMP) in the early 1990s. This was a large scale project by the then members of the European Union to reduce internal non-tariff barriers to trade and other barriers to the free movement and factors of production across borders. The SMP is a large reform, and it was undertaken across a large number of countries. It was, however, undertaken at around the same time across countries. This means that to identify the impact of the SMP from other contemporaneous macroeconomic effects (for example, the recession of the early 1990s) we need to either include countries that were not involved in SMP as a control group, or use variation in the impact it had across different industries.

We also use other indicators of product market reforms to supplement the SMP-based indicators (see Appendix III for a detailed discussion). However, in general we have found that the SMP-based indicators have the most explanatory power and can be most closely linked to specific reforms.

4.3.1 Country-level indicators

We have used various sources of information to construct an indicator of the impact of the SMP at the country level. One identification strategy is to use countries that did not take part in the SMP as a control group for countries that did take part, i.e. use a simple difference-in-difference estimate of the impact of the SMP. In order for these to be good controls they need to represent on average what would have happened in the affected countries in the absence of the SMP. We examine the robustness of our results to using different control groups.

We have also investigated the possibility of differentiating the effects of the SMP between participant countries. This involves refining the simple in-out control group approach by obtaining measures of how large the impact of the SMP was for each participant country. Although this may create more accurate measures of the expected effects of the SMP, it turns out that most of the variation in the data is between SMP and non-SMP countries, so the control group approach continues to be our main identification strategy at the country level.[12]

We use two additional sources of information to refine our SMP indicator. The first is the data on the expected degree of impact of the SMP on different manufacturing industries contained in Buigues et al (1990) (described below). The authors identify which industries are expected to be highly and moderately affected by the SMP, and we combine this information with the share of those industries in manufacturing output before the implementation of the SMP to generate the ex ante share of output in each country that was expected to be affected by the SMP. The second additional source of information that we use to refine our indicator of the SMP is related to the extent and speed with which the SMP was actually implemented in each participant country. We use the European Commission's published Internal Market Scoreboard which contains the rate of non-implementation of single market directives for each candidate country (the "transposition deficit").

We have investigated many other potential indicators of product market reform (see Appendix III for more discussion). For the country-level econometric analysis we use two further indicators that might be expected to be important, and which appear to affect mark-ups in ways that are consistent with theory. The first is an index of "Time senior management spends with government bureaucracy" constructed by the Fraser Institute. This is based on survey

[12] In our main industry-level results (discussed below) we test whether our results are robust to using only variation within the SMP countries.

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. 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 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. Both of these indices are based on data published in the World Economic Forum's "Global Competitiveness Report 2001-2002".

Table 3 shows the mean of the country level indicator. More details about the definitions of these measures and how they vary over time are given in Appendix III.

Table 3: Mean of product market variables

	SMP	Administrative Burden on Business 1=high, 10=low	Ease of entry 1=high regulation, 10=low regulation
Australia	0	7.099	6.860
Belgium	12.929	6.743	4.782
Canada	0	7.110	7.780
Denmark	13.392	8.829	6.320
France	13.043	6.480	3.580
Great Britain	13.364	7.820	8.060
Italy	13.537	4.841	4.201
Netherlands	11.869	7.571	7.510
Norway	0	8.159	7.161
USA	0	7.570	8.400

4.3.2 Industry-level indicator

As well as the country level variation we also use the differential impact of the Single Market Program (SMP) across industries and countries as a source of exogenous variation in product market regulations. The data is taken from a European Commission report by Buigues et al (1990).[13] This analysis is based on information contained in the 1988 Cecchini Report and

[13] Aspects of this data have been used in various studies, including Mayes and Hart (1994), and Allen, Gasiorek and Smith (1998). We are not aware of any studies using the detailed industry-level data across several SMP countries.

other sources, including an extensive survey of businesses in the participating countries. The report identifies groups of 3-digit industries that were expected *ex ante* to be highly and moderately affected by the SMP, as well as the share of each of these industries in each country's manufacturing employment over 1985-1987.[14] The report starts by identifying a common list of industries across all SMP countries, and then national experts from each country were asked to add or remove sectors from the list according to whether the effects of the SMP were expected to be large or small in each sector in their country. Thus, for example, a sector would be removed from the list if it was already very open to international competition before the implementation of the SMP. Examples of such sectors include the aerospace industry in the UK and the brewing and malting industry in Denmark.

There are thus two sources of variation across SMP countries in the ex ante expected impact of the SMP. First, the identified 3-digit sectors make up different shares of employment across countries in the 2-digit industries in our sample. A limitation of the analysis is that some of this variation may not be exogenous with respect to the outcomes we are measuring. However, much of the variation reflects longstanding differences in the share of particular activities in countries' manufacturing activity. Second, the fact that some sectors have been removed from the list at the country level creates further variation in the expected effects of the SMP across SMP countries. This variation stems from the fact that some countries had higher barriers to competition in some sectors than others at the start of the period.

As well as variation across SMP countries, our main results also use non-SMP countries as controls for the impact of the SMP. This introduces a third source of variation in the data. As there may be concerns about the suitability of non-SMP countries as controls for what would have happened in the SMP countries, we test the robustness of our main results to dropping non-SMP countries from the sample. These robustness checks thus use only the first and second sources of variation described above.

The affected sectors are grouped into four main groups. Three of these were expected to be highly affected. The first is a group of "high-technology public procurement sectors" including telecommunications equipment, office machinery and medical and surgical equipment. The second and third are designated as "traditional public-procurement and regulated markets" and are split by the degree of measured price dispersion across countries

[14] This information is contained in Table 26 in the Report's statistical annex.

prior to the SMP. The high price-dispersion group includes, amongst others, pharmaceutical products, and brewing and malting, while the low price dispersion group is dominated by shipbuilding and electrical machinery. Finally there is a fourth group of sectors that were expected to be moderately affected by the SMP, and which includes a range of consumer, investment and intermediate goods.

We allow the estimated effects of the SMP to vary across these four groups of sectors. Table 4 presents the average share of each 2-digit industry in our sample that fell into each of the four groups in 1986, the year before the beginning of our sample period. These four variables across countries and industries are the instruments that we use in our empirical results, and take the form of a step-function that rises from zero to the country-industry-specific affected share in 1992. The table shows that the first group of highly affected sectors are all concentrated in the machinery and equipment industry, while the other groups are spread across a range of industries. Only three of the twelve industries contain no affected sectors. In addition, as discussed above, non-SMP countries contain no affected sectors by definition, so the values of the instruments are equal to zero in all years in all industries in these countries.

Table 4: Single Market Program: average % of 2-digit industry falling into the different affected groups

Group:	(1) High-tech, public procurement markets	(2) Traditional public procurement and regulated markets (high price dispersion)	(3) Traditional public procurement and regulated markets (low price dispersion)	(4) Moderately affected sectors	Unaffected sectors
Industries in SMP countries					
15-16: Food, beverages and tobacco	0	9.1	7.4	0	83.4
17-19: Textiles, leather and footwear	0	0	0	62.4	37.6
21-22: Pulp, paper, printing and publishing	0	0	0	0	100
23: Coke, petroleum and nuclear fuel	0	0	0	0	100
24: Chemicals and chemical products	0	31.1	0	59.8	9.1
25: Rubber and plastics	0	0	0	26.1	73.9
26: Other non-metallic minerals	0	0	0	40.4	59.6
27: Basic metals	0	0	0	0	100
28: Metal products	0	6.4	0	0	93.6
29-33: Machinery and equipment	32.0	0	11.3	39.3	17.3
34: Motor vehicles	0	0	0	97.4	2.6
35: Other transport equipment	0	7.0	27.8	38.1	27.0
All industries in non-SMP countries	0	0	0	0	100

Notes: the SMP countries in the sample are Belgium, Denmark, France, the Netherlands and the UK. The non-SMP countries are Canada, Finland, Norway and the USA.

4.3.3 Other regulations

While our main focus is the impact of product market reforms, the results of our previous study and the literature review suggest that it can be important to control for the effect of labour market regulations on the measured mark-up and other macroeconomic outcomes. In addition, labour market regulations may have an impact on rates of innovation. Predictions about the impact that they have depend on the type of regulation - regulations that increase adjustment costs, such as employment protection legislation (EPL), may slow down the ability of firms to respond to changes in the competitive environment (as in Caballero et al (2004) where EPL slows firms responsiveness to shocks); regulations that increase firms costs, such as benefits replacement rate and the tax wedge, may reduce investment; and institutions that affect the balance of bargaining power between the firm and workers, such as union coverage, union density and coordination, may increase or decrease innovation activity.[15] As we discuss later on, a full investigation of the impacts of different types of labour market regulation is beyond the scope of this study. However, we discuss this issue briefly at the end of section 5, present some results in Appendix V, and discuss the measures we use in more detail in Appendix III.

We also attempt to control for the extent of financial market deregulation. Efficient financial markets may have an impact on competition in the product market, for example by providing easy access to credit for new entrants. As with labour market regulations it is possible that the impact of product market reforms depends on the nature of regulation in financial markets. Our main source of information on financial market regulation is the Fraser Institute indices of financial market regulation. Our attempts to investigate the role of financial market regulation have been hindered by the fact that there is not very much variation in the extent of regulation across the countries in our sample during the sample period.

[15] Machin, S. and Wadhwani, S. (1991), Menezes-Filho, Ulph, and Van Reenen (1998), Ulph and Ulph (1994, 1998, 2001); Aghion, Burgess, Redding and Zilibotti (2003)

5 Empirical findings

We now turn to our empirical findings. We start by briefly presenting results using country-level data on the relationships between product market competition and innovative activity. We show that the results at the country level are sensitive to which countries are included in the sample. We then discuss results using country-industry level data for the manufacturing sector. We also show some findings on the relationship between productivity growth and the extent of product market competition in the service sector. We then show that the effect of increased product market competition on innovation is markedly different for new and incumbent innovators. We examine whether the impact of product market competition on innovation depends on a country or industry's distance from the technological frontier. Finally, we discuss a number of other issues where we have had less success in identifying clear results. These present interesting directions for further research.

5.1 Country-level results

We begin by considering the relationship between different measures of innovation and our measure of the mark-up. We consider two different measures of innovation intensity: Business Enterprise R&D as a share of Gross Domestic product (BERD/GDP), and the number of Triadic Patent Families per capita. The results are similar for both measures.[16] We show that results at the country level are sensitive to the set of countries included in estimation. We believe that this may partly reflect differential changes in industrial composition across countries. We therefore focus in the next section on estimates using industry level data.

Table 5 shows country-level OLS results for the two different innovation outcomes, and for each measure we show results for two different samples. First in columns (1) and (3) we include 13 OECD countries over the period 1986 to 2000. Second in columns (2) and (4) we use data over the same time period but drop three Scandinavian countries: Finland, Sweden and Denmark. In each case we also include a measure of the output-gap which varies at the country-year level to control for country specific fluctuations in the economic cycle, as well as time and country dummies.

[16] The pattern of results is also the same if we restrict attention to *industry-financed* Business Enterprise R&D, i.e. we exclude publicly-financed R&D conducted by the business sector.

Considering the full sample of countries (columns (1) and (3)), we find a positive and significant relationship between innovation and the level of rents in the economy (a *lower* level of product market competition is associated with more innovation). However, when we exclude the three Scandinavian economies from the sample (columns (2) and (4)), this relationship is reversed; we find that a *higher* level of competition (lower mark-up) is associated with more innovation.

We investigated why the presence of Sweden, Finland and Denmark in the sample might be driving the positive relationship between the measures of innovation intensity and the mark-up. The relationships are identified from differential changes in R&D intensity and the level of the mark-up across countries. Denmark, Finland and Sweden experienced the sharpest rises in innovation intensity from the 1990s onwards. At the same time, Denmark, Sweden and in particular Finland experienced rising mark-ups following a period of recession in the early 1990s. Indeed, it may be that part of the response to the recession in these countries was a shift towards more R&D intensive sectors. Differences in industrial structure in Sweden and Finland lie in part behind their relatively high overall R&D intensity. A concern therefore is that differences in industrial structure across countries are at least partly causing the sensitivity of the results to the sample of countries used. To account for this below we use industry-level data for the manufacturing sector, and look at differences in innovation intensity within industries. As expected, we find that our industry-level results are much less sensitive to the composition of the sample than the country level results.

It is also interesting that the output gap has a significant negative coefficient in the full sample, but not in the smaller sample. This may indicate that innovation was particularly cyclical in the three excluded countries. As discussed above, Sweden and Finland in particular experienced severe recessions in the early 1990s, followed by a recovery that coincided with an increase in indicators of innovation (R&D and patenting). A failure to control completely for these extreme cyclical variations might also help to explain why the presence of these countries in the sample is driving the positive coefficient on the mark-up. Industry level variation should also help to address this issue, since there is a significant amount of variation around the aggregate country cycle at the industry level.

Table 5: Innovation and product market competition, basic OLS results, country-level

	(1) BERD/GDP	(2) BERD/GDP	(3) Triadic patent families per capita	(4) Triadic patent families per capita
Mark-up	2.809**	-1.009**	99.150***	-30.940**
(whole economy)	(1.074)	(0.463)	(29.213)	(13.125)
Output Gap	-0.026**	-0.002	-1.435***	-0.251
	(0.011)	(0.008)	(0.335)	(0.196)
Time dummies	Yes	Yes	Yes	Yes
Country dummies	Yes	Yes	Yes	Yes
Obs.	189	144	189	144
R-squared	0.90	0.95	0.89	0.96

*Notes: robust standard errors in parentheses. Columns (1), (3) contain 13 country sample. Columns (2), (4) drop Sweden, Finland and Denmark. *, ** and *** indicate significance at 10%, 5% and 1% levels respectively.*

We have also investigated instrumental variables results for the two different samples of countries (not shown), where we instrument the mark-up with country-level indicators of product market reforms, to generate exogenous variation. As before, the results are particularly sensitive to the set of countries used in estimation. For example, depending on the set of countries our results suggest either an upward bias on the OLS coefficient on the mark-up (as might be expected if higher innovation intensity itself results in higher mark-ups), or a downwards bias.

We revisit the instrumental variables approach in our industry-level results in the next section. There is more differential variation in the effects of product market reforms at the industry level, and our results are robust to the country composition of the sample. We also investigate whether the response of innovative activity to changes in product market competition depends on other country and/or industry characteristics, in particular the distance that an industry is from the technological frontier.

5.2 Industry level analysis

We now investigate the impact of product market reforms on R&D activity and productivity growth in a panel of manufacturing industries across OECD countries. We restrict the sample to country-industries for which we have full or almost full data on R&D, mark-ups and TFP growth over the period 1987-2000. In particular, we drop country-industries for which there is no data before 1991, as they would not allow us to identify the impact of the SMP. This leaves us with 84 country-industry pairs across 9 countries, of which 5 are SMP countries (Belgium, Denmark, France, the Netherlands and the UK) and 4 are non-SMP countries (Canada, Finland, Norway and the USA). In total we have 1,122 country-industry-year observations.

5.2.1 The impact of product market reforms on R&D in the manufacturing sector

To begin with we investigate the impact of product market regulations on R&D expenditure. We use the mark-up as an indicator of product market competition and instrument it with our measures of the expected effect of the SMP across industries. This approach assumes that the impact of product market reforms on innovation operates through their effect on the level of competition, as measured by the level of rents. We also test for additional direct effects of the SMP variables on innovation. We discuss the interpretation of any additional direct effects later on. We also investigate the direct reduced form impact of the SMP variables on R&D and examine whether these are consistent with the impacts implied by the two-stage method.

Table 7 shows the results with log real R&D expenditure while Table 8 shows results using R&D intensity. We use both to check that our results are not driven by the impact of the SMP on output (i.e. the denominator of R&D intensity). All specifications include a full set of country, industry and time dummies, so the coefficients are identified from differential variation over time across countries and industries. We also include a country-level measure of the output gap (from the OECD) to control for country-specific cyclical effects.

Before considering those results, we first show the results from the first stage of the IV estimation in Table 6. Starting with column (1) we see that the SMP is associated with lower mark-ups and that this relationship is stronger in more highly affected sectors, though not in the low price-dispersion sectors (group 3). The partial R^2s and F-tests at the bottom of Table 6 show that the instruments have explanatory power. We return to a discussion of columns (2) and (3) below. The output gap is significantly positive, suggesting that mark-ups are on average pro-cyclical. Note that the output gap is measured at the country level while the mark-up and all other variables are at the industry level.

Table 6: First stage reduced form: mark-ups and product market reforms

Dep. var.: mark-up	(1)	(2)	(3)
		SMP countries only	
	1987-2000	1987-2000	1988-2000
Distance to frontier			0.042
			(0.029)
Output Gap	0.005**	0.007*	0.006**
	(0.002)	(0.004)	(0.002)
SMP group 1	-0.178**	0.004	-0.154**
	(0.075)	(0.081)	(0.070)
SMP group 2	-0.301***	-0.048	-0.336***
	(0.071)	(0.087)	(0.073)
SMP group 3	-0.043	0.412**	0.010
	(0.122)	(0.200)	(0.131)
SMP group 4	-0.113***	-0.077**	-0.109***
	(0.023)	(0.034)	(0.024)
Partial R^2 of SMP groups 1-4	0.041	0.028	0.041
F-test of SMP groups 1-4	13.14	4.66	12.62
(p-value)	(0.000)	(0.001)	(0.000)
Partial R^2 of SMP groups 2-4	0.035		
F-test of SMP groups 2-4	15.2		
(p-value)	(0.000)		
Observations	1122	554	1014
R-squared	0.49	0.41	0.50

*Notes: regression includes a full set of country, industry and year dummies. Robust standard errors in brackets, apart from statistical tests, where p-values are in brackets. The sample consists of 12 two-digit industries or groups of industries across 9 countries over the period indicated. *, ** and *** indicate significance at 10%, 5% and 1% levels respectively.*
SMP group 1: High-tech, public procurement markets
SMP group 2:Traditional public procurement and regulated markets (high price dispersion)
SMP group 3: Traditional public procurement and regulated markets (low price dispersion)
SMP group 4: Moderately affected sectors

Turning to the results in Table 7 we find a small effect of competition (lower mark-ups) on R&D in column (1) in the OLS specification. Column (2) shows IV results which indicate a much stronger relationship between increased competition and innovation. This suggests an upwards bias in the OLS results, for example due to reverse causality from R&D to the mark-up, or possibly as a result of attenuation bias. However, the Hansen J test rejects the over-identifying restrictions (i.e. whether the SMP variables can be excluded from the R&D regression) in this specification. This is due to a direct negative effect of the SMP on R&D in Group 1 sectors, as shown in column (3). That is, the SMP group 1 variable cannot be excluded from the R&D regression and when it is included in the instrument set (as in column 2), the set of instruments is found to be invalid.

Buigues et al (1990) say the group 1 activities *"are characterised by considerable economies of scale which are not always properly exploited at Community level, and by large R&D budgets in which the lack of cooperation between European companies constitutes a handicap"* (p. 23). This raises the possibility that consolidation and rationalisation across countries in these sectors following the SMP may have reduced R&D expenditure. However, if R&D expenditure became more efficient this may not represent a reduction in innovation. Later on (Table 10, Column(7)) we find a small and marginally significant negative effect of the SMP on productivity growth in these sectors, which does not allow us to distinguish between these two interpretations.

Column (4) shows the reduced form estimates; we see that the coefficients are roughly consistent with the two-stage IV results. For example, combining the coefficient of -0.113 on the moderately affected sectors (group 4) in column (1) of Table 6 with the coefficient of -5.494 on the mark-up in column (3) of Table 7 suggests an indirect impact on real R&D of about 0.6, which is close to the direct estimated impact of 0.775 in column (4) of Table 7.

Table 7: Log real R&D

Dep. var.: Ln(R&D)	(1) OLS	(2) IV	(3) IV	(4) Reduced Form
Mark-up (industry)	-0.471***	-4.133***	-5.494***	
	(0.176)	(0.753)	(0.916)	
Output Gap	0.003	0.021	0.028	-0.001
	(0.012)	(0.016)	(0.018)	(0.011)
SMP group 1			-2.159***	-1.451***
			(0.480)	(0.326)
SMP group 2				1.088***
				(0.254)
SMP group 3				0.734
				(0.577)
SMP group 4				0.775***
				(0.113)
Hansen J test of over-id. (p-value)		28.74	2.55	
		(0.000)	(0.280)	
Observations	1122	1122	1122	1122

*Notes: all specifications include a full set of country, industry and year dummies. Robust standard errors in brackets, apart from statistical tests, where p-values are in brackets. The sample consists of 12 two-digit industries or groups of industries across 9 countries over the period 1987-2000. *, ** and *** indicate significance at 10%, 5% and 1% levels respectively.*
SMP group 1: High-tech, public procurement markets
SMP group 2:Traditional public procurement and regulated markets (high price dispersion)
SMP group 3: Traditional public procurement and regulated markets (low price dispersion)
SMP group 4: Moderately affected sectors

The results for R&D intensity, shown in Table 8, are similar. We start in column (1) with OLS results. In column (2) we use all four SMP variables as excluded instruments. The Hansen J test rejects the over-identifying restrictions, and in column (3) we see that, as well as a direct negative effect in Group 1 sectors, we cannot exclude a direct effect of the SMP on R&D in Group 3 sectors - they experience an additional positive effect of the SMP on R&D intensity. In most of the SMP countries shipbuilding and electrical machinery dominate Group 3. It is possible that the additional positive impact on R&D intensity (as opposed to the level of R&D) in Group 3 is due to a reduction in the denominator, for example if low R&D firms and/or sectors exited or contracted following the SMP. As before, the estimated coefficient on the mark-up becomes significantly more negative in the IV specification. Column (4) shows the reduced form estimates (where we simply include the SMP variables directly in the R&D intensity equation). We discuss Column (5) below in section 4.2.3.

Table 8: R&D intensity

Dep. Var.: R&D/VA	(1) OLS	(2) IV	(3) IV	(4) Reduced Form	(5) Reduced Form 1988-2000
Mark-up (industry)	-0.066***	-0.264***	-0.344***		
	(0.014)	(0.063)	(0.068)		
Distance to frontier					-0.024***
					(0.006)
Output Gap	0.000	0.001	0.002	-0.000	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
SMP group 1			-0.206***	-0.135***	-0.086**
			(0.040)	(0.043)	(0.036)
SMP group 2				0.133***	0.121***
				(0.020)	(0.019)
SMP group 3			0.196**	0.204**	0.046
			(0.076)	(0.100)	(0.082)
SMP group 4				0.031***	0.017*
				(0.011)	(0.010)
Hansen J test of over-id. (p-value)		31.43 (0.000)	1.23 (0.268)		
Partial R^2 of SMP variables					0.033
F-test of SMP variables (p-value)					18.72 (0.000)
Observations	1122	1122	1122	1122	1014
R-squared	0.65			0.66	0.66

*Notes: all specifications include a full set of country, industry and year dummies. Robust standard errors in brackets, apart from statistical tests, where p-values are in brackets. The sample consists of 12 two-digit industries or groups of industries across 9 countries over the period 1987-2000. *, ** and *** indicate significance at 10%, 5% and 1% levels respectively.*
SMP group 1: High-tech, public procurement markets
SMP group 2:Traditional public procurement and regulated markets (high price dispersion)
SMP group 3: Traditional public procurement and regulated markets (low price dispersion)
SMP group 4: Moderately affected sectors

What do these results imply about the economic magnitude of our estimated effects? The coefficient on the mark-up in column (3) of Table 8 suggests that a one percentage point fall in the mark-up is associated with on average about a 0.3 percentage point increase in R&D intensity. Consider the impact of the SMP on the chemicals industry in the UK, for example. 30% of the industry fell into Group 2 of highly affected sectors, while a further 39% of the industry fell into Group 4 of moderately affected sectors. Combining these numbers with the coefficients on the SMP variables in column (1) of Table 6 our estimates predict that the SMP was associated with a 13 percentage point fall in the chemical industry's average mark-up. Combining this with the coefficient on the mark-up in column (3) of Table 8 suggests that the SMP was associated with a rise in R&D intensity of 4.6 percentage points. We can compare this to reduced form coefficients on the SMP variables in column (4) of Table 8, which generate a predicted rise in R&D intensity of 5.2 percentage points. The actual average pre- and post-SMP R&D intensities in the chemical sector over the sample period were 14.3% and 19.2% respectively, a rise of 4.9 percentage points. Thus, while many other factors may have affected R&D intensity in this industry in the UK over the period, both our IV and reduced form estimates suggest that in the absence of the SMP it would have remained fairly constant.

5.2.2 Robustness to using only SMP countries

The results above use non-SMP countries as controls, as well as variation in the effects of the SMP between industries in the SMP countries. In Table 9 we show equivalent results using only the SMP countries, thus using only the latter form of variation. One main difference in these results is in the first stage IV results, shown in column (2) of Table 6. We find no significant effect on the mark-up from the first two highly affected groups, and a positive from the third highly-affected group, which is dominated by shipbuilding and electrical machinery. However, a strong negative impact from moderately affected sectors provides most of the explanatory power. The main point here is that, although less precisely estimated, in the R&D results (Table 9) the coefficient on the instrumented mark-up term is similar to that in Table 7. The results are similar for R&D intensity (see Appendix V).

Table 9: Log real R&D, SMP countries only

Dep. var.: Ln(R&D)	(1) OLS	(2) IV	(3) Reduced Form
Mark-up (industry)	-0.402**	-3.670**	
	(0.181)	(1.100)	
Output Gap	0.005	0.025	-0.002
	(0.013)	(0.019)	(0.013)
SMP group 1			-0.057
			(0.292)
SMP group 2			0.010
			(0.256)
SMP group 3			-2.310***
			(0.429)
SMP group 4			0.117
			(0.101)
Hansen J test of over-id. (p-value)		2.19 (0.534)	
Observations	554	554	554

*Notes: all specifications include a full set of country, industry and year dummies. Robust standard errors in brackets, apart from statistical tests, where p-values are in brackets. The sample consists of 12 two-digit industries or groups of industries across 5 SMP countries over the period 1987-2000. *, ** and *** indicate significance at 10%, 5% and 1% levels respectively.*
SMP group 1: High-tech, public procurement markets
SMP group 2:Traditional public procurement and regulated markets (high price dispersion)
SMP group 3: Traditional public procurement and regulated markets (low price dispersion)
SMP group 4: Moderately affected sectors

5.2.3 The impact of product market reforms on productivity growth

We now consider the effect of product market reforms on productivity growth through their effect on R&D, as in equation (2), and consider whether there is evidence for a direct effect on productivity growth. The sample is slightly smaller than above because we lose the first year of data – the right hand side variables are all lagged by one period.

In columns (1) and (3) of Table 10 we find a positive association between R&D and TFP growth and in columns (2) and (3) between competition (lower mark-up) and TFP growth. We also include a measure of the industries' distance to the technological frontier and find that industries that are further from the frontier experience faster TFP growth. This is consistent with productivity convergence, for example if industries further behind the frontier are more able to benefit from imitation and adoption of technologies developed near to the frontier. We discuss further results incorporating measures of distance to the frontier in section 5.4 below.

Table 10: TFP growth

Dep Var.: TFP growth	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	OLS	OLS	OLS	IV	IV	IV	Reduced form
R&D/VA	0.115***		0.079*	0.481**		0.621***	
	(0.045)		(0.044)	(0.215)		(0.238)	
Mark-up (industry)		-0.063***	-0.057***		-0.052	0.065	
		(0.014)	(0.014)		(0.068)	(0.070)	
Distance to frontier	0.036***	0.036***	0.038***	0.046***	0.036***	0.046***	0.034***
	(0.008)	(0.008)	(0.008)	(0.010)	(0.008)	(0.010)	(0.008)
Output gap	-0.004***	-0.004***	-0.004***	-0.004***	-0.004***	-0.004***	-0.005***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
SMP group 1							-0.057*
							(0.033)
SMP group 2							0.059
							(0.043)
SMP group 3							-0.002
							(0.061)
SMP group 4							0.002
							(0.011)
Hansen J test of over-id. (p-value)				1.20	6.64*	0.30	
				(0.754)	(0.084)	(0.863)	
Observations	1014	1014	1014	1014	1014	1014	1014
R-squared	0.23	0.25	0.25				0.23

*Notes: all specifications include a full set of country, industry and year dummies. All right hand side variables are lagged one period. Robust standard errors in brackets, apart from statistical tests, where p-values are in brackets. The sample consists of 12 two-digit industries or groups of industries across 9 countries over the period 1987-2000. *, ** and *** indicate significance at 10%, 5% and 1% levels respectively.*

SMP group 1: High-tech, public procurement markets

SMP group 2:Traditional public procurement and regulated markets (high price dispersion)

SMP group 3: Traditional public procurement and regulated markets (low price dispersion)

SMP group 4: Moderately affected sectors

In columns (4) to (6) we instrument both variables (the mark-up and R&D intensity) with the impact of the SMP (the reduced form regression for the mark-up is shown in column (3) of Table 6 and for R&D intensity in column (5) of Table 8). Column (7) presents the estimated reduced form impact of the instruments on TFP growth. The IV estimates of the impact of R&D on TFP growth (columns (4) and (6)) are larger than the OLS estimates, while the IV estimates of the impact of the mark-up are not significant. Overall, the results in Table 10 suggest that we do not find evidence of a direct effect of competition on productivity growth, but that there is an indirect effect through R&D.

As before, we find similar results using only SMP countries (see Appendix V), though we cannot identify any significant effects when we instrument both R&D and the mark-up in column (6). Note that the direct impact of the SMP variables on TFP growth in the reduced form in column (7) is not jointly significant in either the full sample or the SMP-only sample. Thus we do not find strong evidence of a *direct* impact of the SMP on TFP growth over this period, beyond any indirect effect through the effect on R&D.

What is the economic magnitude of these effects? The coefficient on R&D intensity in columns (4) and (6) of Table 10 suggests that a 1 percentage point increase in R&D intensity is associated with about a 0.5 or 0.6 percentage point increase in TFP growth. As an example, this is similar to the predicted impact of the SMP on the metal products industry in the UK: 7.5% of the industry fell into Group 2 of highly affected sectors, and the coefficient on SMP Group 2 in column (5) of Table 8 is 0.121, suggesting that the SMP program was associated with a 0.9 percentage point increase in R&D intensity in the industry as a whole. This in turn was associated with a 0.4 percentage point increase in TFP growth.[17] The actual increase in TFP growth in the metal products industry was 1.7 percentage points, from 2.5% to 4.2%, so the predicted impact of the SMP can explain about one quarter of this. These seem plausible effects.

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[17] This is 0.9 times the coefficient on R&D intensity in column (4) of Table 10 of 0.481.

5.2.4 Service sector industries

In contrast to manufacturing, for service sectors we lack both good direct measures of innovation across countries and good instruments for the mark-up. We instead look at the direct impact of product market competition on productivity growth in a panel of service industries. Productivity growth could be seen as a proxy for innovation in these sectors.

For the service sectors we are able to use a panel of 5 market service industries across countries covering the following sectors: wholesale and retail, hotels and restaurants, transport and storage, financial intermediation and business services. All regressions include country, industry and year dummies. We exclude the network industries, which include post, telecoms, electricity, water and gas. We examine both labour productivity growth and TFP growth, due to the well-known difficulties in measuring capital stocks in service sectors.

The OLS results suggest that competition increases productivity growth in these service sectors, (wholesale and retail, hotels and restaurants, transport and storage, financial intermediation and business services), as shown in Table 11. The impact of the mark-up on TFP growth in column (2) is smaller than in the equivalent specification for manufacturing in column (2) of Table 10, but without good instruments it is not possible to say much more, in particular whether the effect is causal or merely an association. Identifying the impact of deregulation and product market reforms on innovation in service sectors would be a very interesting area for future research.

Table 11: Productivity growth and product market competition in the service sector, basic OLS, industry-level

	(1) Labour productivity growth	(2) TFP growth
Mark-up	-0.026**	-0.039***
	(0.011)	(0.021)
Distance to frontier	0.013***	0.014***
	(0.005)	(0.004)
Output gap	-0.003***	-0.004***
	(0.001)	(0.001)
Observations	792	792
R-squared	0.16	0.19

*Notes: robust standard errors in parentheses. All specifications include industry, time and country dummies. *, ** and *** indicate significance at 10%, 5% and 1% levels respectively. The sample consists of a panel of 5 broad service sectors across13 OECD countries over 1987-2001. All right-hand-side variables are lagged by one year.*

5.3 *Is the impact on incumbents and/or entrants?*

In this section we investigate whether increased product market competition has a differential effect on innovation among new and incumbent innovators. We find that the positive relationship between product market competition on innovation is driven by the response of incumbent innovators to competition. This accords with our theoretical expectations as discussed in Section 2.

We consider the following relationship:

$$P_{ijt} = \alpha + \beta\mu_{it} + X_{it}^{'}\gamma + \lambda_j + \tau_t + \eta_i + e_{ijt}$$

where i indexes countries, j indexes technology class, t indexes years, P is the number of patents, μ is the markup (level of rents) as discussed above, X are other control variables (the output gap), η_i captures country specific unobservables, λ_j captures technology specific unobservables (through 115 technology dummies), τ_t captures 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. We discuss below how we distinguish between entrants and incumbents.

As above, 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 from patenting to rents. We instrument rents with the indicators of product market reforms discussed above.

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 patents 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 to allocate the patent to a particular year.[18]

[18] 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).

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 previously, entrants are those assignees which did not have any patents prior to 12 months previously.[19] As a dependent variable we use the count of patents scaled by the population of the country in thousands. Table 12 shows descriptive statistics.

Table 12: Mean and (standard deviation) of dependent variables

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

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

Table 13 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, scaled by the population of the country. 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. The output gap measure captures country specific cyclical effects and is measured as the deviation from trend growth.

[19] 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.

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. 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 (a lower mark-up) 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 endogenous. This could lead to spurious correlation between patenting and the level of rents. As before we use 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), (5) and (8) we use three excluded variables as instruments for the mark-up – the impact of the single market programme, the administrative burden on business and the 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 (6) ease of starting a new business is not used as an instrument, since in column (5) 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.

In column (3) 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).[20]

[20] 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.

Table 13: Impact of competition on patenting per 1000 population

	(1) All	(2) All	(3) All GMM	(4) Entrants	(5) Entrants GMM	(6) Entrants GMM	(7) Incumbents	(8) Incumbents GMM
Rents								
(whole economy)	-0.352							
	(0.274)							
Rents								
(manufacturing)		-1.480***	-2.149***	-0.354***	-0.096	-0.064	-1.126***	-2.117***
		(0.291)	(0.514)	(0.070)	(0.144)	(0.145)	(0.201)	(0.430)
Country effects	yes	yes	yes	yes	yes	yes	yes	yes
Year effects	yes	yes	yes	yes	yes	yes	yes	yes
Technology effects	yes	yes	yes	yes	yes	yes	yes	yes
Hansen J test			1.726		8.781	1.589		1.210
(p-value)			(0.422)		(0.012)	(0.207)		(0.546)
Observations	13781	13781	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) (5) and (8) are single market programme, administrative burden on business and ease of starting a new business; in column (6) ease of starting a new business is not used as an instrument *, ** and *** indicate significance at 10%, 5% and 1% levels respectively.*

In columns (4) - (8) we split the 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 already patented more than 12 months ago), and aggregate these separately to the country-year-technology class level. We see that the impact of increased competition is negligible for entrants, but substantially larger for incumbent patenters. This is in line with the theoretical ideas discussed above – increased competition leads incumbents to innovate to escape competition, but may deter entrants.

In Appendix V we also control for labour market institutions (Table V.4). When we do this 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 mark-up 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 increased competition provides incentives to innovate will depend on which is affected more. The estimates in Table V.4 suggest that the net effect is to encourage innovation.

5.4 Distance to the technological frontier

As discussed in Section 2, recent theoretical models predict that the innovative behaviour of firms (industries or countries) will vary with their distance to the technological frontier. We explore whether innovative activity varies with distance to the frontier. At the country level we measure distance to the technological frontier as the difference in total factor productivity between each country and the technological leader in each year (the country with the highest TFP, which is always the US in our sample). An equivalent measure is calculated for each industry in each country relating TFP to TFP in the country that is the technological leader in that industry. When we look at patents we use measures at the country level, because we are not able to attribute patents to industries.[21] Table 14 shows the mean distance to the frontier by country and industry-country, and the standard deviation over years.

Table 14: Distance to the frontier

	Country level distance to frontier (standard deviation)	Industry-country level distance to frontier (standard deviation)
Australia	0.687	-
	(0.018)	
Belgium	0.381	0.443
	(0.023)	(0.267)
Canada	0.127	0.470
	(0.017)	(0.353)
Denmark	0.328	0.454
	(0.031)	(0.243)
France	0.351	0.461
	(0.016)	(0.330)
Great Britain	0.237	0.230
	(0.022)	(0.214)
Italy	0.859	-
	(0.022)	
Netherlands	0.528	0.759
	(0.030)	(0.381)
Norway	0.710	0.440
	(0.054)	(0.317)
USA	0	0.136
	(0)	(0.199)
Total	0.421	0.457
	(0.261)	(0.360)

In Table 15 we investigate whether the impact of product market competition on patenting activity varies with distance to the frontier. The first two columns use all patents, columns (3) and (4) consider patents by new entrants and columns (5) and (6) patents by incumbent firms. Columns (2), (4) and (6) show GMM estimates, with instruments indicated in the notes to the Table.

The level of distance to frontier enters negatively in all cases, and is significant in all GMM specifications.[22] Countries patent less the further they are from the technological frontier. This is not surprising given that patents represent frontier innovation. The impact of competition is positive and significant in all GMM specification - a lower level of rents leads to greater

[21] Patents are categories by technology class. In ongoing work we are matching these patents to firm accounting data, which will help us to identify which industries the patents are used in.
[22] We have treated distance to frontier as exogenous.

patenting activity. The interaction term is positive, suggesting that in industries that are far from the frontier the impact of increasing competition is muted.

Table 15: Patents per 1000 population, distance to the frontier and its interaction with competition

	(1) All	(2) All GMM	(3) Entrants	(4) Entrants GMM	(5) Incumbents	(6) Incumbents GMM
Rents (manufacturing)	-1.217***	-2.253***	-0.273***	-0.932***	-0.944***	-1.537***
	(0.261)	(0.627)	(0.095)	(0.197)	(0.288)	(0.507)
DTF	-1.420*	-6.676**	-0.365	-3.894***	-1.055	-4.684**
	(0.768)	(2.250)	(0.357)	(0.916)	(0.822)	(1.831)
DTF * Rents	1.367***	5.954**	0.303	3.973***	1.064	4.119**
	(0.404)	(2.059)	(0.217)	(0.879)	(0.709)	(1.679)
Country effects	yes	yes	yes	yes	yes	yes
Year effects	yes	yes	yes	yes	yes	yes
Technology effects	yes	yes	yes	yes	yes	yes
Hansen J test		5.449		13.098		5.577
(p-value)		(0.244)		(0.001)		(0.233)
Observations	10370	10370	10370	10370	10370	10370

*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. *, ** and *** indicate significance at 10%, 5% and 1% levels respectively.*

One cause for concern is that the Hansen J test in column (4) rejects the overidentifying restrictions, so the results should be treated with caution. We have not been able to find a set of instruments that are accepted by the model, and more work is needed on this.

The mean distance to frontier in our sample is 0.42. At that level the impact of increasing competition is zero or even detrimental to patenting.[23] It is only in those countries that are relatively close to the technological frontier (in our sample these are Canada, Denmark, France, Great Britain and the US) that increased competition has a positive impact on patenting activity.

[23] In column (2) it is -2.253 + 5.954*0.42 = 0.248, in column (4) it is -0.932 + 3.973*0.42 = 0.737, in column (6) -1.537 + 4.119*0.42 = 0.193.

We can also look at the relation between R&D expenditure in manufacturing and distance to the technological frontier, now measured at the industry level. In Table 16 all right hand side variables, including distance to the frontier, are lagged by one period. As above, we find that country-industries that are further from the technological frontier invest less in R&D, and that competition has less effect the further you are from the frontier (Table 16, Column (3)). Indeed, given the maximum value of our distance to frontier measure (of around 2), these results suggest very little effect of competition at all for country-industries furthest behind the frontier. One concern is that these results do not hold for R&D intensity (see Appendix V), and again, this merits further investigation.

Table 16: Log real R&D, distance to the frontier and its interaction with competition

	(1) OLS	(2) OLS	(3) IV with interactions in the instrument set
Mark-up $_{t-1}$	-0.481***	-0.393*	-7.030***
	(0.172)	(0.220)	(1.485)
Distance to Frontier $_{t-1}$	-0.118	0.044	-3.018*
	(0.092)	(0.282)	(1.617)
Mark-up $_{t-1}$ * DTF $_{t-1}$		-0.145	2.735*
		(0.234)	(1.410)
Output Gap $_{t-1}$	0.003	0.003	0.033*
	(0.012)	(0.012)	(0.019)
SMP Group 1 $_{t-1}$			-1.790***
			(0.475)
Partial R2 of excl. instruments			0.036
Partial R2 (interaction)			0.044
F-test of excl. instruments. (p-value)			9.10 (0.000)
F-test (interaction) (p-value)			10.48 (0.000)
Hansen J test of over-id. (p-value)			1.28 (0.866)
Observations	1122	1122	1122
R-squared	0.89	0.89	

*Notes: all specifications include a full set of country, industry and year dummies. Robust standard errors in brackets, apart from statistical tests, where p-values are in brackets. The sample consists of 12 two-digit industries or groups of industries across 9 countries over the period 1987-2000. Instruments in column (3) include the impacts of the SMP on Groups 2, 3 and 4, and their interactions with distance to frontier. *, ** and *** indicate significance at 10%, 5% and 1% levels respectively.*
SMP group 1: High-tech, public procurement markets
SMP group 2:Traditional public procurement and regulated markets (high price dispersion)
SMP group 3: Traditional public procurement and regulated markets (low price dispersion)
SMP group 4: Moderately affected sectors

These results are broadly consistent with those in ABGHP – increasing competition has the greatest impact in countries in industries that are near the technological frontier and thus have incentives to react to increased competitive pressure by innovating. However, that model focuses on incentives to invest in new innovations. In these countries/industries that are further from the frontier a large part of the response to competition may be through activity that does not contribute to formal R&D or patenting. This may help explain why we find a larger effect closer to the frontier. The dependent variables (patents and R&D) may not capture innovation and imitation activity very well in countries and/or industries that are further from the frontier. Estimating the balance between these two explanations would only be possible with better measures of imitation activity across countries than are available at present.

5.5 *Other issues*

In this section we discuss a range of issues on which we do not have conclusive results. Many of these issues represent interesting avenues for further research.

5.5.1 Non-linearities in the effect of competition

We have investigated whether the impact of competition on innovation is non-linear. For example, in a specification similar to column (3) of Tables 7 or 8 we included the square of the mark-up as an extra regressor and instrumented it with the SMP variables in a similar way to the linear term. There was no robust evidence of a non-linear effect. This was true for various different specifications and instrumenting strategies.

One possibility is that we do not have sufficient variation in the SMP variables across the full range of values of the mark-up to identify a non-linear effect. Studies that have robustly identified a non-linear effect of competition on innovation, such as Aghion et al (2005a), have used a larger number of instruments than we have available across countries. Thus, while we cannot rule out a non-linear effect of competition on innovation, we do not find robust evidence for it in our data.

5.5.2 Credit market regulations

As discussed in Section 4.3.3 we have not had much success in exploring the impact of credit market regulations on innovative behaviour. We believe that this is because we are not able to capture much variation at the country level in the working of financial markets. All of the countries in our sample have fairly well developed financial markets and legal systems. The papers in the literature that have looked at the impact of financial market regulations across countries have largely identified this effect by comparing developed and developing countries (or emerging countries). [24]

5.5.3 Labour market regulations

In Appendix V we present some results investigating the impact of labour market regulations on innovation, using both R&D and patents. There are a large number of ways in which different aspects of labour market regulation could affect innovation, as well as affecting the impact of product market reforms. For example, the results in the Appendix suggest that while some aspects of labour market regulation may reduce innovation (such as employment protection legislation) others appear to increase it (such as union density and bargaining coverage). However, the addition of the labour market regulation measures does not change the main estimated relationships between competition and innovation.

We consider that a full treatment of this issue would require much more detailed investigation that is beyond the scope of this study. In addition, for our industry level results it would be desirable to use variation in characteristics such union density at the industry level, which would require a considerable data collection exercise. However, the important point for the present study is that the addition of the labour market regulation measures does not change the main estimated relationships between competition and innovation.

5.5.4 Sequencing of reforms

A potentially interesting extension would be to examine the impact of the sequencing of reforms. For example, Blanchard and Giavazzi (2003) argue that product market reforms may improve the political economy of reforms to the labour market by reducing the amount of rents that workers are able to capture. However, examining these dynamics is beyond the scope of this study, especially given the relatively short time period available.[25] This is another interesting potential topic for further research, although the most that would be

[24] See recent review in Levine (2004).

[25] The relatively short time period of data available to us also prevents thorough examination of lagged or delayed responses to product market reforms.

possible without more detailed data would be to examine how the impact of one type of reform depends on the average (or beginning-of-period) level of another type of regulation.

6 Summary and conclusions

Taken overall, the results presented in this report show that product market reforms affect the extent to which firms can charge prices above costs (the mark-up) and that this has an impact on innovative activity, which in turn affects total factor productivity growth. In general, the nature of the relationships that we estimate accord strongly with economic theory.

Our specific findings are that product market reforms, and in particular the Single Market Programme, had statistically and economically significant effects on the extent of competition, as measured by the mark-up of prices over average costs. The subsequent increase in competition led to changes in innovative activity and total factor productivity growth that were consistent with theoretical models.

Our main findings suggest the following:

- The product market reforms that were associated with the Single Market Programme lead to a reduction in the average mark-up, i.e. an increase in product market competition, in affected countries and industries.

- Increased competition (as measured by the mark-up) lead to increased R&D investment in manufacturing industries.

- The Single Market Programme may have had an additional direct negative impact on R&D expenditure in some high-tech manufacturing industries. However, it is not clear whether this actually represented a reduction in innovative outputs or an increase in the efficiency of R&D spending in these industries across EU countries.

- Competition increased innovative activity by incumbents, but if anything it decreased incentives for new firms to enter into the innovation process. This is consistent with theory which suggests that increased competition reduces the potential rewards to innovation for entrants, but may increase it for incumbents if it reduces pre-innovation rents by more than post-innovation rents.

- There is some indication that, within an industry, the effect of increasing competition on innovation is larger in countries that are closer to the global technological frontier. However, this result may also reflect the fact that a higher proportion of innovative activity is measured as formal R&D or patents in countries that are more technologically advanced. Without better data on imitation activity than exists at present it is very difficult to distinguish between these two effects.

- Increased R&D investment lead to faster total factor productivity growth in manufacturing industries.

- There is some indication that competition (as measured by the mark-up) is associated with faster productivity growth in the service sector, but this result should be seen as an association rather than a causal relationship. Given their importance in modern economies, the impact of competition on innovation in service sectors represents an interesting avenue for further research.

- The effect of labour market regulations on innovation and productivity growth is complex and a detailed examination is beyond the scope of this study. However, the above results are robust to controlling for the direct effects of a range of labour market regulations on innovation.

Finally, it is important to note that a range of other factors is likely to have affected innovative activity and productivity growth over the period we have considered. These include human capital, infrastructure (broadly defined), and a range of other institutional factors. Reforms to product markets are unlikely to have been the most important determinant. In addition, while we have attempted to investigate the extent to which the impact of product market reforms varies with a number of other factors, we have not been able to draw robust conclusions about a number of potential interactions. In particular, the role of credit and labour market regulations in determining the impact of reforms to product markets would be an interesting topic for further research.

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Final Report Appendices

The link between product market reform, innovation and EU macroeconomic performance

7 Literature review

What does the theoretical and empirical literature tell us about how product market regulations and reforms affect innovation outcomes and macro-economic performance? Product market regulations and reforms are generally not explicitly included in models of innovation or growth. What is usually modeled is the degree of competition in a market or the ease of entry, captured by parameters such as the number of firms in the market, the extent of entry barriers, the degree of differentiation between products, the strength of consumers' preferences for a product or the conduct of firms in the market. We interpret product market reforms as policy reforms that lead to a change in competition in the product market or a change in the market entry conditions that firms face. We focus on the literature that relates the degree of product market competition to innovation outcomes. In a previous report for the European Commission, Cincera and Galgau (2005) survey the literature on entry. There are a large number of other literatures that may also be relevant to our study. While it is not possible to review all of this material, we will draw on it in our study where relevant. We start by reviewing the theoretical literature and then consider the empirical literature.

In summary, our review highlights the following points:

- There is little disagreement over the fact that market power leads to allocative inefficiency - prices do not reflect costs and therefore goods are not allocated optimally.
- There is little disagreement that competition promotes productive efficiency.
- The question is: can these same effects also capture the impact of competition on innovation and growth?
- Specific product market reforms affect competition and innovation in different ways, depending on the nature of the reform and the characteristics of the firm, industry or country in question.
- Entry can be an indicator of both and innovative outcome (particularly in service sectors), but simple counts of entry do not provide a very accurate indication of either.
- The theoretical literature linking competition to innovation does not give clear predictions about the direction of the relationship - different theories point in opposite

directions, and some theories allow for opposite effects for different parameter values within the same model.

- One key feature of many theoretical models is that competition reduces firms' incentives to innovate, because it reduces the level of profits available to firms.
- On the other hand, incumbent firms may face the threat of losing more in a race than entrants, and may therefore have a greater incentive to innovate in order to escape the competition that would follow entry.
- Competition and entry lead to allocative and productive efficiency and encourage the adoption of best practice.
- The empirical literature, on the whole, points to a positive effect of competition on innovation. There are, however, a number of difficult empirical challenges, which are not adequately addressed in much of the literature.
- There is some empirical evidence that the impact of competition on innovation varies with characteristics of the firm or industry – for example the degree to which firms have similar costs, and distance from the technological frontier, and other aspects of the economic environment, such as other regulation (e.g. in labour and credit markets).

7.1 Theoretical literature

In this section we discuss theoretical models that consider the relationship between the extent of product market competition and innovation and imitation (technological diffusion). First, it is worth outlining some concepts. Innovation relates to activity that is devoted to the research and development of either a product that is new to the market or a new process innovation which reduces the costs of producing a good or service. Innovative activity is an inherently risky process and will not always lead to a new product or process. When an innovation is introduced commercially it can be considered either *incremental* or *drastic*. Both incremental and drastic innovations are welfare improving (consumer plus producer surplus increases), but a drastic innovation is one that produces such an increase in welfare that, even if the innovator becomes a monopolist *consumer* surplus will still increase.

Imitation or technological diffusion is the adoption of existing products, production technologies or organizational best practice developed in new firms or environments. Typically the most advanced firms or economies engage in innovation (frontier research), whereas those firms and economies further away from the technological frontier benefit from imitation, though may also innovate themselves. Imitation may itself require some technological know how or *absorptive capacity*.

We will consider the impact of competition on all of these types of innovative activity, although as we will see in the empirical work, it is often difficult to distinguish between them in practice.

7.1.1 Models of product differentiation and price competition

A standard way to model imperfect competition is by allowing products within a market to be differentiated from each other. Firms derive market power by having a product that is located near to a greater number of consumers (location can either be in geographic space or in product characteristics space). The degree of competition is measured by the extent to which consumers see products as substitutes for each other, or have preference for one product over others. There are a variety of models of firm behaviour in differentiated product markets. The most well known models of price competition and product differentiation are the Hotelling linear model, the circular version of that model by Salop (1977) and the symmetric model of monopolistic competition by Dixit and Stiglitz (1977). These 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.

7.1.2 The rent dissipation effect

An alternative way to look at the question of how competition affects innovation is to consider 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.

7.1.3 The importance of vertical differentiation

Aghion and Schankerman (2004) show that more intense product market competition can enhance "innovations" through several channels that counteract the negative effect pointed out above, if we suppose that some firms have higher unit costs than others, so that firms are not only horizontally differentiated, but they are also vertically differentiated by their costs. First, by increasing the market share of low-cost firms at the expense of high-cost firms, more intense competition may end up encouraging entry by low-cost firms (especially if potential low-cost entrants are far less numerous than high-cost entrants). Second, and again because it increases the market share of low-cost firms relative to high-cost firms, more intense competition will induce high-cost firms to invest in "restructuring" in order to become low-cost firms themselves. Note that such an investment amounts to a quality-improving innovation and allows the high-cost firm to suffer less from more intense competition.

7.1.4 Agency cost literature

Many models formalize the "Darwinian" effect of competition. In Hart (1983) competition increases productivity by acting as an incentive scheme to ensure that managers (and workers) do not buy themselves a "quiet life" (i.e. slack or consume leisure on the job). Hart (1983) models "satisficing" managers who seek a quiet life, subject to survival. This has been incorporated into growth models, where we see the conditions under which competition, combined with the threat of bankruptcy, can force managers to innovate and thereby achieve a higher rate of growth. Aghion-Dewatripont-Rey (1999) embed the agency model of Hart in an endogenous growth framework and show that competition should also have a positive effect on innovation and growth, by reducing managerial slack and forcing managers to respond more promptly to cost reductions by other firms. In addition, they show that competition and a hard budget constraint are complementary.

Schmidt (1997) derives a model in which the optimal incentive scheme is a function of the degree of product market competition. An increase in competition leads to a reduction in firms' profits. This has two effects. First, the probability of liquidation goes up giving managers incentives to work harder. Secondly, the reduction in profits may change the profitability of a cost reducing activity. This can lead to either a reduction or an increase in managers incentives depending on the direction of change.

7.1.5 The endogenous growth paradigm

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.[26] 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.

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[26] For example, Romer (1990), Aghion-Howitt (1992), Grossman-Helpman (1991).

7.1.6 Recent developments in endogenous growth literature

Recent endogenous growth models extend the basic Schumpeterian model by allowing incumbent firms to innovate.[27] In this framework firms innovate in order to reduce production costs, and they do it "step-by-step", in the sense that a laggard firm in any industry must first catch up with the technological leader before becoming itself a leader in the future.

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). More product market competition may foster 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".

This should be particularly true in sectors where incumbent firms are operating at similar technological levels, that is in industries in which oligopolistic firms face more similar production costs. The firm with lower unit costs is referred to as the technological leader, and the one with higher unit costs as the follower, in the corresponding industry, and when both firms have the same unit costs they are referred to as neck-and-neck. In these "neck-and-neck" sectors, pre-innovation rents should be especially reduced by product market competition. On the other hand, in sectors where innovations are made by laggard firms with already very low initial profits, product market competition will mainly affect post innovation rents and therefore the Schumpeterian effect of competition should dominate.

The essence of the inverted-U relationship between competition and innovation is that the fraction of sectors with neck-and-neck competitors is itself endogenous, and depends upon equilibrium innovation intensities in the different types of sectors. More specifically, when competition is low a larger equilibrium fraction of sectors involve neck-and-neck competing incumbents, so that overall the escape competition effect is more likely to dominate the Schumpeterian effect. On the other hand, when competition is high, the Schumpeterian effect is more likely to dominate because a larger fraction of sectors in equilibrium have innovation being performed by laggard firms with low initial profits.

[27] Aghion-Harris-Vickers (1997), Aghion, Harris, Howitt, Vickers (2001), ABBGH (2005).

In neck-and-neck industries competition is particularly intense and it is also in those industries that the "escape-competition" effect pointed out above is strongest. On the other hand, in less neck-and-neck, or more "unleveled", industries, more competition may also reduce innovation as the laggard's reward to catching up with the technological leader may fall (this is a "Schumpeterian effect" of the kind emphasized in the earlier models). Finally, by increasing innovation incentives relatively more in neck-and-neck industries than in unleveled industries, an increase in product market competition will tend to reduce the fraction of neck-and-neck industries in the economy in equilibrium; this "composition effect" reinforces the Schumpeterian effect in inducing a negative correlation between product market competition and aggregate productivity growth or the aggregate rate of innovations.

The inverted-U shape can be simply explained as follows. When there is not much product market competition there is hardly any incentive for neck-and-neck firms to innovate, and therefore the overall innovation rate will be highest when the sector is unleveled (when firms differ in their efficiency). Thus the industry will be quick to leave the unleveled state (which it does as soon as the laggard innovates) and slow to leave the leveled state (which will not happen until one of the neck-and-neck firms innovates). As a result the industry will spend most of the time in the leveled state, where the escape-competition effect dominates. In other words, if the degree of competition is very low to begin with, an increase in competition should result in a faster average innovation rate.

On the other hand, when competition is initially very high, there is relatively little incentive for the laggard in an unleveled state to innovate. Thus the industry will be relatively slow to leave the unleveled state. Meanwhile the large incremental profit from innovating gives firms in the leveled state a relatively large incentive to innovate, so that the industry will be relatively quick to leave the leveled state. As a result, the industry will spend most of the time in the unleveled state where the Schumpeterian effect is at work on the laggard, while the leader never innovates. In other words, if the degree of competition is very high to begin with, an increase in competition should result in a slower average innovation rate.

Hence the possibility of an inverse-U relationship between competition and innovation. When competition is low, an increase will raise innovation through the escape-competition effect, but when it becomes intense enough it may lower innovation through the Schumpeterian effect on laggards. The reason why one effect dominates when competition is low and the other when competition is intense is the "composition effect" of competition on the steady-state distribution of technology gaps across sectors.

Recent work by Aghion, Blundell, Griffith, Howitt and Prantl (2004) introduces entry into such a model. They show that the affect of increasing entry threat depends on the country, industry or firm's distance to the frontier. In countries or industries that are close to the (world) technological frontier, fostering entry or competition will increase incumbents incentives to innovate in order to escape potential entrants or competitors. However, in countries and industries that lag far behind the frontier, higher entry or higher competition on their own tend to discourage incumbent firms from innovating. This model suggests that the overall impact of, for example, trade liberalisation will depend on the current state of technology in the country or industry.[28] However, in the long run trade liberalisation will increase the overall average growth rate because in equilibrium there will be more industries where the effect is positive.

7.2 Empirical literature

Most empirical work finds a positive effect of product market competition on innovation. More recent work has shown that the effect varies with a range of firm, industry and country characteristics. As with the theoretical literature, there is also a large amount of related work that could be relevant. We focus on the literature that directly links competition to innovation.

7.2.1 The early literature

A large early empirical literature, inspired by Schumpeter (1943), considered the cross-sectional relationship between innovation and firm size or market concentration.[29] Many studies found that larger firms (either measured by size or market share) were also more innovative (or spent more on R&D). Across a large number of datasets it was seen that the bulk of patenting is done by larger firms. Scherer's early empirical work[30] showed that there was a relationship between firm patenting activity and firm size in the cross section. For example, Scherer (1965a) used patents data on Fortune 500 firms in 1959 and regressed this

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[28] This is based on the model in Acemoglu, Aghion, and Zilibotti (2002).

[29] Cohen and Levin (1989) provide a comprehensive survey of the literature. See also the review by Kamien and Schwartz (1982).

[30] See, inter alia, Scherer (1965a, 1965b).

on sales in 1955. He found a positive relationship. However, interestingly, he also found that when he allowed for non-linearities these suggested a diminishing impact at larger sizes.

7.2.2 Methodological challenges

There are many methodological difficulties faced by empirical researchers in this area, and the literature has failed to reach robust conclusions in large part because of these.[31]

First, it turned out to be important to control for other firm and industry characteristics that affect innovation. This is because these other characteristics are correlated with firm size and market structure. For example, if we showed that firm size was positively associated with innovative output, but we had not controlled for firm age, then it could be the case that firm size is correlated with age (e.g. firms get bigger as they get older) and that firm age is also correlated with innovative output, and that this led to a spurious correlation between firm size and innovation. Unless we control for at least the main observable and unobservable characteristics we can not be sure that we are really picking up the relationship between size and innovation.

Secondly, there is a problem of reverse causality. While firm size or market structure is likely to affect innovation, it is also the case that successful innovation affects market structure. Firms that are successful innovators will either have lower costs, so be able to sell at a lower price, or will have superior quality goods, and in either case will gain market share.[32]

To help deal with these first two difficulties it is important to have panel data - repeated observations of the same firms over time. However, panel data in itself does not solve these problems. What is important is that there is exogenous variation in the degree of competition, for example, policy changes that make entry easier or less costly. In addition, if we are willing to assume that many of the characteristics that are correlated with market power are constant over time, then fixed effects can be used to control for them.[33]

In addition, if we are willing to assume that market structure is predetermined (that is that feedback from innovation to market structure only affects future market shares, the

[31] Cohen and Levin (1989) provide a good discussion of these issues.
[32] This point is emphasised by Demsetz (1973).
[33] There is a substantial literature on the econometric issues involved. See Nickell (1981) for a discussion of the bias in within groups estimator. See Arellano and Bond (1991) for a discussion of first-differences estimation. See Arellano and Bover (1995) and Blundell and Bond (1999) for a discussion of the GMM Systems estimator.

anticipation of innovation does not affect current market structure) then repeated observations allow us to use lags of market structure.

Thirdly, the relationship we are interested in is between product market competition and innovation, while the early literature largely focused on the relationship between firm size or market concentration and innovation. These may not be good measures of the degree of competition, and may in fact reflect other differences, for example, a firm's ability to access finance. It can be difficult to obtain good measures of the degree of product market competition in an industry, and recent work has paid careful attention to this. Boone (2000) shows it is not always the case that an increase in competition reduces firm size, price cost margins or concentration.

There is also a number of difficulties with measuring innovation, which are discussed below. A combination of improved data availability (and in particular the availability of firm level panel data sets), better econometric methods and more computing power meant that many of these problems could be tackled by the mid 1990s.

7.2.3 Evidence from UK micro data

Two studies that used micro data from the UK to tackle these issues were Nickell (1996) and Blundell, Griffith and Van Reenen (1999). Both use data on firms listed on the London Stock Exchange. The UK turned out to be a good place to study the relation between product market competition and innovation because there have been a large number of policy changes which led to (relatively) exogenous variation in the nature and magnitude of product market structures and competition. These included the large scale privatisations of the 1980s and 1990s, reforms associated with EU integration, and the opening up of markets in numerous other ways.

Nickell (1996) considered the link between market structure and both the level and growth rate in total factor productivity (TFP).[34] Nickell's paper was the first to tackle many of the empirical issues head on. Using firm level panel data he was able to control for unobservable (correlated) characteristics that were constant over time. He used better measures of product market competition, in particular a Lerner Index. Nickell provides convincing support for the

[34] Nickell used firm level panel data including 978 observations on 147 stock market listed firms from 1975-1986.

idea that tougher competition in the product market is associated with higher growth rates in TFP - higher concentration and a higher level of rents are associated with lower growth rates of TFP. Nickell's results also imply that the effects where economically important. Increasing competition, by going from the eightieth percentile in the distribution of rents to the twentieth (reducing rents means increasing competition),[35] has the impact of increasing TFP growth by around 3.8 percentage points. This is a large and economically significant effect. Moving from the median to the twentieth percentile would be associated with an increase in TFP growth of around 1.2 percentage points. Nickell's results can also be used to show how much of TFP growth in UK listed firms is explained by differences in competition. They suggest that the differences that arise in average industry growth rates due to differences in the level of competition across these industries, holding everything else constant are substantial. For example, TFP growth in electrical engineering was 2.4 percentage points lower, on average, due to low levels of competition, while mechanical engineering experienced around 1 percentage point higher TFP growth due to relatively higher levels of competition.

Blundell, Griffith and Van Reenen (1999), henceforth BGVR, use UK firm level panel data on innovation counts.[36] This paper explores the two main interpretations of the observed correlation between market dominance and innovation: (i) that financial market failures meant that firms had to rely on their own internal sources of funds in order to finance innovation, and that larger firms had deeper pockets and were thus better able to do this, (ii) the idea (Gilbert and Newbery (1982)) that dominant firms have greater incentives to innovate (because of the greater reduction in total industry profits if entry occurs). BGVR's results show that less competitive industries (those with higher concentration levels and lower imports) had fewer aggregate innovations. But dominant firms innovated the most. Dominant firms get a bigger payoff on the stock market from an innovation, giving them a greater incentive to pre-emptively innovate.

[35] The distribution of rents among firms in Nickell's sample was zero at the twentieth percentile and 0.29 at the eightieth percentile. Looking at a very similar data set we can see that the mean and median are around 0.20. These are combined with Nickell's estimated coefficient on rents of -0.13.

[36] The data are from SPRU and Datastream and include 3511 observations on 340 stock market listed firms over the period 1972-1982.

7.2.4 Recent empirical work suggests the effect varies along several dimensions

The relationship between competition and innovation may be non-linear

As discussed above, new endogenous growth models suggested that the relationship between competition and innovation may be non-linear, with both very high and very low levels of product market competition providing lower incentives to innovation.

Aghion, Bloom, Blundell, Griffith and Howitt (2005), henceforth ABBGH, investigate whether there is a non-monotonic relationship between innovation and product market competition using micro panel data on UK establishments.[37] They use a Lerner index to measure variation in competition across industries. To deal with the potential endogeneity of competition ABBGH instrument product market competition with a large number of policy reforms, including the EU Single Market Programme, competition policy reforms and privatizations. They find strong evidence of an inverted U relationship between innovation, as measured by the citation weighted patent count, and product market competition. The peak of the inverted U lies near the median of the distribution. A simple linear relationship would yield a positive slope, as suggested by earlier work. Controlling for endogeneity and industry characteristics shifts the peak toward the more competitive direction but still suggests the importance of the Schumpeterian effect for a significant minority of firms and industries.

The theory suggests that this effect varies with the degree of neck-and-neckness (the dispersion of firm level technology and costs, see discussion above in section 2.1.6). This is measured by the proportional distance a firm is from the technological frontier (measured by total factor productivity). The theory predicts that the inverted U shaped relationship between competition and growth should be steeper for more neck-and-neck industries,[38] and this is supported by the data. This paper lends empirical support to the model in which incumbent firms can innovate (as well as entrants) so that innovation incentives depend on the *difference* between post-innovation and pre-innovation rents.

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[37] They use data on UK listed firms over the period 1968-1997 and include information on costs, sales, investments and the number of successful patent applications at the US patent office. Detailed information on citations are used to weight the measure of patents granted for each firm in each year.

[38] The reason for this is that in industries where firms are closer to the technological frontier the escape competition effect tends to be stronger (the increasing part of the inverted-U is steeper)

Entry and trade liberalisation encourages innovation in some industries, but discourages it in others

Aghion, Blundell, Griffith, Howitt and Prantl (2004, 2005) find empirical support, using UK plant level data, for the idea that in countries or industries that are close to the (world) technological frontier, fostering entry or competition will increase incumbents' incentives to innovate in order to escape potential entrants or competitors.[39] ABGHP look at the relationship between foreign firm entry and growth in total factor productivity, and how this relationship varies with an industry's distance to the technological frontier. Endogeneity (relative changes in the entry rate across industries may be indirectly caused by shocks to patenting) is controlled for using policy[40] and foreign technology variables as excluded instruments that determine entry but have no direct effect on the growth in TFP or patenting.

The impact of entry on growth in total factor productivity is positive, statistically significant (when entry is instrumented the coefficient gets larger, indicating a negative bias) and economically significant. Increasing the entry rate from the mean by one standard deviation (from 0.44% to 3.8%) would result in a rise in the average growth rate of TFP about 1.3 percentage points. ABGHP interact entry with an incumbent's distance to the technology frontier. The results suggest that the effect of entry on TFP growth is larger when an industry is closer to the technological frontier. In countries and industries that lag far behind the frontier, higher entry or higher competition on their own tend to discourage incumbent firms from innovating. Therefore, the overall impact of liberalisation will depend on the current state of technology in the country or industry.

Nicoletti and Scarpetta (2003) relate a large number of reforms to growth in total factor productivity across OECD countries. In their paper the impact of product market reforms is assumed to affect the rate of TFP convergence across countries and industries, and they find some evidence that the impact of reforms is larger for countries further behind the frontier. Those countries and industries experiencing the greatest reform experience temporarily faster growth rates while they catch up to the international steady-state growth rate. Nicoletti and

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[39] The model is estimated using micro-level data on productivity growth and patenting activity of British firms between 1987 and 1993. Data is combined from three main sources - data on UK manufacturing plants from the Annual Census of Production, data from the US patent office and firm level accounting data from DataStream.

[40] The instruments used are: investigations and decisions by the Monopoly and Merger Commission, privatization cases of large publicly owned companies and indicators for 3-digit industries expected to be highly affected by the EU Single Market Programme.

Scarpetta's work also raises important questions about how we measure and use variation in product market regulations in empirical work.

Aghion, Burgess, Redding and Zilibotti (2003) find very different results using industry level data for Indian states. They compare performance before and after a period of large scale reforms that liberalised entry, and also consider how the impact of liberalisation varied with extent of labour market regulations. In contrast to Nicoletti and Scarpetta, their results suggest that state-industries that are closer to the frontier before the reforms experienced faster growth following the reform than state-industries that were farther from the frontier. They also find that the impact of reforms was lower in states where labour market laws were more pro-worker – these states had lower productivity before the reforms and experienced less of an acceleration after the reforms.

While not our prime area of interest, there is a large cross-country literature on labour market regulation and performance. As suggested by Aghion, Burgess, Redding and Zilibotti (2003), it may be that product and labour market reforms interact in important ways and we hope to be able to capture this in our analysis. For example, recent work by Caballero, Cowan, Engel and Micco (2004) finds that employment protection legislation hampers the creative-destruction process, especially in countries where regulations are likely to be enforced. Work at the OECD (Bassanini and Ernst (2002), Nicoletti, Bassanini, Ernst, Jean, Santiago and Swaim (2001)), *"...provides some cross-country evidence that enhancing competition in the product market -- while guaranteeing intellectual property rights -- seems to have a positive impact on the innovation performance of a country. Conversely, the relationship between innovation and job protection does not seem to be univocal. The sign and magnitude of the effect of the latter crucially depends on the systems of industrial relations and the specific characteristics of each industry."* They find that employment protection policies affect innovation activity, with the sign of the effect varying with other institutions and technological regimes. Countries with stricter employment regulations tend to specialise in industries with relatively lower R&D intensity and wages.

7.2.5 Previous studies on product market reforms and macro-economic performance

This study follows on from two previous studies for the European Commission. The first, Griffith and Harrison (2004), analyses the macro-economic impact of product market reforms undertaken in the European Union over the 1980s and 1990s. The second, Cincera and Galgau

(2005), examines the macroeconomic impact of entry and exit. Both studies took a similar two-stage approach, which is also followed in this study.

Griffith and Harrison (2004) identified the level of competition (as measured by the markup or Lerner Index) as a key determinant of economic outcomes in that it determines firms' incentives to adopt best practice and to innovate. This is the channel highlighted in the literature. As discussed above, product market reforms affect the level of economic rents in the economy, either directly or by encouraging the entry of new firms. This method captures the impact of product market reforms on competition and the impact of competition on allocative, productive and dynamic efficiency, and includes the impact of competition on both innovation and imitation, as measured by R&D expenditure and total factor productivity. It does not capture returns to scale.

This study showed that product market reforms that ease entry, reduce tariff rates and regulatory barriers to trade, remove price controls, and reduce public involvement in production affect the average level of economic rents in the economy in diverse ways. Reforms to labour and credit markets are associated with reductions in the level of economic rents available. The level of economic rents is negatively associated with employment and investment, or in other words greater competition is associated with higher levels of employment and investment, particularly in the service sector. These results accord with theoretical predictions. Increases in competition bring prices closer to marginal costs, increasing output demanded and thus leading to increases in factor demands.

Cincera and Galgau (2005) found that PMRs lead to increased entry and exit. In particular, decreasing price controls and hidden import barriers and increasing the ease of starting a new business had positive effect on both entry and exit. A decrease in transfers and subsidies from government to the private sector lead to a decline in entry and exit as did lower tariff rates. There was some indication that entry and exit were associated with higher productivity levels and growth rates and higher R&D investment.

Griffith and Harrison (2004) found that regulatory reforms that reduced the level of economic rents appear to be associated with lower levels of labour and total factor productivity. In addition, while there appears to be a non-linear relationship between the level of economic rents and levels of R&D expenditure and growth rates of labour and total factor productivity, most countries appear to have levels of economic rents where a reduction in rents is associated with a reduction in R&D and growth rates. This is identified by looking at changes over time within countries. When the average differences across countries are considered we see the opposite – countries with lower average levels of rents are those that have higher productivity, TFP and R&D investment. Interpreting these latter results is, however, problematic as it was not possible to separately identify the impact of the average level of rents across countries from the impact of measurement issues and other country characteristics that are not observed. There are a number of further reasons why caution should be used in interpretation – some to do with possible measurement issues, others to do with timing and dynamics.

The first issue is related to the most robust effect of product market reforms that was identified in the study – increasing employment. To the extent that increases in employment as a result of product market reforms bring less skilled workers into the workforce, this will act to reduce the average level of productivity. One indication of this effect is that a large proportion of the gains in employment were in relatively low productivity service sectors. This composition effect should act as a one-off reduction in productivity, unless sectors with high employment growth also have low potential for productivity improvements.

Secondly it is also likely that dynamic processes are important here, and with the limited time series of data available it was not possible to fully investigate these. For example, the literature emphasises the fact that adjustment costs in R&D are high (higher than for general employment or physical capital)[41] and it may take firms and others a long time to adjust to change.

7.3 Implications for our study

What does the literature suggest about the way we should proceed to understand the relationship between competition, innovation and TFP performance at the macro level across EU countries?

[41] See, inter alia, Hall (1993).

7.3.1 Product market reforms, entry and rents

First, the literature emphasises the importance of economic profits, or rents, in providing incentives for firms to enter markets and to innovate. Competition reduces the level of these profits and so discourages innovation and entry (for a given level of entry costs). At the same time, lower rents may encourage firms to innovate to escape the consequences of competition. For this reason, one of our main interests is in investigating empirically how product market reforms have affected the level of rents, and in turn how the level of rents have affected entry and innovation.

However, the macroeconomic relationship between product market reforms, entry and rents is likely to be complex. In most macroeconomic models of product market regulation (for example Blanchard and Giavazzi, (2003)) product market reforms can affect competition either directly, through the intensity with which firms interact in the product market, or indirectly through the costs of entry. In equilibrium the level of rents reflects both these factors, so that high rents will encourage entry, which will in turn reduce rents up until the point at which they just cover entry costs. Reducing barriers to entry will thus be reflected in equilibrium in lower levels of rents. This is the reason why one of our main interests will be the way that product market reforms affect rents. In the short run, however, rents may take time to respond to increased entry. While we would have liked to also look at entry rates, as they could provide a more timely indication of some types of competition, we found that the data was not suitable to do so (see Appendix II.2.3).

Secondly, the methodological difficulties discussed in section 7.2.2 suggest that it is important that we use panel data, and have exogenous variation over time in product market reforms, to allow us to identify the impact of product market reforms on competition. This is a particular challenge for this work, as there have not been a large number of differential reforms across EU countries, and for those that there have been we often do not have very good measures. Because of this we pay careful attention in Section 9 to which reforms we can use, and how in fact they might affect rents and entry rates.

7.3.2 Competition, innovation and imitation

The relationship between rents, innovation activity and productivity growth will introduce further uncertainty and lags into the relationship between product market reforms and innovation performance. The literature has emphasised that fact that investment in innovative activity is a long-term and high risk decision, and thus is potentially subject to high adjustment costs and uncertain returns. This means it may take time for product market reforms to be reflected in firms' innovation decisions and in productivity outcomes. The entry of new firms in response to lower entry costs, and the exit of inefficient firms in response to more intense competition may also occur only after a significant amount of time. We will attempt to take account of these factors in our methodology, but data limitations may limit our ability to estimate lagged relationships. In particular we have data on entry and exit only for a relatively short time period.

The literature also suggests that competition and the threat of entry have important implications for firms' incentives to adopt the latest technologies. While frontier innovation may drive TFP growth in leading edge firms and industries, imitation and the spread of new technologies will also feed through into macroeconomic performance. However, imitation itself may provide a disincentive for frontier innovation, so there may be a trade off in this dimension. Although it is generally easier to measure innovation than imitation, in 4 we examine various empirical measures of innovation and imitation that we could use in our empirical analysis.

7.3.3 Interactions with firm, industry and country characteristics

Finally, much of the recent literature emphasizes that the impact of product market competition on innovation and imitation may depend on other characteristics of the firm, industry or country. The main characteristics highlighted by the literature are distance to the technological frontier, and labour and financial market institutions. The first of these is clearly linked to the distinction between frontier innovation and imitation, while labour and financial market institutions may also have direct effects on innovative activity. In the main results we discuss these factors.

8 Innovation and imitation

In this section we start by discussing issues in the measurement of innovation and imitation. Our focus is to determine which measures we will use in our empirical analysis. We then provide an overview of innovation and imitation activity across EU countries. This provides us with a useful indication of where variation occurs and thus where our attention should focus in modeling the relationships between product market reforms, innovation, imitation and total factor productivity.

This discussion highlights the following key points:

- The main measures of innovation we will use are Business Enterprise R&D (BERD) and patents (including data on all patents taken out at the European Patents Office and triadic patents). We use both because R&D expenditures will capture resources devoted to all private sector innovative activity, not just that that is ultimately successful in producing new products and processes, whereas patents only capture successful innovation. Both will capture process and product innovation and both drastic and incremental innovation.

- Imitation is harder to measure. As our primary measure we will proxy a country's scope for benefiting from technological diffusion by the distance that it lies behind the technological frontier (the country with the highest productivity). As a robustness check on our main measure we check that the distance to the technological frontier measure is correlated with other measures such as payments for purchases of technology from abroad which we might expect to be directly related to the extent of imitation.

- Our focus will be on activities conducted by firms (not by governments), since these are the activities most directly affected by product market reforms. However, there are large and important differences across countries and industries in the extent to which governments *finance* innovative activities undertaken by the private sector, and it will be important to account for this in our empirical analysis;

- Innovative activity has become more internationalised over time; we see an increase in the share of R&D within countries that is conducted by foreign affiliates, and an increase in the level of imported technologies. These vary substantially across countries.

- Trends in labour productivity highlight three groups of countries: (i) those with high levels of labour productivity, including Belgium, France and Italy, (ii) those with initial low levels of labour productivity which grow more rapidly than the average over the 1980s and 1990s (i.e. converge to the frontier), including some Scandinavian countries and the UK, and (iii) those with initially middle range levels which do not show strong growth, including Canada, the Netherlands and Spain.

- Trends in R&D intensity show that: (i) Sweden and Finland have increased R&D intensity both by shifting towards more R&D intensive industries, and also by increasing R&D intensity within industry, (ii) all other countries (except Belgium) have shifted towards less R&D intensive industries, largely reflecting the growing importance of service industries

- Variation across countries and industries suggests that it will be important for us to model heterogeneity in the impact of product market reforms. Ascertaining which factors are the most important determinants of this variation in performance will be an important and difficult challenge in our empirical work.

8.1 Measuring innovation and imitation

For the purpose of the current study we require robust measures of innovative activity that are comparable both across countries and industries. Here we discuss a range of measures that have been used in the literature, focusing on those which we will exploit in this study, distinguishing between measures of inputs into innovative activity, outputs of innovative activity and indicators of imitation and technological diffusion.

8.1.1 Innovation

Indicators of innovative activity cover both inputs into the innovation process and outputs. Commonly used measures of inputs are research and development expenditure or employment in innovative activities, while patent counts and TFP growth are often used as measures of innovative outputs.

Innovation inputs

When making international comparisons of innovative activity two commonly cited measures are Gross Expenditure on R&D (GERD) as a percentage of GDP, (which includes both public and private sector R&D expenditure, and which is used for the EU 3% target), and Business Enterprise R&D (BERD) as a percentage of GDP which includes only R&D conducted by the private sector. As shown in Section 8.2, the latter measure of R&D intensity varies substantially across European countries. It is also possible to break Business Enterprise R&D down by source of funding and differentiate between private and public sector funding. The extent to which private sector R&D is funded by the private versus the public sector varies by industry and country.

An alternative indicator of market sector innovation inputs is how intensively research staff are employed in the private sector within each country. As the majority of R&D expenditure is devoted to wages this alternative indicator is highly correlated with GERD and BERD intensity. However, if PPP deflators used in international comparisons of R&D expenditure do not accurately reflect the relative price of R&D across countries then such headcount measures may be a useful alternative. On the other hand, a headcount does not reflect potential differences in the quality of workers across industries or countries.

It is important to consider a measure of innovation inputs as well as a measure of innovation outputs, as product market reforms and changes in the degree of product market competition affect firms' incentives to carry out innovative activity, not all of which will ultimately result in an innovation. Our main measure will be Business Enterprise R&D measured at the country and industry level. We will also investigate incorporating measures of government financed (private and public sector) R&D expenditure at the country level to control for differences in the extent of public sector R&D across countries. While we would not expect this to be directly affected by product market reforms, there may be interactions between public and private sector R&D activity in determining an economy's innovative performance which it may be important to account for in our empirical work.

Innovation outputs

Patents

Two commonly used measures of innovation outputs are counts of patents and counts of patents weighted by citations, which aims to reflect the variation in their quality or value – the more a patent is cited the greater its scientific importance.

Patents are a very heterogeneous measure of innovation.[42] One patent can represent a path breaking new technology, worth billions of Euros, while another can represent a fairly incremental improvement in an existing technology, worth only tens of thousands of dollars. In order to get around this problem many researchers use citation-weighted patents,[43] or use stock market data to put a value to a patent.[44] Another problem with patents is that the propensity to patent, and the degree to which they provide protection of intellectual property rights, varies substantially from industry to industry. For example, patents are widely used in the pharmaceuticals industry, but rarely used in the computer software industry.

In addition, the extent to which patents are used by firms in practice will vary both across industries and countries. In Section 8.2 we discuss how a country's industrial structure affects overall R&D intensity in more detail. The extent to which firms within different countries use specific patent offices (e.g. the European and US Patent Offices) will also vary. A commonly used measure that avoids this latter bias is "triadic patent families", that is inventions that are registered at the three main patent offices (US, Europe and Japan). This measure also focuses on high value patents, since it is only those patents that are worth a considerable amount that a firm will patent in all three locations. Innovation outputs are then expressed as the number of triadic patent families per capita. As Section 8.2 illustrates, there is substantial variation in this measure across European countries. This measure of innovation outputs is also highly correlated with the measure of innovation inputs (BERD as a % of GDP), described above.

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[42] See Griliches (1990) for a comprehensive treatment of this issue.
[43] This method assumes that valuable patents are cited more frequently by other patents than lower value patents. Each patent is weighted by the number of citations it receives, thus helping to measure the importance or quality of the patent. See, for example, Jaffe, Trajtenberg and Henderson(1993).
[44] See, for example, Pakes (1986).

TFP growth

Total factor productivity (TFP) growth, is a measure of technological progress (and thus reflects both implemented frontier innovation and imitation), but it can be difficult to accurately measure, because of the well known problem that commonly used measures of TFP are themselves biased in the presence of imperfectly competitive product markets.[45] Aggregate TFP growth is affected both by frontier innovation and by imitation and the diffusion of new technologies.

New entry

New entry may also serve as an informative indicator of innovation. In particular new entrants may be more likely to pursue drastic innovation strategies compared to incumbent firms, as by innovating they do not cannibalise rents from existing products. By comparison incumbent firms may be more likely to pursue incremental innovations. This comparison between entrants and incumbents is most appropriate for "greenfield" entrants, compared to entry by acquisition. Greenfield entrants might be most likely to introduce new, leading-edge technologies. A number of microdata studies emphasise the importance of greenfield entrants in contributing to productivity growth over the longer term. [46]

Relationship between inputs and outputs

We would expect there to be a strong relationship between innovation inputs and outputs. Using data across countries for 2001, Figure 1 shows that there is a strong correlation between the two main measures of innovation inputs and innovation outputs – BERD as a % of GDP and triadic patent families per 1000 population. This strong correlation can also be seen in Figure 5 and Figure 6 in Section 8.2.1 which rank countries on the individual measures.

Figure 1 also highlights a couple of important measurement issues. First, Switzerland is an outlier in that its number of triadic patent families is higher than its BERD as a % of GDP would suggest. Reasons for this may include both the fact that Switzerland has high GDP per

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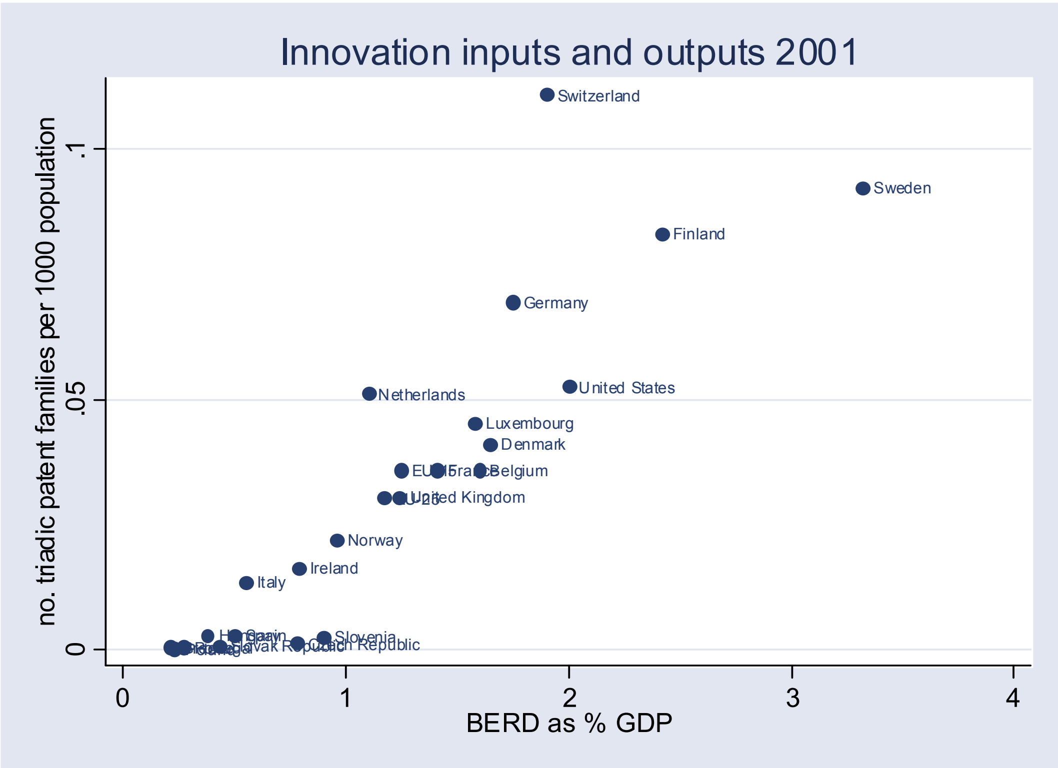
[45] See, inter alia, Hall (1988), Klette and Griliches (1996) and Klette (1999).

[46] See Foster, Haltiwanger and Krizan (2000) and Disney, Haskel and Heden (2003). See also Henderson (1993) with regard to drastic innovation by entrants.

capita, but also the fact that a large proportion of its R&D is concentrated in pharmaceuticals, an industry where patents are crucial for protecting the returns from innovation. Secondly, there are a number of countries clustered along the x-axis with very low counts of triadic patent families. Most of these are new EU members, which may indicate that a large proportion of their R&D expenditure represents imitation activity rather than frontier innovation, and thus generates few patents. We discuss the distinction between innovation and imitation further in the next section.

Figure 1: relationship between innovation inputs and outputs



Source: Authors' calculations using OECD MSTI.

Note: data for BERD as a % GDP for Luxembourg and Switzerland are for 2000.

8.1.2 Imitation

Measuring technological diffusion or imitation is far from straightforward. At best we can produce proxies for this activity. As discussed above, TFP growth will reflect imitation as well as innovation. The most direct measure is probably citations in patents. We also consider a very broad measure of the scope for technology transfer, distance from the technological frontier, and more direct measures of cross border technological diffusion in the form of R&D activity carried out by affiliates of foreign owned multinationals in the host country and "technology imports" which might provide a better measure of technology transfer in the service sector.

Patent citations

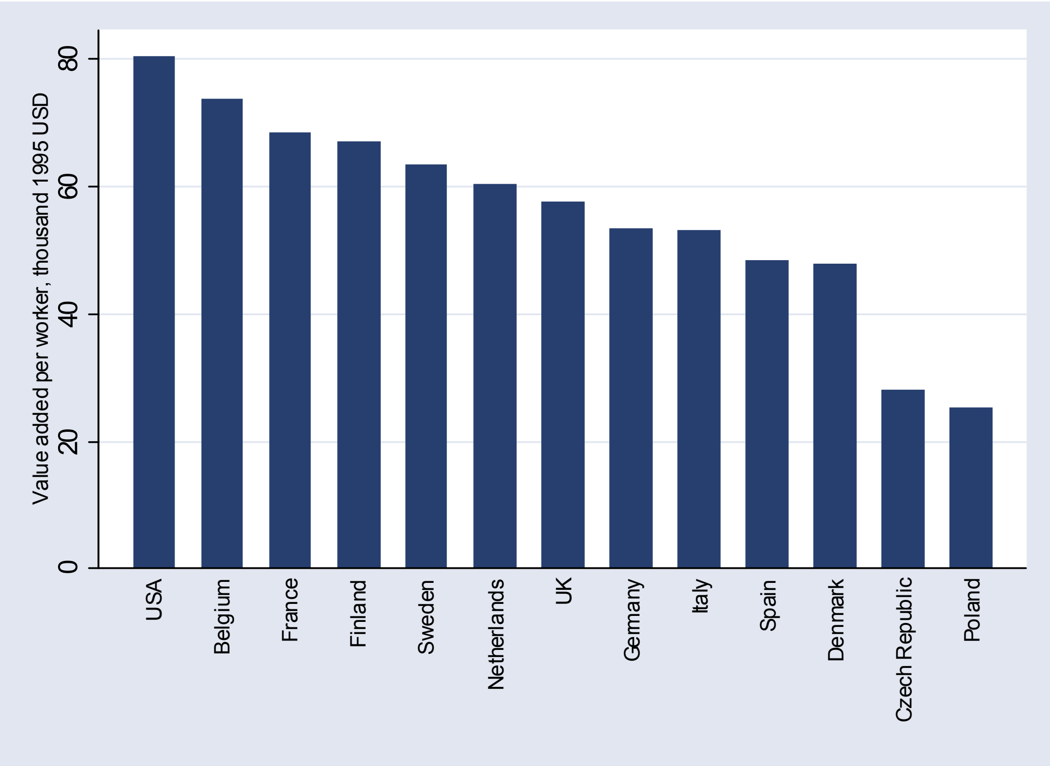
Patent citations can provide direct information on knowledge flows between firms. However, it is important to note that citations are only observed when a firm applies for a patent. That is, patent citations are only observed for those firms that are successful innovators, and not necessarily for those firms that imitate technologies but do not build upon them. They may, therefore, understate the true extent of imitative activity.

Convergence in productivity

The distance that a country, industry or firm lies from the technological frontier can be used as a measure of the potential for imitation or technological diffusion. For example, the technological frontier might be defined as the country with the highest level of productivity within a given industry. For each non-frontier country the potential for imitation is then measured as the gap between their own level of productivity and productivity at the frontier. The further a country lies behind the frontier the greater the scope for technological diffusion. This approach is taken in the recent literature. Griffith, Redding and Van Reenen (2004) find that within industries, total factor productivity (TFP) growth is higher the further a country lies behind the frontier. They also find that R&D has a specific role in increasing the rate of TFP growth (technology transfer) by raising absorptive capacity. Nicoletti and Scarpetta (2003) use this approach and find that product market reforms directly affect the speed of productivity convergence.

Figure 2 below shows value added per worker (a measure of labour productivity) in 2000 in manufacturing for some EU countries and the USA. Following the discussion above, we could consider the USA as the frontier country according to this measure, so that the potential for technology transfer through imitation is least for countries like Belgium, larger for countries like the UK, and largest for the Czech Republic and Poland, whose labour productivity in manufacturing is only about one third of that of the USA. The picture is similar when we look at the service sector or individual manufacturing industries, although the identity of the frontier country, and countries' relative distance to the frontier, vary somewhat across industries. In Section 8.2.1 we examine the convergence of productivity levels over time.

Figure 2: Value added per worker in manufacturing in 2000 (thousand 1995 US dollars)



Source: Authors' calculations using OECD STAN database and PPP exchange rates.

We will use measures of the distance to the technological frontier as proxies for the scope for technological diffusion. This has the merit that it is easily measurable in the available data for a wide range of countries and time periods. It can also be directly related to theoretical models that predict different effects of competition on innovative activity depending on whether a country lies on or behind the frontier. In our empirical work we will therefore investigate whether product market reforms have different impacts on innovative activity and on macro-performance depending on the extent to which countries lie behind the frontier. If they do, this implies that policy reforms of this type may have differential effects depending on a country's relative technological position.

As a robustness check, in section II.2.1 we relate this measure to information on more direct measures of the potential mechanisms through which this cross border technology transfer might operate, two of which we consider below. Other factors, which we do not consider in our analysis, might be common language and the migration of highly skilled or R&D employees.

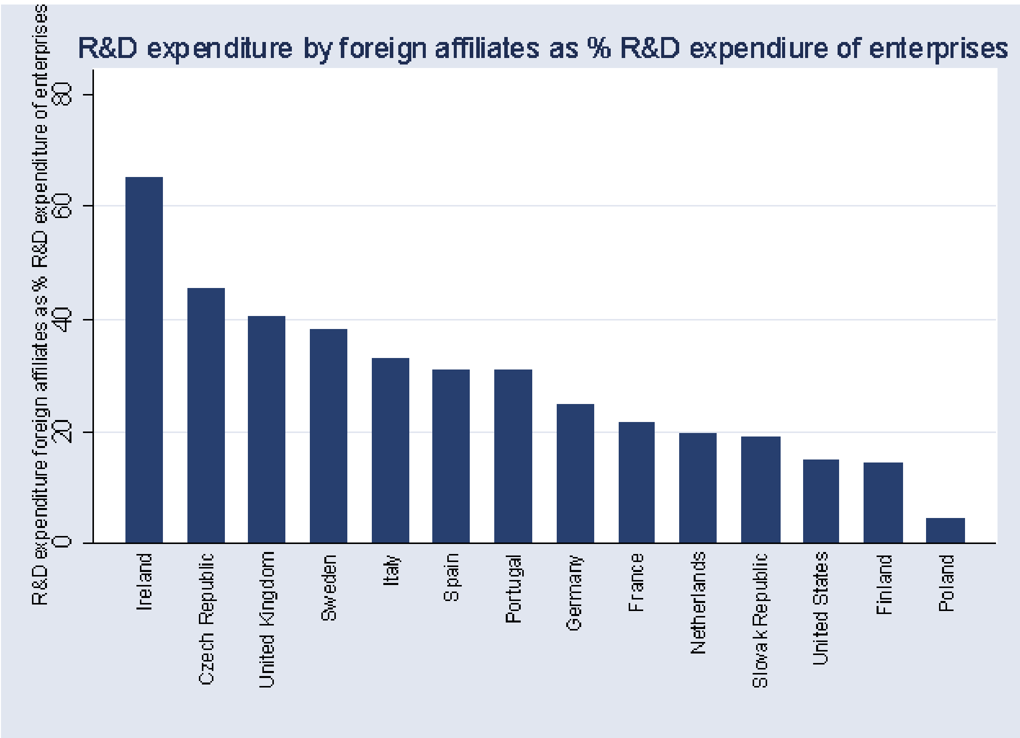
Foreign direct investment, R&D expenditure by foreign-owned affiliates

One measure is the percentage of host country R&D expenditures by enterprises that is carried out by foreign affiliates in the host country. This is shown in Figure 3 below, and suggests that a number of the more peripheral EU countries Ireland, Italy and Spain exhibit a high proportion of R&D expenditures being carried out by foreign affiliates located in those countries.

This may well be positively correlated with more general measures of foreign direct investment (FDI). Indeed, much broader measures of foreign direct investment could also be used as measures of the potential for imitation, such as employment in foreign-owned affiliates in production and service activities. Such measures of the presence of foreign-owned firms are often used when examining whether domestic-owned firms benefit from technological spillovers from FDI. While much attention has been paid to trying to estimate the extent to which domestic firms benefit from spillovers from FDI, it is also possible that outward FDI in R&D is actually carried out in order to benefit from technological expertise and know-how abroad. That is, technology sourcing may be a motivation for carrying out R&D abroad – spillovers may flow to, rather than from the foreign investor. Recent literature has shown this to be an important motivation for R&D locations of multinational firms.[47]

[47] See, inter alia, Griffith, Harrison and Van Reneen (2004) and Branstetter (2004).

Figure 3: R&D expenditure by foreign affiliates as a % of R&D expenditure of enterprises in the host country, 2001

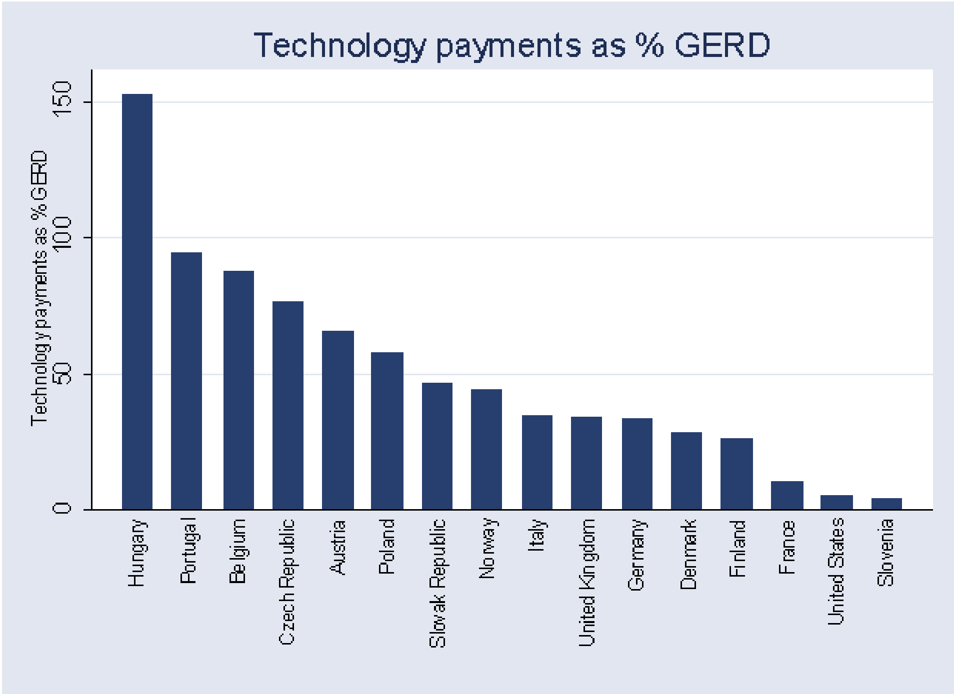


Source: Authors' calculations, OECD MSTI.

Imported technology

A second potential indicator of cross-border technology transfer is technology payments, (that is payments for the acquisition or use of licenses, patents, trademarks etc, and for R&D carried out abroad), measured as a proportion of GERD or of GDP. This gives an idea of how intensively a country imports technology from abroad relative to total domestic R&D activity. This is shown below in Figure 4 for the year 1999 for the countries where it is available. There has been an increase since the early 1980s in this measure of imported technology, with significant variation across countries. For example, in 1981 the UK, France Germany all had technology payments of around 6 to 9% of GERD. In 2001 the UK figure was over 30%, and Germany over 40%, whereas the figure for France remained at around 10% of GERD.

Figure 4: Technology payments as a percentage of GERD, 1999



Source: Authors' calculations using OECD MSTI.

For the countries where data is available there is some evidence of a negative correlation between this measure and GERD intensity, (for example, for the year shown in Figure 4 the correlation is –0.55). Hungary, Portugal and the Czech Republic are among the most intensive technology importing countries but had relatively low GERD intensity.

8.2 Mapping innovative activity

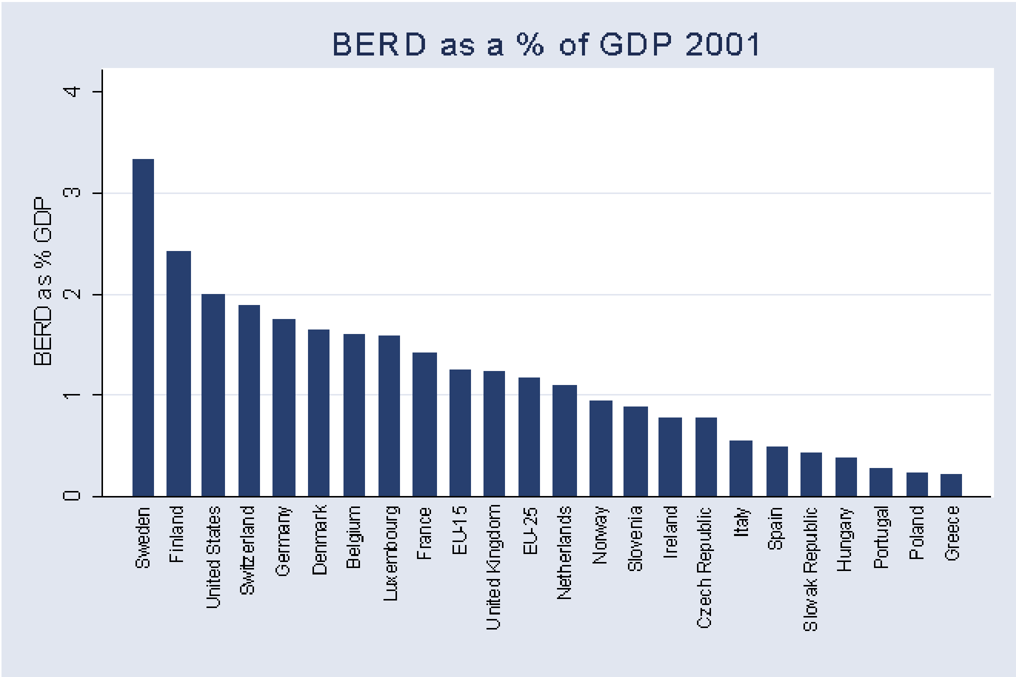
We begin by providing some aggregate cross-country descriptive statistics based on the main innovation measures outlined in section II.1. We also look at evidence on productivity convergence over time across countries. This description is important in informing us about the sort of variation we see in the data, and therefore which effects we will be able to identify in modeling the relationship between product market reforms, innovation, imitation and productivity growth. We then look at the role of industrial structure in accounting for differences in R&D intensity. Finally we describe entry and exit activity of both firms in general and patenting firms.

8.2.1 Aggregate cross-country comparisons

In this section we focus on private sector R&D activity. Figure 5 shows that Business Enterprise R&D (BERD) as a proportion of GDP, varies dramatically across European countries. In 2001 BERD comprises over 3% of GDP in Sweden and Finland, but under 1% in more peripheral regions of the EU 15 (Ireland, Italy, Spain, Portugal and Greece), as well as in a number of 2004 accession countries (Hungary, Poland, Czech Republic, Slovak Republic, Slovenia). This measure is highly correlated with a measure of the intensity with which research staff are employed in the private sector. Finland and Sweden have over 10 researchers per 1000 industry employees, whereas Portugal and Poland have less than one.

Within countries there has also been substantial variation in the path of BERD as a % of GDP over time. For example between 1981 and 2001 BERD intensity in Sweden and in Finland increased by over 1.5 percentage points of GDP, whereas in the UK it actually decreased by 0.25 percentage points. Most OECD countries experienced a modest increase of between 0 and 0.5 percentage points of GDP. In the next section we discuss the extent to which differences in industrial structure can explain differences in aggregate BERD intensity across countries. This covers all R&D conducted by business. As highlighted above, the amount of this R&D expenditure that is financed by government varies over industries and countries. This is important in considering the impact of product market reforms, as these will affect privately financed R&D more than government financed R&D. There is also variation in the extent to which R&D is funded by foreign firms. For example, in 2001 the UK has the highest proportion of BERD funded from abroad, at around 25%, compared to 9% in France and 2% in Germany.

Figure 5: BERD as a % of GDP, 2001

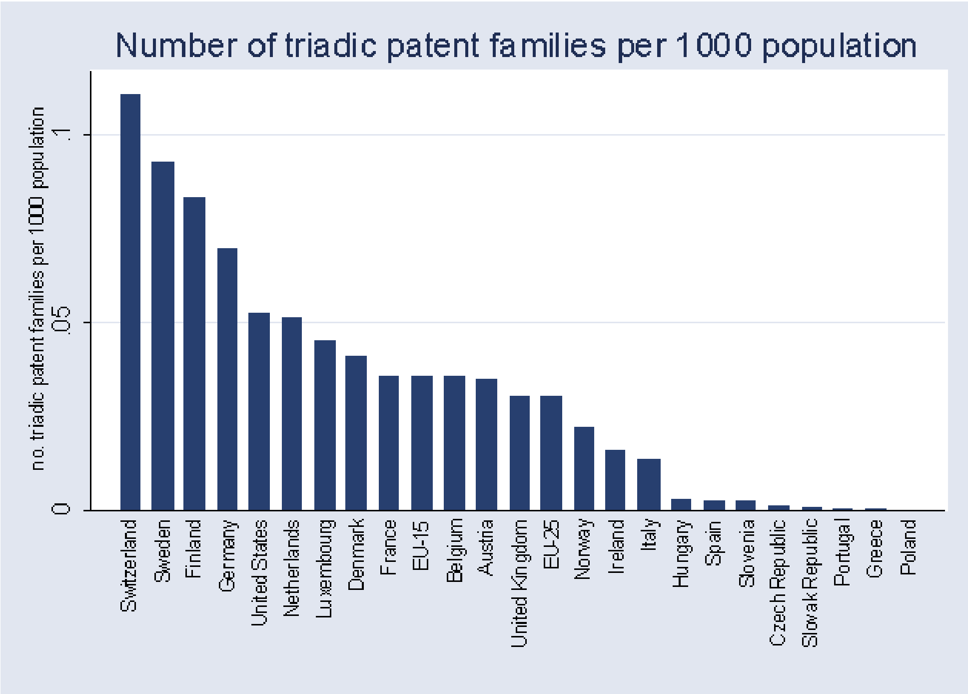


Source: Authors' calculations using OECD MSTI.

Note: data for Luxembourg and Switzerland are for 2000.

Figure 6 shows the number of triadic patent families (patents registered in Europe, US and Japan) per 1000 population for the year 2001. This is a measure of innovation that gives some account of the quality and importance of the innovation. Again, Sweden and Finland have the highest numbers of registered patents with Poland, Portugal and Greece at the bottom of the distribution.

Figure 6: Number of triadic patent families per 1000 population, 2001



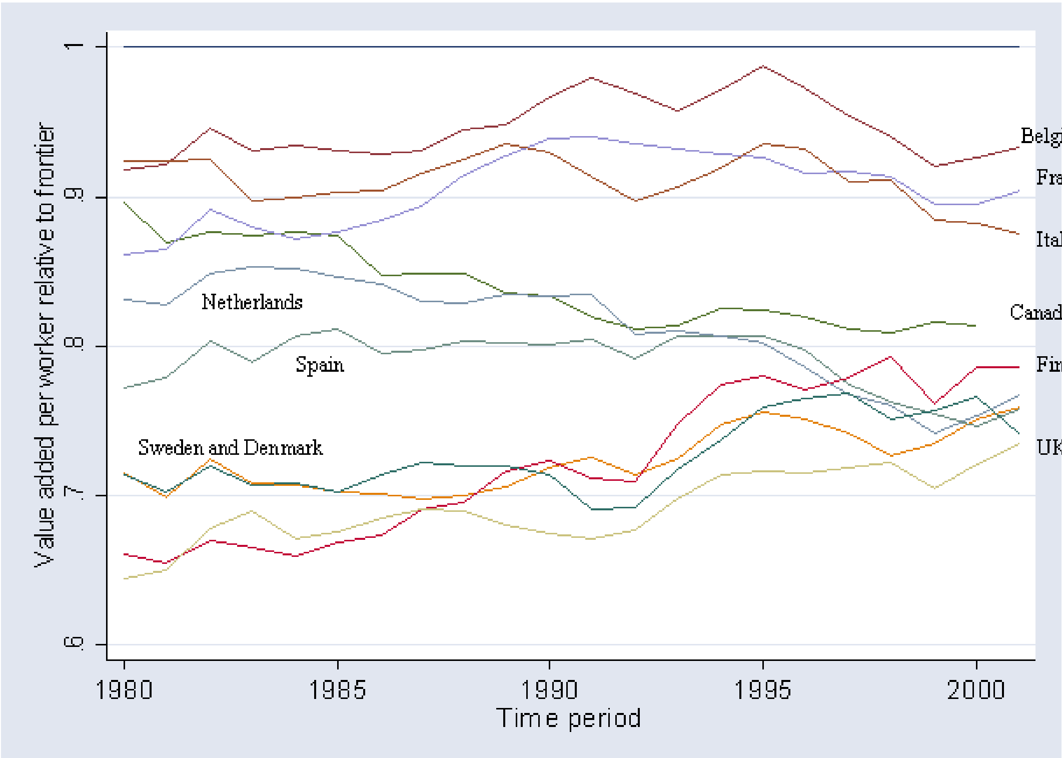
Source: Authors' calculations using OECD MSTI.

Productivity convergence

An important focus of our attention will be the impact of product market reforms on labour productivity and total factor productivity growth (largely through their impact on innovation, imitation and entry). We therefore consider recent trends in productivity, and whether EU countries show signs of convergence. The patterns we see vary across countries. Figure 7 illustrates this for a measure of labour productivity, value-added per worker. Labour productivity in each country is indexed relative to the technological frontier, which in each year is the USA. The frontier is indexed at 1.00, so the figure expresses labour productivity in each country in each year as a percentage of labour productivity in the USA.

Three distinct groups of countries can be distinguished. Three countries have quite high levels of labour productivity relative to the US throughout the period. These are France, Belgium and Italy. They exhibit convergence over the 1980s but not over the 1990s. Three countries – Canada, the Netherlands and Spain – show divergence or no convergence during the 1980s and then divergence over the 1990s. Finally the third group, comprising some Scandinavian economies and the UK, starts off with much lower labour productivity relative to the USA and shows convergence until around 1995, at which labour productivity relative to the USA remains fairly constant. A similar variation in convergence emerges using Total Factor Productivity (TFP), although some of the relative levels look quite different. For example, Italy's relative TFP is significantly lower than its relative labour productivity, reflecting high capital intensity in the data for Italy.

Figure 7: Value added per worker relative to the frontier, whole economy



Source: Authors' calculations using OECD STAN database and PPP exchange rates

The figure above conceals quite different patterns across sectors. In general we observe more productivity convergence in services than in manufacturing, which is similar to the results of Bernard and Jones (1996). There are some individual exceptions in manufacturing, such as Sweden, Finland over the 1990s, and Belgium and the UK over the 1980s and early 1990s.

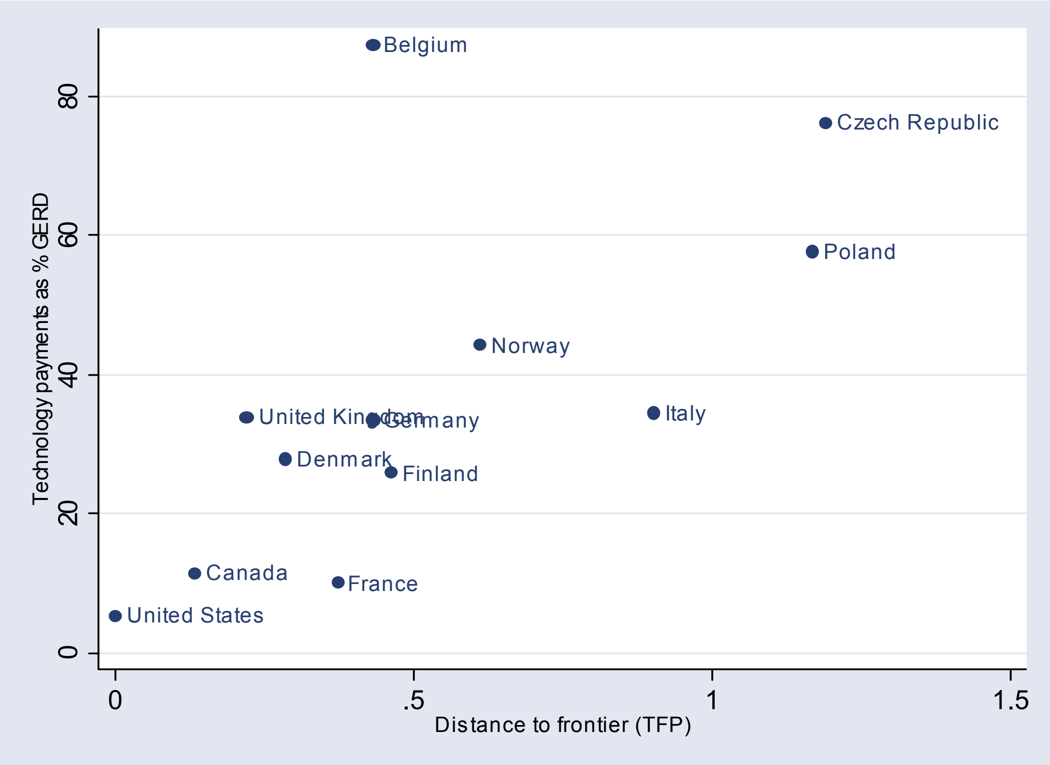
One potential explanation for the difference in the extent of convergence across the manufacturing and service sectors is that specialization in (traded) manufacturing acts against convergence, while the composition of (largely non-traded) service sectors is much more similar across countries. Recent work by the OECD suggests there may even be divergence in high-tech manufacturing sectors (Nicoletti and Scarpetta, 2003). In the next section we examine the role of differences in industrial structure within countries in accounting for differences in R&D intensity.

Distance to the technological frontier

In empirical work we also use measures of distance to the technological frontier as a proxy for the scope for technological diffusion. Although the available data does not allow us to use more direct indicators of technological diffusion over time, we can check that our measure of distance to the technological frontier is highly correlated with these other indicators. Figure 8 shows that there is a strong positive correlation between a country's distance to the technological frontier (measured by ln(frontier TFP) - ln(country's own TFP)), and a measure of the extent to which a country is making payments for imported technologies as a proportion of it's total R&D expenditures ('Technology payments as a % of GERD'). The only outlier is Belgium, which appears to make more technology payments than would be expected given its relatively small distance to the frontier. The correlation between the two measures across countries is 0.64, rising to 0.87 if we exclude Belgium.[48] This suggests that the distance to the technological frontier is a good proxy for the ratio of technology payments to R&D expenditure. In other words, distance to frontier is a good proxy for the potential for technological diffusion as opposed to innovation.

[48] The correlation is slightly lower but still strongly positive if we use distance to the frontier based on labour productivity. The equivalent numbers are 0.45 and 0.77 respectively.

Figure 8: Distance to the technological frontier and technology payments as a % of GERD, 1999



We also looked at the correlation between the measure of distance to the technological frontier and 'R&D expenditure by foreign affiliates as a percentage of BERD'. Here the correlation is less strong which is consistent with the possibility that foreign multinationals may be conducting R&D in some countries in order to source technology and access skilled labour, rather than acting solely as a conduit for spillovers *to* domestic firms.

8.2.2 The role of industrial structure

Countries can have high overall BERD intensity because they have high BERD intensity within particular industries, or because their industrial structure is concentrated in industries that have high average BERD intensity, or both.[49] To investigate this between 1987 and 2000 we decompose the difference between each country's overall BERD intensity and an average for the 7 EU countries for which data is available into two components.[50] The first component

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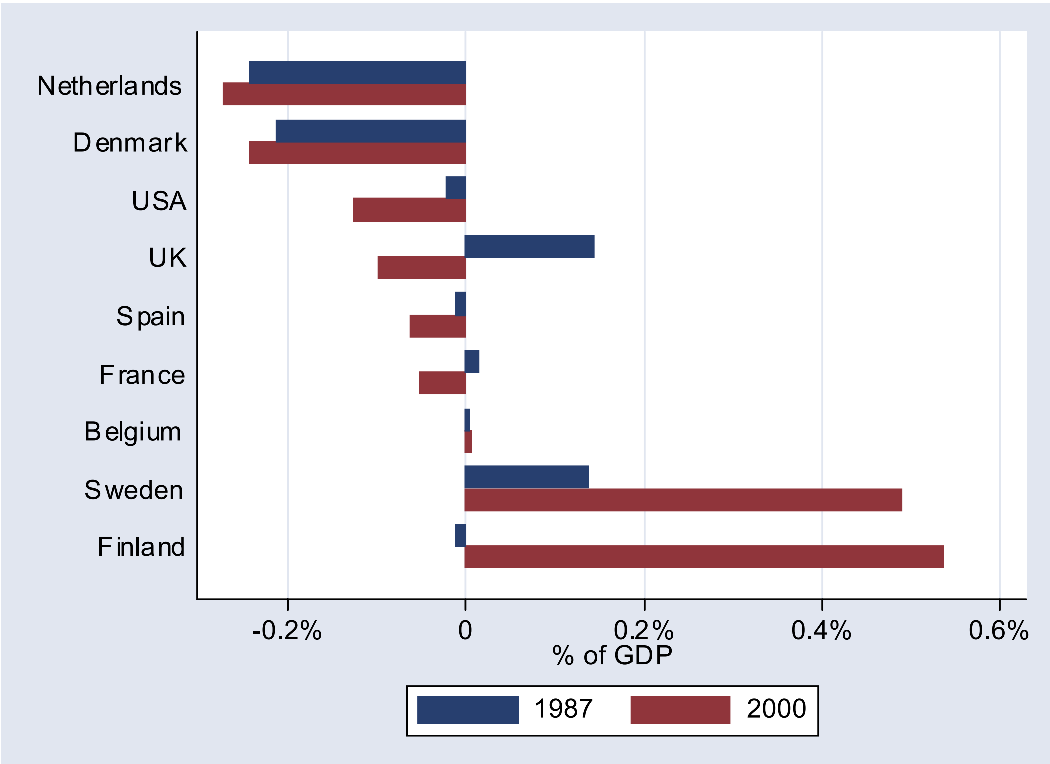
[49] In analysing this it should be noted that the results should be seen simply as a snapshot of a point in time, rather than as causal explanations of overall R&D intensity. This is because R&D intensity affects an industry's share in value added by raising its productivity.

[50] The comparison group is an un-weighted average of Belgium, Spain, Finland, France, the UK, the Netherlands and Sweden. The choice of comparison is driven by data availability, but the exact choice does not affect the conclusions.

is the part of the difference that is due to a different composition of output between high-tech manufacturing industries, low-tech manufacturing industries, and non-manufacturing sectors. The second component is the part of the difference that is due to higher or lower BERD intensity *within* these three broad sectors.

Figure 9 shows the first "industrial structure" component in 1987 and 2000 for the countries for which data is available. Bars to the right hand side of the vertical line show that industrial structure made a positive contribution to R&D intensity in a particular country relative to the average. Looking at the figures for 2000, we can see that, for example, Sweden and Finland's industrial structure results in an overall BERD intensity that is around 0.5% of GDP higher than the average, and 0.8% of GDP higher than Denmark or the Netherlands. For Sweden and Finland this has increased substantially between 1987 and 2000, given an overall increase in average R&D intensity of 0.4% GDP. In all other countries, except Belgium, it has moved in the opposite direction, reflecting the shift in most economies towards service sectors.

Figure 9: Contribution of industrial structure to BERD intensity, 1987 and 2000

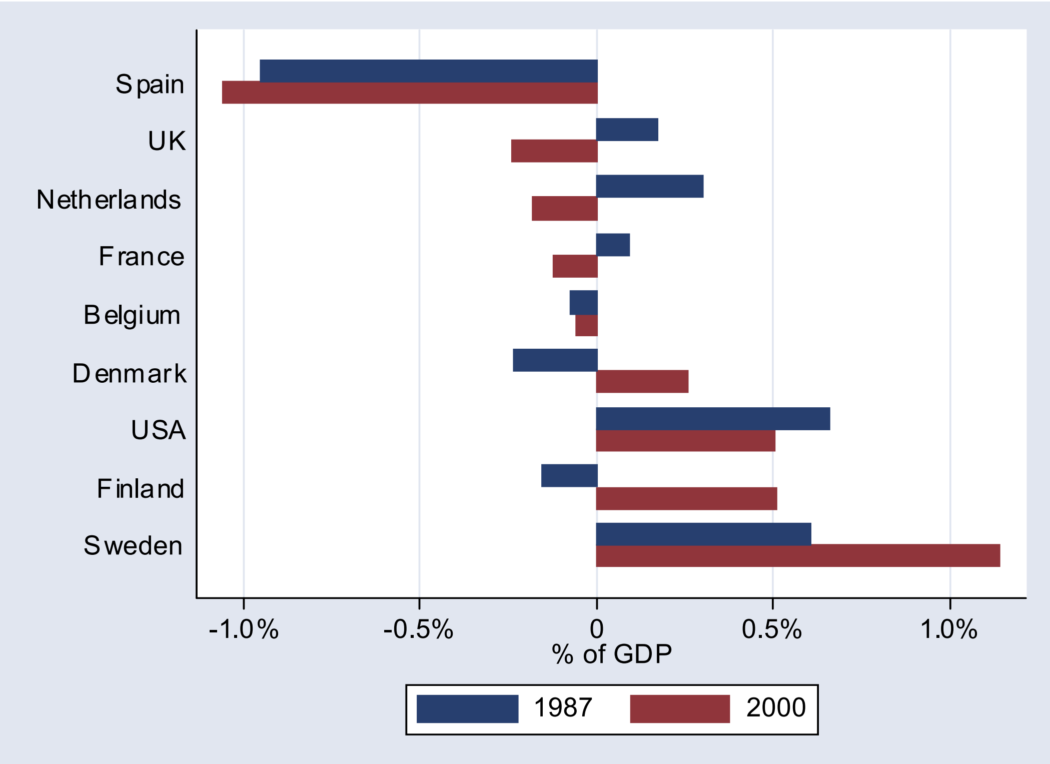


Source: Authors' calculations using OECD STAN and ANBERD databases.
Notes: 2000 figure for Denmark relates to 1999.

Figure 10 looks at the second component, the extent to which differences in R&D intensity from the EU average are due to differences in R&D intensity within sectors. Here again we see that Sweden and Finland top the chart. R&D intensity within sectors has increased substantially. In all countries except the Scandinavian countries and Belgium we see a decline in R&D intensity within industries relative to the average.

Taken together Figures 9 and 10 show that in most countries the within-sector variation accounts for more than the between variation. For example, in both years, for Spain it is *within* sector R&D intensity that accounts for the vast majority of the lower measured R&D intensity relative to the EU average. Whereas for Finland and Sweden by 2000 both industrial structure and above average R&D intensity within sectors make significant contributions to the overall higher R&D intensity in these countries.

Figure 10: Contribution of within-sector intensity to BERD intensity, 1987 and 2000



Source: Authors' calculations using OECD STAN and ANBERD databases.
Notes: 2000 figure for Denmark relates to 1999.

Increased economic integration might be expected to result in increased specialisation – that is as trade or transport costs decrease countries might specialise in the production of particular products. It is possible that this also leads to specialisation in research and development activity in particular industries. Therefore we also looked at the extent to which R&D expenditure has become concentrated in particular locations over time.

In general we find that countries' shares of total R&D expenditure do not vary much over time. Although R&D in some industries did become more geographically concentrated, the reverse pattern occurred in other sectors. For example between 1995 and 2000,[51] business enterprise R&D in the motor vehicles sector (3400) becomes significantly more geographically concentrated. While R&D in machinery and equipment (2933) and services (5099) become less concentrated.

These results highlight the point made in 7 that there is likely to be heterogeneity in the effects of product market reforms on innovation activity across countries, regions and industries. In particular, greater flexibility in product markets may lead some innovative industries to concentrate in particular countries or regions within the EU, so that the amount of innovative activity in some countries may fall even though the total amount of innovative activity in the EU has increased. This precise effect may be difficult to capture in the empirical analysis, since the indicators of product market reform that we have collected mostly vary at the national level.

8.2.3 Entry and exit

New entry may serve as an informative indicator of innovation, particularly in service sectors where R&D and patents are not very informative. In particular new entrants may be more likely to pursue drastic innovation strategies compared to incumbent firms, as by innovating they do not cannibalise rents from existing products. By comparison incumbent firms may be more likely to pursue incremental innovations. This comparison between entrants and incumbents is most appropriate for "greenfield" entrants, compared to entry by acquisition. Greenfield entrants might be most likely to introduce new, leading-edge technologies. A number of microdata studies emphasise the importance of greenfield entrants in contributing to productivity growth over the longer term. [52]

We have examined detailed data on individual patents taken out at the European Patent Office (EPO) and on triadic patent families (an indicator of high quality or drastic innovations). We use these data to look at how product market reforms affect innovation (patenting) by entrant and incumbent firms.

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[51] We have data for 11 EU countries over this period.

[52] See Foster, Haltiwanger and Krizan (2000) and Disney, Haskel and Heden (2003). See also Henderson (1993) with regard to drastic innovation by entrants.

Cincera and Galgau (2005) provides a detailed summary of entry and exit patterns across EU countries. We have examined the data collected from Dun and Bradstreet for the Cincera report. The main characteristics of the data, brought out in Cincera and Galgau (2005), are that for the EU as a whole entry declines over the period (1997-2003) while exit increases slightly. The net entry rate is declining throughout the period, it becomes negative by 2003 (Cincera and Galgau Figure 2). There is substantial variation in entry, exit and net entry rates across countries and industries (Cincera and Galgau Figures 3 and 4).

Two serious limitations of the data on entry and exit are:

- the short time series available (1997-2003), which makes it difficult to convincingly identify the effects of product market reforms from other cyclical and unobserved factors that affect entry and exit rates across countries,
- the fact that the data do not contain information on the size of entrants or their performance subsequent to entry (see, for example, Geroski (1995) and Aghion, Blundell, Griffith, Howitt and Prantl (2005) who emphasise this point).

In addition, we have several concerns about measurement error in these data. For example, the number of firms in France is surprisingly large compared to the other countries, especially in a few industries, including Real Estate industry, Retail and Construction. While these problems are most obvious for France, they also raise doubts about the quality of the data for the other countries. Potential reasons for these results include different definitions of what constitutes a firm across countries, and inconsistencies in the way firms are assigned to industries.

Before we realized the problems with this data, we planned to look at the relationship between product market reforms and entry and exit. The Table below shows the estimates from an equation of the form

$$E_{ijt} = \alpha + \beta PMR_{it} + X'_{ijt}\,\gamma$$

where E is entry, exit or the number of incumbents. PMR stands for product market regulations. We use the Fraser Institute index of the ease of starting a new business (see Appendix III for a discussion). This is likely to be the most relevant type of regulation, as most entrants are very small firms.

In columns (1) and (4) we simply regress the number of entrants and exits, respectively, on the ease of starting a new business (controlling for the total number of firms), and find a positive and significant effect in both cases. However, in columns (2) and (5) we add country dummies and in columns (3) and (6) we add industry dummies, and these effects disappear. This suggests that the result in columns (1) and (4) is driven by variation between countries, while within countries over the short time period there is no evidence of a relationship between entry or exit and the index. We have not explored these results further due to our concerns about the quality of the data.

Table II.1: Entry and Exit results

Dependent variable	(1) Number entrants	(2) Number entrants	(3) Number entrants	(4) Number exits	(5) Number exits	(6) Number exits
Ease of starting a new business	135.873	-193.010	-192.802	152.523	128.897	123.567
	(40.287)	(154.258)	(155.670)	(55.576)	(94.538)	(94.186)
Number of active firms	0.056	0.056	0.056	0.013	0.013	0.008
	(0.002)	(0.002)	(0.003)	(0.002)	(0.002)	(0.002)
Constant	-602.244	1,426.240	2,294.759	-656.376	-899.741	73.523
	(295.105)	(842.964)	(1,307.211)	(353.103)	(538.765)	(728.363)
Year dummies	yes	yes	yes	yes	yes	yes
Country dummies	no	yes	yes	no	yes	yes
Industry dummies	no	no	yes	no	no	yes
Observations	1488	1488	1488	1488	1488	1488
R-squared	0.92	0.92	0.94	0.48	0.50	0.62

*Robust standard errors in parentheses (clustered on country-year) * significant at 5%; ** significant at 1%*

9 Product market regulations and reforms

What have happened to product market regulations over the past two decades, and what reforms have been undertaken? In this section we document the main changes that have occurred across EU countries. In doing this we are mainly interested in two things - to describe patterns of reform and the type of changes we have seen, and to consider what variation can be used for econometric work.

For the purposes of our analysis it is extremely important to have measures of product market regulation that vary over time, both in terms of data coverage, and the actual variation of regulation. The reason is that purely cross-sectional measures of regulation (those that do not change over time) do not allow us to identify separately the impact of regulation from other unobservable factors that affect competition and innovation outcomes across countries. Collecting time-varying measures of regulation allows us to use panel data techniques that control for any unobservable factors that do not change over time.

The problems associated with using non-time-varying indicators are clearly illustrated in Nicoletti and Scarpetta (2003). This paper was discussed at some length in the previous study, Griffith and Harrison (2004), but it is useful to re-emphasize a few key points. Firstly the main countrywide measure of regulation used by Nicoletti and Scarpetta (N&S) refers to the situation in a single year (1998) towards the end of their sample period. This is problematic for two reasons: first it is purely cross-sectional information, and second it implies an underlying assumption that end-of-period values are representative of cross-country patterns of regulation over the entire 1984-1998 period. This will not be true if some countries have liberalized their markets faster than others. These problems make causal interpretations of the results extremely problematic.

N&S do use some time-varying indicators of regulation, but these refer to specific aspects of regulation in seven network industries, which are unlikely to be representative of regulatory trends in the economy as a whole. In this current study we will not examine network industries separately as we consider the nature of regulation in those industries to be qualitatively different from regulation in the rest of the economy, both in terms of its goals and its effects. A reliable evaluation of the impact of regulation in those industries would require a detailed microeconomic investigation of each industry, which is beyond the scope of this study.

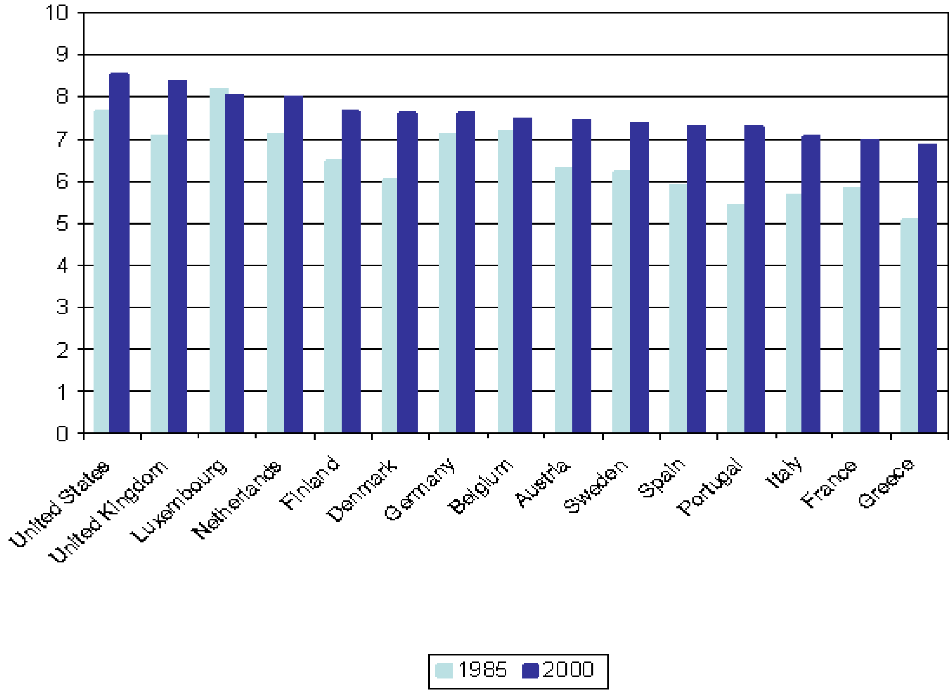
Another aspect of the measures of regulation used by N&S is worth mentioning: the information on product market regulations is aggregated into a single summary measure. This imposes strong and possibly arbitrary restrictions on the way in which individual regulations can affect productivity growth. It also means that it is not possible to deduce from the results which specific regulations have the largest effects, and how economically important those effects are. Capturing these differential effects in practice will be difficult due to high levels of correlation between different regulations ('multicollinearity' in technical terms) - many countries undertook several reforms at the same time - but a more flexible approach that uses greater numbers of individual indicators could be both more robust and more informative. Wherever possible this is the approach we take in this study.

9.1 Overall Product Market Regulations

The Fraser Institute Index of Economic Freedom is a collection of country-level indicators of the extent of regulation and government intervention in various areas, including product, labour and credit market regulation. The data are available at five year intervals starting in 1975, though many of the indicators relating to product markets begin only in the 1990s. The indices are constructed using information from various sources, including the IMF, World Bank, WTO and OECD, as well as publications such as the World Economic Forum's Global Competitiveness Report.

The key advantage of the Fraser Institute index is that it provides a long time series. As an example Figure 11 shows changes in the overall summary index of Economic Freedom between 1985 and 2000 for a group of EU countries plus the USA (note that higher values denote more "economic freedom", i.e. less regulation). The figure shows that there has been a general trend towards more economic freedom (less regulation) in these countries over the period, and that on average those countries with lower levels of economic freedom to start with changed the most.

Figure 11: Fraser Institute Summary Index of Economic Freedom, 1985, 2000



The most recent and comprehensive data on the extent of product market regulations across countries comes from data recently published by the OECD in Conway, Janod and Nicoletti (2005).[53] While the Fraser Institute data is mainly based on a combination of economic outcomes and cross-country surveys, the key advantage of the OECD regulation data is that it is based on actual legislative and policy differences across countries. However, the main drawback of this data for our purposes is that it is collected for only two points in time, 1998 and 2003. This provides only a relatively short single difference, and many of the outcome variables that we are interested in are not yet widely available across countries for such recent years, particularly at the industry level.

[53] Data and full description are available from the OECD at www.olis.oecd.org/olis/2005doc.nsf/linkto/eco-wkp(2005)6, www.oecd.org/eco/pmr All variables are measured on a scale of 1-6.

Figure 12: OECD Summary Index of product market regulations

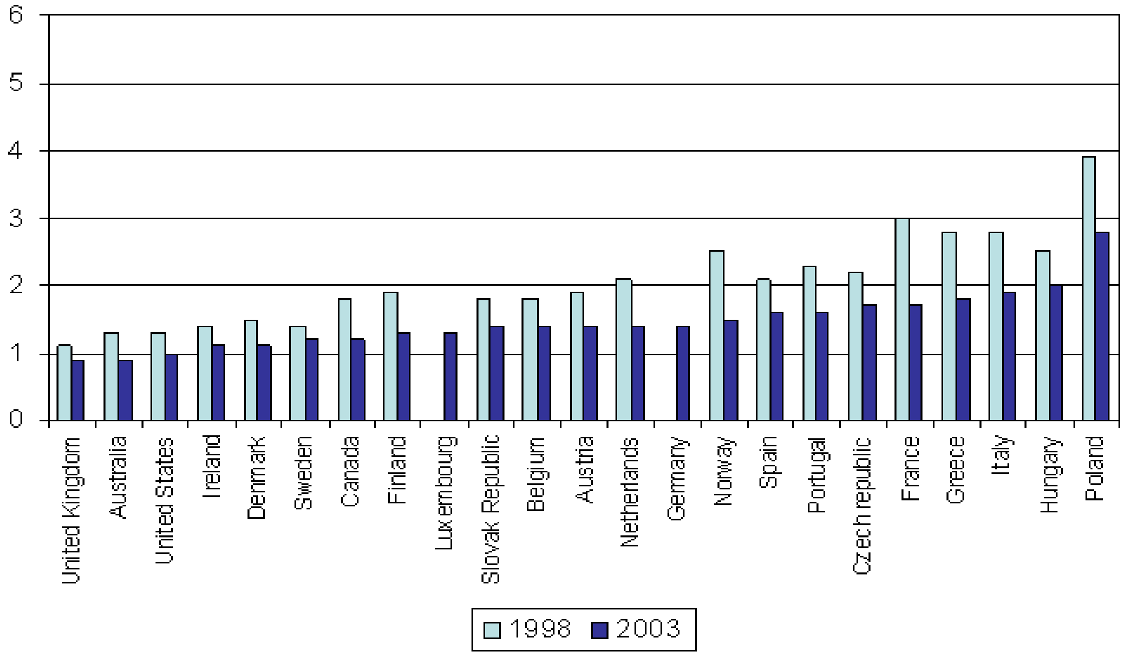


Figure 12 shows changes over five years 1998 to 2003 in the OECD's overall index of product market regulations. Over this period we also see convergence in levels of regulation – countries with higher initial levels of regulation have on average experienced a greater reduction in regulation. Looking across countries, Conway, Janod and Nicoletti (2005) categorise countries into those that are "relatively liberal" - including the UK, US, Ireland and Denmark, "relatively restrictive" - including Poland, Czech Republic, Greece, Italy, France, Hungary and Spain, with the others being in between. However, the fact that the cross-sectional variation in regulation has reduced over time may, in econometric work, make it harder to identify associations between regulation and economic outcomes using cross-country differences. Convergence in levels of regulation also raises the possibility that regulatory changes may not be "exogenous" in the sense that countries may reduce regulation in response to poor economic performance. This might bias any results towards the conclusion that reductions in regulation are associated with improved performance.

An advantage of the Fraser Institute and OECD indicators are that we can compare countries within the EU with those outside the EU. To the extent that product market reforms have been similar across EU countries this makes comparison with non-EU countries important for identifying the effects of product market reforms. There are also some indicators that exist only for EU countries, for example the European Commission Structural Indicators. These are available annually starting in the early 1990s and cover member states of the European Union. Available variables include 'Sectoral and ad hoc state aids as a % of GDP', 'Public procurement as a % of GDP', and 'Openly advertised public procurement as a % of public procurement'. We used this data in the previous study (Griffith and Harrison (2004)) with limited success, and so will not focus on these indicators in the current study.

In some cases we can use comparisons between EU countries and non-EU countries to identify the effects of product market reforms that have been undertaken across the EU. This is particularly the case with the effects of the Single Market Programme, which we discuss in some detail below. This provides a natural source of variation across countries, time and possibly industries.

9.2 Different types of regulation

Both the Fraser Institute indices and the OECD indicators cover various different types of product market regulation. For example, in empirical work, we use FI indices of the ease of the starting a new business, the time senior management spends with government bureaucracy, and the extent of use of price controls.[54] The OECD usefully splits regulation into three broad categories - state control, barriers to entrepreneurship and barriers to trade and investment. The extent of change over the period 1998-2003 has varied across these. Figures 13, 14 and 15 show the OECD indicators for each of these types of regulation for 1998 and 2003. For all three we see similar patterns of convergence, with EU countries becoming more similar over the period. State control is the category with the most remaining cross-country variation in 2003.

[54] For further description see Griffith and Harrison (2004).

Figure 13: State Control

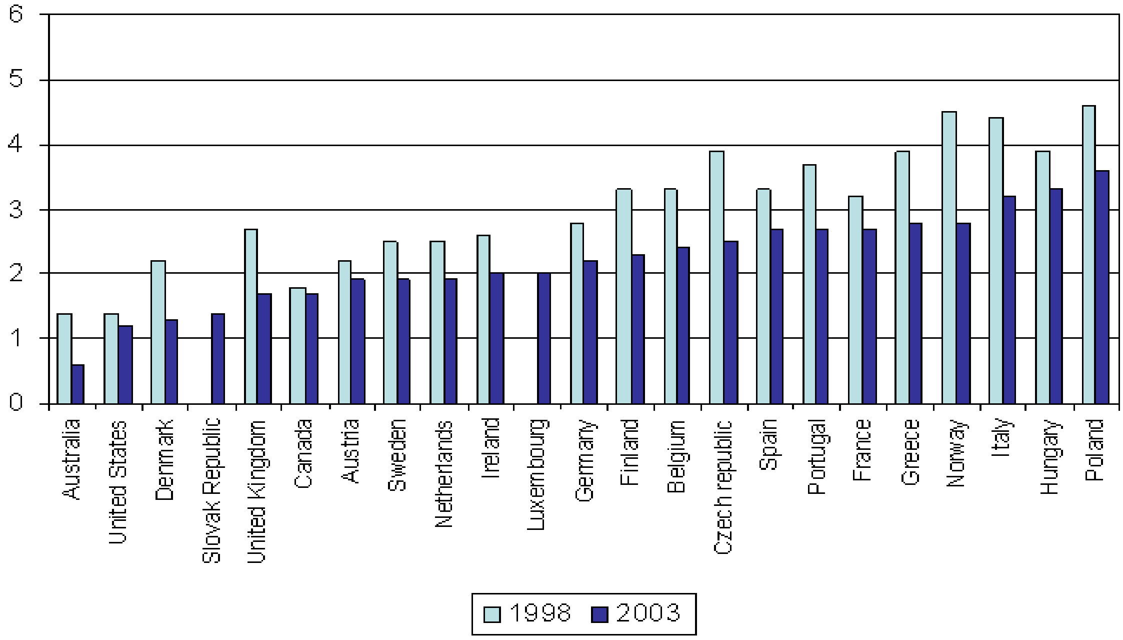


Figure 14: Barriers to Entrepreneurship

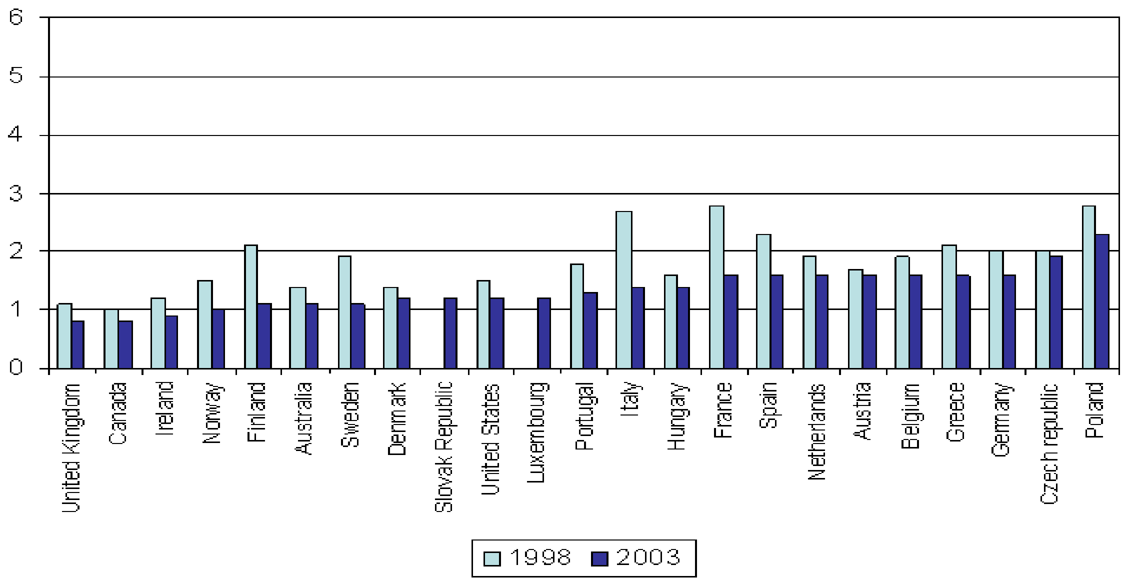
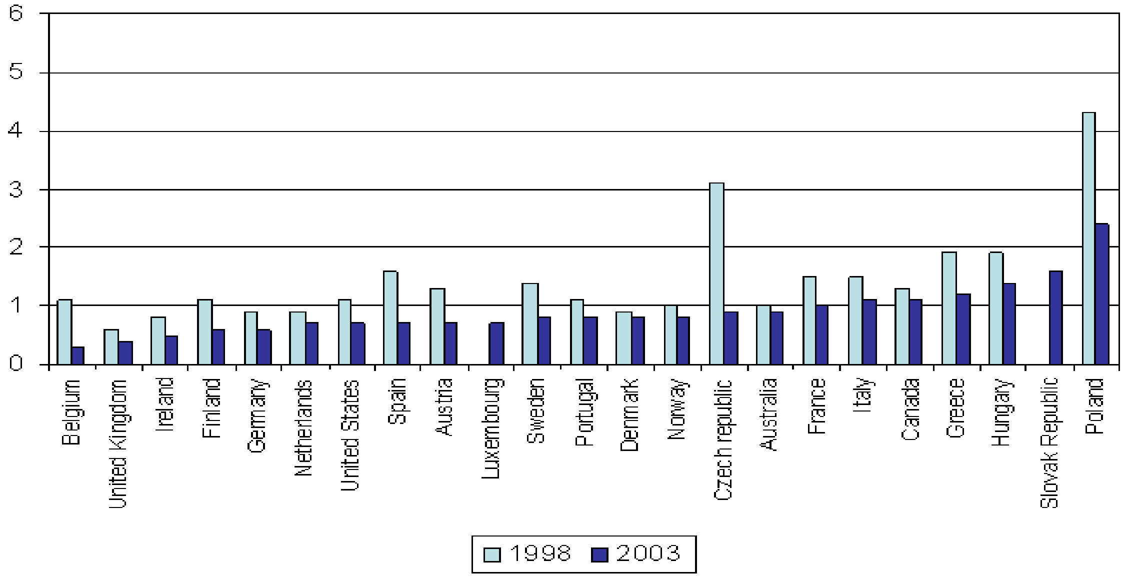


Figure 15: Barriers to Trade and Investment



In terms of their impact on economic performance we might expect the effects of these different regulations to vary across sectors of the economy. For example state control is mainly important in network industries, which we exclude from our analysis. Barriers to entrepreneurship apply across all industries, but their impact is likely to be largest in less capital intensive industries (e.g. many service industries) where licensing and administrative costs are a larger proportion of total start-up costs. Finally, barriers to trade and investment are likely to have most impact in traded manufacturing industries. However, some service industries are becoming increasingly traded and so this may not be universally the case.

In the above examples, differential impacts across industries of different types of regulation arise because of the way country-level regulations affect industries with different characteristics. However, there may also be direct variation in product market reforms across industries. Below we discuss the potential use of this type of variation in the context of the Single Market Programme, which was expected to affect some manufacturing industries more than others.

9.3 Single Market Programme

An important indicator of product market reform that we will use is based on the implementation of the European Single Market Programme (SMP) in the early 1990s. This was a large scale project by the then members of the European Union to reduce internal non-tariff barriers to trade and other barriers to the free movement and factors of production across borders. While the SMP is a large reform, it was undertaken across a large number of countries at around the same time. This means that it is difficult to separately identify the impact of the SMP from the effects of other contemporaneous macroeconomic effects (for example, the recession of the early 1990s).

We have used various sources of information to construct an indicator of the impact of the SMP at the country level. One possible identification strategy is to use countries that did not take part in the SMP as a control group for countries that did take part. In technical terms this is a simple difference-in-difference estimate of the impact of the SMP. This means that we compare changes between before and after the SMP in countries that did take part with contemporaneous changes in countries that did not take part. Various issues arise relating to the choice of control countries, the main requirement being that controls are a good representation of what would have happened in the affected countries in the absence of the SMP. For example, other European countries that did not take part in the SMP are obvious candidates, but it is possible that they were affected by the SMP either directly or indirectly through trade and other economic linkages. Nevertheless, we expect that the impact of the SMP was greater for countries that did take part than for other European countries that did not take part. Non-European OECD countries such as the USA, Canada and Australia are also potential control countries. While these countries may have been subject to other regulatory changes that did not affect European countries (for example NAFTA) we would nevertheless expect the SMP to affect the economic performance of participant countries relative to non-European OECD countries. We will examine the robustness of our results to using different control groups.

We have also investigated the possibility of differentiating the effects of the SMP between participant countries. This involves refining the simple in-out control group approach by obtaining measures of how large the impact of the SMP was for each participant country. Although this may create more accurate measures of the expected effects of the SMP, it turns out that most of the variation in the data is between SMP and non-SMP countries, so the control group approach will continue to be our main identification strategy. We discuss this further below.

We use two additional sources of information to refine our SMP indicator. The first is the data on the expected degree of impact of the SMP on different manufacturing industries contained in Buigues et al (1990).[55] This analysis is based on information contained in the 1988 Cecchini Report and other sources. The authors identify which industries are expected to be highly and moderately affected by the SMP, and we combine this information with the share of those industries in manufacturing output before the implementation of the SMP to generate the ex ante share of output in each country that was expected to be affected by the SMP. There are thus two sources of variation across countries: first the sectors that were expected to be affected, which are modified from a common list by national experts for each country, and secondly the importance of those sectors in each country's manufacturing output. The resulting data is shown in Table III.2. The country with the highest percentage of manufacturing output that was expected to be affected is Portugal, with 68%, while the lowest is Spain with 39%.

Table III.2: Percentage of manufacturing output expected to be affected by the SMP

Country	High impact sectors	Medium impact sectors	Total
Belgium	15.6	33.2	48.8
Denmark	9.6	39.8	49.4
Spain	12.2	26.9	39.1
France	14.9	35.9	50.8
UK	14.5	35.5	50.0
Greece	19.4	42.1	61.5
Italy	22.4	29.7	52.2
Netherlands	17.9	27.0	44.9
Portugal	23.6	44.4	68.1

Source: Calculations based on Buigues et al (1990)

The second additional source of information that we use to refine our indicator of the SMP is related to the extent and speed with which the SMP was actually implemented in each participant country. We use the European Commission's published Internal Market Scoreboard which contains the rate of non-implementation of single market directives for

[55] This data has been used in various studies, including Mayes and Hart (1994), and Allen, Gasiorek and Smith (1998).

each candidate country (the "transposition deficit"). This is published twice a year, although the first scoreboard was published in 1997. Table III.3 shows the percentage of single market directives not implemented in 1997 and in 2000. The table shows that the degree of implementation varied more across countries in 1997 than in 2000, and that implementation generally improved over this short period.[56] In our econometric work the fact that the deficit is calculated on a different base of outstanding directives in each year will be captured by common time dummies.

Table III.3: Transposition deficit in 1997 and 2000

Country	1997	2000
Austria	10.1	2.9
Belgium	8.5	2.9
Denmark	3.2	1.1
Finland	4.3	1.3
France	7.4	4.5
Germany	8.5	3.1
Greece	7.5	6.5
Italy	7.6	3.2
Luxembourg	6.5	3.2
Netherlands	4.6	2.5
Portugal	5.9	4.4
Spain	4.7	1.6
Sweden	6.2	1.2
UK	3.5	2.7

Source: EU Internal Market Scoreboard
http://europa.eu.int/comm/internal_market/score/index_en.htm

There are several ways in which we might be able to use these two types of information to refine our simple in-out indicator of the impact of the SMP. Possibly the simplest is to use the information on the proportion of manufacturing output that was expected to be affected to change the height of the "step function" representing the impact of the SMP for 'in' countries. Thus, instead of using a step function that changes from zero to one in 1992 for countries that were part of the SMP, we could use a step function that changes from zero to 0.488 for Belgium and from zero to 0.681 for Portugal. As with the unrefined step function, the variable would be equal to zero in all years for control countries that were not part of the SMP. Such a variable is shown for the SMP countries in our data in Figure 16.

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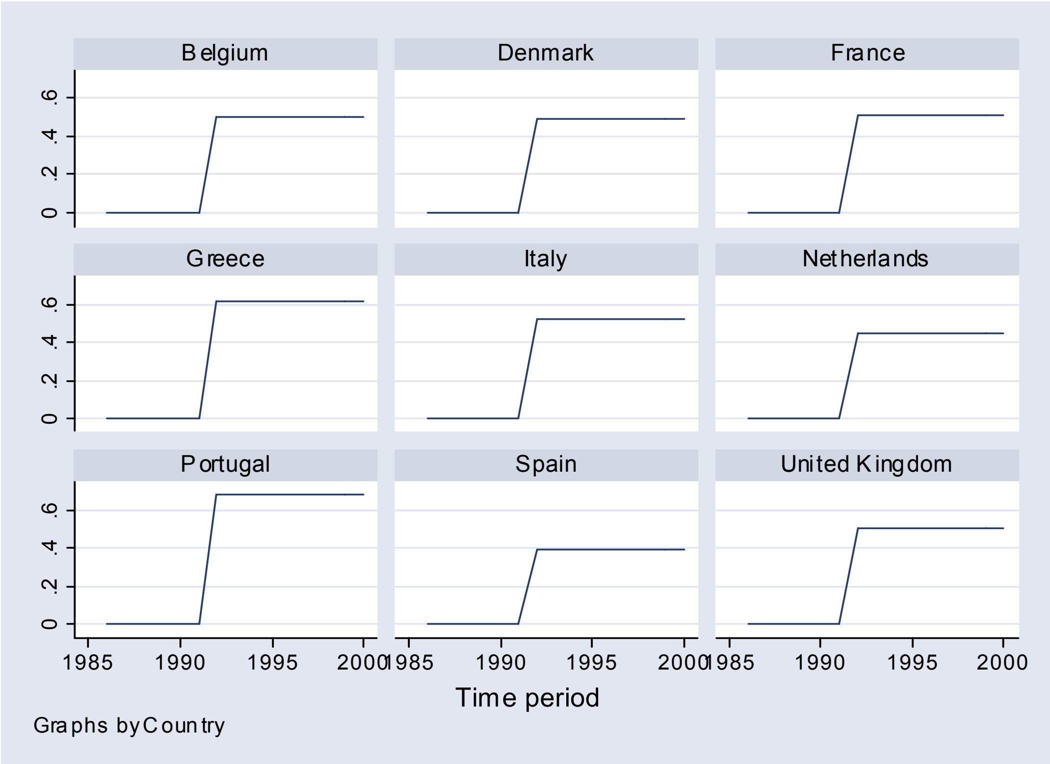
56 Note, however, that the speed of implementation is a choice variable for national governments. It is possible that countries where the SMP was expected to have a larger effect were slower at implementing single market directives in order to delay disruptive effects on sensitive industries or groups of workers.

Figure 16: Simple SMP indicator refined using information from Buigues et al (1990)

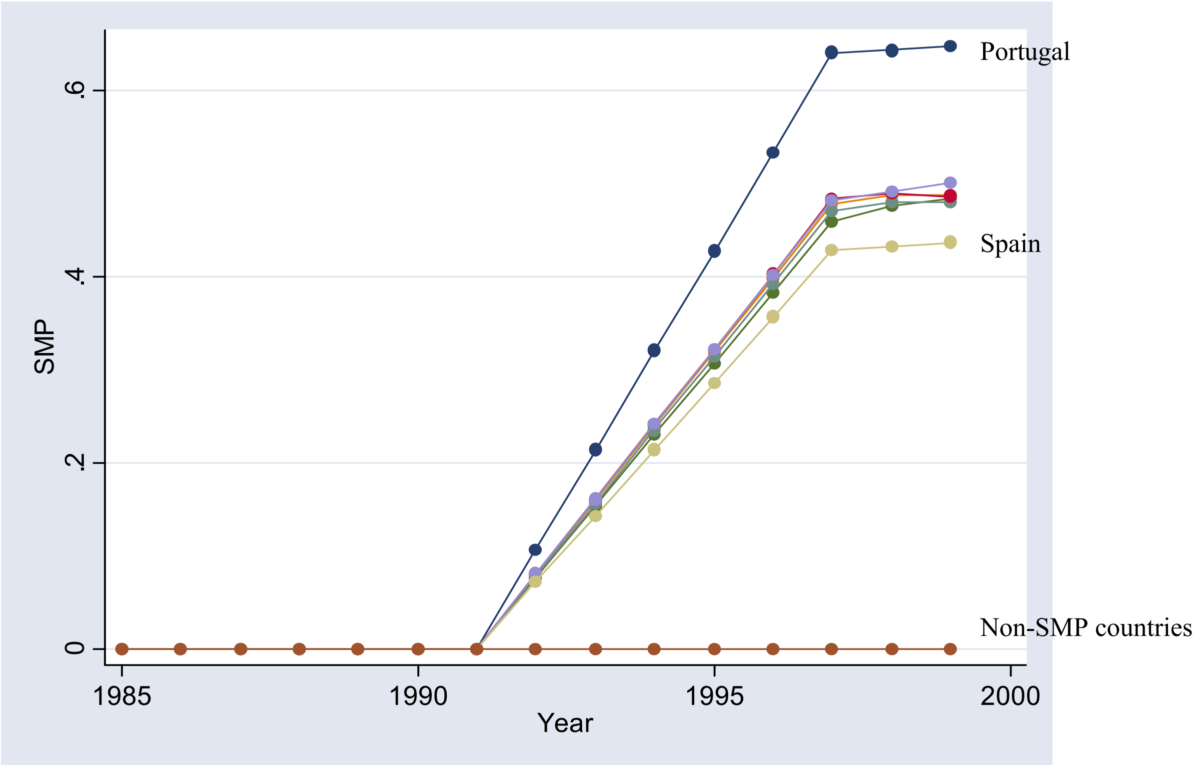


The information contained in the transposition deficit could also be used in several ways. The simplest would be as in the above case, where we would assume that the impact of the SMP was proportional to the percentage of single market directives that had been implemented by 1997. However, this approach contains an implicit assumption that all single market directives are on average equally important. If the single market directives that *had not* been implemented by 1997 were on average expected to have a bigger impact than those that *had* been implemented (as would be the case if countries implement the least 'painful' directives more quickly) then we could use a non-linear transformation of the transposition deficit. This would increase the implied difference in expected effect between countries resulting from a given difference in the percentage of single market directives that had been implemented by 1997. In other words this would increase the implied difference in implementation rates between a country such as Austria, which has a transposition deficit in 1997 of 10.1%, and a country such as the UK, which has a deficit of only 3.5% in the same year.

A second way in which we could use the information contained in the transposition deficit is to modify the timing of the impact of the SMP. A simple step function like that in Figure 16 compares the situation before 1992 to that after 1992, and so implicitly assumes that the impact of the SMP was immediate. Instead we could use the information from the transposition deficit to modify the rate at which the SMP was implemented in practice. There are several ways in which this could be done, for example we could assume that a given proportion of directives were implemented in each year between 1992 and 1997 at rate proportional to each country's total rate of implementation in 1997. We could also investigate whether some of the impact of the SMP occurred before 1992.

While these refinements may slightly improve the accuracy with which we can estimate the effects of the SMP, we should emphasize that most of the variation in the data still relates to whether a country was in or out of the SMP. Figure 17 shows a refined version of the SMP indicator where we have used both types of information to refine the expected effect from 1997 onwards, and have linearly interpolated the size of the effect between 1991 and 1997. The Figure clearly shows that even after this type of modification the biggest source of variation in the data is still the contrast between countries that took part in the SMP and countries that did not, for whom the indicator is zero in all years. In other words, the difference in expected effect between the most affected SMP country, Portugal, and the least affected, Spain, is much less than the average difference in expected effect between SMP countries and non-SMP countries.

Figure 17: Refined SMP indicator using linear interpolation between 1992 and 1997



A further consideration is that three countries joined the EU in 1995 (Austria, Finland and Sweden), after the beginning of implementation of the SMP for existing members. It is possible that these three countries implemented many of the SMP reforms at a similar time as preparation for joining the EU. However, none of these countries is present in any of the samples used for our main econometric results.

We also use variation in the expected effects of the SMP at a disaggregated industry level using data contained in Buigues et al (1990). We discuss how we do this in section 3 of the main text. The data in Buigues et al (1990) provide the share of total manufacturing employment that falls into each of the affected sectors in each country. We match the sectors to the 2-digit industries in the industry-level dataset, and then calculate the proportion of employment in the two-digit industry accounted for by 3-digit sectors in each of the affected groups. Non-SMP countries are given values of zero for all 2-digit industries.

9.4 Other Regulations

9.4.1 Labour market regulations

While our main focus is the impact of product market reforms, the results of our previous study and the literature review suggest that it can be important to control for the effect of labour market regulations on the measured mark-up and other macroeconomic outcomes. For example, Blanchard and Giavazzi (2003) and Boulhol (2005) discuss the possibility that rising measured aggregate mark-ups in Europe over the 1980s and 1990s may be partly a short-term result of declining bargaining power of workers. In addition, as discussed in the literature review, there are several reasons why labour market regulations may have an impact on rates of innovation. It is also possible that the effect of product market reforms may depend on the nature of regulation in the labour market.

In the previous study (Griffith and Harrison (2004)) we used a summary index of labour market regulation provided by the Fraser Institute. In this study we investigate the impact of more detailed indicators of specific aspects of labour market regulation, including the tax wedge between gross wages and consumption, employment protection legislation, union bargaining coverage, benefit replacement ratios and bargaining coordination indices. Sources for this data include the OECD, Nickell et al (2005) and the World Bank.

9.4.2 Financial market regulations

As in our previous study, we also examine the impact of controlling for various aspects of financial market regulation. Efficient financial markets may have an impact on competition in the product market, for example by providing easy access to credit for new entrants. As with labour market regulations it is possible that the impact of product market reforms depends on the nature of regulation in financial markets. Our main source of information on financial market regulation is the Fraser Institute indices of financial market regulation. However, as we discuss in the main text, our attempts to investigate the role of financial market regulation have been hindered by the fact that there is not very much variation in the extent of regulation across the countries in our sample during the sample period.

10 Measuring the mark-up

As discussed, 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. To capture this we construct a measure of the mark-up, or profitability, at the whole economy level, and for sub-sectors of the economy including manufacturing and business service sector industries. The mark-up is not the only measure of competition in a market, but as discussed in Boone (2000) it is more robust than many commonly used measures, particularly those based on market concentration and market shares. In addition, the mark-up is the only commonly-used measure of competition that is available across countries without using firm-level data. Factors other than competition may affect our measure of the mark-up (or profitability), in particular cost and demand shocks. However our strategy is to used indicators of product market regulations as instruments for the mark-up in order to isolate variation in the mark-up that is associated with changes in competition.

We construct a mark-up of value added over costs as follows:

$$markup = \frac{ValueAdded}{LabourCosts + CapitalCosts},$$

where all variables are in nominal prices. This simple measure of the mark-up can be shown to be equivalent to that proposed by Roeger (1995),[57] 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.

Another 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 then calculate the cost of capital in several ways using interest rates, rates of depreciation and capital deflators. Our preferred "open economy" measure assumes that capital flows freely across borders so that all countries face a world interest rate, which we model as the US interest rate. We may also want to consider how the markup varies independently of

[57] See Klette (1999) for a discussion.

changing capital costs. To do this we also construct a measure based on a fixed 10% of the capital stock in all years for all countries, which is close to the average for the "open economy" measure. Finally, the opposite extreme to the "open economy" measure is based on the assumption that capital markets are closed and uses national interest rates to construct the cost of capital. The true situation is that some countries have increased their openness to capital flows during the period we examine. This could raise the possibility of spurious correlation between the markup and product market reforms if financial market reforms are correlated with product market reforms. However as mentioned in the main text, we check that none of our main results is sensitive to the treatment of capital costs.

We consider our approach to measuring the markup to be more transparent and less subject to modeling error than other approaches in the literature. The measurement of capital costs is always problematic, but as 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.

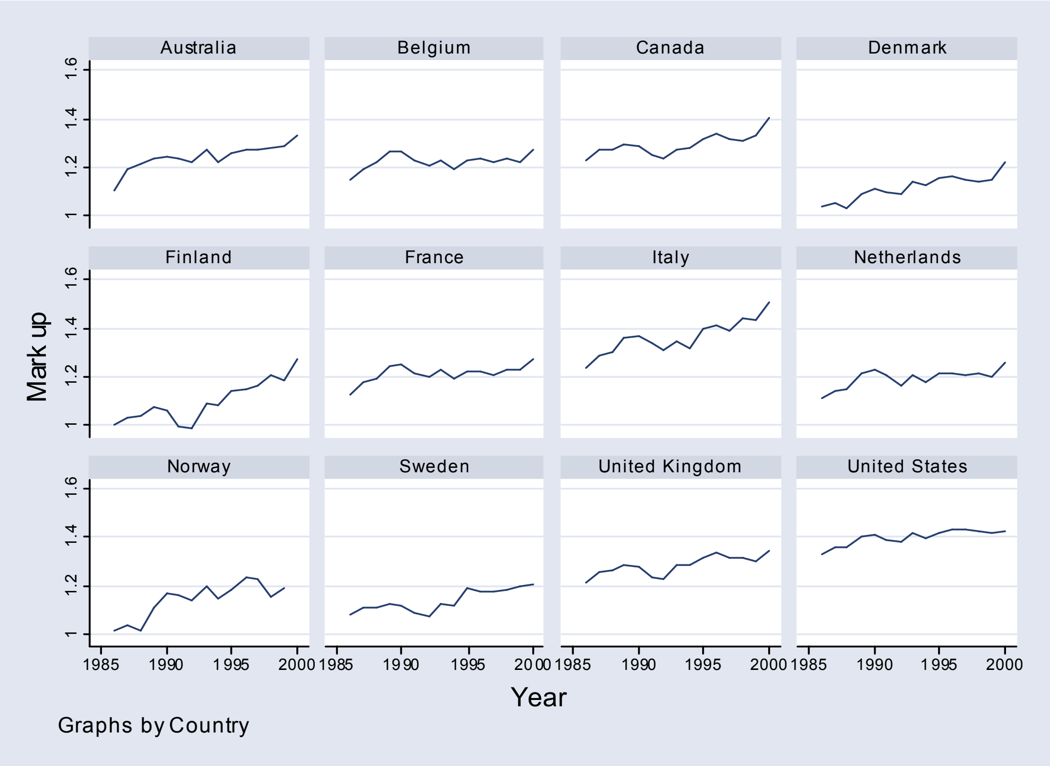
Figure 18 shows our "open economy" measure of the mark-up at the whole economy level for selected European countries and the USA over the period 1986-2000.[58] Several features of the data emerge from the figure. First, there is wide and sometimes surprising variation in the average level of the mark-up across countries. For example, the US has one of the highest mark-ups, 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 the mark-up, 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 are based on time-series variation in mark-ups *within* countries and/or industries.

The second surprising feature of the measured mark-up is that it appears to trend upwards over time for most countries. At first this may seem to conflict with most preconceptions

[58] In our econometric work we also use the greater differential variation in the mark-up over time at the industry level, but this is difficult to present graphically.

about changes to competition associated with product market reforms, globalisation and opening to trade. One explanation, emphasised by Blanchard and Giavazzi (2003) and Boulhol (2005), is that upwards trending measured mark-ups 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 the mark-up 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 investigate including proxies for workers' bargaining power in our regressions, such as union density, bargaining coverage, benefit replacement rates and employment protection legislation.

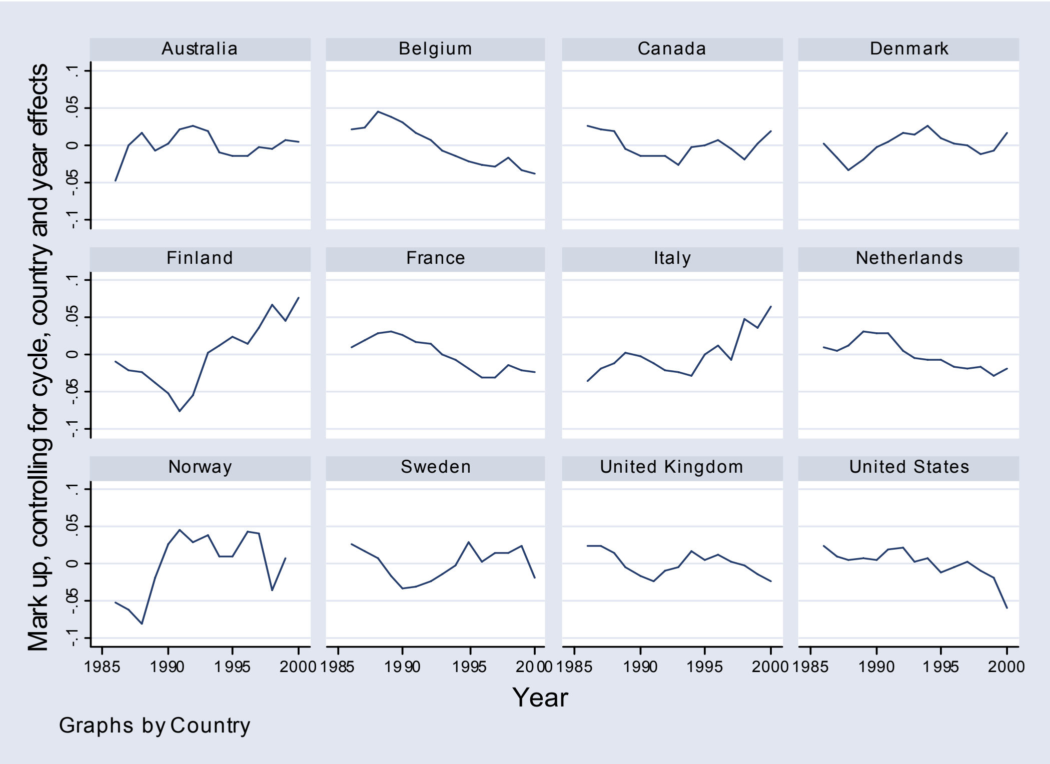
Figure 18: Measured markup for selected countries, 1986-2000



Source: Authors' calculations using OECD STAN database

Figure 19 shows the same measure of the mark-up after controlling for the economic cycle, country and year dummies (our measured mark-ups tend to be pro-cyclical, particularly in manufacturing). The Figure shows the remaining within-country variation that we will relate to our measures of product, labour and financial market regulations. Our two stage instrumental variables approach should also help to control for any remaining measurement error in the mark-up that is not correlated with our measures of regulation.

Figure 19: Measured mark-up after controlling for cycle, country and year effects



Source: Authors' calculations using OECD STAN database and OECD output gap measure

Several trends are noticeable in the figure above. First, some countries that experienced particularly severe recessions during the period still show significant cyclical variation even after controlling for the economic cycle, in particular Finland, Sweden and the UK at the beginning of the 1990s. While this reduction in the mark-up over this period probably was associated with increases in competitive pressure, any excess variation should be removed once we instrument the mark-up with our indicators of product market regulation.

Secondly, all of the Single Market Programme countries show a reduction in the adjusted mark-up over the period apart from Denmark and Italy.[59] In particular, Belgium, France and the Netherlands show a strong downwards sloping trend starting in the early 1990s. On average, comparing the periods before and after 1992, the SMP countries show a reduction in

[59] We discuss in section 5.1 of the main report how the Scandinavian countries appear to have very different paths of both the markup and various innovation indicators.

the average mark-up compared to non-SMP countries of about three percentage points. This is reflected in our econometric results, where we find a significant negative impact of the SMP on measured mark-ups, particularly in manufacturing.

11 Additional results

This Appendix provides additional results.

Table V.1: R&D intensity, SMP countries only

	(1) OLS	(3) IV	(4) Reduced Form
Mark-up	-0.118***	-0.505***	
(industry)	(0.022)	(0.127)	
Output Gap	0.001	0.004*	0.000
	(0.001)	(0.002)	(0.001)
SMP group 1			0.069
			(0.055)
SMP group 2			0.112***
			(0.021)
SMP group 3			-0.271
			(0.172)
SMP group 4			0.023
			(0.016)
Partial R2 of excl. instr.		0.028	
F-test of excl. instr.		4.66	
		(0.001)	
Hansen J test of overid.		5.89	
		(0.117)	
Observations	554	554	554
R-squared	0.83		0.82

*Notes: all specifications include a full set of country, industry and year dummies. Robust standard errors in brackets, apart from statistical tests, where p-values are in brackets. The sample consists of 12 two-digit industries or groups of industries across 5 SMP countries over the period 1987-2000. *, ** and *** indicate significance at 10%, 5% and 1% levels respectively.*
SMP group 1: High-tech, public procurement markets
SMP group 2:Traditional public procurement and regulated markets (high price dispersion)
SMP group 3: Traditional public procurement and regulated markets (low price dispersion)
SMP group 4: Moderately affected sectors

Table V.2: R&D intensity, interaction with DTF

	(1) OLS	(2) OLS	(5) IV-int
Mark-up $_{t-1}$	-0.055***	-0.074***	-0.204*
	(0.012)	(0.018)	(0.108)
Distance to Frontier $_{t-1}$	-0.025***	-0.061**	0.157
	(0.006)	(0.027)	(0.111)
Mark-up $_{t-1}$ * DTF $_{t-1}$		0.032	-0.154
		(0.022)	(0.097)
Output Gap $_{t-1}$	0.000	0.000	0.002
	(0.001)	(0.001)	(0.001)
SMP Group 1 $_{t-1}$			-0.170***
			(0.041)
SMP Group 3 $_{t-1}$			0.168*
			(0.087)
Partial R2 of excl. instr.			0.034
Partial R2 (interaction)			0.044
F-test of excl. instr.			11.59
(p-value)			(0.000)
F-test (interaction)			14.42
(p-value)			(0.000)
Hansen J test of overid.			0.66
(p-value)			(0.718)
Observations	1122	1122	1122
R-squared	0.66	0.66	

*Notes: all specifications include a full set of country, industry and year dummies. Robust standard errors in brackets, apart from statistical tests, where p-values are in brackets. The sample consists of 12 two-digit industries or groups of industries across 9 countries over the period 1987-2000. Excluded instruments in columns (3) and (4) are the impact of the SMP on Groups 2 and 4, and in column (5) are these plus their interactions with distance to frontier, all lagged by one period. *, ** and *** indicate significance at 10%, 5% and 1% levels respectively.*
SMP group 1: High-tech, public procurement markets
SMP group 2:Traditional public procurement and regulated markets (high price dispersion)
SMP group 3: Traditional public procurement and regulated markets (low price dispersion)
SMP group 4: Moderately affected sectors

Table V.3: TFP growth, SMP countries only

	(1) OLS	(2) OLS	(3) OLS	(4) IV	(5) IV	(6) IV	(7) Reduced Form
R&D/VA	0.266**		0.148	0.578**		0.710	
	(0.133)		(0.161)	(0.271)		(0.495)	
Mark-up (industry)		-0.113**	-0.092		-0.233*	0.107	
		(0.049)	(0.058)		(0.125)	(0.269)	
Distance to Frontier	0.038***	0.023	0.027*	0.043***	0.010	0.056	0.030**
	(0.014)	(0.015)	(0.016)	(0.016)	(0.021)	(0.041)	(0.014)
Output Gap	-0.001	0.000	0.000	-0.001	0.001	-0.002	-0.001
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)
SMP group 1							0.056
							(0.049)
SMP group 2							0.096*
							(0.055)
SMP group 3							-0.159
							(0.131)
SMP group 4							0.010
							(0.024)
Hansen J test of overid.				2.65	6.88	2.51	
				(0.449)	(0.076)	(0.285)	
Observations	508	508	508	508	508	508	508
R-squared	0.17	0.18	0.18				0.16

*Notes: all specifications include a full set of country, industry and year dummies. Robust standard errors in brackets, apart from statistical tests, where p-values are in brackets. The sample consists of 12 two-digit industries or groups of industries across 5 SMP countries over the period 1988-2000. All right hand side variables are lagged by one period. *, ** and *** indicate significance at 10%, 5% and 1% levels respectively.*
SMP group 1: High-tech, public procurement markets
SMP group 2:Traditional public procurement and regulated markets (high price dispersion)
SMP group 3: Traditional public procurement and regulated markets (low price dispersion)
SMP group 4: Moderately affected sectors

11.1 Labour market regulations

In this section we consider the impact of labour market regulations on patenting and R&D expenditure. The results show that the impact varies considerably across different types of regulation. We also investigated whether the impact of changing competition varied with the extent of labour market regulations, but no clear picture has yet emerged. A full examination of these issues is beyond the scope of this study.

Table V.4: Labour market regulations: effect on patents per 1000 population

	(1) All	(2) All GMM	(3) Entrants	(4) Entrants GMM	(5) Incumbents	(6) Incumbents GMM
Markup (manufacturing)	-0.466*	-0.396	-0.062	0.755***	-0.404*	-1.368**
	(0.254)	(0.532)	(0.074)	(0.165)	(0.214)	(0.478)
Employment protection legislation	-0.540***	-0.444***	-0.118***	-0.121***	-0.422***	3.166***
	(0.090)	(0.082)	(0.024)	(0.019)	(0.078)	(2.200)
Benefits replacement rate	-0.503**	-0.583***	0.046	0.103*	-0.549***	0.160
	(0.181)	(0.191)	(0.058)	(0.062)	(0.147)	(0.567)
Tax wedge on labour	-0.020**	-0.014**	-0.008***	-0.006**	-0.012*	-0.037*
	(0.008)	(0.007)	(0.002)	(0.002)	(0.007)	(0.019)
Coordination index	-0.123**	-0.049	0.008	0.032*	-0.130**	-0.204**
	(0.062)	(0.056)	(0.020)	(0.017)	(0.052)	(0.091)
Bargaining coverage	0.002	0.003	-0.001	-0.001	0.004**	0.012**
	(0.002)	(0.002)	(0.001)	(0.000)	(0.002)	(0.005)
Union density	0.038***	0.035***	0.013***	0.012***	0.025***	0.030***
	(0.005)	(0.005)	(0.002)	(0.001)	(0.004)	(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. *, ** and *** indicate significance at 10%, 5% and 1% levels respectively.*

Table V.5: Labour market regulations: effect on log R&D and R&D intensity

	(1) Ln(R&D)	(2) R&D/VA	(3) First stage	(4) IV - Ln(R&D)	(5) IV - R&D/VA
Mark-up (industry)	-0.454***	-0.055***		-5.947***	-0.394***
	(0.174)	(0.012)		(1.166)	(0.089)
Distance to Frontier	-0.118	-0.026***	0.031	0.060	-0.013
	(0.091)	(0.006)	(0.028)	(0.186)	(0.011)
Output Gap	0.001	0.001	0.010***	0.062**	0.005***
	(0.014)	(0.001)	(0.003)	(0.026)	(0.002)
CMR index	0.100	-0.011	-0.092***	-0.528*	-0.052***
	(0.166)	(0.009)	(0.035)	(0.292)	(0.019)
Union density	0.001	0.000	0.001	0.009	0.001
	(0.005)	(0.000)	(0.001)	(0.008)	(0.001)
Employment protection legislation	-0.212*	-0.023***	0.012	-0.170	-0.022*
	(0.125)	(0.008)	(0.028)	(0.196)	(0.012)
Tax wedge on labour	0.026*	0.000	-0.004	0.006	-0.001
	(0.014)	(0.001)	(0.003)	(0.023)	(0.001)
Benefits replacement rate	-0.056	-0.009	0.048	0.579	0.035
	(0.995)	(0.065)	(0.185)	(1.451)	(0.095)
Coordination index	-0.151	0.001	0.025	0.007	0.013
	(0.131)	(0.009)	(0.030)	(0.206)	(0.013)
SMP group 1			-0.131*	-1.704***	-0.169***
			(0.070)	(0.486)	(0.041)
SMP group 2			0.029		0.170*
			(0.123)		(0.088)
SMP group 3			-0.296***		
			(0.068)		
SMP group 4			-0.089***		
			(0.024)		
Observations	*1122*	*1122*	*1122*	*1122*	*1122*
R-squared	0.89	0.66	0.49		

*Notes: all specifications include a full set of country, industry and year dummies. Robust standard errors in brackets. The sample consists of 12 two-digit industries or groups of industries across 9 countries over the period 1987-2000. All right hand side variables are lagged by one period. *, ** and *** indicate significance at 10%, 5% and 1% levels respectively.*
SMP group 1: High-tech, public procurement markets
SMP group 2:Traditional public procurement and regulated markets (high price dispersion)
SMP group 3: Traditional public procurement and regulated markets (low price dispersion)
SMP group 4: Moderately affected sectors

12 Data sources

Our main data sources are the following:

- OECD ANBERD database (2004)
- OECD STAN database (2004)
- OECD MSTI database (2004)
- OECD Economic Outlook (2004)
- OECD Triadic Patents Database (2004)
- EPO / OECD Citations Database (2005)
- OECD International Regulation Database (2000, and updated 2005)
- Entry and exit data from Dunn and Bradstreet 1997-2003, used in Cincera and Galgau (2005)
- Fraser Institute Economic Freedom of the World index (2004)
- Data on expected impact of the SMP from Buigues et al (1990)
- The EU Internal Market Scoreboard (1997-2000)