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CENTRE POUR LA RECHERCHE ECONOMIQUE ET SES APPLICATIONS

Competition, Innovation and Distance to Frontier

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Titre : Effets de la concurrence et de la réglementation sur l'activité d'innovation

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Résumé : Ce papier teste les effets de la concurrence et de la réglementation sur l'activité d'innovation mesurée à l'aide de brevets. Divers indicateurs sont utilisés: le nombre relatif de firmes dans un secteurs ainsi que des indicateurs de réglementation des marchés des biens et services. L'échantillon comprend un panel de 15 industries pour 17 pays de l'OCDE sur la période 1979-2003. Les résultats sont que l'effet positif de la concurrence sur l'innovation supposé être à son maximum lorsque l'économie s'approche de la frontière technologique mondiale est introuvable. Deux configurations émergent. Dans la première, la réglementation a un effet positif sur l'innovation quelle que soit la distance à la frontière et son impact est d'autant plus grand qu'on se rapproche de la frontière. Dans la deuxième, l'effet de la réglementation est de diminuer l'innovation loin de la frontière et devient favorable à l'innovation (parfois non significatif) lorsque l'écart technologique diminue. Ces résultats contredisent la croyance dans l'effet d'incitation à l'innovation d'une augmentation de la concurrence qui est sous-jacente à la stratégie de Lisbonne.

Mots-clés : concurrence économique, reglementation, innovation technologique, brevet

Classification JEL : O3, O57

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Competition, Innovation and Distance to Frontier
(first draft)

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Ce papier teste les effets de la concurrence et de la réglementation sur l'activité d'innovation mesurée à l'aide de brevets. Divers indicateurs sont urilisés: le nombre relatif de firmes dans un secteurs aisni que des indicateurs de réglementation des marchés des biens et services. L'échantillon comprend un panel de 15 industries pour 17 pays de l'OCDE sur la période 1979-2003. Les résultats sont que l'effet positirf de la concurrence sur l'innovation supposé être à son maximum lorsque l'économie s'approche de la frontière technologique mondiale est introuvable. Deux configurations émergent. Dans la première,

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la réglementation a un effet positif sur l'innovation quelle que soit la distance à la frontière et son impact est d'autant plus grand qu'on se rapproche de la frontière. Dans la deuxième, l'effet de la réglementation est de diminuer l'innovation loin de la frontière et devient favorable à l'innovation (parfopis non significatif) lorsque l'écart technologique diminue. Ces résultats contredisent la croyance dans l'effet d'incitation à l'innovation d'une augmentation de la concurrence qui est sous-jacente à la stratégie de Lisbonne.

1 Introduction

Concerns about the lack of convergence of Europe's productivity level vis-à-vis the US over the past decade have been expressed not only in academic circles but also among policy makers and politicians. As numerous reports have shown (Kok, 2004; Sapir, 2004), Europe seems to be losing ground, not because of an insufficient rate of capital accumulation, but for lack of innovation capability. The so-called Lisbon Strategy, which aims at fostering innovation and productivity, proposes a series of structural reforms for labour, financial and product markets. Regarding the latter, a link between competition and innovation underlies the whole Lisbon Strategy: more product market competition should bolster innovation and thus productivity and growth.[1]

According to economic theory, the relation between competition and innovation is ambiguous. For Schumpeter (1934), monopoly profits are rewards to innovators; the appropriability of innovation output is thus a crucial incentive issue. A rise in competition is expected to decrease rents stemming from innovation and thus incentives to innovate. This traditional 'Schumpeterian effect' of competition is featured in numerous innovation-based endogenous growth models, in particular Aghion and Howitt (1992) where innovation effort increases with the Lerner index.

On the other hand, competition may encourage innovation. Incumbents may innovate to keep their market power and fend off new entrants, or potential entrants may hope to capture the market position of incumbents by surpassing them with new and better products. In both cases, innovation would be the means for a firm to get the upper hand over its competitors. Extensions of the Schumpeterian innovation-based endogenous growth model (Aghion and Howitt, 1998) allow to take into account differentiated influences of competition on innovation. The situation taken into account in Aghion et al. (2005) is that of a competition between rivals with different productivity levels. Firms innovate to decrease their production costs 'step by step': a technological laggard has to catch-up with the technological level of the leader before having the possibility of becoming itself a leader in the industry. The risks for the leader to lose its position are therefore increased when the com-

[1] e.g. the Integrated Guidelines 12 to 16 (European Commission, 2005).

petitor is only one step away from catching-up. When competitors have comparable productivity levels, i.e. the so-called 'neck and neck' competition, a stronger competition will induce firms to increase their innovative investments in order to acquire a competitive lead over rival firms. This pro-innovation effect of competition is less prominent in industries where the leader has a marked advantage over its competitor. The incorporation of both innovation-inducing and innovation-deterring effects of competition into a single model leads to a nonlinear, inverted U-shaped, relation between product market competition and innovation (Aghion et al. 2005).

The link between competition and innovation has been investigated primarily at the firm level. The possible existence of an effect of the firm's size or market power on its innovative activity is a well-known topic in the innovation literature (Baldwin and Scott, 1987; Cohen and Levin, 1989; Geroski, 1995). Although both pro- and anti-innovation effects of competition may be found in the empirical literature, the recent contributions tend to establish contrasted results differencing firm size effects from more general competition influences. Using a sample of 10000 French firms, Crépon, Duguet and Kabla (1995) found that market power stimulates innovation, although this effect seems to be small in magnitude. Crépon, Duguet and Mairesse (1998), in a four equation model for French manufacturing firms taking into account the firm's decision to engage in R&D activities, the R&D intensity, the effects of R&D on patenting and the effects of patenting on productivity, confirmed the existence of a size effect in the decision to engage in R&D activity but not the R&D intensity. On the other hand, market share and diversification affect positively both the decision to undertake R&D and R&D intensity. Competition may also exert negative effects such as those found in Crépon and Duguet (1997): competitors' R&D may have a negative impact on a firm's own innovation effort, indicating the existence of a rivalry externality that acts as a disincentive to innovate.

On the other hand, Nickell (1996) showed with a panel of 670 UK firms that competition, measured by an high number of competitors or low levels of rents, is associated to high rates of TFP growth. Whether this reveals a direct effect of competition on productivity, through a slack-reducing effect for instance, or an indirect effect through innovation is undecided. Blundell, Griffith and Van Reenen (1999) used a panel of 340 British manufacturing firms between 1972 and 1982 and showed that the relation between competition and innovation possesses contrasted features. Industries where concentration is higher and import penetration lower have fewer innovations. This finding tends to support the existence of a positive relationship between competition and innovation. However, within industries, firms with a higher market share tend to commercialise more innovations. They also showed that larger firms produce innovations of a greater commercial value than smaller firms.

The duality of competition's effects on innovation are summarised in the findings of Aghion (2003) and Aghion et al. (2005). With the help of firm-level data and US Patent Office data quoted on the London Stock Exchange between 1968 and 1997, they presented evidence of an inverted U-shaped relationship between the Lerner index and the number of patents granted . The 'Schumpeterian effect' of competition should dominate when the level of competition is high whereas the 'escape competition' effect should be prominent at low levels of product market competition. Moreover, following the prediction of the theoretical model, the inverted U-shaped relationship was found to be steeper for firms that are closer to the leading edge in their industry.

Empirical evidence at the industry level is far less abundant than at the firm level. Industry-level studies have the advantage of allowing to escape from the limits of the proxies for competition usually taken into account by micro-level studies such as firm size, market power or profitability level, and consider actual industry-specific or macroeconomy-wide competition policy measures. Griffith, Harrison and Simpson (2006) measured innovation by Business Entreprise R&D expenditure for 12 industries and nine countries over the 1987-2000 period and investigated the effect of the Single Market Programme. They found that the SMP had a positive impact on innovative activity in affected industries and countries. They interpreted their results as a support for the competition-enhancing reforms advocated within the Lisbon Agenda. Nicoletti and Scarpetta (2003) considered a sample of 23 industries for 18 OECD countries over the period 1984-1998. They tested a model of TFP growth using product market regulation indicators devised by the OECD both alone and in interaction with a technology gap variable. They found statistically significant positive coefficients on the interacted variable, a result they interpreted as a catch-up slowing-down effect of product market regulation. Conway et al. (2006) tested a similar model of labour productivity with interaction terms between product market regulation indicators and a technology gap measure on a slightly extended sample of OECD countries. They found a significantly positive coefficient on the interacted variables term too, which they interpreted as a catch-up slowing-down effect.

The differentiated effect of product market competition according to the distance to the technological frontier is a central issue of the whole competition and innovation debate. The received argument is that the economic costs of product market regulation would increase the closer an economy is to the technological frontier (Aghion, 2006). For Aghion et al. (2006), increased competition, represented by a higher entry threat, spurs innovation incentives in sectors close to the technological frontier, whereas it discourages innovation in laggard sectors through a traditional Schumpeterian rent-diminishing effect. Testing a model of TFP growth and a model of innovation (patenting) with foreign entry and distance to the technological frontier variables included both alone and interacted along with other competition variables on micro-level data for the UK, they concluded that as an economy moves closer to the technological frontier, the competitiveness of all industries in a high-cost, high-productivity economy depends on the ability to innovate. This applies to all sectors of the economy, 'high-tech' or not, since the R&D intensity of all industries increases when economies move closer to the technological frontier (Acemoglu, Aghion & Zilibotti, 2006). The evidence presented and the theoretical models would then support the argument presented by Aghion (2006): "*During the immediate post-war period, the European (or Japanese and Korean) firms were predominantly technological laggards, whose catching-up could have been diminished by very intense competition. [...] However, as Europe approached the global technological frontier, competition and entry have become increasingly important catalysts for innovation and productivity growth.*"

The aim of this paper is to assess the validity of the argument according to which competition spurs innovation, and that this effect is all the more important that an economy is close to the technological frontier. A dynamic model including variables for the distance to the frontier, competition, as well an interaction term between them is estimated. The empirical strategy of this paper differs from the existing academic literature on three levels. First, the analysis is conducted at the industry level, while most empirical evidence focuses on micro studies. To the best of our knowledge, this is the first paper testing the impact of competition on *innovation* at the industry level with a cross-country panel. Second, we use not only indicators for observed measures of competition but also indicators of regulation policy (institutional indicators, and output measure of competition). Finally, we run regressions using different estimators (OLS, fixed effects and system GMM) in order to take into account the dynamic nature of the innovative process and propose different extensions of the baseline model. The use of different variants of the model, different estimators and different indicators to measure the intensity of competition helps to assess the robustness of our findings.

The paper is organised as follows. The next Section discusses the empirical strategy and the problems related to the estimations. Section 3 presents the data used in the empirical analysis. The following Section presents the results of the baseline model. Section 5 proposes extensions and robustness tests of this model. A brief conclusion follows.

2 Empirical Strategy

3 Dynamic Issues

Our purpose is to test the impact of competition on innovation with a country-industry panel data. This structure has two particularities. First, information on innovation is aggregated and belongs to individuals which represent different activities performed in different countries. Second, a plausible model of the innovation process should exploit this panel structure and allow for a dynamics in which past innovations help to explain current ones. These particularities imply a non negligible unobserved heterogeneity among individuals that will be present in both past and current innovation. More specifically let p_{it} be our proxy of innovation activity in natural log and we summarize, for the moment, our explicative covariates in the vector x_{it}. Our problem can be formulated as the estimation of the following dynamic multivariate model in logs:[2]

$$p_{it} = \alpha p_{it-1} + \beta x_{it} + \epsilon_{it} \tag{1}$$

Where $\epsilon_{it} = \eta_i + \mu_{it}$

The main issue is that the past realization of our dependant variable will be endogenous to the fixed effect in the error term. In this framework, the estimates of α provided by OLS will be upward biased and those coming from the within-group estimator will be downward biased (Bond 2002; Benavente et al. 2005). While the former neglects the unobserved time invariant heterogeneity η_i which is the source of correlation between p_{it-1} and ϵ_{it}, the latter includes past values of p_{it} when subtracting the mean in order to transform the model and to eliminate η_i. Although these estimators are biased, they are useful because they give an interval in which a consistent estimation of α should lie.

Several strategies might be adopted to face these dynamic concerns. They go from the estimation of the model in differences instrumenting $\Delta p_{it-1}$with p_{it-2} using a two stage least squares (Andersen and Hsiao 1981) to different techniques based on the generalized method of moments (GMM), which improves efficiency by exploiting the moment conditions that relate deeper lags of the dependent variable, some times transformed, to the error term. Among GMM techniques we are particularly interested in the one suggested by Arellano and Bover (1995) and fully developed by Blundell and Bond (1998), usually called system GMM (S-GMM). The difference GMM (D-GMM) proposed by Arellano and Bond (1991), which applies a transformation in differences and uses the orthogonality conditions of available lags of p_{it-1}, is augmented by S-GMM under the assumption that first differences of the instrumenting variables are uncorrelated to the error in levels. This assumption allows to

[2] Our measure of innovation is based on the aggregation of patents at the country level and distributed at the industry level according to a transformation matrix linking technology and industry classification. In order to take into account fixed effects related to size and economic activity we normalize this measure dividing by the hours worked. In this context, it seems reasonably to treat this aggregated normalized measure of innovation as a continuous variable rather than counts coming from independant experiments (Aghion et al., 2006).

include the original equation in levels and to use Δp_{it-2} and deeper lags as instruments for p_{it-1}. The transformed equation and the one in levels make a system in which more instruments can be exploited.

The use of a new set of instruments in differences improves efficiency as it deals with the problem of weak instruments of D-GMM in persistent series. Note that equation (1) is equivalent to state $\Delta p_{it} = (\alpha - 1)\, p_{it-1} + \beta x_{it} + \epsilon_{it}$. Hence Δp_{it} is weakly correlated with p_{it-1} if α is close to 1. Intuitively, in the case of a process close to a random walk, past values will not predict current changes as good as past changes can predict current values. In that sense, one can expect that instrumenting p_{it-1} with Δp_{it-s} $(s = 2..T)$ should give more accurate estimates. On the other hand the inclusion of the equation in levels will be useful to keep information of variables that do not change too much during time. This is namely the case of our institutional proxies of competition.

3.1 Specifying regressors x_{it}

One advantage of GMM techniques is that they allow the other regressors x_{it} to be predetermined (explained by their past realizations) or endogenous (explained by current and past realization of other variables and their own autoregressive process). In our basic estimation, we consider as explicative variables x_{it} the closeness to the frontier cl_{it}, the product market competition proxy mc_{it}, their interaction $mc_{it} * cl_{it}$. As elemental controls we also include in all regressions the capital intensity kl_{it} and the externalities ex_{it} coming from the innovative activity of the same industry in the rest of the world. The interaction term will capture the extent to which product market competition influences the innovative process as an industry in a country get close to the frontier technological level. We also include year dummies d_t in order to control for macroeconomic shocks homogeneous across individuals. At the end we estimate the following baseline model (M1):

$$p_{it} = \alpha\ p_{it-1} + \beta_1\ cl_{it} + \beta_2\ mc_{it} * cl_{it} + \beta_3\ mc_{it} + \beta_4\ kl_{it} + \beta_5\ ex_{it} + \beta_6\ d_t + \epsilon_{it} \quad (2)$$

Even though the S-GMM estimator deal with the potential endogeneity of the regressors, as a robustness check, we also estimate the model considering the explicative variables lagged once (M1L) to reduce the risk of reverse causality:

$$p_{it} = \alpha\ p_{it-1} + \beta_1\ cl_{it-1} + \beta_2\ mc_{it-1} * cl_{it-1} + \beta_3\ mc_{it-1} + \beta_4\ kl_{it-1} + \beta_5\ ex_{it-1} + \beta_6\ d_t + \epsilon_{it} \quad (3)$$

Aiming at getting further insights about the concavity of the effect of competition we augment the reduced form of the interaction and include the squares terms of the closeness to the frontier and product market competition (M2):

$$p_{it} = \alpha p_{it-1} + \beta_1 cl_{it} + \beta_2 mc_{it} * cl_{it} + \beta_3 mc_{it} + \beta_4 kl_{it} + \beta_5 ex_{it} + \beta_7 cl_{it}^2 + \beta_8 mc_{it}^2 + \beta_6 d_t + \epsilon_{it} \quad (4)$$

This specification is equivalent to consider a translog approximation of a constant elasticity function between both variables that can be more precise to capture an eventual complementarity between them. A similar equation is also estimated for the model with all regressor in lag 1 (M2L). Finally, we test an extended version of M1 and M2, including further controls such as import penetration, financial deepness and labour market regulation.

In all S-GMM regressions the set of instruments is composed by p_{it}, cl_{it}, $mc_{it}{*}cl_{it}$, mc_{it} in lag two or deeper and by ex_{it} in lag 1 or deeper as we can exploit its expected exogeneity. Since the Sargan-Hansen test for overidentifying restriction, which tests the exogeneity of instruments, becomes less rigorous as the number of instruments increases, the recommendation is to have less instruments than individuals (Roodman 2006) which is in line with some evidence provided by simulation (see Windmeijer 2005). Since the number of instrument is quadratic in time dimension and S-GMM generates not only a set of instrument for the transformed equation but also for the equation in levels, this restriction for our sample size is constrained. We overcome this difficulty by using limited lags, by considering most informative instruments and by collapsing in some cases the matrix of an instrumenting variable into a vector. The latter strategy is equivalent to sum up independent moment conditions in one equation. Examples of this strategy are Calderon et al. (2002) or Beck and Levine (2004). In each case the main criterion to accept the instrumentation strategy is the Sargan/Hansen test and its version in difference that allow testing a subset of instruments. In addition, we pay special attention to the autocorrelation of the error term, a crucial assumption for the validity of instruments in lag 2. To do so use is made of the Arellano-Bond test for serial correlation in differences. Since by construction first order correlation is expected we only focus on the test for second order correlation in difference, which relates ϵ_{it-1} with ϵ_{it-2} by looking at the correlation between $\Delta\epsilon_{it}$ and $\Delta\epsilon_{it-2}$.

3.2 The Marginal Effect of Competition on Innovation

Since we have included an interaction term between product market competition and closeness to technological frontier ($mc_{it}{*}cl_{it}$), the assessment concerning the expected overall effect of $.mc_{it}$ needs the computation of its marginal effect conditional on specific values of cl_{it} (Braumeoller 2004):

$$\frac{\partial E(p_{it}/x_{it})}{\partial mc_{it}} = \widehat{\beta}_2 cl_{it} + \widehat{\beta}_3 \tag{5}$$

For the M2 version:

$$\frac{\partial E(p_{it}/x_{it})}{\partial mc_{it}} = \widehat{\beta}_2 cl_{it} + \widehat{\beta}_3 + 2\widehat{\beta}_8 mc_{it} \tag{6}$$

Similar expressions hold for M1L and M2L. It is easy to see, for instance, that a positive and significant $\widehat{\beta}_2$ means nothing but that competition increases innovation activity *only* for an individual completely far away the technological frontier ($cl_{it} = 0$). That is for the unrealistic case of zero labour productivity. Notice that for the augmented version M2, the calculation of the marginal effect of competition depends on the level of competition itself mc_{it}.

As each of these linear combinations is computed using the estimated values of β_2,β_3 and β_8 one still needs to determine their significance, which in turns will depend on the variance of estimates and the value at which cl_{it} is evaluated (Friedrich 1982). For the M1 specification, this significance will depend on the ratio

$$\frac{\widehat{\beta}_2 cl_{it} + \widehat{\beta}_3}{\sqrt{\widehat{\sigma}_{\widehat{\beta}_3\widehat{\beta}_3} + cl_{it}^2 \widehat{\sigma}_{\widehat{\beta}_2\widehat{\beta}_2} + 2cl_{it}^2 \widehat{\sigma}_{\widehat{\beta}_2\widehat{\beta}_3}}}$$

Where $\widehat{\sigma}_{\gamma\delta}$ is the sample covariance between γ and δ. Statistically insignificant coefficients may combine to produce statistically significant conditional effects. In our regression we evaluate the marginal effect and its significance for the minimum, one deviation under the mean, the mean, one deviation over the mean and the maximum sample values of cl_{it}. For the M2 version we take the mean value of mc_{it}.

3.3 Testing for unit root

The validity of lagged differences as instruments for levels depends on whether this lagged differences are uncorrelated with the error term. Blundell and Bond (1998) state this assumption in terms of the stationarity of the initial conditions of the autoregressive process. Let us consider the reduced AR(1) version of our model:

$$p_{it} = \alpha p_{it-1} + \epsilon_{it} \qquad \epsilon_{it} = \eta_i + \mu_{it}. \tag{7}$$

If the initial conditions do not deviate systematically from their long term stationary value $\left(\frac{\eta_i}{1-\alpha}\right)$, they will be uncorrelated with the fixed effect itself. Thus for the second period onwards the difference of the dependent variable will be also uncorrelated with the fixed effect. In other words, under this assumption, a first difference transformation of the instrument will be enough to purge η_i. If there is no serial correlation of μ_{it}, then $E\left[\Delta p_{it-1}\epsilon_{it}\right] = 0$.

As a consequence we verify the risk of unit root of our main time series variables by the means of the Fisher test developed by Madala and Wu (1999) for panel data. Alternative test such as Levin, Lin and Chu (2002) and Im, Pesaran and Shin (2003) seem less convenient for our case. First of all, Levin, Lin and Chu (2002) consider the strong assumption that all units have the same autoregressive coefficient. This assumption constraints the alternative hypothesis to posit that all series are stationary. Second, the single statistic of the Fisher test, resuming the significance of all individual unit root test, has an exact χ^2 distribution. On the contrary, Im, Pesaran and Shin (2003) consider the mean of the t-statistic of each Augmented Dickey-Fuller individual test, whose normality is asymptotic. Finally, as both tests assume that the sample period is the same for all cross-section units, they need a balanced panel data. This reduces the size of the sample and the efficiency of the test.

Results are reported in Appendix Table 7. In order to allows for serial correlation in the error term we consider one and two lags of Δy_{it} for each individual Augmented Dickey-Fuller test. We do not take a risk rejecting the null hypothesis of non stationary for all series when the autoregressive model considers a constant (drift). This specification is consistent with our regressions.

4 Data

We collected information for 17 OECD countries and 15 manufacturing industries at the two digit level (ISIC-Rev3) from 1979 to 2003 (Appendix Table A1). Original data come from the OECD-STAN, GGDC-ICOP project and EUROSTAT databases. From OECD-STAN we used trade indicators and investment series. Starting from OECD-STAN, the GGDC-ICOP data complete the information with surveys and their own estimations, consistent with national accountings. This data is our original source for value added series, implicit deflators and hours worked. Patent series were obtained from EUROSTAT, which distribute by industries the number of patents granted according to a matrix relating technology and industry classification .

4.1 Distance to the frontier

Labour productivity (value added per hour worked) is used as the main measure of efficiency. The technological frontier is defined as the most productive available technology for each ISIC-Rev3 Industry at every period. The individual (country-industry couple) having the maximum labour productivity among all countries in a given year is identified as the technological leader for that year. The closeness (distance) to the frontier is measured as the (inverted) ratio of labour productivity relative to that of the frontier. For instance, the closeness to the frontier of Spain in chemical industry in 1994 is the labour productivity of the Spanish chemical industry in 1994 divided by the highest labour productivity level for chemicals among all countries in that year. We consider a moving average of three year in order to smooth the series.[3]

All nominal series were deflated to 1997 in their national currency. In order to make an international comparison at the industry level, we need to take into account price differences among countries at the industry level (cross section deflation). This is namely important for the value added series since we base our productive measure on it. Use is made of the industry purchasing power parities (I-PPPs) provided by Timmer, Ympa and van Ark (2006) for 1997. The authors consider a mix between purchasing power parities based on expenditure and production. Expenditure PPPs are computed from ICP index and production PPPs from average producer prices calculated at the industry level dividing output values by quantities. While the former includes only final goods and must be adjusted for taxes, distribution margins and trade costs, the latter needs to face the problem of matching varieties of goods that may differ in quality and definition among countries. The selected PPPs measure (adjusted-expenditure or production) depends on the specificity of each industry. At the end the authors propose a harmonized dataset of PPPs disaggregated at the industry level for a wide sample of developing countries. They also apply the multilateral weighted aggregation method proposed by Elteto and Koves (1964) and Szulc (1964) (EKS). This method allows obtaining transitivity in multilateral comparisons starting from binary comparisons.

Appendix Table A3 shows the average labour productivity of each country for

[3] GGDC-ICOP estimate OECD-STAN missing information going to alternative sources and applying different estimation methods. However, the resulting dispersion is considerably bigger (See GGDC rows in Appendix Table A2). We drop GGDC-ICOP estimations of industry 30 (office machinery) because of its high dispersion and keep the OECD-STAN values for GGDC-ICOP outliers when OECD information exists. The global dispersion considerably diminishes (Filtered Data). With this filter we get 6098 observation instead of 4129, with series quite comparable to those available in OECD-STAN.

the full sample period and compares the values whether one uses the standard (non-adjusted) expenditure PPPs at the country level or the industry-PPP computed by Timmer, Ympa and van Ark (2006). Appendix Table A4 presents similar figures at the industry level (world sample average). At the scope of the country level the average of labour productivity during the full sample period seems similar among countries. However, the variation induced by both measures increases when considering the industry level. This is important because the hierarchy in terms of productivity and namely the identification of the frontier level might change. This is what Appendix Table A5 shows. There we present the number of times being that a country is at the frontier level in any of its industries.

4.2 Innovation

As a proxy of innovation we consider the number of patents. At the industry level they are provided by EUROSTAT. In this database the applications at the European Patents Office (EPO) are linked to industry standard classifications by the means of a detailed matrix relating the latter to the subclasses of International Patent Classification (IPC) categories. The US counterpart of the EPO is the United States Patents and Trademarked Office (USPTO). However they are not directly comparable since the EPO system informs about applications and the USPTO about patent granted. We consider the EPO system as it is more representative for the countries present in our sample. Aiming at controlling for market size issues, patents are normalized by the hours worked of the industry. At the end we get a continuous aggregated measure of innovation that enables international comparisons at the industry level.

Information on R&D expenditure, disaggregated at the industry level, is available from the OECD ANDBERD database. Nevertheless, missing values represent 65% of total observations (mainly Austria, Greece, Ireland and Portugal) and the data is only available from 1987.

4.3 Competition and Institutional Measures

Five indicators have been selected to capture product market competition. On one hand we consider four indicators related to institutions: (1) the global product market regulation PMR (OECD) computed by Conway and Nicoletti (2005); (2) the size of the public enterprise sector PMR_SC_SIZE, a component of PMR that focuses on state control; (3) the regulatory provisions in non-manufacturing sectors (telecoms, electricity, gas, post, rail, air passenger transport, and road freight) summarized by the REGREF (OECD) indicator and (4) the corresponding effect of these regulation on the manufacturing sector computed by the OECD through the REGIMPACT indicator (Conway and Nicoletti 2006). The latter is the result of the distribution of

REGREF among industries considering the use of non-manufacturing sectors as inputs with the help of Input/Output tables. On the other hand, we take into account (5) the numbers of firms per value added (DNVA) as a proxy of market atomicity, usually expected to be an outcome of market regulation.

The scope of these indicators is as follow. REGIMPACT and DNVA are consistent with our panel data structure. REGREF, by definition, is a time series at the country level reflecting the evolution of the competitive environment. Finally, PMR and PMR_SC_SIZE are computed at the country level for two point times (1998 and 2003). They have been distributed for two periods: before and after 2000. Since PMR is based on a collection of private and governmental practices, this distribution should be in line with the evolution of European market reforms.

We also include in the data the import penetration ratio MPEN available in OECD-STAN at the industry level and the employment protection indicator (EPLBLD) proposed by Amable, Demmou and Gatti [2007] at the country level, which updates the EPL indicator of the OECD, and the financialisation ratio defined as the total assets of institutional investors relative to GDP. Appendix Table A6 summarizes the main descriptive statistics.

4.4 Other Controls

Capital series were constructed using investment series and the standard Perpetual Inventory Method (PIM). This method uses the dynamic rule by which current capital stock equals the stock of the preceding period, after depreciation, plus current investment. To compute the initial stock, the PIM method supposes that pre sample investment grows at a constant rate. Under the assumption of steady state this rate equals the one of value added. After applying this to the dynamic rule, the initial stock becomes a function of initial investment, the global depreciation rate and the steady state growth rate of value added. We proxy the latter with the mean of the sample period and use a depreciation rate of 7.5%, the standard assumption.

The externalities in the innovative process are measured as the innovation of the rest of the world in the same manufacturing activity. Accordingly to the case of our dependant variable, externalities were computed as the number of patents per hour worked produced by the same industry in the rest of the world.

5 Results

Table 1 presents results of the tests of the effects of competition on patenting using different indicators for competition: the number of firms relative to value added (regressions [1] to [3]), the regulation impact indicator ([4] to [6]), the indicator of competition in nonmanufacturing sectors ([7] to [9]), the economy-wide indicator of product market regulation PMR ([10] to [12]) and the indicator for public sector PMR ([13] to [16]). The models differ with the inclusion of the lagged dependant variable and the estimator: OLS or fixed effect panel estimator. Models [3], [6], [9], [12] and [15] are first difference equations with no lagged dependent variable. This amounts to forcing the coefficient of the lagged dependent variable in level to be equal to one.

As expected, the coefficient on the lagged dependent variable differs greatly between the OLS and fixed-effect estimator, being greater for the former model. Also the signs of the coefficients for the externality effect and the capital/labour ratio are mostly significantly positive. For each regression, the lower panel of the Table presents the estimated marginal effects of the competition indicator for different levels of the relative productivity level. The first line of the lower panel gives the value of the marginal effect when the relative technological level is at its minimum (min), i.e. when the distance to frontier is at its maximum. The last lines give the marginal effects and standard errors when the relative productivity level is at the maximum of the sample, i.e. at the technology frontier. Marginal effects coefficients are also presented for the mean value of the relative technological level, the mean value minus one standard deviation and plus one standard deviation. Therefore, reading a column of the lower panel of the Table shows how the marginal effect of competition changes as the distance to the technological frontier decreases and vanishes.

The interpretation of the marginal effect for regressions [1] to [3], with the relative number of firms indicator, differs from the interpretation for the other indicators. A higher relative number of firms is also a lower average size for firms in the industry, which can be interpreted as a lower concentration in the industry. If competition is more favourable to innovation near the technological frontier, the marginal effects should increase as the relative technological level augments from its minimum to its maximum. Indeed, if one follows strictly the predictions of Aghion et al. (2005), Aghion (2006), one would expect a negative marginal effect of competition far from the technological frontier (i.e. the Schumpeterian effect) and a positive effect close to the frontier (the 'escape competition' effect). However, the results reported in Table 1 show that the effect of the relative number of firms decreases as the industry moves closer to the technological frontier. Having a less concentrated industry seems to matter more when the industry is far from the leading edge than when it is near. This result is true whatever the estimator or specification, only the magnitude of the effects and their significance change. This result could be compared with the positive size effect found in many micro studies of innovation. If the firm size is a positive influence on innovation, one may suppose that it will be all the more important that the innovation competition is fierce, i.e. that the industry is close to the leading edge.

Using a proxy for size or concentration in the industry is subject to the usual limitations: it measures the outcome of the competition process, not so much the competitive environment. In this respect, the use of indicators of regulation will make it possible to avoid ambiguous interpretations of the results. The interpretation of the marginal effects according to the distance to frontier is straightforward. Again, if competition is good for innovation, product market regulation should exert a negative influence on patenting, all the more so that the distance to frontier diminishes. However, following Aghion (2006), regulation could be good when the industry is far from the frontier, but should gradually become detrimental as the distance to frontier is reduced. The regressions using the regulation impact indicator (columns [4] to [6] in Table 1) give contrasted results. The OLS regression gives marginal effects non significantly different from zero, i.e. no impact of product market regulation on innovation whatever the distance to frontier. The fixed effect regression gives a statistically negative impact of regulation increasing with the relative technological level. On the other hand, considering the model without the lagged dependent variable gives significant positive marginal effects of regulation.

	firms per value added			regulation impact			regulation in services			product market regulation			product market regulation (public sector)		
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]
lagged dependent variable	0.974***	0.328***		0.961***	0.557***		0.960***	0.599***		0.961***	0.637***		0.944***	0.596***	
	(0.009)	(0.072)		(0.006)	(0.032)		(0.006)	(0.029)		(0.007)	(0.029)		(0.007)	(0.030)	
distance to frontier	-0.030	-0.096*	0.003	0.026	-0.181	-0.077	-0.021	-0.001	0.062	0.001	0.013	0.068*	0.028	0.082**	0.027
	(0.027)	(0.056)	(0.054)	(0.089)	(0.161)	(0.151)	(0.042)	(0.045)	(0.048)	(0.029)	(0.038)	(0.038)	(0.038)	(0.039)	(0.043)
interaction distance ×competition	-0.010	-0.089***	-0.006	0.012	-0.075	-0.043	0.023	-0.011	-0.047	-0.027	-0.069	-0.131*	-0.007	-0.084***	-0.013
	(0.016)	(0.028)	(0.026)	(0.042)	(0.078)	(0.069)	(0.034)	(0.041)	(0.047)	(0.052)	(0.071)	(0.079)	(0.030)	(0.032)	(0.037)
competition	0.059	0.402***	0.060	-0.024	-0.514	0.568*	-0.026	-0.138	0.187	0.228	0.322	1.070***	0.114	0.064	0.573*
	(0.065)	(0.117)	(0.107)	(0.174)	(0.348)	(0.312)	(0.142)	(0.189)	(0.219)	(0.220)	(0.341)	(0.358)	(0.125)	(0.285)	(0.333)
externalities	0.032***	0.330***	-0.066	0.039***	0.419***	-0.021	0.041***	0.351***	0.005	0.038***	0.306***	0.013	0.057***	0.327***	0.011
	(0.009)	(0.088)	(0.100)	(0.006)	(0.065)	(0.062)	(0.006)	(0.061)	(0.062)	(0.007)	(0.059)	(0.059)	(0.007)	(0.060)	(0.061)
capital labour ratio	0.011	0.537***	0.103	0.002	0.254***	0.087**	0.002	0.246***	0.082**	0.000	0.233***	0.082**	0.004	0.249***	0.081**
	(0.011)	(0.083)	(0.072)	(0.009)	(0.031)	(0.036)	(0.009)	(0.031)	(0.036)	(0.009)	(0.031)	(0.036)	(0.009)	(0.031)	(0.035)
year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of Obs	1352	1352	1352	2646	2646	2646	2646	2646	2646	2521	2521	2521	2646	2646	2646
individuals		133	133		148	148		148	148		134	134		148	148
Estimator	OLS	FE	FE	OLS	FE	FE	OLS	FE	FE	OLS	FE	FE	OLS	FE	FE

Marginal effect of regulation

productivity level relatively to the frontier

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]
min	0.039	0.233***	0.048	-0.001	-0.655***	0.487**	0.016	-0.158	0.099	0.176	0.190	0.820***	0.101	-0.094	0.549*
	(0.035)	(0.064)	(0.059)	(0.095)	(0.219)	(0.195)	(0.078)	(0.116)	(0.134)	(0.123)	(0.224)	(0.226)	(0.069)	(0.245)	(0.280)
mean_less_1sd	0.021**	0.080***	0.037**	0.019	-0.781***	0.415***	0.054**	-0.177***	0.020	0.127***	0.066	0.586***	0.089***	-0.236	0.527**
	(0.010)	(0.019)	(0.018)	(0.028)	(0.137)	(0.118)	(0.026)	(0.061)	(0.068)	(0.037)	(0.145)	(0.140)	(0.020)	(0.216)	(0.240)
mean	0.017***	0.043***	0.035***	0.025	-0.815***	0.395***	0.065***	-0.182***	-0.001	0.117***	0.039	0.535***	0.086***	-0.274	0.522**
	(0.006)	(0.013)	(0.012)	(0.017)	(0.130)	(0.110)	(0.018)	(0.052)	(0.057)	(0.025)	(0.138)	(0.135)	(0.010)	(0.211)	(0.231)
mean_plus_1sd	0.013*	0.006	0.032**	0.030	-0.849***	0.376***	0.075***	-0.187***	-0.022	0.106***	0.013	0.485***	0.083***	-0.312	0.516**
	(0.007)	(0.016)	(0.015)	(0.022)	(0.133)	(0.110)	(0.022)	(0.049)	(0.052)	(0.027)	(0.135)	(0.136)	(0.014)	(0.206)	(0.222)
max	0.011	-0.008	0.031*	0.032	-0.859***	0.370***	0.078***	-0.188***	-0.028	0.102***	0.002	0.465***	0.082***	-0.323	0.514**
	(0.009)	(0.019)	(0.017)	(0.026)	(0.136)	(0.112)	(0.025)	(0.049)	(0.052)	(0.031)	(0.136)	(0.138)	(0.017)	(0.204)	(0.220)

Note: Standard errors in parentheses

Looking at the results documented in Table 1 (columns [4] to [15]), three configurations emerge. The most frequent case is that of a positive impact of regulation policy, which is decreasing as the industry approaches the technological frontier but remains significantly positive even at the frontier([6], [10],[12],[13],[15]). In regression [7], this positive marginal appears on the contrary to increase as the industry moves closer to the frontier. Also, regulation policy turns out to have a negative significant marginal effect in regressions [5] and [8]. Although this effect is decreasing with the closeness to the frontier, it appears significantly negative for laggard industries. Furthermore, in some cases regulation turns out to have non significant marginal effects, no matter what the distance to the frontier is ([4][9][11][14]). Finally, it should be stressed that even if these regressions do not allow to conclude to a single pattern of the relationship between competition and innovation, none of them reproduce the Aghion story about the effects of regulation.

	firms/VA	reg_impact	reg_services	PMR	PMR (public se
	[1]	[2]	[3]	[4]	[5]
lagged dependent variable	0.896***	0.903***	0.843***	0.922***	0.887***
	(0.064)	(0.032)	(0.049)	(0.022)	(0.033)
distance to frontier	-0.013	1.924**	-0.284	0.003	0.046
	(0.126)	(0.972)	(0.230)	(0.053)	(0.129)
interaction distance ×competition	-0.113*	0.936**	0.494**	0.020	0.068
	(0.067)	(0.469)	(0.198)	(0.114)	(0.096)
competition	0.509*	-3.794**	-1.926**	0.257	-0.144
	(0.280)	(1.909)	(0.823)	(0.450)	(0.397)
externalities	0.177*	0.116**	0.219***	0.084***	0.114***
	(0.105)	(0.046)	(0.064)	(0.024)	(0.036)
capital labour ratio	0.032	-0.032	0.122	-0.041	0.118**
	(0.057)	(0.041)	(0.079)	(0.039)	(0.055)
year dummies	Yes	Yes	Yes	Yes	Yes
Number of Obs	1352	2646	2646	2521	2646
Sargan-Hansen p	0.387	0.164	0.117	0.187	0.224
AR(2)p	0.522	0.908	0.919	0.654	0.946
instruments	122	136	131	106	142
individuals	133	148	148	134	148
Estimator	SY_GMM	SY_GMM	SY_GMM	SY_GMM	SY_GMM
		Marginal effect of competition			
productivity level relatively to the frontier					
min	0.294*	-2.033**	-0.997**	0.294	-0.017
	(0.153)	(1.027)	(0.455)	(0.264)	(0.217)
mean_less_1sd	0.100**	-0.451*	-0.162	0.330*	0.098
	(0.045)	(0.240)	(0.150)	(0.175)	(0.063)
mean	0.053*	-0.028	0.061	0.338*	0.128***
	(0.028)	(0.062)	(0.105)	(0.183)	(0.038)
mean_plus_1sd	0.006	0.395**	0.284**	0.345*	0.159***
	(0.035)	(0.200)	(0.125)	(0.199)	(0.052)
max	-0.012	0.516**	0.348**	0.348*	0.167***
	(0.042)	(0.258)	(0.141)	(0.208)	(0.062)

Note: Standard errors in parentheses
* p<0.10, ** p<0.05, *** p<0.01

Table 2.

As argued in the previous Section, OLS and fixed effect estimators may not be appropriate for the problem considered here. The use of the S-GMM estimator will allow us to deal with the lagged dependent variable bias and the potential endogeneity of several of the regressors. One may indeed suppose that the competition indicators taken into account here are endogenous. For instance, lagging firms or industries may pressure for protection from competition in exchange for political support, whereas the support for regulation would be less pronounced in the vicinity of the technological frontier. Other variables may also be endogenous to the growth process. For these reasons, the competition indicators and the capital/labour ratio will be considered as endogenous in the S-GMM estimations.

Table 2 presents the S-GMM estimations of the effects of competition on innovation. As in our previous results, the number of firms plays a positive role for innovation, but only when industries are far from the technological frontier(Column [1]). This effect vanishes once the relative productivity level rises above the mean. Figure 1 presents the plot of the marginal effect against the closeness to the technological frontier. As one notices clearly with the confidence intervals, a significant innovation-boosting effect exists only for industries under the mean relative productivity. The Figure displays also the histogram of the relative productivity levels. One notices that only a limited number of industry laggards are likely to benefit from increased competition while the bulk of the industries would benefit very little if anything.

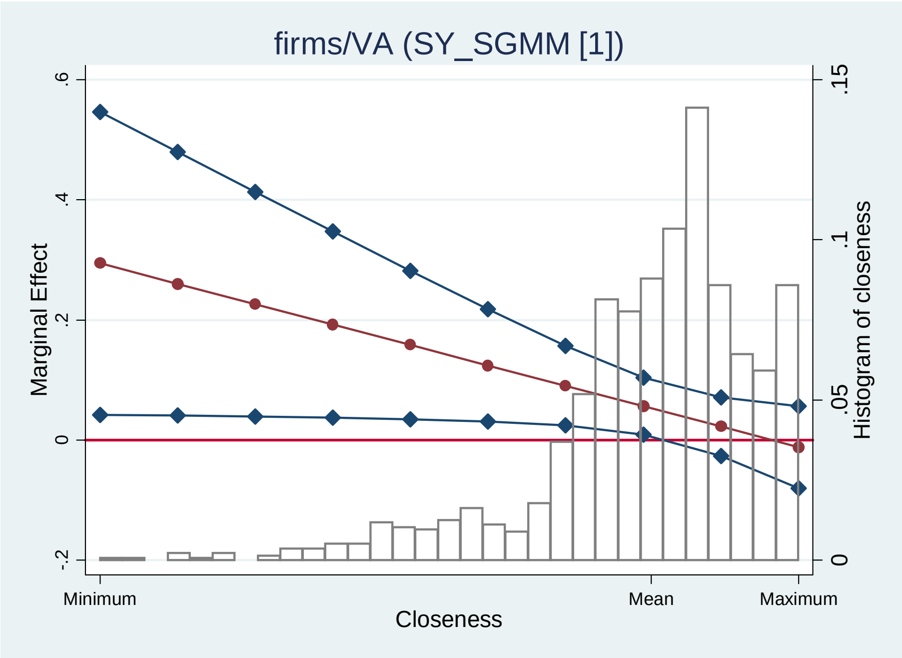

Figure 1.

This effect of competition is broadly confirmed by the results obtained using the indicators of regulation. For the regulation impact (Column [2] and Figure 2) and regulation in nonmanufacturing activities (Column [3] and Figure 3) indicators, competition regulation has a negative impact on innovation far from the frontier. This effect becomes gradually positive as the relative productivity level increases above the mean and turns out to be significantly positive at the frontier. The effect of competition regulation are therefore exactly the opposite of what Aghion (2006) mentions. The results for the economy-wide product market regulation indicators (Columns [4] and [5], Figures 4 and 5) are in line with those just mentioned. Product market regulation has no impact on innovation far from the frontier, and an increasingly positive effect as the productivity level rises.

On the whole, the use of an estimator well-suited to a dynamic specification allows to depict a clearer picture about the marginal effect of competition and regulation according to the proximity to the technological frontier: product market regulation has an increasingly positive impact on innovation as the industry moves closer to the frontier, i.e. the marginal effects of regulation indicators display a positive slope. The findings with the relative number of firms as a proxy for actual market competition are consistent with this result. The next Section checks the robustness of these results by considering alternative specifications under system GMM.

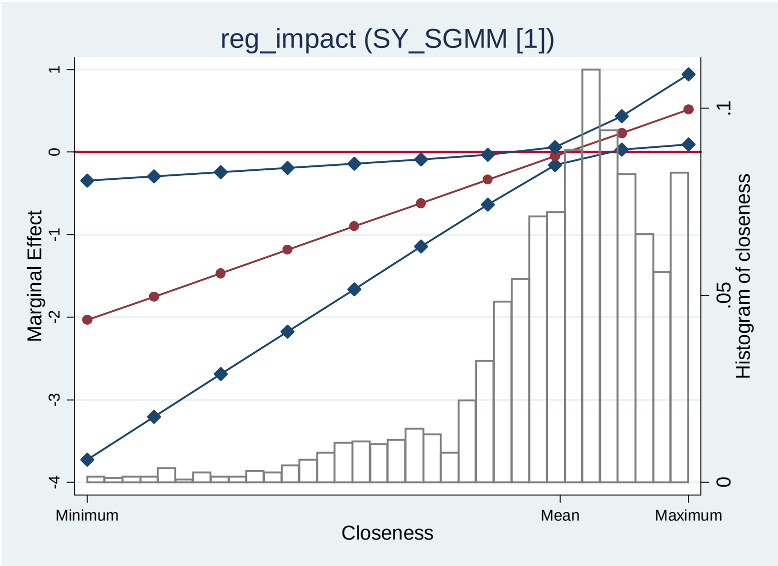

Figure 2.

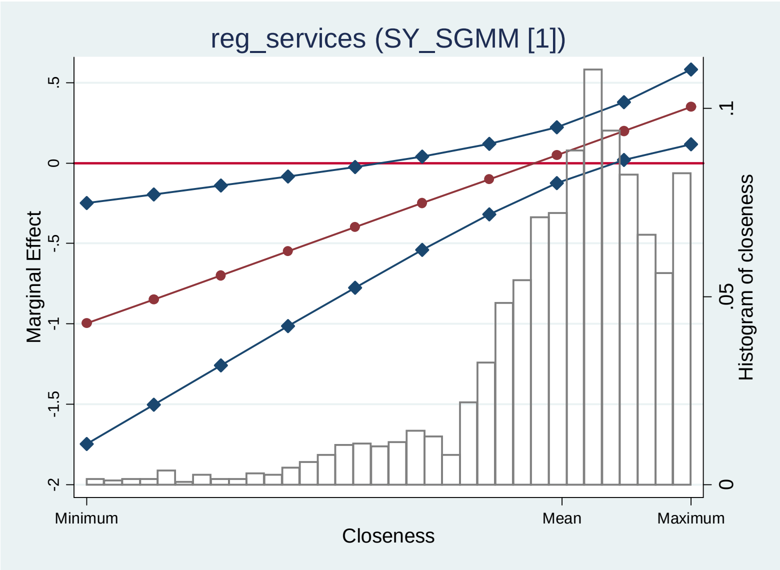

Figure 3.

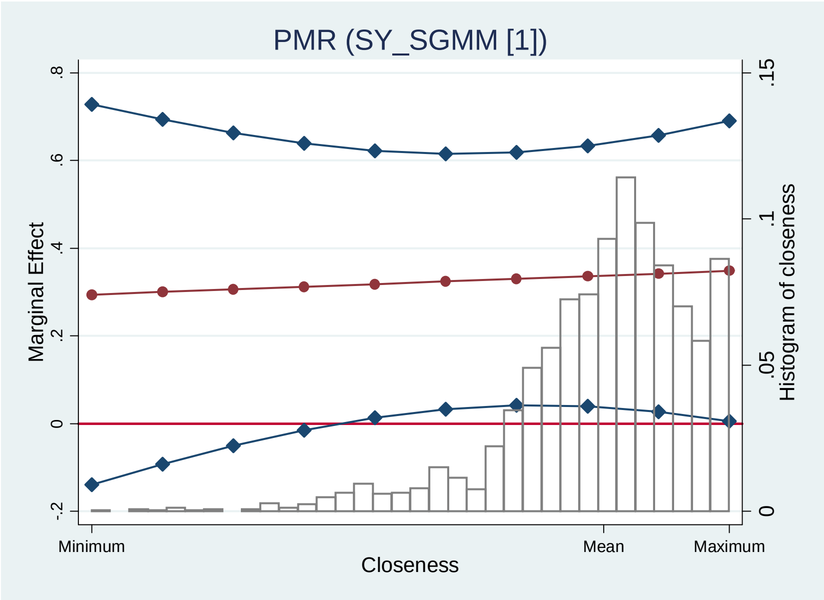

Figure 4.

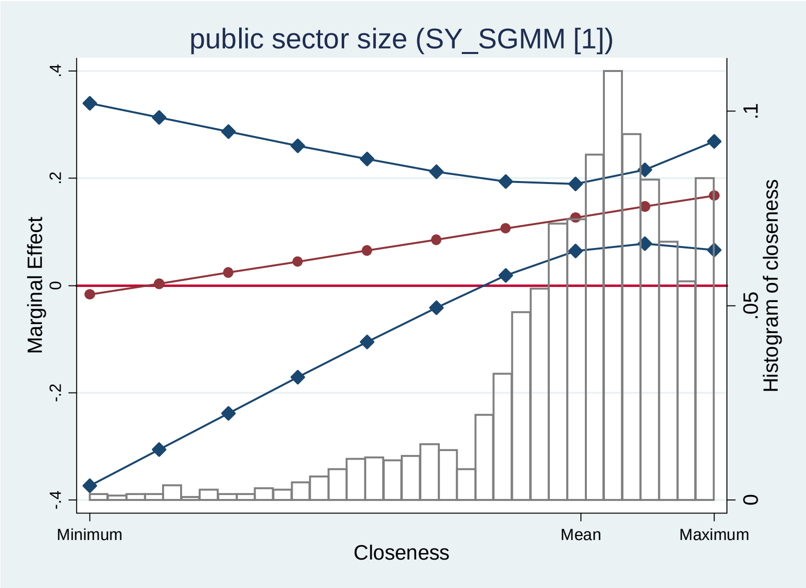

Figure 5.

6 Robustness tests

6.1 Extended model

The model considered in the preceding Section is now extended with the inclusion of other variables. The competition indicators considered previously referred to the domestic situation only. However competition from foreign firms can be important in some industries. In order to control for this effect, the import penetration ratio is included in the regressions. Other institutional variables may have an influence too. The literature on competition and innovation refers particularly to labour and financial markets (Aghion, 2006). More labour market flexibility is supposed to favour restructuring and hasten the decline of sunset industries, allowing factors to be transferred to sunrise industries (Saint-Paul, 2002). Also, more developed financial markets are expected to boost innovative investment since credit-constrained firms may not be able to finance the fixed costs necessary to develop new product or processes. For these reasons, two variables were introduced in the regression: a measure of employment protection and the ratio of total financial assets of institutional investors to GDP (OECD). results for the extended models are presented in Table 3.

Import penetration turns out to have significant coefficients for models [1] and [4].

Each time, the coefficient is positive, which means that the innovation-boosting effect of foreign competition is present. However, changing the competition indicator leads to non significant coefficients in models [2], [3] and [5]. The labour market legislation (employment protection) variable obtains significant coefficients with all regulation indicators. However, the impact is negative with the economy-wide product market regulation indicators ([4] and [5]) but positive with the nonmanufacturing regulation indicators ([2] and [3]). one cannot therefore conclude to the existence of an innovation-hindering effect of employment legislation. Finally, the financial variable obtains significant, positive, coefficients with the economy-wide indicators ([4] and [5]).

The extension of the model with the three variables do not significantly change the results concerning the marginal effect of product market regulation or competition. The magnitude of the effect is sometimes changed (for instance with the regulation impact indicator) but the positively-sloped relationship of the regulation effect with the relative productivity level is maintained. The same applies for the negative slope of the marginal effect of the relative number of firms ([1]) The only change worth mentioning takes place with the *REGREF* variable ([3]), where regulation now fails to have a positive impact on innovation even at the frontier. However, since the *regimpact* variable seems more suited to the industry-level data used in the estimations, the results of model [2] are certainly more accurate. One can also note that the positive impact of the PMR variable restricted to the Public Sector [5] turns now significant far from the technological frontier whereas it was not the case in the baseline model (Table 2, column [5]).

We also consider the extension that the consideration of a translog function for innovation represents. To this effect, quadratic terms for the distance to frontier and the competition indicators were introduced in the regressions. This more flexible function should make it possible to estimate more accurately the effects of regulation. Results are presented in Table 4. Once again, nothing substantial is altered in comparison with the results in Tables 2 or 3. The slopes of the marginal effects remain the same and the magnitude of the effects is not changed very much. However, this time, regulation fails to have a positive innovation effect at the frontier even with the regimpact indicator.

	firms/VA	***reg_impact***	***reg_services***	***PMR***	***PMR (public se***
	[1]	**[2]**	**[3]**	**[4]**	**[5]**
lagged dependent variable	0.919***	0.857***	0.840***	0.835***	0.693***
	(0.027)	(0.044)	(0.044)	(0.051)	(0.082)
distance to frontier	-0.125	1.411***	-0.031	-0.117	-0.027
	(0.133)	(0.516)	(0.125)	(0.106)	(0.111)
interaction distance ×competition	-0.104	0.665***	0.065	0.265	0.059
	(0.069)	(0.257)	(0.115)	(0.163)	(0.086)
competition	0.469	-2.814***	-0.780	-0.010	0.775
	(0.289)	(1.067)	(0.551)	(0.927)	(0.485)
externalities	0.061*	0.156***	0.152***	0.106*	0.282***
	(0.035)	(0.041)	(0.043)	(0.062)	(0.086)
capital labour ratio	0.168**	-0.069	0.033	0.015	0.119**
	(0.070)	(0.074)	(0.054)	(0.063)	(0.057)
import penetration	0.109*	-0.054	0.015	0.239**	0.052
	(0.062)	(0.047)	(0.060)	(0.118)	(0.092)
labour market legislation	-0.045	0.118*	0.169*	-0.444**	-0.278*
	(0.033)	(0.069)	(0.098)	(0.207)	(0.153)
financial assets	-0.019	-0.001	-0.012	0.293**	0.518**
	(0.051)	(0.060)	(0.055)	(0.117)	(0.207)
year dummies	Yes	Yes	Yes	Yes	Yes
Number of Obs	1154	2110	2110	2110	2110
Sargan-Hansen p	0.378	0.148	0.125	0.128	0.117
AR(2)p	0.823	0.920	0.885	0.900	0.873
instruments	99	122	93	75	106
individuals	125	126	126	126	126
Estimator	SY_GMM	SY_GMM	SY_GMM	SY_GMM	SY_GMM
			Marginal effect of competition		
productivity level relatively to the frontier					
min	0.232*	-1.425***	-0.644*	0.545	0.899**
	(0.134)	(0.534)	(0.341)	(0.673)	(0.394)
mean_less_1sd	0.086**	-0.349**	-0.538**	0.974*	0.994***
	(0.042)	(0.142)	(0.222)	(0.545)	(0.371)
mean	0.045*	-0.104	-0.513**	1.072**	1.016***
	(0.024)	(0.091)	(0.209)	(0.531)	(0.373)
mean_plus_1sd	0.004	0.142	-0.489**	1.171**	1.038***
	(0.029)	(0.119)	(0.204)	(0.522)	(0.377)
max	-0.012	0.248*	-0.479**	1.213**	1.047***
	(0.037)	(0.150)	(0.205)	(0.521)	(0.380)

Note: Standard errors in parentheses

* p<0.10, ** p<0.05, *** p<0.01

Table 3.

	firms/VA	reg_impact	reg_services	PMR	PMR (public se
	[1]	[2]	[3]	[4]	[5]
lagged dependent variable	0.918***	0.836***	0.865***	0.913***	0.880***
	(0.031)	(0.041)	(0.033)	(0.024)	(0.031)
distance to frontier	0.891*	0.385	0.674	0.115	0.301
	(0.479)	(0.681)	(0.846)	(0.580)	(0.298)
interaction distance ×competition	-0.061	0.396*	0.505**	0.042	0.052
	(0.038)	(0.218)	(0.242)	(0.096)	(0.089)
competition	0.295**	-1.248	-4.420***	1.001*	-0.132
	(0.147)	(1.070)	(1.406)	(0.514)	(0.345)
externalities	0.102**	0.191***	0.180***	0.095***	0.119***
	(0.047)	(0.051)	(0.042)	(0.026)	(0.035)
capital labour ratio	0.037	0.011	0.014	-0.033	0.103***
	(0.046)	(0.041)	(0.038)	(0.043)	(0.036)
distance to frontier²	-0.139**	-0.099	0.078	-0.014	-0.037
	(0.064)	(0.113)	(0.082)	(0.084)	(0.041)
competition²	0.013	-0.095	-0.553***	-0.533***	0.087
	(0.010)	(0.201)	(0.161)	(0.169)	(0.111)
year dummies	Yes	Yes	Yes	Yes	Yes
Number of Obs	1352	2646	2646	2521	2646
Sargan-Hansen p	0.556	0.185	0.211	0.288	0.117
AR(2)p	0.524	0.950	0.904	0.651	0.958
instruments	121	142	144	106	143
individuals	133	148	148	134	148
Estimator	SY_GMM	SY_GMM	SY_GMM	SY_GMM	SY_GMM
			Marginal effect of competition		
productivity level relatively to the frontier					
min	0.178**	-0.765*	-1.180**	0.485*	0.152
	(0.076)	(0.429)	(0.542)	(0.286)	(0.263)
mean_less_1sd	0.073***	-0.096	-0.327**	0.560**	0.240
	(0.021)	(0.132)	(0.147)	(0.234)	(0.160)
mean	0.048**	0.082	-0.098	0.576**	0.263*
	(0.020)	(0.137)	(0.074)	(0.238)	(0.148)
mean_plus_1sd	0.022	0.261	0.130	0.592**	0.286**
	(0.030)	(0.198)	(0.115)	(0.247)	(0.145)
max	0.013	0.312	0.195	0.598**	0.293**
	(0.034)	(0.221)	(0.141)	(0.252)	(0.147)

Note: Standard errors in parentheses
* p<0.10, ** p<0.05, *** p<0.01

Table 4.

The two above-mentioned extensions can be combined to obtain a translog model with added institutional controls. Table 5 presents the estimations of this model with the various competition or regulation indicators. The results concerning the marginal effects are basically unchanged. The main result, i.e. the non existence of a significant negative effect of product market regulation at the technological frontier, is preserved. However, it should be also noticed that, relatively to the simple translog model, the extended one provides a better assessment of the impact of regulation.

While in the previous table (Table 4, columns [2] and [3]) the marginal effects of regulation in services and their impact on industries were only significant far from the frontier, they are now significant for a larger interval. Concerning the effects of additional controls, results are not substantially modified. The positive effects of labour market legislation obtained with the regimpact and REGREF indicators now turn out to be insignificant (columns [2] and [3]) while the negative impact obtained with the economy-wide regulation indicators is maintained. The financial assets variable only obtains a significant coefficient with the PMR variable restricted to the Public sector (column [5]).

Besides some changes in the significance and magnitude of the marginal effect of regulation, the picture depicted in the first regressions (Table 2) remains qualitatively unchanged after this first robustness test. Indeed, most of the time, regulation policy improves innovative performances as one moves closer to the leading edge of technology (columns [2][4][5], Tables 2, 3, 4). Only the model with additional institutional controls using the regulation in services indicator (column [3],Tables 3 and 5) delivers divergent results. Product market regulation turns out significantly detrimental to innovative performances near the frontier only in regression [3] in Table 3. Nevertheless, this adverse impact of services regulation is weaker the closer to the frontier an industry is.

	firms/VA	*reg_impact*	*reg_services*	*PMR*	*PMR (public s*
	[1]	**[2]**	**[3]**	**[4]**	**[5]**
lagged dependent variable	0.920***	0.950***	0.814***	0.927***	0.688***
	(0.023)	(0.031)	(0.053)	(0.040)	(0.076)
distance to frontier	0.344	1.632	1.495	-0.520	0.791
	(0.825)	(1.103)	(1.148)	(0.599)	(0.817)
interaction distance ×competition	-0.101	0.565**	0.401	0.101	0.075
	(0.066)	(0.276)	(0.246)	(0.143)	(0.076)
competition	0.462*	-4.143**	-1.016	0.850	0.814
	(0.274)	(2.003)	(0.860)	(0.951)	(0.529)
externalities	0.066**	0.062**	0.165***	0.025	0.292***
	(0.033)	(0.029)	(0.052)	(0.036)	(0.080)
capital labour ratio	0.154**	0.006	0.087	0.032	0.127**
	(0.064)	(0.103)	(0.058)	(0.053)	(0.061)
import penetration	0.099*	-0.023	0.073	0.205**	0.032
	(0.054)	(0.069)	(0.061)	(0.104)	(0.094)
labour market legislation	-0.031	-0.026	0.058	-0.276*	-0.308*
	(0.036)	(0.077)	(0.093)	(0.161)	(0.177)
financial assets	-0.000	-0.021	-0.017	0.088	0.490**
	(0.050)	(0.060)	(0.061)	(0.092)	(0.204)
distance to frontier²	-0.062	-0.046	-0.249	0.064	-0.113
	(0.107)	(0.103)	(0.182)	(0.093)	(0.116)
competition²	0.008	-0.421	-0.391**	-0.416	-0.057
	(0.011)	(0.300)	(0.189)	(0.429)	(0.159)
year dummies	Yes	Yes	Yes	Yes	Yes
Number of Obs	1154	2110	2110	2110	2110
Sargan-Hansen p	0.294	0.137	0.219	0.231	0.210
AR(2)p	0.815	0.928	0.893	0.920	0.889
instruments	103	95	88	77	110
individuals	125	126	126	126	126
Estimator	SY_GMM	SY_GMM	SY_GMM	SY_GMM	SY_GMM
			Marginal effect of competition		
productivity level relatively to the frontier					
min	0.233*	-1.222**	-1.250*	0.596	0.846**
	(0.125)	(0.578)	(0.651)	(0.501)	(0.348)
mean_less_1sd	0.091**	-0.308*	-0.601**	0.759*	0.967***
	(0.038)	(0.187)	(0.284)	(0.448)	(0.351)
mean	0.052**	-0.099	-0.453**	0.796*	0.995***
	(0.023)	(0.150)	(0.216)	(0.452)	(0.357)
mean_plus_1sd	0.013	0.109	-0.305*	0.833*	1.022***
	(0.031)	(0.175)	(0.172)	(0.462)	(0.366)
max	-0.003	0.199	-0.241	0.849*	1.034***
	(0.039)	(0.201)	(0.164)	(0.468)	(0.370)

Note: Standard errors in parentheses

* p<0.10, ** p<0.05, *** p<0.01

Table 5.

6.2 The model with lagged regressors

To test further the robustness of the results, regressors are now included with a lag. This specification is sometimes adopted in the competition and innovation literature (ref). Results for the base and for the translog models are presented in Tables 6 and 7 and are compared with those of the contemporaneous model (Tables 2 and 4).

Concerning the base model for the S-GMM estimates, two main differences emerge. First, while the contemporaneous model account for a positive significant impact of regulation close to the frontier (Table 2, columns [2] and [3]), regulation policy in the lagged model does not have a significant impact near the frontier (Table 6, columns [2] and [3]). In contrast, the economy-wide regulation indicator for the Public sector turns out now to have a significant and positive impact for laggard industries , while they were non significant in the baseline model (Table 2 and 6, columns [4] and [5]). For all regulation indicators the main result obtained with system-GMM estimations is confirmed, i.e. a positively-sloped relationship for the marginal effect of regulation as the distance to the frontier decreases. Also, one should note that the negative slope for the relative number of firms is preserved.

	firms/VA	reg_impact	reg_services	PMR	PMR (public se
	[1]	[2]	[3]	[4]	[5]
lagged dependent variable	0.875***	0.875***	0.863***	0.953***	0.705***
	(0.054)	(0.041)	(0.041)	(0.023)	(0.061)
distance to frontier $_{(t-1)}$	-0.163	1.007**	-0.173	0.048	0.207**
	(0.112)	(0.490)	(0.152)	(0.083)	(0.096)
interaction distance ×competition (t-1)	-0.110*	0.453**	0.212	0.001	0.019
	(0.066)	(0.229)	(0.131)	(0.110)	(0.067)
competition (t-1)	0.476*	-2.017**	-1.072*	0.194	0.292
	(0.277)	(0.988)	(0.553)	(0.482)	(0.273)
externalities (t-1)	0.140**	0.128***	0.136***	0.062	0.374***
	(0.063)	(0.044)	(0.045)	(0.042)	(0.084)
capital labour ratio (t-1)	-0.028	0.026	0.039	0.070	0.227***
	(0.075)	(0.054)	(0.053)	(0.053)	(0.087)
year dummies	Yes	Yes	Yes	Yes	Yes
Number of Obs	1321	2649	2649	2455	2649
Sargan-Hansen p	0.565	0.143	0.130	0.284	0.146
AR(2)p	0.961	0.689	0.715	0.969	0.702
instruments	93	143	134	131	136
individuals	133	148	148	134	148
Estimator	SY_GMM	SY_GMM	SY_GMM	SY_GMM	SY_GMM
		Marginal effect of competition			
productivity level relatively to the frontier					
min	0.267*	-1.165**	-0.674**	0.196	0.328**
	(0.152)	(0.561)	(0.316)	(0.278)	(0.159)
mean_less_1sd	0.077*	-0.394**	-0.314**	0.197*	0.361***
	(0.043)	(0.191)	(0.136)	(0.112)	(0.089)
mean	0.031	-0.192	-0.219*	0.198**	0.369***
	(0.024)	(0.119)	(0.117)	(0.093)	(0.088)
mean_plus_1sd	-0.014	0.010	-0.124	0.198**	0.378***
	(0.028)	(0.112)	(0.126)	(0.092)	(0.097)
max	-0.031	0.068	-0.098	0.198**	0.380***
	(0.035)	(0.126)	(0.133)	(0.097)	(0.101)

Note: Standard errors in parentheses
* p<0.10, ** p<0.05, *** p<0.01

Table 6.

Results for the translog model estimations are given in Table 7. Two main remarks can be made. First, for the impact of service regulation and Public sector indicators, the magnitude of the marginal effect is higher in the translog lagged model than in contemporaneous one (see Tables 4 and 7). Second, the adverse impact of the *REGREF* and *regimpact* indicators ([2] and [3] appear significant for a wider interval, at least up to the mean value of the relative productivity level, whereas this effect was only significant for small values in the translog contemporaneous model (Table 4). Most importantly, the upward slope of the marginal effect is still observed.

One should stress that here again the main result is not substantially modified: there is no evidence of an adverse impact of regulation near the frontier and the marginal effects of regulation display a positively-sloped relationship against the relative productivity level of the industry. Similarly, the marginal effect of the number of firms per value added on patenting is significantly positive for laggard industries and decreases with the productivity gap, becoming non significant at the frontier.

	firms/VA	*reg_impact*	*reg_services*	*PMR*	*PMR (public sector)*
	[1]	[2]	[3]	[4]	[5]
lagged dependent variable	0.915***	0.874***	0.861***	0.889***	0.688***
	(0.032)	(0.040)	(0.041)	(0.053)	(0.064)
distance to frontier (t-1)	1.112	1.213	-0.810	0.457	-0.861
	(0.876)	(0.888)	(0.708)	(0.674)	(1.025)
interaction distance ×competition (t-1)	-0.033	0.513**	0.185	0.004	0.049
	(0.035)	(0.244)	(0.136)	(0.172)	(0.093)
competition (t-1)	0.189	-2.731*	-0.649	0.299	0.012
	(0.139)	(1.482)	(0.601)	(0.727)	(0.406)
externalities (t-1)	0.112**	0.131***	0.141***	0.134*	0.397***
	(0.053)	(0.044)	(0.044)	(0.069)	(0.089)
capital labour ratio (t-1)	-0.034	0.025	0.024	0.002	0.213**
	(0.038)	(0.057)	(0.056)	(0.055)	(0.087)
distance to frontier² (t-1)	-0.161	-0.011	0.096	-0.054	0.149
	(0.115)	(0.097)	(0.109)	(0.099)	(0.141)
competition² (t-1)	0.009	-0.109	-0.134	0.061	0.181
	(0.012)	(0.180)	(0.104)	(0.146)	(0.134)
year dummies	Yes	Yes	Yes	Yes	Yes
Number of Obs	1321	2649	2649	2455	2649
Sargan-Hansen p	0.671	0.136	0.147	0.244	0.197
AR(2)p	0.962	0.690	0.709	0.986	0.706
instruments	116	143	134	82	136
individuals	133	148	148	134	148
Estimator	SY_GMM	SY_GMM	SY_GMM	SY_GMM	SY_GMM
		Marginal effect of competition			
productivity level relatively to the frontier					
min	0.126*	-1.318**	-0.676**	0.376	0.495*
	(0.074)	(0.594)	(0.309)	(0.398)	(0.262)
mean_less_1sd	0.069***	-0.445**	-0.361**	0.383*	0.579***
	(0.025)	(0.199)	(0.143)	(0.204)	(0.191)
mean	0.056**	-0.216*	-0.279**	0.384*	0.601***
	(0.023)	(0.121)	(0.136)	(0.203)	(0.191)
mean_plus_1sd	0.042	0.014	-0.196	0.386*	0.623***
	(0.029)	(0.116)	(0.155)	(0.222)	(0.199)
max	0.037	0.078	-0.173	0.386*	0.630***
	(0.033)	(0.132)	(0.164)	(0.234)	(0.203)

Note: Standard errors in parentheses
* p<0.10, ** p<0.05, *** p<0.01

Table 7.

7 Conclusion

This paper has examined the proposition according to which the impact of competition on innovative performances depends on the distance to the technological frontier. Basically, this proposition states that competition discourages innovation for laggard firms or industries but represents a major incentive to innovate as the economy moves closer to the technological frontier (Aghion 2006). This is consistent with the idea an inverted U-shape relationship between competition and innovation that is stepper for economies at the leading edge of technology. To test the empirical validity of this proposition we used a panel of industries for OECD countries.

The outcome of the estimations presented in this paper do not support the existence of an innovation-bolstering effect of product market competition at the technological frontier. Whilst global regulation indicators (PMR and PMR for Public sector) turn out to have always a significant positive impact on patenting, time varying indicators (regulation in services and regulation impact) in some cases have a negative impact, especially far from the frontier. One also finds a certain regularity concerning the relationship between distance to the frontier and regulation: the marginal effect of regulation policy is increasing as an industry comes near to the technological frontier. Two main configurations emerge. First, regulation has a positive effect whatever the distance to the frontier and the magnitude of its impact is higher the closer the industry is to the frontier; this is the case when one considers the indicators for PMR and PMR Public sector. Second, the effect of regulation is negative far from the frontier and becomes positive (or non significant) when the technology gap decreases. In other words, based on these estimates, the marginal effect has the opposite slope of what Aghion et al. (2005) predict.

These results, though contradicting the recent belief in the positive effects of competition on innovation, are compatible with previous theoretical work and micro empirical studies that emphasized the existence of a Schumpeterian effect or even a size effect in innovation. Similarly, results concerning the positive impact of the public sector on innovation are also consistent with arguments highlighting the sub-optimality of the market equilibrium in the presence of technological externalities. At the end, the lack of evidence supporting the benefits of market competition when industries come close to the technology frontier raises important questions concerning economic policy. Namely, strategies, such as those adopted in the Lisbon Agenda, strongly relying on a positive effect of market deregulation on innovation seem weakly supported by the data.

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9 Appendix:

9.1 The data

	Industry	Country list
15-16	Food products, beverages and tobacco	Austria
17-19	Textiles, textile products, leather and footwear	Belgium
17	Textiles	Denmark
18	Wearing apparel, dressing and dyeing of fur	Finland
19	Leather, leather products and footwear	France
20	Wood and products of wood and cork	Germany
21-22	Pulp, paper, paper products, printing and publishing	Greece
24	Chemicals and chemical products	Ireland
25	Rubber and plastics products	Italy
26	Other non-metallic mineral products	Japan
27	Basic metals	Netherland
28	Fabricated metal products, except machinery and equipment	Norway
29	Machinery and equipment, n.e.c.	Portugal
30	Office, accounting and computing machinery	Spain
31	Electrical machinery and aPPPratus, nec	Sweden
32	Radio, television and communication equipment	UK
33	Medical, precision and optical instruments, watches and clocks	US
34	Motor vehicles, trailers and semi-trailers	

Table 1: Table A1. List of industries and countries

9.2 Regressions

Sample	**N**	**mean**	**Std. Dev.**	**min**	**max**
OECD-STAN	4129	28,73	19,68	2,82	309,13
GGDC	6345	37,58	216,74	-12,21	12233,91
GGDC Industry 30	423	198,40	818,60	-12,21	12233,91
Final Filtered Data	6099	25,73	23,85	0,02	581,73

Table 2: Table A2. Descriptive statistics of labour productivity in I-PPPs for different samples

Country	**Mean I-PPPs**	**CV I-PPPs**	**Mean PPPs**	**CV PPPs**
Austria	23,19	0,80	25,98	0,60
Belgium	33,27	0,66	32,30	0,71
Denmark	23,44	0,55	23,60	0,46
Finland	26,87	0,73	25,86	0,76
France	28,01	0,99	29,79	0,88
Germany	28,61	0,74	28,19	0,85
Greece	12,24	0,66	13,51	0,68
Ireland	30,35	1,99	32,34	2,03
Italy	29,17	0,63	26,49	0,71
Japan	24,05	1,28	22,54	1,14
Netherland	31,84	0,63	32,86	0,44
Norway	25,42	0,49	26,64	0,45
Portugal	14,03	0,79	15,86	0,70
Spain	25,77	0,49	24,25	0,52
Sweden	27,98	0,58	26,88	0,52
UK	22,74	0,68	25,44	0,62
US	30,86	0,60	30,86	0,60
Total	25,73	0,93	26,07	0,91

Table 3: Table A3. Mean values and coefficient of variation of Labour Productivity by country

Industry	**Mean I-PPPs**	**CV I-PPPs**	**Mean PPPs**	**CV PPPs**
Basic metals	29,21	0,39	28,36	0,38
Chemicals and ch	54,73	0,94	45,16	0,78
Electrical machi	22,93	0,47	25,00	0,45
Fabricated metal	20,53	0,42	19,50	0,36
Food products, b	24,20	0,44	25,41	0,37
Machinery and eq	23,02	0,36	23,57	0,32
Medical, precisi	19,97	0,50	24,08	0,46
Motor vehicles,	18,92	0,70	26,81	0,47
Office, accounti	29,69	1,49	27,68	1,41
Other non-metall	30,97	0,36	25,28	0,34
Pulp, paper, pap	26,80	0,35	28,27	0,34
Radio, televisio	26,20	1,78	35,74	1,90
Rubber and plast	32,02	0,44	23,26	0,35
Textiles, textil	12,89	0,39	15,64	0,35
Wood and product	16,25	0,43	18,25	0,37
Total	25,73	0,93	26,07	0,91

Table 4: Table A4. Mean values and coefficient of variation of Labour Productivity by industry

Country	Frequency at the frontier (I-PPPs)	Frequency at the frontier (PPPs)
Austria	7	10
Belgium	59	56
Denmark	8	15
Finland	20	10
France	7	8
Germany	3	4
Greece	3	13
Ireland	24	42
Italy	55	1
Japan	35	23
Netherland	70	95
Norway	17	38
Portugal	6	7
Sweden	18	3
UK	10	22
US	33	28
Total	375	375

Table 5: Table A5. Frequency at the frontier level by country

Variable	N	Mean	Std. Dev.	Min	Max
Labor productivity	6099	25,73	23,85	0,02	581,73
Closeness to the frontier (%)	6099	56,89	24,07	1,93	100
R&D over added value	2852	10,40	50,00	0,00	711,03
Patents over hour worked	6345	0,00165	0,00939	0,00000	0,39679
Capital intensity	2785	0,05	0,03	0,00	0,20
REGREF	6375	4,19	1,31	1,05	6,00
REGIMP	6375	0,13	0,04	0,05	0,22
PMR	5760	1,80	0,44	0,92	2,78
PMR_SC_SIZ	6375	3,01	1,28	0,00	4,61
DNVA	2599	2,06	3,67	0,00	37,70
EPLBLD	5685	1,23	0,52	0,10	2,04
MPEN	5057	45,28	44,95	0,6	988,1

Table 6: Table A6. Global descriptive statistics

Variable	**Model**	χ**2**	**p-value**
p_{it}	AR(1)	770.384	0.000
p_{it}	AR(1)+trend	451.852	0.970
p_{it}	AR(1)+drift	1810.240	0.000
cl_{it}	AR(1)	897.568	0.000
cl_{it}	AR(1)+trend	811.743	0.000
cl_{it}	AR(1)+drift	1809.637	0.000
kl_{it}	AR(1)	268.474	0.855
kl_{it}	AR(1)+trend	320.743	0.136
kl_{it}	AR(1)+drift	608.019	0.000
ex_{it}	AR(1)	565.012	0.046
ex_{it}	AR(1)+trend	217.560	1.000
ex_{it}	AR(1)+drift	1615.682	0.000
p_{it}	AR(2)	615.627	0.001
p_{it}	AR(2)+trend	284.219	1.000
p_{it}	AR(2)+drift	1593.648	0.000
cl_{it}	AR(2)	542.291	0.083
cl_{it}	AR(2)+trend	433.096	0.984
cl_{it}	AR(2)+drift	1334.333	0.000
kl_{it}	AR(2)	255.967	0.947
kl_{it}	AR(2)+trend	640.608	0.000
kl_{it}	AR(2)+drift	526.042	0.000
ex_{it}	AR(2)	311.474	1.000
ex_{it}	AR(2)+trend	188.493	1.000
ex_{it}	AR(2)+drift	1244.758	0.000

Table 7: Table A7. Unit Root Test Madala and Wu (1999) (Ho: Non Stationary)

	firms per value added			*regulation impact*			*regulation in services*			*product market regulation*			*product market regulation (public sector)*		
	[1]	**[2]**	**[3]**	**[4]**	**[5]**	**[6]**	**[7]**	**[8]**	**[9]**	**[10]**	**[11]**	**[12]**	**[13]**	**[14]**	**[15]**
lagged dependent variable	0.972***	0.315***		0.957***	0.517***		0.955***	0.574***		0.951***	0.633***		0.943***	0.596***	
	(0.009)	(0.074)		(0.006)	(0.033)		(0.007)	(0.030)		(0.008)	(0.029)		(0.007)	(0.030)	
distance to frontier	0.187	-0.703**	0.607***	0.213	0.362	0.429	0.185	0.115	0.426*	0.233*	0.111	0.487**	0.277**	0.187	0.424*
	(0.164)	(0.320)	(0.235)	(0.155)	(0.239)	(0.266)	(0.132)	(0.212)	(0.233)	(0.135)	(0.196)	(0.195)	(0.139)	(0.217)	(0.238)
interaction distance ×competition	-0.006	-0.094***	-0.004	0.011	0.110	-0.004	0.018	0.028	-0.022	0.031	-0.031	-0.064	-0.020	-0.091***	-0.007
	(0.015)	(0.026)	(0.023)	(0.043)	(0.086)	(0.074)	(0.033)	(0.045)	(0.052)	(0.054)	(0.078)	(0.086)	(0.028)	(0.030)	(0.033)
competition	0.045	0.422***	0.051	-0.836***	-5.573***	-0.686	0.389***	0.557***	0.087	0.521**	1.047***	1.187***	0.193*	-0.248	0.703
	(0.062)	(0.110)	(0.098)	(0.304)	(0.672)	(0.646)	(0.125)	(0.191)	(0.218)	(0.250)	(0.343)	(0.338)	(0.113)	(0.875)	(1.048)
externalities	0.033***	0.329***	-0.052	0.045***	0.564***	0.007	0.046***	0.387***	0.004	0.048***	0.309***	0.010	0.059***	0.331***	0.009
	(0.009)	(0.088)	(0.102)	(0.007)	(0.066)	(0.061)	(0.007)	(0.062)	(0.062)	(0.007)	(0.059)	(0.059)	(0.007)	(0.060)	(0.061)
capital labour ratio	0.014	0.535***	0.098	0.005	0.276***	0.096***	0.006	0.231***	0.087**	0.005	0.243***	0.091**	0.006	0.250***	0.088**
	(0.012)	(0.085)	(0.080)	(0.009)	(0.030)	(0.036)	(0.009)	(0.030)	(0.037)	(0.009)	(0.031)	(0.036)	(0.009)	(0.031)	(0.036)
distance to frontier²	-0.028	0.084**	-0.084***	-0.025	-0.016	-0.057*	-0.027	-0.024	-0.053	-0.034*	-0.015	-0.061**	-0.032*	-0.013	-0.055*
	(0.021)	(0.041)	(0.032)	(0.019)	(0.030)	(0.032)	(0.018)	(0.031)	(0.034)	(0.019)	(0.028)	(0.029)	(0.018)	(0.029)	(0.032)
competition²	0.004	-0.003	0.008	-0.190***	-0.928***	-0.242***	-0.173***	-0.380***	-0.000	-0.444***	-0.537***	-0.248*	-0.023	0.161	-0.075
	(0.003)	(0.005)	(0.006)	(0.050)	(0.095)	(0.093)	(0.045)	(0.051)	(0.049)	(0.097)	(0.133)	(0.143)	(0.023)	(0.342)	(0.409)
year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of Obs	1352	1352	1352	2646	2646	2646	2646	2646	2646	2521	2521	2521	2646	2646	2646
individuals		133	133		148	148		148	148		134	134		148	148
Estimator	OLS	FE	FE	OLS	FE	FE	OLS	FE	FE	OLS	FE	FE	OLS	FE	FE
							Marginal effect of competition								
productivity level relatively to the frontier															
min	0.032	0.244***	0.044	-0.032	-1.528***	0.305	-0.052	-0.430***	0.044	0.085	0.389*	0.788***	0.105	-0.074	0.528**
	(0.034)	(0.061)	(0.054)	(0.100)	(0.257)	(0.226)	(0.088)	(0.137)	(0.155)	(0.125)	(0.218)	(0.214)	(0.073)	(0.214)	(0.240)
mean_less_1sd	0.022**	0.082***	0.037**	-0.014	-1.342***	0.298**	-0.021	-0.383***	0.007	0.141***	0.334**	0.673***	0.070**	-0.228	0.517**
	(0.010)	(0.019)	(0.018)	(0.033)	(0.162)	(0.135)	(0.039)	(0.075)	(0.079)	(0.038)	(0.153)	(0.151)	(0.036)	(0.203)	(0.222)
mean	0.020***	0.043***	0.036***	-0.009	-1.292***	0.296**	-0.013	-0.370***	-0.003	0.153***	0.322**	0.648***	0.061**	-0.269	0.514**
	(0.006)	(0.013)	(0.013)	(0.022)	(0.150)	(0.122)	(0.031)	(0.063)	(0.065)	(0.028)	(0.153)	(0.155)	(0.030)	(0.203)	(0.219)
mean_plus_1sd	0.017**	0.003	0.035**	-0.004	-1.242***	0.294**	-0.005	-0.358***	-0.014	0.165***	0.310*	0.623***	0.052*	-0.311	0.510**
	(0.007)	(0.015)	(0.015)	(0.025)	(0.149)	(0.117)	(0.029)	(0.057)	(0.057)	(0.032)	(0.159)	(0.165)	(0.029)	(0.203)	(0.218)
max	0.016*	-0.011	0.034**	-0.003	-1.228***	0.293**	-0.002	-0.354***	-0.017	0.170***	0.305*	0.614***	0.049	-0.322	0.510**
	(0.009)	(0.018)	(0.017)	(0.029)	(0.150)	(0.118)	(0.029)	(0.056)	(0.056)	(0.036)	(0.162)	(0.170)	(0.030)	(0.203)	(0.217)

Note: Standard errors in parentheses
* p<0.10, ** p<0.05, *** p<0.01

Table A8.

	firms per value added			regulation impact			regulation in services			product market regulation			product market regulation (public sector)		
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]
lagged dependent variable	0.960***	0.269***		0.933***	0.547***		0.935***	0.602***		0.942***	0.614***		0.924***	0.602***	
	(0.013)	(0.097)		(0.013)	(0.045)		(0.013)	(0.040)		(0.012)	(0.039)		(0.012)	(0.040)	
distance to frontier	-0.016	-0.030	-0.125*	0.015	-0.343**	-0.044	0.032	0.120***	0.099*	0.005	0.092***	0.043	0.024	0.221***	0.021
	(0.029)	(0.052)	(0.067)	(0.088)	(0.144)	(0.162)	(0.037)	(0.046)	(0.051)	(0.024)	(0.035)	(0.033)	(0.029)	(0.043)	(0.036)
interaction distance ×competition	-0.011	-0.076***	-0.066**	0.013	-0.167**	-0.011	-0.034	-0.090**	-0.109**	-0.022	-0.143**	-0.132**	-0.032	-0.169***	-0.042
	(0.018)	(0.025)	(0.031)	(0.039)	(0.068)	(0.075)	(0.034)	(0.042)	(0.049)	(0.044)	(0.064)	(0.064)	(0.021)	(0.035)	(0.033)
competition	0.056	0.318***	0.293**	-0.182	-0.262	0.460	-0.008	0.129	0.524**	0.084	0.734**	0.802***	0.307***	0.328*	0.450**
	(0.074)	(0.103)	(0.128)	(0.157)	(0.298)	(0.319)	(0.146)	(0.189)	(0.219)	(0.184)	(0.331)	(0.306)	(0.100)	(0.199)	(0.201)
externalities	0.037***	0.346***	-0.115	0.058***	0.458***	-0.026	0.056***	0.400***	-0.009	0.050***	0.374***	-0.009	0.067***	0.368***	-0.009
	(0.012)	(0.101)	(0.090)	(0.011)	(0.080)	(0.072)	(0.011)	(0.077)	(0.071)	(0.011)	(0.075)	(0.072)	(0.010)	(0.075)	(0.072)
capital labour ratio	0.016	0.608***	0.179***	0.017	0.260***	0.095**	0.011	0.243***	0.099**	0.007	0.243***	0.093**	0.010	0.249***	0.090**
	(0.015)	(0.083)	(0.065)	(0.011)	(0.035)	(0.040)	(0.011)	(0.034)	(0.040)	(0.011)	(0.034)	(0.040)	(0.011)	(0.034)	(0.040)
import penetration	0.039***	0.187***	0.074	0.034***	0.141***	0.077*	0.035***	0.145***	0.072*	0.032***	0.143***	0.068*	0.031***	0.166***	0.067
	(0.014)	(0.057)	(0.069)	(0.010)	(0.038)	(0.041)	(0.010)	(0.038)	(0.042)	(0.010)	(0.037)	(0.041)	(0.010)	(0.039)	(0.042)
labour market regulation	0.020	-0.096	0.047	0.066***	0.041	0.005	0.088***	-0.109*	0.114*	0.046**	-0.201***	0.122*	-0.048	-0.189***	0.132**
	(0.016)	(0.092)	(0.100)	(0.015)	(0.063)	(0.073)	(0.019)	(0.065)	(0.069)	(0.019)	(0.069)	(0.067)	(0.029)	(0.067)	(0.067)
financial assets	-0.017	0.089***	-0.062**	-0.026**	-0.039*	-0.051**	0.002	-0.022	-0.053**	-0.001	-0.047**	-0.042*	0.031***	-0.059***	-0.048**
	(0.012)	(0.031)	(0.026)	(0.011)	(0.021)	(0.023)	(0.010)	(0.021)	(0.024)	(0.010)	(0.020)	(0.024)	(0.011)	(0.020)	(0.024)
year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of Obs	1154	1154	1154	2110	2110	2110	2110	2110	2110	2110	2110	2110	2110	2110	2110
individuals		125	125		126	126		126	126		126	126		126	126
Estimator	OLS	FE	FE	OLS	FE	FE	OLS	FE	FE	OLS	FE	FE	OLS	FE	FE

Marginal effect of competition

productivity level relatively to the frontier	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]
min	0.031	0.145***	0.143**	-0.154*	-0.611***	0.437**	-0.078	-0.058	0.297**	0.038	0.436**	0.525***	0.241***	-0.025	0.363**
	(0.033)	(0.048)	(0.059)	(0.079)	(0.195)	(0.184)	(0.081)	(0.109)	(0.123)	(0.097)	(0.222)	(0.203)	(0.064)	(0.159)	(0.158)
mean_less_1sd	0.015	0.039**	0.050***	-0.132***	-0.882***	0.419***	-0.133***	-0.203***	0.121*	0.002	0.205	0.311**	0.190***	-0.297**	0.295**
	(0.009)	(0.017)	(0.019)	(0.030)	(0.163)	(0.121)	(0.042)	(0.063)	(0.063)	(0.048)	(0.164)	(0.158)	(0.046)	(0.147)	(0.141)
mean	0.011*	0.009	0.024*	-0.127***	-0.944***	0.415***	-0.146***	-0.236***	0.081	-0.006	0.152	0.263*	0.178***	-0.360**	0.280**
	(0.006)	(0.013)	(0.014)	(0.029)	(0.165)	(0.120)	(0.038)	(0.059)	(0.056)	(0.046)	(0.158)	(0.156)	(0.044)	(0.147)	(0.140)
mean_plus_1sd	0.006	-0.021	-0.002	-0.122***	-1.006***	0.411***	-0.158***	-0.269***	0.041	-0.015	0.100	0.214	0.166***	-0.422***	0.264*
	(0.009)	(0.016)	(0.017)	(0.034)	(0.171)	(0.126)	(0.039)	(0.058)	(0.054)	(0.049)	(0.155)	(0.158)	(0.044)	(0.149)	(0.139)
max	0.005	-0.033*	-0.013	-0.120***	-1.032***	0.409***	-0.164***	-0.284***	0.023	-0.018	0.077	0.193	0.161***	-0.449***	0.258*
	(0.011)	(0.018)	(0.021)	(0.037)	(0.175)	(0.130)	(0.040)	(0.059)	(0.055)	(0.052)	(0.154)	(0.159)	(0.044)	(0.150)	(0.140)

Note: Standard errors in parentheses
* p<0.10, ** p<0.05, *** p<0.01

Table A9.

	firms per value added			regulation impact			regulation in services			product market regulation			product market regulation (public sector)		
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]
lagged dependent variable	0.959***	0.255***		0.931***	0.509***		0.932***	0.567***		0.939***	0.607***		0.916***	0.595***	
	(0.013)	(0.098)		(0.013)	(0.046)		(0.013)	(0.042)		(0.012)	(0.039)		(0.013)	(0.040)	
distance to frontier	-0.000	-0.970***	0.212	0.268*	0.264	0.498**	0.179	0.074	0.368	0.180	0.025	0.409*	0.198	0.230	0.457**
	(0.214)	(0.319)	(0.303)	(0.157)	(0.221)	(0.249)	(0.145)	(0.188)	(0.225)	(0.147)	(0.193)	(0.222)	(0.158)	(0.213)	(0.230)
interaction distance ×competition	-0.011	-0.100***	-0.057*	0.024	0.032	0.044	-0.008	-0.002	-0.074	0.032	-0.110*	-0.067	-0.039*	-0.161***	-0.038
	(0.019)	(0.028)	(0.033)	(0.039)	(0.072)	(0.080)	(0.037)	(0.046)	(0.054)	(0.048)	(0.067)	(0.063)	(0.022)	(0.035)	(0.032)
competition	0.058	0.416***	0.258*	-0.809***	-5.226***	-0.969	0.221	0.929***	0.513**	0.663***	1.705***	0.935***	0.562***	4.655***	0.911
	(0.078)	(0.115)	(0.139)	(0.292)	(0.703)	(0.677)	(0.152)	(0.202)	(0.227)	(0.217)	(0.394)	(0.335)	(0.128)	(1.007)	(1.037)
externalities	0.038***	0.355***	-0.105	0.061***	0.617***	0.007	0.060***	0.451***	-0.011	0.054***	0.384***	-0.012	0.076***	0.362***	-0.013
	(0.012)	(0.100)	(0.094)	(0.011)	(0.084)	(0.072)	(0.011)	(0.077)	(0.071)	(0.011)	(0.076)	(0.071)	(0.011)	(0.073)	(0.072)
capital labour ratio	0.014	0.618***	0.154**	0.018	0.288***	0.102**	0.011	0.241***	0.099**	0.010	0.249***	0.097**	0.010	0.259***	0.095**
	(0.016)	(0.087)	(0.079)	(0.011)	(0.034)	(0.040)	(0.011)	(0.033)	(0.041)	(0.011)	(0.034)	(0.040)	(0.011)	(0.035)	(0.041)
import penetration	0.034**	0.186***	0.070	0.033***	0.120***	0.065	0.034***	0.180***	0.071*	0.033***	0.154***	0.067	0.028***	0.170***	0.062
	(0.015)	(0.056)	(0.069)	(0.010)	(0.036)	(0.040)	(0.010)	(0.039)	(0.042)	(0.010)	(0.038)	(0.042)	(0.010)	(0.039)	(0.042)
labour market legislation	0.024	-0.094	0.037	0.066***	-0.051	-0.025	0.081***	-0.104	0.112	0.001	-0.278***	0.090	-0.132***	-0.220***	0.124*
	(0.016)	(0.090)	(0.099)	(0.015)	(0.065)	(0.074)	(0.018)	(0.064)	(0.069)	(0.022)	(0.072)	(0.069)	(0.037)	(0.069)	(0.067)
financial assets	-0.016	0.084***	-0.057**	-0.027**	-0.061***	-0.052**	0.007	-0.089***	-0.056**	0.000	-0.067***	-0.042*	0.025**	-0.067***	-0.042*
	(0.012)	(0.030)	(0.026)	(0.011)	(0.021)	(0.024)	(0.010)	(0.024)	(0.028)	(0.009)	(0.021)	(0.025)	(0.011)	(0.020)	(0.024)
distance to frontier²	-0.001	0.123***	-0.043	-0.030	-0.020	-0.055*	-0.023	-0.007	-0.041	-0.027	0.008	-0.053*	-0.021	-0.002	-0.059*
	(0.026)	(0.042)	(0.038)	(0.019)	(0.026)	(0.031)	(0.020)	(0.028)	(0.033)	(0.020)	(0.028)	(0.031)	(0.019)	(0.028)	(0.031)
competition²	0.007*	-0.004	0.009	-0.135***	-0.894***	-0.265**	-0.136***	-0.495***	-0.057	-0.541***	-0.704***	-0.256**	-0.114***	-1.701***	-0.186
	(0.004)	(0.005)	(0.007)	(0.051)	(0.111)	(0.106)	(0.037)	(0.060)	(0.050)	(0.112)	(0.123)	(0.114)	(0.034)	(0.393)	(0.402)
year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of Obs	1154	1154	1154	2110	2110	2110	2110	2110	2110	2110	2110	2110	2110	2110	2110
individuals		125	125		126	126		126	126		126	126		126	126
Estimator	OLS	FE	FE	OLS	FE	FE	OLS	FE	FE	OLS	FE	FE	OLS	FE	FE

Marginal effect of competition

productivity level relatively to the frontier	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]
min	0.032	0.189***	0.127**	-0.199**	-1.460***	0.219	-0.167*	-0.432***	0.203	0.126	0.688***	0.510**	0.235***	0.666***	0.432**
	(0.035)	(0.053)	(0.064)	(0.083)	(0.238)	(0.208)	(0.091)	(0.127)	(0.137)	(0.100)	(0.233)	(0.205)	(0.066)	(0.207)	(0.219)
mean_less_1sd	0.016	0.049***	0.047**	-0.160***	-1.408***	0.290**	-0.179***	-0.435***	0.083	0.178***	0.510***	0.402**	0.172***	0.406**	0.371*
	(0.010)	(0.019)	(0.021)	(0.036)	(0.188)	(0.133)	(0.046)	(0.073)	(0.067)	(0.064)	(0.182)	(0.176)	(0.046)	(0.193)	(0.207)
mean	0.012*	0.010	0.025*	-0.151***	-1.396***	0.306**	-0.182***	-0.436***	0.055	0.189***	0.469***	0.377**	0.158***	0.347*	0.357*
	(0.006)	(0.014)	(0.015)	(0.033)	(0.185)	(0.128)	(0.042)	(0.067)	(0.059)	(0.067)	(0.178)	(0.177)	(0.045)	(0.192)	(0.206)
mean_plus_1sd	0.007	-0.029*	0.002	-0.142***	-1.384***	0.322**	-0.185***	-0.436***	0.028	0.201***	0.428**	0.353*	0.144***	0.288	0.343*
	(0.009)	(0.016)	(0.018)	(0.037)	(0.186)	(0.130)	(0.041)	(0.065)	(0.056)	(0.074)	(0.177)	(0.181)	(0.044)	(0.192)	(0.206)
max	0.005	-0.045**	-0.007	-0.139***	-1.378***	0.329**	-0.186***	-0.437***	0.016	0.206***	0.411**	0.342*	0.137***	0.262	0.338
	(0.012)	(0.019)	(0.021)	(0.040)	(0.188)	(0.133)	(0.042)	(0.066)	(0.057)	(0.078)	(0.178)	(0.183)	(0.045)	(0.192)	(0.206)

Note: Standard errors in parentheses

* p<0.10, ** p<0.05, *** p<0.01

	firms per value added			*regulation impact*			*regulation in services*			*product market regulation*			*product market regulation (public sector)*		
	[1]	**[2]**	**[3]**	**[4]**	**[5]**	**[6]**	**[7]**	**[8]**	**[9]**	**[10]**	**[11]**	**[12]**	**[13]**	**[14]**	**[15]**
lagged dependent variable	0.971***	0.232***		0.959***	0.574***		0.958***	0.606***		0.963***	0.631***		0.941***	0.609***	
	(0.009)	(0.087)		(0.006)	(0.032)		(0.006)	(0.029)		(0.007)	(0.033)		(0.007)	(0.030)	
distance to frontier (t-1)	-0.031	-0.142**	-0.021	-0.008	-0.280*	-0.124	0.006	0.019	0.073	0.025	0.041	0.070*	0.021	0.070*	0.007
	(0.028)	(0.066)	(0.049)	(0.088)	(0.162)	(0.154)	(0.042)	(0.046)	(0.050)	(0.031)	(0.042)	(0.041)	(0.041)	(0.042)	(0.047)
interaction distance ×competition (t-1)	-0.010	-0.086***	0.017	0.002	-0.112	-0.054	-0.007	-0.049	-0.079	-0.066	-0.139*	-0.141*	-0.012	-0.091***	-0.019
	(0.016)	(0.033)	(0.024)	(0.041)	(0.079)	(0.071)	(0.034)	(0.040)	(0.048)	(0.052)	(0.074)	(0.079)	(0.031)	(0.034)	(0.039)
competition (t-1)	0.055	0.393***	-0.059	0.019	-0.174	0.644**	0.099	0.077	0.362	0.385*	0.752**	1.025***	0.135	0.455	0.782**
	(0.068)	(0.138)	(0.100)	(0.169)	(0.343)	(0.310)	(0.141)	(0.184)	(0.220)	(0.223)	(0.356)	(0.357)	(0.131)	(0.302)	(0.359)
externalities (t-1)	0.030***	0.396***	-0.061	0.040***	0.360***	-0.059	0.042***	0.311***	-0.034	0.037***	0.296***	-0.011	0.058***	0.297***	-0.028
	(0.009)	(0.094)	(0.099)	(0.006)	(0.067)	(0.062)	(0.006)	(0.064)	(0.062)	(0.007)	(0.064)	(0.057)	(0.007)	(0.063)	(0.062)
capital labour ratio (t-1)	0.005	0.461***	-0.131*	-0.003	0.176***	0.035	-0.002	0.173***	0.033	-0.013	0.167***	-0.016	-0.001	0.171***	0.031
	(0.012)	(0.102)	(0.077)	(0.010)	(0.026)	(0.040)	(0.010)	(0.026)	(0.041)	(0.008)	(0.037)	(0.028)	(0.010)	(0.025)	(0.041)
year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of Obs	1328	1328	1328	2649	2649	2649	2649	2649	2649	2455	2455	2455	2649	2649	2649
individuals		133	133		148	148		148	148		134	134		148	148
Estimator	OLS	FE	FE	OLS	FE	FE	OLS	FE	FE	OLS	FE	FE	OLS	FE	FE
							Marginal effect of competition								
productivity level relatively to the frontier															
min	0.037	0.230***	-0.026	0.022	-0.385*	0.543***	0.087	-0.016	0.213	0.258**	0.488**	0.756***	0.113	0.284	0.747**
	(0.037)	(0.075)	(0.056)	(0.093)	(0.212)	(0.190)	(0.078)	(0.113)	(0.134)	(0.124)	(0.234)	(0.226)	(0.072)	(0.259)	(0.304)
mean_less_1sd	0.020**	0.082***	0.003	0.025	-0.575***	0.452***	0.075***	-0.100*	0.078	0.140***	0.239	0.503***	0.093***	0.129	0.716***
	(0.010)	(0.023)	(0.019)	(0.027)	(0.128)	(0.111)	(0.025)	(0.059)	(0.065)	(0.037)	(0.151)	(0.143)	(0.020)	(0.230)	(0.262)
mean	0.016***	0.046***	0.010	0.026	-0.625***	0.428***	0.072***	-0.122**	0.043	0.114***	0.186	0.449***	0.088***	0.088	0.708***
	(0.006)	(0.015)	(0.013)	(0.017)	(0.122)	(0.104)	(0.018)	(0.051)	(0.054)	(0.025)	(0.144)	(0.138)	(0.010)	(0.224)	(0.253)
mean_plus_1sd	0.012	0.010	0.018	0.027	-0.675***	0.404***	0.070***	-0.144***	0.007	0.089***	0.133	0.395***	0.083***	0.048	0.699***
	(0.007)	(0.017)	(0.014)	(0.023)	(0.126)	(0.107)	(0.023)	(0.049)	(0.050)	(0.027)	(0.142)	(0.140)	(0.014)	(0.219)	(0.245)
max	0.010	-0.003	0.020	0.027	-0.690***	0.397***	0.069***	-0.151***	-0.003	0.079**	0.112	0.374***	0.081***	0.036	0.697***
	(0.009)	(0.021)	(0.016)	(0.027)	(0.128)	(0.109)	(0.026)	(0.050)	(0.051)	(0.031)	(0.142)	(0.143)	(0.017)	(0.218)	(0.243)

Note: Standard errors in parentheses
* p<0.10, ** p<0.05, *** p<0.01

	firms per value added			regulation impact			regulation in services			product market regulation			product market regulation (public sector)		
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]
lagged dependent variable	0.970***	0.220**		0.956***	0.538***		0.954***	0.585***		0.953***	0.628***		0.941***	0.610***	
	(0.009)	(0.088)		(0.006)	(0.034)		(0.007)	(0.031)		(0.008)	(0.034)		(0.007)	(0.030)	
distance to frontier $_{(t-1)}$	0.065	-0.834***	0.377	0.120	0.225	0.383	0.162	0.107	0.471**	0.174	-0.021	0.249	0.203	0.119	0.449*
	(0.181)	(0.308)	(0.253)	(0.157)	(0.228)	(0.267)	(0.133)	(0.202)	(0.230)	(0.141)	(0.204)	(0.192)	(0.145)	(0.206)	(0.235)
interaction distance ×competition (t-1)	-0.007	-0.093***	0.019	0.005	0.049	-0.046	-0.008	-0.007	-0.048	-0.016	-0.135*	-0.118	-0.024	-0.072**	0.016
	(0.016)	(0.030)	(0.024)	(0.042)	(0.086)	(0.074)	(0.034)	(0.046)	(0.056)	(0.054)	(0.080)	(0.090)	(0.030)	(0.032)	(0.035)
competition (t-1)	0.047	0.420***	-0.066	-0.686**	-4.540***	0.372	0.406***	0.655***	0.122	0.707***	1.232***	0.803**	0.213*	1.122	1.835*
	(0.065)	(0.128)	(0.101)	(0.296)	(0.676)	(0.652)	(0.127)	(0.194)	(0.221)	(0.257)	(0.355)	(0.338)	(0.121)	(0.899)	(1.092)
externalities (t-1)	0.031***	0.403***	-0.058	0.044***	0.481***	-0.056	0.045***	0.339***	-0.042	0.047***	0.299***	-0.013	0.060***	0.288***	-0.044
	(0.009)	(0.095)	(0.100)	(0.007)	(0.069)	(0.061)	(0.007)	(0.065)	(0.063)	(0.008)	(0.064)	(0.058)	(0.007)	(0.064)	(0.062)
capital labour ratio (t-1)	0.006	0.454***	-0.132	-0.002	0.193***	0.041	0.000	0.164***	0.039	-0.009	0.171***	-0.014	-0.000	0.173***	0.038
	(0.012)	(0.107)	(0.091)	(0.010)	(0.029)	(0.039)	(0.010)	(0.025)	(0.040)	(0.008)	(0.039)	(0.029)	(0.010)	(0.026)	(0.039)
distance to frontier² (t-1)	-0.012	0.096**	-0.055	-0.016	-0.019	-0.066**	-0.021	-0.020	-0.059*	-0.022	0.009	-0.026	-0.023	-0.010	-0.065**
	(0.023)	(0.040)	(0.036)	(0.019)	(0.028)	(0.031)	(0.018)	(0.030)	(0.035)	(0.019)	(0.029)	(0.029)	(0.018)	(0.027)	(0.031)
competition² (t-1)	0.003	-0.003	0.005	-0.161***	-0.800***	-0.052	-0.130***	-0.336***	0.049	-0.436***	-0.299**	0.069	-0.027	-0.354	-0.576
	(0.003)	(0.006)	(0.007)	(0.050)	(0.101)	(0.096)	(0.046)	(0.055)	(0.052)	(0.106)	(0.148)	(0.159)	(0.022)	(0.351)	(0.422)
year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of Obs	1328	1328	1328	2649	2649	2649	2649	2649	2649	2455	2455	2455	2649	2649	2649
Individuals		133	133		148	148		148	148		134	134		148	148
Estimator	OLS	FE	FE	OLS	FE	FE	OLS	FE	FE	OLS	FE	FE	OLS	FE	FE

Marginal effect of competition

productivity level relatively to the frontier	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]
min	0.033	0.244***	-0.030	-0.014	-1.155***	0.496**	0.028	-0.295**	0.167	0.181	0.636***	0.657***	0.109	0.224	0.624**
	(0.036)	(0.071)	(0.056)	(0.096)	(0.250)	(0.221)	(0.089)	(0.140)	(0.165)	(0.127)	(0.224)	(0.216)	(0.078)	(0.226)	(0.256)
mean_less_1sd	0.020**	0.085***	0.003	-0.005	-1.073***	0.417***	0.015	-0.307***	0.086	0.152***	0.395**	0.445***	0.069*	0.101	0.650***
	(0.010)	(0.022)	(0.019)	(0.032)	(0.155)	(0.131)	(0.040)	(0.076)	(0.082)	(0.038)	(0.156)	(0.145)	(0.036)	(0.214)	(0.238)
mean	0.017***	0.046***	0.011	-0.003	-1.051***	0.396***	0.012	-0.310***	0.064	0.146***	0.343**	0.400***	0.058*	0.068	0.658***
	(0.006)	(0.015)	(0.014)	(0.022)	(0.144)	(0.119)	(0.032)	(0.064)	(0.066)	(0.029)	(0.155)	(0.149)	(0.030)	(0.214)	(0.236)
mean_plus_1sd	0.014*	0.008	0.019	-0.000	-1.029***	0.376***	0.008	-0.313***	0.043	0.140***	0.292*	0.355**	0.048	0.036	0.665***
	(0.008)	(0.016)	(0.014)	(0.026)	(0.144)	(0.115)	(0.030)	(0.058)	(0.057)	(0.032)	(0.160)	(0.161)	(0.029)	(0.214)	(0.234)
max	0.013	-0.006	0.022	0.000	-1.023***	0.370***	0.007	-0.314***	0.037	0.138***	0.272*	0.338**	0.045	0.027	0.667***
	(0.009)	(0.019)	(0.016)	(0.029)	(0.146)	(0.116)	(0.031)	(0.058)	(0.056)	(0.037)	(0.164)	(0.167)	(0.030)	(0.214)	(0.234)

Note: Standard errors in parentheses

Table A10.