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Product Market Reform and Innovation in the EU*

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Abstract

European Union countries have implemented widespread reforms to product markets to stimulate competition, innovation, and economic growth. We provide empirical evidence that the reforms carried out under the EU Single Market Programme (SMP) were associated with increased product market competition, as measured by a reduction in average profitability, and with a subsequent increase in innovation intensity and productivity growth for manufacturing sectors. Our analysis exploits exogenous variation in the expected impact of the SMP across countries and industries to identify the effects of reforms on average profitability, and the effects of profitability on innovation and productivity growth.

Keywords: Competition; innovation; productivity growth

JEL classification: *L*1; *O*31; *O*47

I. Introduction

Over the last two decades, EU member states and other OECD countries have implemented widespread reforms to product markets with the aim of stimulating competition and raising rates of innovation and growth.[1]

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[1] See Buigues, Ilzkovitz, and Lebrun (1990) and Conway, Janod, and Nicoletti (2005) for discussions of earlier and recent reforms, respectively. Lower innovation rates are widely seen as a reason for lagging EU productivity growth. The "Barcelona Target" aims to raise R&D investment to 3% of EU GDP, and the Lisbon Agenda contains an aspiration to become "the most competitive and dynamic knowledge-based economy in the world" by 2010.

Economic theory suggests that changes in the degree of product market competition will affect the incentives firms face to engage in innovative activity, but is ambiguous as to whether incentives will increase or decrease. In this paper, we empirically investigate the impact that past reforms, in the form of the Single Market Programme (SMP), had on innovation activity in the EU.

This paper makes two advances over the existing literature. The first is that we pay careful attention to the source of identification. We exploit exogenous variation in product market conditions that arises from the EU Single Market Programme; this varied over time, industries, and EU countries; additionally, some countries were part of the EU while others were not. The use of these time–country–industry varying indicators allows us to identify the reduced-form impact of product market reforms separately from other contemporaneous changes in the economic environment. The second contribution is that we explicitly consider the effect of product market reforms on profits as the key channel through which they affect firms' incentives to innovate, in contrast to studies that relate product market reforms directly to outcomes.[2] As well as being motivated by theory, our approach provides direct evidence on the impact of the SMP reforms on competition, innovation, and productivity growth, which is of interest in the context of the EU's Lisbon Agenda and other potential future reforms.

The SMP was a significant, large-scale programme of reforms carried out by EU member states in the early 1990s to reduce internal non-tariff barriers to trade and open up competition. Changes to national legislation aimed to reduce administrative and regulatory trade barriers and increase cross-border public procurement. Analysis carried out by the European Commission before implementation identified the extent to which industries and countries were expected to be affected by the reforms. We use this information to construct indicators of reform that vary differentially over time across countries and industries. We focus our analysis on the manufacturing sector, because this is where the reforms had the greatest impact and is also where the majority of research and development (R&D) is carried out.[3]

Our findings suggest that the SMP reforms did lead to an increase in product market competition (as measured by a reduction in average profitability) in at least some affected countries and industries, and this in turn led to an increase in R&D investment. We also find evidence that

[2] For example, see Nicolleti and Scarpetta (2003).

[3] Network industries also experienced substantial reforms. However, the nature of reforms and the processes driving innovation in these industries differ substantially from the rest of the economy and require detailed modelling of each industry.

increased R&D intensity fed through into faster total factor productivity (TFP) growth.

The paper relates to two strands of the empirical literature. First, a number of studies investigate the relationships between competition, innovation, and productivity growth using firm-level data within a single country,[4] and a few consider the impact of the SMP (though not on innovation).[5] Second, there is a small but growing body of literature investigating the impact of product market reforms using data across countries.[6] Most related to our work are three studies that examine the impact of the SMP across countries—Allen, Gasiorek, and Smith (1998) find that the SMP reduced barriers to trade and was associated with reductions in price–cost margins, Badinger (2007) also finds evidence of reduced mark-ups in manufacturing, and Notaro (2002) finds that the SMP was associated with significant productivity gains.

Firm heterogeneity has been emphasised in recent theoretical and empirical research. Melitz and Ottaviano (2008) develop a model in which market size and trade liberalisation affect the degree of product market competition. An increase in market size, such as that brought about by a move to free trade, leads to a decrease in average mark-ups and an increase in average productivity. Firms respond to an increase in competition by decreasing mark-ups, and the least productive firms exit. In addition, increased opportunities to export through market enlargement can raise the returns to productivity-enhancing investments such as innovation.[7] Lileeva and Trefler (2007) find that lower productivity plants, which were induced to start exporting by tariff cuts made under the Canada–US Free Trade Agreement, engaged in both greater product innovation and technology adoption, and increased their labour productivity. Our use of data at the country–industry–year level will necessarily mask heterogeneous responses at the firm level (for example, by firms with different productivity levels, or between exporting and non-exporting firms), and compositional changes.[8] What we identify is the overall net effect.

[4] These include Nickell (1996), Blundell, Griffith, and Van Reenen (1999), and Aghion, Bloom, Blundell, Griffith, and Howitt (2005), which relate competition to innovation, Harrison (1994) which looks at the effects of trade liberalisation on competition and productivity, and Pavcnik (2002) and Scarpetta, Hemmings, Tressel, and Woo (2002) on productivity and industrial restructuring.

[5] See, *inter alia*, Bottasso and Sembenelli (2001) and Gullstrand and Johansson (2005).

[6] See Salgado (2002), Nicoletti and Scarpetta (2003), and Alesina, Ardagna, Nicoletti, and Schiantarelli (2005).

[7] For theoretical models encompassing this type of effect see, for example, Ekholm and Midelfart (2005), Yeaple (2005), Lileeva and Trefler (2007), Costantini and Melitz (2008), and Ederington and McCalman (2008).

[8] European Commission (2002) reports that exports from the EU to developing countries increased from 6.9% of EU GDP in 1992 to 11.2% in 2001, and inflows of foreign direct investment more than doubled as a percentage of GDP. Scarpetta *et al.* (2002) show

The paper is structured as follows. In the next section we discuss the theoretical background and our empirical strategy. Section III describes the data. Section IV presents our results, and a final section concludes.

II. Theoretical Background and Empirical Strategy

The theoretical literature on product market competition and growth emphasises the importance of economic profits in providing incentives for firms to innovate, but it is inconclusive regarding the direction of effect. Greater competition may increase incentives for incumbent firms to reduce slack,[9] or to innovate in order to protect or enhance their market position (i.e., an "escape-competition effect").[10] On the other hand, increased competition may reduce the rewards to innovation or entry into a market and thus discourage these activities (a "Schumpeterian effect").[11]

A recent strand of the literature has attempted to bring these two effects together in a single model.[12] These models predict that innovation is initially increasing and then decreasing in the strength of product market competition. A key feature of these models is that firms innovate "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. Two types of industries can be distinguished: those where firms are very close technologically, "neck-and-neck" industries, and those where firms are unequal, "unlevelled" industries. Firms compete in a duopoly setting where the intensity of competition is modelled as a function of the degree of substitutability between the goods produced by the two firms, and where in an unlevelled industry only the leader can make a positive profit. In neck-and-neck industries, the escape-competition effect dominates and greater product market competition increases innovation incentives, since the reward to innovation in the form of increased profits becomes higher. In unlevelled industries the Schumpeterian effect is expected to dominate and greater competition may reduce innovation incentives, since the laggard firm's *ex post* reward to catching up with the technological leader falls as product market competition intensifies.

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that productivity patterns in OECD countries are largely the result of within-firm performance. Pavcnik (2002) shows that exit (of relatively unproductive firms) results from trade liberalisation in Chile.

[9] See, for example, Hart (1983) and Schmidt (1997).

[10] See Gilbert and Newbury (1982) and Aghion *et al.* (2001, 2005).

[11] This is at work in the growth models of Grossman and Helpman (1991) and Aghion and Howitt (1992), and can be seen in models of rent dissipation; for example, Arrow (1962) and Tirole (1998).

[12] These include Aghion and Howitt (1998, Ch. 7) and Aghion *et al.* (1999, 2001, 2002, 2005, 2009).

The economy-wide effect of increasing product market competition on innovation will depend on the mix of neck-and-neck and unlevelled sectors in the economy and on the initial level of competition. In these models, an increase in product market competition increases innovation incentives relatively more in neck-and-neck than in unlevelled industries and acts to reduce the fraction of neck-and-neck industries in the overall economy. This composition effect reinforces the Schumpeterian effect.

Our interest is to identify the aggregate impact of the SMP on innovation. As outlined, these models predict that the effects will depend on the initial level of product market competition and on whether industries are neck-and-neck. In principle we might expect to find evidence of both escape-competition and Schumpeterian effects. However, given the nature of the SMP, our prior is that in this context the escape-competition effect will dominate and that innovation incentives will increase as product market competition strengthens. The aim of the SMP was to reduce non-tariff barriers to competition within the EU, and these policy changes were expected to have a greater impact on countries and industries that were *ex ante* shielded from international competition. At relatively low levels of competition, neck-and-neck industries are expected to be prevalent, and hence greater exposure to international competition as a result of the SMP would be expected to increase innovation incentives.

Moreover, the SMP itself was likely to make industries more neck-and-neck (e.g., by harmonising standards). Our empirical analysis therefore focuses on the linear effect of competition on innovation, although we check for any non-linearity. In line with the discussion above, and with the findings of Nickell (1996) and Aghion *et al.* (2005), we find that the escape competition effect dominates when the relationship is restricted to be linear.

Empirical Approach

Our main empirical model takes the form of a two-stage instrumental variables specification. We assume a linear functional form for both equations. We begin by examining the relationship between product market reforms and the degree of product market competition as measured by the average level of profitability.[13] This is given by

$$\mu_{ijt} = PMR_{ijt}\beta_{PMR} + \alpha_{it} + \eta_{jt} + e_{ijt}, \tag{1}$$

[13] This is in contrast to other papers in the literature, such as Nicoletti and Scarpetta (2003), who aggregate product market reforms into a single index giving indicators equal weight. We use the estimated impact of product market reforms on profitability as a way of aggregating the reforms.

where i indexes industry, j country, t time, μ_{ijt} is the average level of profitability, and PMR_{ijt} is a vector of indicators of product market reforms (both defined in Section III). We also include *industry–time* effects, α_{it}, and *country–time* effects, η_{jt}, to control for unobservables that may be correlated with product market reforms.[14] The parameters of interest are the β-coefficients on the product market reforms. The inclusion of industry–time and country–time effects means that the β-coefficient is identified using differential variation over time within industries and within countries, as well as industry–country variation. If product market reforms are associated with increased competition (i.e., lower average profitability) we would expect these β-coefficients to be negative. The implicit assumption is that the expected effects of the SMP were exogenous for profitability. This seems reasonable since, while the SMP was conceived partly as a response to poor relative economic performance, it was designed at a supranational level by the European Commission.

Equation (1) is used as the first stage in an instrumental variables estimation of the second-stage equation that characterises the relationship between competition and innovation:

$$innov_{ijt} = \beta_\mu \mu_{ijt} + \alpha_{it} + \eta_{jt} + u_{ijt}. \quad (2)$$

The error term here may be correlated with average profitability, which may lead to possible simultaneity bias in a simple OLS estimate. 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, so we include industry–time and country–time dummies. Our key identifying assumption is that we exclude most or all of the product market reforms from the innovation equation. We test the empirical validity of these exclusion restrictions—that is, whether product market reforms directly affect innovation—and we compare the results to an unrestricted reduced form.

As a final exercise we investigate the effect of product market reforms on productivity growth. We relate the growth rate of TFP to the intensity of innovation following the approach of Griliches (1979) and others:

$$\Delta TFP_{ijt} = \beta_I innov_{ijt-1} + \lambda_1 \mu_{ijt-1} + \lambda_2 DTF_{ijt-1} + \alpha_{it} + \eta_{jt} + \varepsilon_{ijt}. \quad (3)$$

Here, as before, we estimate this by instrumental variables, and the excluded instruments are the product market reforms. To start, we exclude profitability from the TFP growth equation ($\lambda_1 = 0$). However, it is possible that product market competition increases productivity directly—for example, through the reallocation of resources towards more productive firms

[14] We show that our main results are also robust to including country–industry and country–time effects.

or activities—and we therefore also consider a more general model where we include measures of both innovation and profitability, and instrument these two variables with the product market reforms. All our specifications include a lagged measure of the distance to the technological frontier at the country–industry–year level (DTF_{ijt-1}), capturing a country's scope for technological catch-up.[15] This is measured by the difference in TFP with respect to the leading country within industry and year. We include industry–time and country–time dummies to control for unobserved factors.

It is likely that the error terms in equations (1), (2), and (3) exhibit some degree of autocorrelation. To allow for this, we use Newey–West standard errors with a maximum lag length of three periods and we check that our results are robust to clustering the standard errors at the country–industry level.

III. Data

We use measures of product market reforms, average profitability, innovation activity, and productivity growth, which we discuss in turn. Our sample consists of an unbalanced panel of nine countries (listed in Table 2) and 12 two-digit manufacturing industries over the period 1987–2000.

Product Market Regulations and Reforms

Our indicators of product market reforms are based on the implementation of the EU SMP. This was a large-scale project by the EU members to reduce internal non-tariff barriers to trade and other barriers to the free movement of factors of production across borders. The reforms involved changes to national legislation aimed at easing the physical movement of goods across borders (e.g., reducing trade administration costs by removing customs documentation); reducing "technical" barriers to trade (e.g., through a programme of "mutual recognition" of other countries' technical standards, and through full technical harmonisation in some sectors, such as pharmaceuticals and motor vehicles); and increasing cross-border public procurement (e.g., through the use of mandatory international tendering for high-value procurement).[16] The SMP was undertaken at the same time across EU countries. To identify the impact of the SMP from other contemporaneous macroeconomic effects, we exploit variation in the impact that the SMP had across different industries and affected countries, and we include countries that were not involved in the SMP as a control group.

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[15] See Cohen and Levinthal (1989), Aghion and Howitt (1998), Howitt (2000), and Griffith, Redding, and Van Reenen (2004) for research that emphasises the role of absorptive capacity and distance to the technological frontier.

[16] See European Commission (2002) for further details.

Our data on the SMP are taken from a European Commission report by Buigues *et al.* (1990).[17] This is based on information contained in the 1988 Cecchini Report and other sources, including an extensive survey of businesses in the participating countries. The report identifies three-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, prior to the implementation of the SMP.[18] The researchers identified a common list of highly and moderately affected industries across all SMP countries and then asked national experts to add or remove industries from the list according to whether the effects of the SMP in their country were expected to deviate from the average expected effects in each sector. For example, an industry in a specific country would be removed if it had lower pre-existing barriers to competition before the implementation of the SMP. Examples include aerospace in the UK and brewing and malting in Denmark, where international competition meant that the SMP was not expected to have a significant impact.

There are therefore two sources of differential variation across SMP countries in the *ex ante* expected impact of the SMP on each industry. First, the identified three-digit sectors make up different shares of employment across countries in the two-digit industries in our sample. A potential limitation is that some of this variation may not be exogenous with respect to the outcomes we are measuring. However, much of the variation reflects long-standing differences in the share of particular activities in countries' manufacturing activity. Second, the fact that some sectors have been removed from the common list at the country level creates further variation. As well as variation across five SMP countries (Belgium, Denmark, France, the Netherlands, and the UK), our main results also use four non-SMP countries as controls (Canada, Finland, Norway, and the US). This introduces a third source of variation in the data.[19] We consider the robustness of our results to dropping non-SMP countries from the sample and using only the first and second sources of identifying variation described above.

The sectors affected by the SMP fall into four main groups. Three 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

[17] Aspects of these data have been used in Mayes and Hart (1994), Allen *et al.* (1998), and Notaro (2002).

[18] This information is contained in Table 26 in the statistical annex of Buigues *et al.* (1990).

[19] These countries were also experiencing reforms; for example, there was trade liberalisation between Canada and the US, and Finland joined the EU in the latter part of our estimation period. What is important for our identification strategy is that the SMP was a bigger reform and that it generated independent variation. The interpretation of the SMP variables should be relative to other contemporaneous reforms.

both designated as "traditional public-procurement and regulated markets" and are distinguished by the degree of measured price dispersion across EU countries 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. The fourth group is sectors that were expected to be moderately affected by the SMP, which includes a broad range of consumer, investment, and intermediate goods. Finally, the reference group includes those sectors and countries that were not affected by the SMP.

Our instruments therefore take the form for each two-digit industry (i), country (j), and year (t):

$$SMP^S_{ijt} = \begin{cases} 0 & \text{if } t < 1992 \\ \sum_{k \in i} w_{kj} I^S_{kj} & \text{if } t \geq 1992 \end{cases} \qquad S = 1, 2, 3, 4, \tag{4}$$

where w_{kj} is the share of employment in three-digit industry k within total employment in two-digit industry i in country j in 1985–1987. I^S_{kj} is an indicator variable that takes the value 1 if the three-digit industry was expected to be affected by the SMP. We allow the estimated effects of the SMP to vary across the four groups of sectors ($S = 1, 2, 3, 4$) discussed above.

Table 1 shows the average share of employment in each two-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 shares, each of which varies across countries and industries, are the variables that we use as instruments in our empirical results. In each case, the variable takes the form of a step-function that is equal to zero in all years prior to 1992 and then rises in 1992 and all subsequent years to the country–industry specific share affected, as shown in equation (4).[20] The table shows that the first group of highly affected sectors are concentrated in the machinery and equipment industry, while the other groups are spread across a range of industries. Group 4 contains the most variation across industries, and as a result contributes much of the explanatory power of our instruments. Only three of the 12 two-digit industries contain no affected sectors. In industries that were not expected to be affected by the SMP, and in all industries in the set of non-SMP control countries, the values of the instruments are equal to zero in all years; that is, SMP $= 0$.

[20] The year in which all the SMP measures were supposed to have been implemented was 1992. In practice, not all countries had implemented all reforms by 1992, but as an indication the European Commission found that nearly 93% of all SMP measures had been transposed into domestic legislation by mid-1996 (Notaro, 2002).

Table 1. *Single Market Programme: average % of two-digit industry employment falling into the different affected groups*

% of employment falling into group:	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	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 US.

Average Profitability

As discussed above, the main channel through which product market reforms are expected to affect innovation incentives and hence innovation outcomes is the level of economic profits in the market. In the models discussed in Section II (see Aghion, Harris, Howitt, and Vickers, 2001 (AHHV) and Aghion *et al.*, 2002), the degree of substitutability between goods in an industry captures the degree of product market competition and can be shown to be a monotonically increasing transformation of the elasticity of demand faced by the firm (given some minimal assumptions). AHHV and Aghion *et al.* (2002) also show that, given a firm's industry share, the Lerner index is a monotonically decreasing function of the substitutability parameter. Boone (2000) shows that the Lerner index is preferred to most other commonly used measures of competition. 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.[21] We use a measure that is an increasing function of the Lerner index: the average level of profitability. We calculate this at the country–industry–year level using the OECD STAN database, which provides information at the two-digit industry level on value-added, labour, and investment. Our measure of average profitability is value-added as a share of labour and capital costs:

$$\mu_{ijt} = \frac{ValueAdded_{ijt}}{LabourCosts_{ijt} + CapitalCosts_{ijt}}, \tag{5}$$

where all variables are in nominal prices. This can be shown to be equivalent to the measure proposed by Roeger (1995) and is equivalent to the price–cost margin under the assumption of constant returns to scale, such that marginal cost is equal to average cost.[22] To the extent that there are increasing (decreasing) returns to scale, this measure will be biased downwards (upwards) compared to the true mark-up that firms charge. 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. For countries where capital deflators are not available we use cross-country averages of those that are available. We calculate the cost of capital assuming open capital markets so that all countries face a world interest rate, for which we use the US long-term interest rate. In our main results we instrument average profitability with exogenous changes

[21] Several studies use a similar measure, including Nickell (1996), Salgado (2002), and Aghion *et al.* (2005).

[22] See Klette (1999) for a discussion. We checked that our results were robust to using a Lerner index measure and a measure of average profitability calculated using sales rather than value-added. We use value-added due to greater data availability.

Table 2. *Descriptive statistics*

	(1) Profitability (standard deviation)	(2) R&D intensity (standard deviation)	(3) ln real R&D expenditure (standard deviation)	(4) Growth in TFP (standard deviation)	(5) Number of observations
SMP countries					
Belgium	1.214	0.051	4.489	0.011	95
	(0.169)	(0.050)	(1.396)	(0.091)	
Denmark	1.128	0.043	5.331	0.010	91
	(0.076)	(0.058)	(1.853)	(0.064)	
France	1.213	0.105	5.978	0.016	82
	(0.186)	(0.160)	(1.230)	(0.097)	
United Kingdom	1.146	0.061	5.435	0.020	150
	(0.117)	(0.065)	(1.556)	(0.050)	
Netherlands	1.248	0.041	4.126	0.012	136
	(0.161)	(0.050)	(1.686)	(0.065)	
Non-SMP countries					
Canada	1.314	0.033	4.892	0.021	161
	(0.231)	(0.049)	(1.409)	(0.050)	
Finland	1.199	0.050	3.601	0.029	140
	(0.197)	(0.042)	(1.234)	(0.064)	
Norway	1.053	0.041	5.045	0.007	108
	(0.107)	(0.043)	(1.380)	(0.061)	
United States	1.241	0.078	7.967	0.016	154
	(0.200)	(0.099)	(1.615)	(0.058)	
Total	1.203	0.055	5.228	0.017	1,117
	(0.187)	(0.075)	(1.963)	(0.065)	

Notes: The sample consists of an unbalanced panel of 12 two-digit industries over nine countries for the period 1987–2000. Profitability is as specified in equation (5). R&D is Business Enterprise Research and Development (BERD). Growth in TFP is as specified in equation (6).

in competition, which should help control for classical measurement error. Assuming that all countries face the same world interest rate might 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. We check the sensitivity of our main results to the alternative assumptions of closed capital markets or a constant cost of capital across countries.[23] The results are not very sensitive to different ways of constructing the cost of capital, and the main conclusions are robust to these alternatives.

Column (1) of Table 2 shows the mean and standard deviation of the profitability variable across industries and time for each country in our sample (we discuss the remaining columns in the next subsection). There

[23] Under the closed capital markets assumption we use a time-varying observed long-term interest rate (from the OECD) for each country. Under the constant cost of capital assumption we use an assumed constant rate of 10%.

is wide, and sometimes surprising, variation in the average level of profitability across countries. For example, on average the US has one of the highest levels, 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 profitability. For this reason it is important that we include country dummies (we include country–time dummies) when we estimate equations (1), (2), and (3).

The second somewhat surprising feature of measured profitability is that it appears to trend upwards over time for most countries. At first this may seem to conflict with preconceptions about changes to the degree of competition associated with product market reforms, globalisation, and opening to trade. This has been noted in the literature, and one explanation, discussed in Blanchard and Giavazzi (2003), is that upward-trending measured profits could be a short-term response to reductions in the bargaining power of workers.[24] There are a range of other factors that might explain this upward trend, including increases in returns to scale. However, what is important from our point of view is that *differential* changes in profitability across countries and industries can be shown to be related to product market reforms in ways that accord with theory; in other words, increased market liberalisation reduces average profitability.

Another feature of our measure of profitability is that it is generally procyclical. We include country–time and industry–time dummies in all regressions to control for this, but there remains a possibility that this will not remove all of the cyclical variation. However, any excess procyclicality in profitability would be likely to induce a positive bias in our OLS estimates. For example, if R&D or productivity growth is procyclical (as we find in our data), excess cyclicality in average profitability could bias the coefficient on profitability in a positive direction, meaning that the magnitude of our results would be understated (we find negative coefficients on average profitability).

Innovative Activity and Total Factor Productivity Growth

Our main measure of innovation activity is Business Enterprise R&D (BERD) expenditure from the OECD ANBERD database. There is substantial variation in business sector R&D intensity both across and within countries. For example, between 1981 and 2001 BERD as a percentage

[24] The intuition is that declining bargaining power reduces the share of rents that is captured by workers as wages and increases the share that is measured in firms' profits. In the long term, the increase in profitability 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.

of GDP in Finland increased by more than 1.5 percentage points, whereas in the UK it decreased by 0.25 percentage points. We use these data at the country–industry–year level. Columns (2) and (3) of Table 2 show the means and standard deviations for the two indicators of innovation activity that we use in our analysis: R&D intensity (R&D expenditure as a percentage of value-added), which is our main measure; and log real R&D expenditure, which we use as a robustness check.

We measure TFP growth using a superlative index (Caves, Christensen, and Diewert, 1982a,b) using data from the OECD STAN database. The growth rate of TFP for a country–industry is defined as

$$\Delta TFP_{ijt} = \ln(V_{ijt}/V_{ijt-1}) - \tilde{\alpha}_{ijt,t-1}\ln(L_{ijt}/L_{ijt-1}) - (1-\tilde{\alpha}_{ijt,t-1})\ln(K_{ijt}/K_{ijt-1}), \quad (6)$$

where V denotes real value-added in US dollars (we use country–industry specific deflators and convert to US dollars using an economy-wide PPP); $\tilde{\alpha}_{ijt,t-1}$ is the average labour share over t and $t-1$, defined as $\tilde{\alpha}_{ijt,t-1} = 1/2(\alpha_{ijt} + \alpha_{ijt-1})$; L is numbers employed; and K is real capital stock in US dollars (we use country–industry specific deflators and convert to US dollars using an economy-wide PPP).[25] Column (4) of Table 2 provides descriptive information on our TFP growth measure.

IV. Empirical Results

We now turn to our empirical results. We first discuss the impact of product market reforms on product market competition and R&D, including a number of robustness checks. Then we discuss our results for productivity growth.

The Impact of Product Market Reforms on R&D

We start by considering the relationship between product market reforms and profitability, the first stage of the IV estimation, in Table 3. In column (1) we include separate country dummies, industry dummies, and time dummies. In column (2) we include country–time and industry–time dummies, meaning that we identify the coefficients of interest from differential variation in the indicators of product market reforms over time within countries and industries and from variation at the country–industry level. The partial R-squareds and F-tests for joint significance of the SMP variables at the bottom of the table show that the instruments have explanatory power.

[25] The measured share of labour in value-added can be volatile, which might suggest measurement error. We check that standard approaches to smoothing (see Harrigan, 1997) do not affect our results.

For example, the value of the F-statistic for the four SMP variables in column (2) is above the critical values for the test of weak instruments provided by Stock and Yogo (2004). Looking at how the impact varies across different industry groups we see that for industries in Groups 2 and 4 (public procurement and regulated markets with high price dispersion, and moderately affects sectors, respectively), the SMP was associated with a statistically significant lower level of profitability, while for Groups 1 and 3 the coefficients are negative but statistically insignificant.[26]

Column (2) of Table 3 is our preferred specification. In column (3), we include only SMP participant countries, removing one source of variation and identifying the effects of the SMP purely from variation across participant countries. All of the coefficients are less precisely estimated, as expected. However, a strong negative impact from the moderately affected sectors, Group 4, remains and provides most of the explanatory power. As can be seen in Table 1, there are many moderately affected sectors, providing substantial variation in our data. However, the F-test and partial R-squared are significantly lower than in the first two columns, indicating the possibility of weak instruments in this restricted sample.[27]

We now turn to the relationship between competition and innovation in Table 4. In the OLS specification in column (1) we find a small effect of competition (lower profitability) on R&D intensity.[28] Column (2) shows IV results, which indicate a much stronger relationship between increased competition and innovation. As expected, this suggests an upward bias in the OLS results, for example due to reverse causality from R&D intensity to profitability, or possibly as a result of attenuation bias. However, the Hansen test of over-identifying restrictions (i.e., whether the SMP

[26] Our main results use Newey–West standard errors with the maximum lag length set to three periods. The results are not sensitive to the maximum lag length used. The results are also generally robust to clustering the standard errors by country–industry. For example, the standard error on SMP Group 2 in column (1) increases from 0.110 to 0.164 in this case, while the standard error on SMP Group 4 increases from 0.032 to 0.039.

[27] It is possible that the reduction in profits is driven by a temporary increase in costs as firms ramp up production in anticipation of a larger market. We do not think this is driving our results, for two reasons. First, it is likely that this would have occurred prior to 1992, making profitability appear lower in the pre-SMP period and leading us to understate any subsequent reduction post-SMP. Second, if the temporary increase did occur post-1992, then later, as sales increased and costs decreased, we would expect profitability to rise at the end of our estimation period. We found no evidence of this effect.

[28] In line with the theoretical model in Section II, we examined the presence of a non-linear relationship by including an additional profitability squared term. The estimated coefficients (standard errors) on the profitability and profitability squared variables are −0.294 (0.235) and 0.087 (0.086), in an OLS specification as in column (1) of Table 4. The signs of these coefficients are in line with an inverted-U relationship, but since there is insufficient variation in the data to identify this precisely we focus on a linear relationship in our results.

Table 3. *First-stage reduced form: profitability and the SMP*

Dep. var.: profitability	(1) Full sample	(2) Full sample	(3) SMP countries only
SMP Group 1	−0.173	−0.247	−0.163
	(0.122)	(0.162)	(0.174)
SMP Group 2	−0.295	−0.358	−0.050
	(0.110)***	(0.102)***	(0.090)
SMP Group 3	−0.042	−0.273	−0.220
	(0.181)	(0.210)	(0.304)
SMP Group 4	−0.109	−0.137	−0.157
	(0.032)***	(0.040)***	(0.053)***
Country dummies	Yes	No	No
Industry dummies	Yes	No	No
Year dummies	Yes	No	No
Country–year dummies	No	Yes	Yes
Industry–year dummies	No	Yes	Yes
F-statistic	10.85	12.25	2.74
Partial *R*-squared	0.039	0.051	0.027
Observations	1,117	1,117	554
R-squared	0.49	0.59	0.58

Notes: Robust Newey–West standard errors in parentheses with maximum lag length set to 3; the sample in columns (1) and (2) consists of 12 two-digit industries or groups of industries across nine countries (five are SMP countries—Belgium, Denmark, France, the Netherlands, and the UK; and four are non-SMP countries—Canada, Finland, Norway, and the US) over the years 1987–2000. In column (3) only the five SMP countries are included.

F-statistic is a test of the joint significance of the SMP variables. The partial *R*-squared is for the SMP variables.

*, **, and *** indicate significance at the 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.

variables can legitimately be excluded from the R&D regression) is rejected. This is due to a direct negative effect of the SMP on R&D in Group 1 sectors, as shown when this variable is included directly in column (3). Now the Hansen test does not reject the three remaining exclusion restrictions.

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 directly reduced R&D expenditure. This may explain why the data reject the hypothesis that the Group 1 variable can legitimately be excluded from the equation conditional on profitability.

Table 4. *R&D intensity*

Dep. var.: R&D/VA	(1) OLS	(2) IV	(3) IV	(4) Reduced form
Profitability	−0.073 (0.024)***	−0.295 (0.088)***	−0.452 (0.114)***	
SMP Group 1			−0.245 (0.091)***	−0.190 (0.064)***
SMP Group 2				0.163 (0.031)***
SMP Group 3				0.347 (0.147)**
SMP Group 4				0.063 (0.018)***
Country–year dummies	Yes	Yes	Yes	Yes
Industry–year dummies	Yes	Yes	Yes	Yes
F-statistic	—	12.25	13.11	—
Partial R-squared	—	0.051	0.042	—
Hansen J-test	—	11.93	2.27	—
(p-value)		(0.008)	(0.322)	
Observations	1,117	1,117	1,117	1,117
R-squared	0.67	0.64	0.64	0.69

Notes: Robust Newey–West standard errors in parentheses with maximum lag length set to 3; the sample consists of 12 two-digit industries or groups of industries across nine countries over the period 1987-2000.
F-statistic is a test of the joint significance of the excluded SMP variables in the first-stage regression; the partial R-squared is for the SMP variables in the first-stage regression (see Table 3). The Hansen J-test is a test of the exclusion restrictions.
*, **, and *** indicate significance at the 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 column (4) we examine the direct reduced-form impact of the SMP variables on innovation. The estimated coefficients are consistent with the two-stage IV results. For example, combining the coefficient of −0.137 on the moderately affected sectors (Group 4) in column (2) of Table 3 with the coefficient of −0.452 on profitability in column (3) of Table 4 suggests an indirect impact on R&D intensity of about 0.06, which is close to the direct estimated impact of 0.063 in column (4) of Table 4. The reduced-form coefficients are also larger for the highly affected groups (2 and 3). The implication of these results is that the reduced-form impact of the SMP variables on innovation is consistent with their effects via the profitability variable. This explains why the exclusion restrictions are not rejected in the IV specification in column (3). As discussed above, the exception is the Group 1 variable, which appears to have an additional direct negative impact on innovation.

In terms of the economic magnitude of our estimated effects, the coefficient on profitability in column (3) of Table 4 suggests that a fall of one percentage point in profitability is associated, on average, with an increase of 0.45 percentage point in R&D intensity. For example, consider the impact of the SMP on the chemicals industry in the UK, one of the most highly affected industries in the sample. Thirty percent of employment in the industry fell into Group 2 of highly affected sectors, and 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 (2) of Table 3, our estimates predict that the SMP was associated with average profitability in the sector that was 16 percentage points lower than in the absence of the SMP. In fact the average level of profitability in the sector in the UK only fell by about one percentage point over the period, but this is in stark contrast to the *increases* experienced in some other non-SMP countries such as Finland and the US, where average profitability in the sector rose by 15 and 13 percentage points, respectively. Combining this effect with the coefficient on profitability in column (3) of Table 4 suggests that the SMP was associated with R&D intensity that was 7.3 percentage points higher than in the absence of the SMP. We can compare this to the reduced-form coefficients on the SMP variables in column (4) of Table 4, which also generate a predicted increase in R&D intensity of 7.3 percentage points. The actual increase in R&D intensity in the industry over the period was just over 10 percentage points (from 12.4% in 1987 to 22.8% in 2000). 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 increased by far less than it did.

Robustness

We address two concerns with regard to the robustness of our results. First, we ensure that our results are not driven by the impact of the SMP on output (i.e., the denominator of R&D intensity). Second, we exclude non-SMP countries from the control group and identify the effects of the SMP from variation across industries in SMP countries only. We also address a number of more specific points.

Table 5 shows results using log real R&D expenditure instead of R&D intensity. The results are consistent with those in Table 4. We start in column (1) with OLS results. In column (2) we use all four SMP variables as excluded instruments. The Hansen test rejects the over-identifying restrictions, and in column (3) we see again that we cannot exclude a direct effect of the SMP on log real R&D expenditure in Group 1 sectors. As before, the estimated coefficient on profitability becomes significantly more

Table 5. *Log real R&D*

Dep. var.: ln(R&D)	(1) OLS	(2) IV	(3) IV	(4) Reduced form
Profitability	−0.522	−4.790	−5.901	
	(0.298)*	(0.991)***	(1.302)***	
SMP Group 1			−3.318	−2.028
			(1.255)***	(0.643)***
SMP Group 2				1.522
				(0.481)***
SMP Group 3				1.898
				(1.190)
SMP Group 4				1.149
				(0.231)***
Country–year dummies	Yes	Yes	Yes	Yes
Industry–year dummies	Yes	Yes	Yes	Yes
F-statistic	—	12.25	13.11	—
Partial R-squared	—	0.051	0.042	—
Hansen J-test	—	11.85	1.66	—
(p-value)		(0.008)	(0.436)	
Observations	1,117	1,117	1,117	1,117
R-squared	0.89	0.85	0.83	0.90

Notes: Robust Newey–West standard errors in parentheses with maximum lag length set to 3; the sample consists of 12 two-digit industries or groups of industries across nine countries over the period 1987–2000.
F-statistic is a test of the joint significance of the excluded SMP variables in the first-stage regression; the partial R-squared is for the SMP variables in the first-stage regression (see Table 3). The Hansen J-test is a test of the exclusion restrictions.
*, **, and *** indicate significance at the 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.

negative in the IV specification, suggesting a positive OLS bias. Column (4) contains the reduced-form results, which are again consistent with the IV results.

We next consider robustness to exploiting only the variation in the effects of the SMP across industries in the SMP countries. Table 6 shows equivalent results to Table 4 but using only the SMP countries. We use the first-stage IV estimation from column (3) of Table 3. The key result is that the estimated coefficient on profitability in column (3) of Table 6 is similar to that in column (3) of Table 4. Note that in column (2) of Table 6, with the full set of instruments, the Hansen test again rejects the over-identifying restrictions. When we include SMP Group 2 (traditional public procurement and regulated markets, high price dispersion) directly in column (3) the over-identification test no longer rejects. This is consistent with the reduced-form results in column (4) of Table 6. The SMP appears to be positively associated with R&D intensity in Group 2 sectors

Table 6. *R&D intensity, SMP countries only*

Dep. var.: R&D/VA	(1) OLS	(2) IV	(3) IV	(4) Reduced form
Profitability	−0.124	−0.474	−0.435	
	(0.034)***	(0.141)***	(0.135)***	
SMP Group 1				0.126
				(0.056)**
SMP Group 2			0.128	0.146
			(0.052)**	(0.045)***
SMP Group 3				−0.225
				(0.240)
SMP Group 4				0.063
				(0.037)*
Country–year dummies	Yes	Yes	Yes	Yes
Industry–year dummies	Yes	Yes	Yes	Yes
F-statistic	—	2.74	3.63	—
Partial R-squared	—	0.027	0.026	—
Hansen J-test	—	8.18	4.37	—
(p-value)		(0.042)	(0.112)	
Observations	554	554	554	554
R-squared	0.85	0.77	0.79	0.85

Notes: Robust Newey–West standard errors in parentheses with maximum lag length set to 3; the sample consists of 12 two-digit industries or groups of industries across nine countries over the period 1987–2000.
F-statistic is a test of the joint significance of the excluded SMP variables in the first-stage regression; the partial R-squared is for the SMP variables in the first-stage regression (see column (3) of Table 3). The Hansen J-test is a test of the exclusion restrictions.
*, **, and *** indicate significance at the 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.

and also with the first-stage results in column (3) of Table 3 where the estimated impact on competition is dampened when only comparing within SMP countries.[29]

A number of other features of the results in Table 6 are worth noting. First, the reduced-form coefficients in column (4) are very similar to those in Table 4 for Groups 2 and 4, but we no longer find evidence of a direct negative impact of the SMP on R&D intensity in Group 1, and there is no evidence of a positive impact in Group 3. In addition, the F-statistics

[29] Group 2 sectors include pharmaceuticals, rolling stock, and energy-producing equipment. Opening up public procurement and widening the market may have led to direct incentives to increase R&D; that is, other than through increased competition. For example, in the R&D-intensive pharmaceuticals sector where drug discovery represents a substantial sunk cost, a larger market for successful drugs might be expected to have a direct impact on R&D expenditure.

and partial *R*-squareds in columns (2) and (3) suggest that the instruments are fairly weak when we remove the additional variation provided by non-SMP countries. However, as pointed out above, the estimated coefficient on profitability is very similar to that in Table 4, suggesting that any weak instruments bias may be fairly small in this case.

Our main results use country–year and industry–year effects. We believe that it is important to allow the country and industry effects to vary over time to capture potential measurement error, cyclical effects, and other factors that may be changing differentially over time. An alternative would be to include country–industry and country–year effects. When we do this we find coefficients (standard errors) on profitability in the equivalent specification to column (2) in Table 4 of −0.142 (0.053) and in column (2) of Table 5 of −1.492 (0.759), where the exclusion restrictions are not rejected. Another concern is that high levels of R&D intensity for France might be driving our results.[30] When we exclude France we find that the coefficient (standard error) for the equivalent specification to column (3) of Table 4 is −0.249 (0.081) and to column (3) of Table 5 is −6.139 (1.353).

Product Market Reforms and Productivity Growth

Finally we consider the effect of product market reforms on productivity growth through their effect on R&D, and we examine whether there is any evidence for a direct effect of the degree of product market competition on productivity growth.

In columns (1) and (3) of Table 7, which show OLS specifications, we find a positive association between R&D intensity and TFP growth and between competition (lower profitability) and TFP growth. Following the literature on productivity growth, we also control for the industry's distance to the technological frontier and find that country–industries that are further from the frontier experience faster TFP growth. This is consistent with productivity convergence; for example, countries further behind the frontier are more able to benefit from imitation and adoption of technologies developed closer to the frontier. The positive relationship between innovation and TFP growth is in line with other studies. For example, Coe and Helpman (1995) find that a country's TFP depends on both domestic and foreign R&D, and they also find that foreign R&D has a greater effect the more open a country is to trade.[31] In columns (2) and (4) we instrument R&D intensity and

[30] There are missing data for France (82 observations for France versus 150 for the UK, Table 2). Data are missing for several low R&D intensity industries. In addition, France has very high R&D intensity in a few industries, in particular in aerospace and motor vehicles.
[31] See also Griffith *et al.* (2004) for a country–industry level study that investigates absorptive capacity, and Jones and Williams (1998) and references therein for evidence on the private and social returns to R&D.

Table 7. *TFP growth*

Dep. var.: TFP growth	(1) OLS	(2) IV	(3) OLS	(4) IV	(5) Reduced form
R&D/VA	0.119	0.598	0.075	0.802	
	(0.036)***	(0.149)***	(0.034)**	(0.255)***	
Profitability			−0.085	0.084	
			(0.013)***	(0.091)	
Distance to frontier	0.037	0.055	0.044	0.053	0.034
	(0.007)***	(0.010)***	(0.007)***	(0.012)***	(0.007)***
SMP Group 1					−0.120
					(0.034)***
SMP Group 2					0.078
					(0.033)**
SMP Group 3					0.050
					(0.050)
SMP Group 4					0.017
					(0.011)
Country–year dummies	Yes	Yes	Yes	Yes	Yes
Industry–year dummies	Yes	Yes	Yes	Yes	Yes
F-statistic	—	11.11	—	4.50	—
Partial *R*-squared (1)	—	0.052	—	0.033	—
Partial *R*-squared (2)	—	—	—	0.028	—
Hansen *J*-test	—	1.76	—	0.65	—
(*p*-value)		(0.624)		(0.723)	
Observations	1,008	1,008	1,008	1,008	1,008
R-squared	0.42	0.47	0.46	0.46	0.43

Notes: Robust Newey–West standard errors in parentheses with maximum lag length set to 3; the sample consists of 12 two-digit industries or groups of industries across nine countries over the period 1988–2000.
F-statistic is the Cragg–Donald *F*-statistic, a measure of the power of the excluded SMP variables in the first-stage regressions; the partial *R*-squareds are for the SMP variables in the first-stage regressions for R&D intensity and profitability respectively. The Hansen *J*-test is a test of the exclusion restrictions.
*, **, and *** indicate significance at the 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.

profitability with our SMP indicators. The IV estimates of the impact of R&D on TFP growth in columns (2) and (4) are significantly larger than the OLS estimates, while the IV estimate of the impact of profitability in column (4) is not significant. Finally, column (5) presents the reduced-form impact of the instruments on TFP growth.

A number of features of these results are worth noting. First, the results in column (2) suggest that product market reforms associated with the SMP raised productivity growth through their impact on R&D intensity. However, it is not immediately clear why the IV coefficient on R&D intensity in column (2) should be significantly *larger* than the OLS coefficient. One possibility is measurement error in R&D, but this is unlikely to account for such a large OLS bias. Another possible explanation is that the IV estimate in column (2) corresponds to a local average treatment effect (LATE).[32] For example, if the average rate of return to R&D is significantly higher in those industries where our instruments display most variation, this could explain why the IV estimate of the coefficient on R&D intensity is larger than the OLS estimate.[33] This implies that our results would provide an overestimate of the average effect of R&D on productivity growth across all sectors. This cautions against drawing more general conclusions based on the magnitude of our results. However, given that we are interested in the impact that the SMP had on productivity growth in affected sectors through its impact on R&D, a local average treatment effect is a parameter of interest in itself.

Second, the results in column (4) suggest that there is no significant direct impact of profitability on productivity growth, once profitability is instrumented. However, the F-statistic suggests that the instruments may be too weak to separately identify both the impact of profitability and R&D intensity. Finally, in the reduced-form estimates in column (5), we find a significant positive effect of the SMP on productivity growth only in Group 2 (highly affected) industries. In line with our findings for R&D intensity in Table 4, there is also evidence of a direct *negative* effect of the SMP in high-tech public procurement sectors (Group 1).

In terms of the economic magnitude of these effects column (2) of Table 7 suggests that an increase of one percentage point in R&D intensity is associated with an approximate increase of 0.6 percentage points in TFP growth.[34] As an example, the size of this effect is similar to the predicted impact of the SMP on the metal products industry in the UK: 7.5% of

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[32] In the context of heterogeneous returns, an IV estimate can be interpreted as a weighted average of the returns in the sample, where the "weights" are the relative size of the increment in the endogenous variable induced by the instruments. See Imbens and Angrist (1994) and Card (2001) for a discussion in the context of returns to education.

[33] To investigate this, we split the sample into country–industries where our instruments display variation over time and those where they do not. The former group contains 394 out of 1,008 observations. In an OLS regression equivalent to column (1) the coefficient (standard error) on R&D/VA for this sample is 0.235 (0.050), while for the latter group it is −0.001 (0.039). The fact that the coefficient is significantly higher in those country–industries where our instruments display variation is consistent with a LATE interpretation of the difference between the OLS and IV estimates.

[34] Following Griliches (1979) we could also interpret this as suggesting that the social rate of return to R&D is about 60%, assuming that spillovers occur only within industries. Compared to other studies of own-industry social returns, this is relatively high. Jones and Williams (1998) show that estimates of around 30% in the empirical literature represent lower bounds, and Griffith *et al.* (2004) find an estimate of around 40%. However, the previous discussion about local average treatment effects cautions against interpreting our estimate as an average rate of return.

employment in the industry fell into Group 2 of highly affected sectors, and the coefficient on SMP Group 2 in column (4) of Table 4 is 0.163, suggesting that the SMP programme was associated with an increase of 1.2 percentage points in R&D intensity in the industry as a whole. This in turn was associated with an approximate increase of 0.7 percentage points in TFP growth.[35] 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 just over one-third of this. As with the results for R&D intensity, these are plausible and economically significant effects.

We carried out two robustness checks on these results. First, we ascertained that our results hold if we exclude the distance to the frontier measure.[36] Second, we constructed an alternative measure of TFP growth that allows for imperfect competition.[37] To do this, we adjust the factor shares used to measure TFP growth, equation (5), by the average value of the price–cost mark-up in industry i, country j, over t and $t-1$. The results are very similar using this adjusted measure of TFP growth.[38]

V. Conclusions

This paper presents evidence that the EU Single Market Programme reduced the average level of profitability in some of those industries and countries that were expected to be affected; this had a positive impact on innovative activity in these industries and countries, which in turn affected total factor productivity growth. These relationships are robust to a variety of econometric concerns and accord well with economic theory, for example, the "escape competition" effect that has been recently emphasised.

We interpret the results for profitability as indicating that, as part of the SMP, EU countries implemented product market reforms that reduced the extent to which firms could charge prices above costs. If the main impact of the SMP was instead through reductions in input costs, then the impact would be expected to be felt across all industries, and not concentrated in

[35] This is 0.012 times the coefficient on R&D intensity in column (2) of Table 7 of 0.598.

[36] For column (2) of Table 7 we find a coefficient (standard error) on R&D/VA of 0.473 (0.136), and for column (4) we find 0.791 (0.259) on R&D/VA and 0.122 (0.091) on profitability if we exclude distance to the frontier.

[37] Following Hall (1988), Roeger (1995), and Klette (1999) it is well known that imperfect competition can lead to bias in measured TFP; in the presence of positive mark-ups, measured TFP growth will be biased upwards or downwards depending on whether capital per worker is increasing or decreasing over time.

[38] The estimated coefficients (standard errors) for column (2) of Table 7 are R&D/VA: 0.523 (0.152) and distance to frontier: 0.051 (0.010), and for column (4) are R&D/VA: 0.829 (0.264), profitability: 0.125 (0.095), and distance to frontier: 0.048 (0.012).

those industries highlighted as likely to be most affected in Buigues *et al.* (1990).

Our analysis has some bearing on the expected effects of possible future reforms, such as those being considered under the EU's Lisbon Agenda. Our findings suggest that such reforms could go at least some way towards increasing innovation intensity within the EU. However, it is important to note that our results, and in particular the magnitude of the estimated effects, relate to the specific reforms carried out under the SMP and to the industries affected, and they will not necessarily translate directly to future reforms.

It is also important to note that many other factors are also likely to have affected innovative activity and productivity growth over the period we have considered. These include human capital, infrastructure, and a range of other institutional factors. An interesting possibility is that these may interact with product market conditions, with the result that the effects of product market reforms may vary across countries and/or industries. For example, poorly functioning financial markets may restrict firms' abilities to respond to increased competition. The role of credit and labour market regulations, and other institutions, in determining the impact of reforms to product markets would be an interesting topic for further research.

References

Aghion, P., and Howitt, P. (1998), *Endogenous Growth Theory*, MIT Press, Cambridge, MA.

Aghion, P., and Howitt, P. (1992), A Model of Growth through Creative Destruction, *Econometrica 60*, 323–351.

Aghion, P., Bloom, N., Blundell, R., Griffith, R., and Howitt, P. (2002), Competition and Innovation: An Inverted U Relationship, IFS Working Paper no. W02/04.

Aghion, P., Bloom, N., Blundell, R., Griffith, R., and Howitt, P. (2005), Competition and Innovation: An Inverted U Relationship, *Quarterly Journal of Economics 120*, 701–728.

Aghion, P., Blundell, R., Griffith, R., Howitt, P., and Prantl, S. (2009), The Effects of Entry on Incumbent Innovation Productivity, *Review of Economics and Statistics 91*, 20–32.

Aghion, P., Dewatripont, M., and Rey, P. (1999), Competition, Financial Discipline and Growth, *Review of Economic Studies 66*, 825–852.

Aghion, P., Harris, C., Howitt, P., and Vickers, J. (2001), Competition, Imitation and Growth with Step-by-Step Innovation, *Review of Economic Studies 68*, 467–492.

Alesina, A., Ardagna, S., Nicoletti, G., and Schiantarelli, F. (2005), Regulation and Investment, *Journal of the European Economic Association 3*, 791–825.

Allen, C., Gasiorek, M., and Smith, A. (1998), The Competition Effects of the Single Market in Europe, *Economic Policy 13*, 439–486.

Arrow, K. (1962), Economic Welfare and the Allocation of Resources for Invention, in R. Nelson (ed.), *The Rate and Direction of Inventive Activity*, Princeton University Press, Princeton, NJ, 609–625.

Badinger, H. (2007), Has the EU's Single Market Programme Fostered Competition?, *Oxford Bulletin of Economics and Statistics 69*, 497–519.

Blanchard, O., and Giavazzi, F. (2003), Macroeconomic Effects of Regulation and Deregulation in Goods and Labour Markets, *Quarterly Journal of Economics 118*, 879–907.

Blundell, R., Griffith, R., and Van Reenen, J. (1999), Market Share, Market Value and Innovation in a Panel of British Manufacturing Firms, *Review of Economic Studies 66*, 529–554.

Boone, J. (2000), Measuring Product Market Competition, CEPR Working Paper no. 2636.

Bottasso, A., and Sembenelli, A. (2001), Market Power, Productivity and the EU Single Market Programme, *European Economic Review 45*, 167–186.

Buigues, P.-A., Ilzkovitz, F., and Lebrun, J.-F. (1990), The Impact of the Internal Market by Industrial Sector: The Challenge for Member States, *European Economy*, Special Issue.

Card, D. (2001), Estimating the Return to Schooling: Progress on Some Persistent Econometric Problems, *Econometrica 69*, 1127–1160.

Caves, D. W., Christensen, L. R., and Diewert, I. (1982a), Multilateral Comparisons of Output, Input, and Productivity using Superlative Index Numbers, *Economic Journal 92*, 73–86.

Caves, D. W., Christensen, L. R., and Diewert, I. (1982b), The Economic Theory of Index Numbers and the Measurement of Input, Output, and Productivity, *Econometrica 50*, 1393–1414.

Coe, D., and Helpman, E. (1995), International R&D Spillovers, *European Economic Review 39*, 859–887.

Cohen, W., and Levinthal, D. (1989), Empirical Studies of Innovation and Market Structure, in R. Schmalensee and R. D. Willig (eds.), *Handbook of Industrial Organization*, North-Holland, New York.

Conway, P., Janod, V., and Nicoletti, G. (2005), Product Market Regulation in OECD Countries; 1998 to 2003, OECD Economics Department Working Paper no. 419.

Costantini, J., and Melitz, M. (2008), The Dynamics of Firm-level Adjustment to Trade Liberalization, in E. Helpman, D. Marin, and T. Verdier (eds.), *The Organization of Firms in a Global Economy*, Harvard University Press, Cambridge, MA.

Ederington, J., and McCalman, P. (2008), Endogenous Firm Heterogeneity and the Dynamics of Trade Liberalization, *Journal of International Economics 74*, 422–440.

Ekholm, K., and Midelfart, K.-H. (2005), Relative Wages and Trade-induced Changes in Technology, *European Economic Review 49*, 1637–1663.

European Commission (2002), *The Internal Market—Ten Years Without Frontiers*, http://ec.europa.eu/internal_market/10years/docs/workingdoc/workingdoc_en.pdf.

Gilbert, R., and Newbery, D. (1982), Preemptive Patenting and the Persistence of Monopoly, *American Economic Review 72*, 514–526.

Griffith, R., Redding, S., and Van Reenen, J. (2004), Mapping the Two Faces of R&D, *Review of Economics and Statistics 86*, 883–895.

Griliches, Z. (1979), Issues in Assessing the Contribution of Research and Development to Productivity Growth, *Bell Journal of Economics 10*, 92–116.

Grossman, G., and Helpman, E. (1991), Quality Ladders in the Theory of Growth, *Review of Economic Studies*, *58*, 43–61.

Gullstrand, J., and Johansson, H. (2005), The Disciplinary Effect of the Single Market on Swedish Firms, *Open Economies Review 16*, 381–398.

Hall, R. E. (1988), The Relationship between Price and Marginal Cost in U.S. Industry, *Journal of Political Economy 96*, 921–947.

Harrigan, J. (1997), Technology, Factor Supplies and International Specialization, *American Economic Review 87*, 475–494.

Harrison, A. (1994), Productivity, Imperfect Competition and Trade Reform: Theory and Evidence, *Journal of International Economics 36*, 53–73.

Hart, O. (1983), The Market Mechanism as an Incentive Scheme, *Bell Journal of Economics 14*, 366–382.

Howitt, P. (2000), Endogenous Growth and Cross-country Income Differences, *American Economic Review 90*, 829–846.
Imbens, G., and Angrist, J. (1994), Identification and Estimation of Local Average Treatment Effects, *Econometrica 62*, 467–475.
Jones, C., and Williams, J. (1998), Measuring the Social Return to R&D, *Quarterly Journal of Economics 113*, 1119–1135.
Klette, T. J. (1999), Market Power, Scale Economies and Productivity: Estimates from a Panel of Establishment Data, *Journal of Industrial Economics 47*, 451–476.
Lileeva, A., and Trefler, D. (2007), Improved Access to Foreign Markets Raises Plant-level Productivity . . . for Some Plants, NBER Working Paper no. 13297.
Mayes, D., and Hart, P. (1994), *The Single Market Programme as a Stimulus to Change*, Cambridge University Press, Cambridge.
Melitz, M., and Ottaviano, G. (2008), Market Size, Trade, and Productivity, *Review of Economic Studies 75*, 295–316.
Nickell, S. (1996), Competition and Corporate Performance, *Journal of Political Economy 104*, 724–746.
Nicoletti, G., and Scarpetta, S. (2003), Regulation, Productivity and Growth: OECD Evidence, *Economic Policy 18*, 9–72.
Notaro, G. (2002), European Integration and Productivity: Exploring the Gains of the Single Market, London Economics working paper.
Pavcnik, N. (2002), Trade Liberalization, Exit and Productivity Improvements: Evidence from Chilean Plants, *Review of Economic Studies 69*, 245–276.
Roeger, W. (1995), Can Imperfect Competition Explain the Difference between Primal and Dual Productivity Measures?, *Journal of Political Economy 103*, 316–330.
Salgado, R. (2002), Impact of Structural Reforms on Productivity Growth in Industrial Countries, IMF Working Paper no. 02/10.
Scarpetta, S., Hemmings, P., Tressel, T., and Woo, J. (2002), The Role of Policy and Institutions for Productivity and Firm Dynamics, Economic Working Paper no. (2002)15.
Schmidt, K. (1997), Managerial Incentives and Product Market Competition, *Review of Economic Studies 64*, 191–213.
Stock, J., and Yogo, M. (2004), Testing for Weak Instruments in Linear IV Regression, manuscript, Department of Economics, Harvard University.
Tirole, J. (1998), *The Theory of Industrial Organization*, MIT Press, Cambridge, MA.
Yeaple, S. (2005), A Simple Model of Firm Heterogeneity, International Trade, and Wages, *Journal of International Economics 65*, 1–20.

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