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Résumé

Cette étude caractérise l'importance des deux principaux canaux habituellement évoqués dans la littérature et par lesquels les régulations anticompétitives des secteurs amont influencent la croissance de la productivité de l'ensemble des secteurs : l'investissement en R&D et l'investissement en TIC. Pour cela, trois fonctions sont estimées. Tout d'abord, une fonction de production dans laquelle la productivité est influencée par les régulations anticompétitives des secteurs amont et par l'importance du capital en R&D et en TIC. Ensuite, deux fonctions de demande de facteurs en R&D et TIC, faisant également intervenir les régulations anticompétitives des secteurs amont. Ces estimations sont réalisées sur un panel de 14 pays de l'OCDE, décomposés en 13 secteurs, sur la période 1987-2007. Les résultats obtenus confirment ceux d'études antérieures et montrent que l'impact des régulations anticompétitives dans les secteurs amont sur la productivité de l'ensemble des secteurs est important, et qu'une grande part de cet impact passe par l'investissement en TIC et surtout en R&D.

Mots-clés : Productivité, Croissance, Régulations, Concurrence, Rattrapage, R&D, TIC
Codes JEL : O43, L5, O33, O57, L16, C23

Abstract

Our study aims at assessing the actual importance of the two main channels usually contemplated in the literature through which upstream sector anticompetitive regulations may impact productivity growth: business investments in R&D and in ICT. We thus precisely try to estimate what are the specific impacts of these two channels and their shares in total impact as against alternative channels of investments in other forms of intangible capital such as improvements in skills, management and organization. For this, we specify an extended production function relating productivity explicitly to R&D and ICT capital as well as to upstream regulations, and two factor demand functions relating R&D and ICT capital to upstream regulations. These relations are estimated on a panel of 14 OECD countries and 13 industries over the period 1987-2007. Our estimates confirm the results of previous similar studies finding that the impact of upstream regulations on total factor productivity can be sizeable, and they provide evidence that a good part of the total impact, though not a predominant one, goes through both investments in ICT and R&D, and particularly the latter.

Keywords: Productivity, Growth, Regulations, Competition, Catch-up, R&D, ICT
JEL Classification: O43, L5, O33, O57, L16, C23

I. **Introduction**

Competition is an important determinant of productivity growth. Much firm-level microeconomic research has supported the idea that competitive pressure enhances innovation and is a driver of productivity (among others, see Geroski, 1995a, 1995b; Nickell, 1996; Nickell *et al.*, 1997; Blundell *et al.*, 1999; Griffith *et al.*, 2002; Haskel *et al.*, 2007; Aghion *et al.*, 2004), especially for incumbent firms that are close to the technological frontier (Aghion *et al.*, 2005; Aghion *et al.*, 2006). Reinforcing evidence has also been found in investigations at a macroeconomic level, either using country panel data (Conway *et al.*, 2006; Aghion *et al.*, 2009) or country-industry panel data (Nicoletti and Scarpetta, 2003; Griffith *et al.*, 2010; Inklaar *et al.*, 2008; Buccirossi *et al.*, 2009). Most of these empirical studies have provided within country-industry evidence of the link between competitive conditions and productivity enhancements.

In contrast to these studies who investigated the direct influence of product market regulations in industries on these industries themselves, Bourlès *et al.* (2010) focused on the indirect influence of product market regulations in non-manufacturing industries, called “upstream” industries thereafter, on productivity outcomes in the industries, often called for convenience “downstream” industries, which are using the intermediate inputs from these upstream industries.[1] Regulations that protect rents in upstream industries can reduce incentives to search for and implement efficiency improvements in downstream industries, since they will have to share the expected rents from such improvements with upstream industries.[2] One can also conjecture that, contrary to the downstream influence of downstream regulations, the downstream influence of upstream regulations has remained largely unaffected in the last fifteen years or so in most OECD countries. Indeed in this period and these countries, downstream industries have become more competitive largely due to increasing international competition, while that was not the case for upstream industries. Actually, this is actually what can be concluded from Bourlès *et al.* where using country-industry panel data and

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1 Note that the distinction between upstream and downstream industries is not a priori clear-cut, since upstream industries use intermediate inputs from other upstream industries. As will become clear in the implementation of our analysis the non-manufacturing upstream industries are kept in our study sample. We thus estimate the overall average influence of upstream product market regulations (that is precisely the average influence of regulations in each upstream industry on all industries excluding that upstream industry).

2 A formalization of such links between upstream competition and downstream productivity based on an extension of the endogenous growth model of Aghion *et al.* can be found in the working paper version of Bourlès *et al.* (2010) and in chapter 2 of Lopez (2011).

relying on a version of a dynamic "neo-Schumpeterian" model, we found that lack of upstream competition curbs downstream efficiency improvements.

The goal of the present investigation is to go further than Bourlès *et al.* (2010) in an attempt to characterize the channels through which upstream regulations impact downstream productivity growth.[3] As it is generally agreed, we consider investments in R&D and innovation as being a vital channel and we estimate how important it is actually. We consider jointly investments in ICT, since they are also deemed to be a key channel for competitiveness.[4] In order to implement such investigation, as explained in Section II, we consider a three equations model that is simple enough to be specified and estimated with the data available at country-industry level. We thus estimate a relation where the distance of country-industry multifactor productivity to the corresponding industry multifactor productivity in the USA (where the USA is taken as the country of reference) depends not only on the upstream regulatory burden indicator as in Bourlès *et al.*, but also on the distance of country-industry R&D and ICT capital intensities to that in the USA. In parallel we estimate two factor demand relations, for R&D and ICT capital respectively, which both include the upstream regulation burden indicator. To assess the robustness and validity of our results we consider in fact different econometric specifications of our model.

Our investigation is performed on a cleaned unbalanced country-industry panel dataset for fourteen OECD countries and thirteen manufacturing and market service industries over the twenty one years 1987 to 2007. This sample is somewhat different from the one of Bourlès *et al.*, since our purpose is to assess to what extent the impact of upstream regulations on downstream productivity work through R&D and ICT investment. We cover in particular thirteen industries instead of eighteen, since we delete five industries that are (almost) not investing in both ICT and R&D. Among these thirteen industries we also exclude five of them to estimate the R&D investment demand equation, since they are almost not investing in R&D.

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3 We highlight the similarities and differences with Bourlès *et al.* (2010) along the paper and the Appendix C presents a detailed comparison

4 Investing in training and investing in skilled labor and investing in organization and management are also potentially important channels that we could not consider here for lack of data or good enough data at the country--industry level. It is likely that these channels are to some extent complementary to the ICT and R&D channels, and thus that the regulatory impact working through them may be partly taken into account in our estimates. Note also that although patents are not as good a predictor of innovation output as R&D investment, the numbers of country-industry patents would be a worthwhile indicator to consider in the future (see Aghion *et al.*, 2013).

We rely on the same basic upstream regulatory burden indicator as in Bourlès *et al.*, which is computed from the OECD indicators of anti-competitive regulations on product market in the six following non-manufacturing industries: energy, transport, communication, retail, banking and professional services. However, our main variable of multifactor productivity is defined differently than in Bourlès *et al.,* since we have to explicitly include ICT and R&D capital as regressors in the productivity equation. We explained the construction of the data and present a number of descriptive statistics in section III and Appendix A.

In terms of identification strategy and estimation method, as discussed in Section IV, we proceed somewhat differently than Bourlès *et al*. We focus on the long-term estimates of our parameters of interest and the discussion of their robustness. In particular we systematically compare the estimation results obtained in two econometric specifications: the first one in which we interact country and year fixed effects in each of the three equations of the model, and the second in which we also interact industry and year fixed effects. We consider likely that the first one provides optimistic or "upper bound" estimates, while the second provides pessimistic or "lower bound" estimates.

We present our estimation results in Section V, and illustrate them by presenting in Section VI simulations of what would be the long term multifactor productivity gains if all countries were to adopt the observed best or lightest anticompetitive upstream regulations. In spite of the substantial differences in sample, model specification and estimation, we find that our upper bound estimates of the total long term impacts do confirm very well the main estimates of Bourlès *et al.* showing that upstream anticompetitive regulations can slow down multifactor productivity importantly. Although our lower bound estimates are much lower they remain quite significant. We find for example that the upper and lower bound estimates of the total productivity impacts of upstream regulations are the highest for Italy and the Czech Republic, of about 11-12% and 4-5% respectively, and the lowest for the United Kingdom and the USA, of about 2-3% and 1% respectively. We also find that the indirect productivity impact for the R&D investment channel is generally much higher than the one for ICT investment, but that the direct productivity impact is also much higher than both of them, pointing to the fact that the channels through which upstream regulations manifest themselves must be many and even possibly everywhere.

In Section VII we conclude by indicating the limits of our present findings and sketching what should and could be done to extend and deepen them, and in particular by stressing the need to investigate jointly the productivity impacts of product and labor regulations and to rely on different types of data and levels of analysis from micro to macro.

II. Econometric model specification

Our model consists of three simple equations: the productivity equation and two similar factor demand equations respectively for R&D and ICT. We shall explain now in some details our choice of specifications for these equations.

Productivity equation

Our productivity equation is based on the assumption of a cointegrated long term relationship linking the levels of (multi-factor) productivity between countries and industries, which includes our product market regulation variable of interest or regulatory burden indicator *REG*. This equation can be simply written as a relation between the industry productivity in a given country of reference $\bar{c}$ and all the other countries c. Although it is convenient to interpret this relation as a catch-up relation where the country of reference $\bar{c}$ can be considered as a leading country and the other countries c as followers countries, it is important to realize that such interpretation need not to be taken strictly and can be misleading. The basic hypothesis, which we actually test in Section IV, is that of cointegration for the set of country-industry time series that are considered in the analysis. In fact as long as the equation includes controls for country, industry and year unobserved common factors, we checked that the choice of the country of reference does not practically affect our results. In this work, for the sake of simplicity we take the USA as the leading country $\bar{c}$. [5] We can thus write our long term productivity relation as the following log linear regression equation:

$$\widetilde{mfp}_{ci,t} = cst + \widetilde{mfp}_{\bar{c}i,t} - \mu \, REG_{ci,t-1} + u_{ci,t} \quad (1)$$

5 The USA is in fact leading for 85% of the country-industry-year observations of our panel, This choice of a given country as the reference in all industries is different from the one taken in Bourlès et al. where the country of reference for a given industry was the country leading for that industry, and thus could differ across industries and over time. As just mentioned, our estimates remain practically unaffected if we choose the leading country-industry-year definition. Note more generally that when we include industry*year effects θ_{it} in the specifications of our productivity and R&D and ICT investments equations (see below), these effects will proxy for the evolution of productivity and R&D and ICT investments for the country-industry pairs taken as reference as long as the reference country for a given industry will not change over time (i.e., $\bar{c}$(i)i,t = $\bar{c}$i,t). Hence our lower bound estimates based on specifications including such effects are strictly identical irrespective of the choice of the country-industry pairs of reference.

The variables $\widetilde{mfp}_{ci,t}$ and $\widetilde{mfp}_{\bar{c}i,t}$ are respectively the multifactor productivity in logarithms for year t of industry i in country c and in the leading country $\bar{c}$ (the USA), where $t \in T, i \in I\ , and\ (c, \bar{c}) \in C\ with\ c \neq \bar{c}$.

The variable $REG_{ci,t-1}$ is the regulatory burden indicator lagged one year for industry i in country c, and μ is a parameter of main interest measuring an average long term "direct" impact of regulation on multifactor productivity, where direct means here that this impact does not operate through the channels of ICT and R&D investments as made explicit below.[6]

The term $u_{ci,t}$ stands for the error in the equation that can be specified in different ways. In a panel analysis such as ours, it is generally found appropriate to control for separate country, industry and year unobserved common factors or effects θ_c , θ_i and θ_t, in addition to an idiosyncratic error term $\varepsilon_{ci,t}$. Here for reasons of econometric identification which we discuss in Section IV, we privilege two specifications that also include interaction effects: either country*year effects θ_{ct} or both country*year effects θ_{ct} and industry*year effects θ_{it}. As we shall explain, we can consider that the first of these specifications provides an upper bound estimate of the direct regulatory impact parameter μ, while the second one provides a lower bound estimate of μ.

The major novelty in our approach here with respect to Bourlès et al. is that we want to assess to what extent the effects of anticompetitive regulations (proxied by REG) on productivity work through the two channels of R&D and ICT investments or otherwise. To do so we have to modify in two ways the "conventional" measure of multifactor productivity used previously. We have to take into account explicitly the contribution of ICT capital to productivity and for that to separate ICT capital (*D*) from the other forms of physical capital (*C*) in total capital (*CT*). We also have to take into account explicitly the contribution of R&D capital (*K*), which is ignored in the "conventional" measure of total capital (*CT*), since R&D is not yet integrated in official national accounts as an investment. As explained in Section III,

6 Note that in equation (1) we impose that the coefficient of $\widetilde{mfp}_{\bar{c}i,t}$ is 1, implying that the difference between the multifactor productivity of the follower countries and the leader country is bounded in the long term for given common factors $\theta's$. This is a reasonable identification hypothesis generally made in the literature. As shown in one of our robustness check variants in Appendix B, our results remain roughly the same if this hypothesis is relaxed; they are strictly identical if we include industry*year effects θ_{it} as in our lower bound specification. Note also that a variant of equation (1) that may seem more satisfactory will include the regulatory burden indicator in difference to its value for the country-industry of reference: $(REG_{ci,t-1} - REG_{\bar{c}i,t-1})$. However, this variant and equation (1) as written here provide estimates that are strictly identical when we include industry*year effects θ_{it}, and we have found that they also remain very close even when we do not include them.

the explicit integration of R&D implies that we had to correct the measures of industry output and labor from respectively expensing out R&D intermediate consumption and double counting R&D personnel.

Precisely, using small letters for logarithms (i.e., $x \equiv Log\ X$), we have two conventional measures of multifactor productivity $mfpc1$ and $mfpc2$ and the appropriate measure $\widetilde{mfp}$ to be used in the present analysis, where:

$$mfpc1 = y - \alpha(ct) - \beta l \text{ and } mfpc2 = y - \alpha c - \beta l - \gamma d ,$$

while

$$\widetilde{mfp} = y - \alpha c - \beta l - \gamma d - \delta k .$$

We can define partial multifactor productivity before taking into account the ICT and R&D contributions, which will noted *mfp* for simplicity, as:

$$mfp \equiv \widetilde{mfp} + \gamma d + \delta k$$

and thus rewrite regression equation (1) to include explicitly ICT and R&D contributions as regression equation (2):

$$mfp_{ci,t} = cst + mfp_{\bar{c}i,t} + \gamma\left(d_{ci,t} - d_{\bar{c}i,t}\right) + \delta\left(k_{ci,t} - k_{\bar{c}i,t}\right) - \mu\, REG_{ci,t-1} + u_{ci,t} \quad (2)$$

In equation (2), we estimate jointly the productivity elasticities γ and δ of ICT and R&D capital stocks and μ the parameter of direct regulatory impact on productivity. While we can estimate the ICT and R&D productivity elasticities, however, in order to measure our multifactor productivity variable *mfp* it remains to calibrate the non-ICT capital and labor elasticities α and β. As usually done and explained in Section III and Appendix A, we did in two ways: first by calibrating α and β respectively by the shares $\tilde{\alpha}_i$ and $\tilde{\beta}_i$ of the user cost of non-ICT capital and the labor cost in nominal value-added; second by still calibrating the elasticity of labor β by the share of labor cost $\tilde{\beta}_i$ but calibrating *a priori* the returns to scale λ to be constant, that is $\lambda = \alpha + \tilde{\beta}_i + \gamma + \delta = 1$, and thus implying that α is estimated as well as γ and δ . Since trying to assess returns to scale on aggregate industry data such as ours does not really make sense, and measuring industry shares of user cost of capital not too reliable, we much preferred the second option. In fact, as documented in Appendix B on robustness, when we do not impose constant returns to scale and rely on the first option, our results are practically unaffected with an estimated scale elasticity λ that negligibly differs from 1.

Finally, calibrating α by $\tilde{\alpha}_i$ and assuming constant returns to scale implies that we normalize regression (2) with respect to labor and modify slightly the measure of our multifactor productivity variable *mfp*. We can express (2) equivalently as:

$$mfp_{ci,t} = cst + mfp_{\bar{c}i,t} + \gamma[(d_{ci,t} - l_{ci,t}) - (d_{\bar{c}i,t} - l_{\bar{c}i,t})]$$
$$+ \delta[(k_{ci,t} - l_{\bar{c}i,t}) - (k_{\bar{c}i,t} - l_{\bar{c}i,t})] - \mu\, REG_{ci,t-1} + u_{ci,t}$$

with $mfp_{ci,t} = (y_{ci,t} - l_{ci,t}) - \tilde{\alpha}_i(c_{ci,t} - l_{ci,t})$ and $mfp_{\bar{c}i,t} = (y_{\bar{c}i,t} - l_{\bar{c}i,t}) - \tilde{\alpha}_i(c_{\bar{c}i,t} - l_{\bar{c}i,t})$

Or denoting $[(x_{ci,t} - l_{ci,t}) - (x_{\bar{c}i,t} - l_{\bar{c}i,t})]$ more simply by $x\_gap_{ci,t}$, we can rewrite it as regression (3):

$$mfp\_gap_{ci,t} = cst + \gamma d\_gap_{ci,t} + \delta k\_gap_{ci,t} - \mu\, REG_{ci,t-1} + u_{ci,t} \quad (3)$$

ICT and R&D capital demand equations

The specifications of our ICT and R&D capital demand are very simple. They are based on the long term equilibrium relationships derived from of the assumption of firms' intertemporal maximization of their profit, augmented by the regulatory burden indicator REG.

Assuming the Cobb-Douglas production function underlying our productivity equation $y = \alpha c + \beta l + \gamma d + \delta k$, we can write simply:

$$\log(P_D D/WL) = \log(\gamma/\beta) - \mu_D.REG_{-1}$$
$$\log(P_K K/WL) = \log(\delta/\tilde{\ }\beta) - \mu_K.REG_{-1}$$

where $P_D D/WL$ and $P_K D/WL$ are of the user costs shares of ICT and R&D capitals relative to the labor cost share. Rewriting these equations in terms of ICT and R&D capital user cost ratios to average employee cost (or ICT-labor and R&D-labor cost ratios for short, and adding errors terms to control for country, industry and year unobserved common factors as in the productivity equation (and with $x \equiv Log\ X$) we obtain the regression equations:

$$(d-l)_{ci,t} = \text{Cst} + (p_D - w)_{ci,t} - \mu_D REG_{ci,t-1} + u^D_{ci,t}$$
$$(k-l)_{ci,t} = \text{Cst} + (p_K - w)_{ci,t} - \mu_K REG_{ci,t-1} + u^K_{ci,t}$$

These equations are strictly consistent with the hypothesis of a Cobb-Douglas production function, implying that the elasticity of substitution between factors are all equal to 1 and that the price elasticities are constrained to be 1. Since these constraints may be too restrictive and although they do not lead to significantly different estimates of our two parameters of interest μ_D and μ_K , we actually prefer to consider equations (4) in which they are not *a priori* imposed and can be tested:

$$\begin{aligned}(d-l)_{ci,t} &= \text{Cst} + \sigma_d (p_D - w)_{ci,t} - \mu_D REG_{ci,t-1} + u^D_{ci,t} \\ (k-l)_{ci,t} &= \text{Cst} + \sigma_k (p_K - w)_{ci,t} - \mu_K REG_{ci,t-1} + u^K_{ci,t}\end{aligned} \quad (4)$$

These equations can be viewed as deriving from a CES (Constant Elasticity of Substitution) production function, and the parameters σ_d and σ_k interpreted as elasticities of substitution between factors. Note, however, that the CES production function with more than two factors is also restrictive since it imposes that these elasticities would be the same for all pair of factors: that is here $\sigma_d = \sigma_k$ $(= \sigma_l = \sigma_c)$, which will see is not far from being the case for our results.

III. <u>Main Data and Analysis of Variance</u>

We now explain the construction of the central explanatory variable of our analysis: the upstream regulatory burden indicator REG, while in Appendix A we give information on our sample and on the multifactor productivity and ICT and R&D capital variables. We also present simple descriptive statistics and an analysis of variance for all the variables in terms of separate country, industry and year effects, and a relevant sequence of two-way effects.

Regulatory burden indicator

Our empirical analysis focus on the productivity and ICT and R&D impacts of the regulatory burden indicator REG, which is constructed on the basis the OECD Non-Manufacturing Regulations (NMR) indicators. These indicators measure “to what extent competition and firm choices are restricted where there are no a priori reasons for government interference, or where regulatory goals could plausibly be achieved by less coercive means”, in six non-manufacturing industries. Referred here as upstream industries they are: energy (gas and electricity), transport (rail, road and air), communication (post, fixed and cellular communication), retail distribution, banking services and professional services. Undoubtedly they constitute the most regulated and sheltered part in OECD countries economies, while few explicit barriers to competition remain in markets for the products of manufacturing industries.

The NMR indicators are based on detailed information on laws, rules and market and industry settings, which are classified in two main areas: state control, covering specific information on public ownership and public control on business activity, and barriers to entrepreneurship, covering specific information on legal barriers to entry, market structure and or industry structure. For a given upstream industry the NMR indicators can take at minimum a value of 0 in the absence of all forms of anticompetitive regulations and at maximum a value of 1 in the presence of all of them, and they thus vary on a scale of 0 and 1 across countries and industries. They also available for all years of our estimation period in energy, transport and communication, for 1998, 2003 and 2007 in retail distribution and professional services, and for 2003 only in banking. More information on the construction of the NMR indicators is given in Appendix A; and a detailed presentation can be found in Conway and Nicoletti (2006) for all six non-manufacturing industries except banking, and in De Serres *et al*. (2006) for banking.

The NMR indicators have the basic advantage that they establish relatively direct links with policies that affect competition. Econometric studies using them to measure imperfect competition are also much less concerned by endogeneity problems that affect studies depending on traditional indicators of product market competitiveness, as mark-ups or industry concentration indices (see Boone 2000 for a discussion of endogeneity issues in such studies).

In a macro-econometric analysis as ours, however, NMR indicators cannot separately be used in practice to assess the upstream regulatory impacts on productivity as well on ICT and R&D, and they have to be combined in a meaningful way. We do, as usually done, by considering that their individual impacts are most likely to vary with the respective importance of upstream industries as suppliers of intermediate inputs. Our regulatory burden indicator REG is thus constructed in following way:

$$REG_{ci,t} = \sum_{j \neq i} NMR^j_{c,t}.w^j_i \ with \ w^j_i \equiv \frac{input^j_{i,R}}{output_{i,R}}$$

where $NMR^j_{c,t}$ is the NMR indicator of the upstream industry *j* for country *c* in year *t*, and w^j_i stands for the intensity of use of intermediate inputs from industry *j* by industry, as measured from the input–output table for a given country and year as the ratio of the intermediate inputs from industry *j* to industry *i* over the total output of industry *i*. We prefer to use a fixed reference input-output table to compute the intensity of use ratios rather than the different country and year input and output tables, to avoid endogeneity biases that might arise from potential correlations between such ratios and productivity or R&D and ICT, since the importance of upstream regulations may well influence the use of domestic regulated intermediate inputs. We have actually used the 2000 input-output table for the USA, already taken as reference for the productivity gap and R&D and ICT gap variables. For similar endogeneity as well as measurement error concerns, note also that in estimating REG for the upstream industries we exclude within-industry intermediate consumption (or $w^j_J = 0$) .

Chart 1 shows the country averages of REG for 1987, 1997 and 2007. The relatively restrictive regulations, which prevailed overall in 1987 in most countries, weakened in the two following decades in all countries at different paces. The cross-country variability of REG appears quite important in all three years, with the USA, UK and Sweden remaining the the most pro-competitive countries and Austria and Italy followed by France in 1987 and by Canada in 2007 being the less pro-competitive countries.

Chart 2 shows the six average country NMR components of REG in 2007. Their relative contributions to REG differ significantly, reflecting country-industry variability, although they appear roughly proportional to the average country level of REG as could be expected. The first left bar of the chart correspond to the value of REG for an hypothetical country in which the six NMR indicators are at their ‘lightest’ levels defined as the country average of their three lowest values in 2007. We will use this lightest REG value as a target for the hypothetical long run simulation policies we consider in Section VI to illustrate our estimation results.

Chart 1: Country averages of REG in 1987, 1997 and 2007

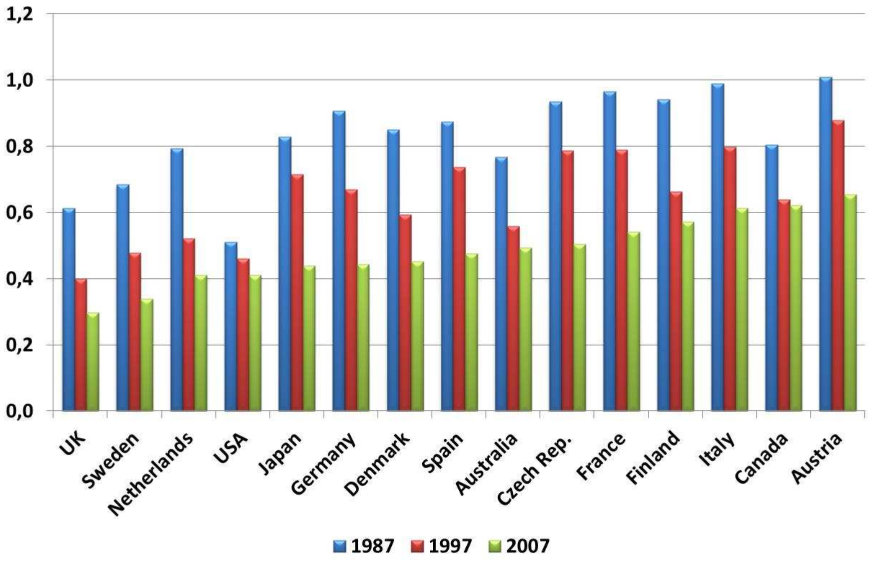
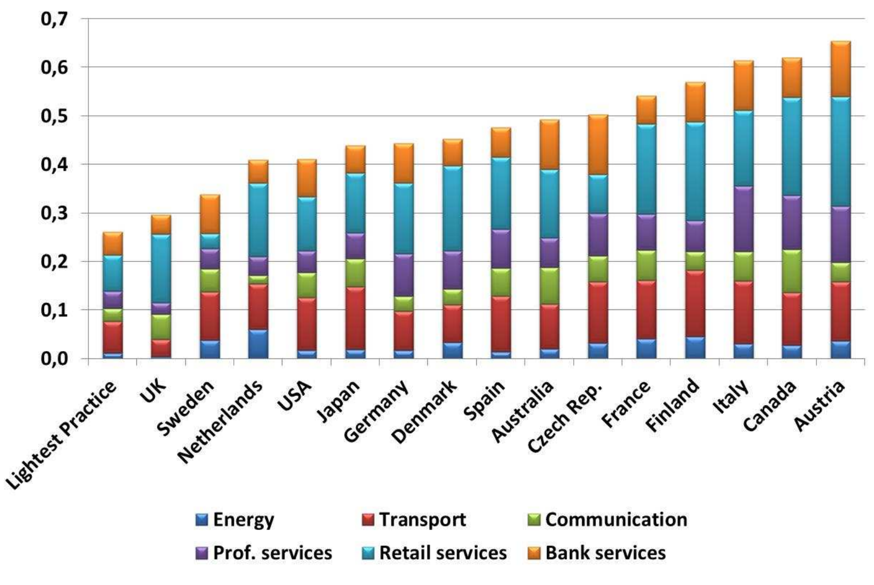


Chart 2: Average country contributions of six NMR indicators to REG in 2007



Descriptive statistics and analysis of variance

Table 1 gives the means and medians, first and third quartiles for the eight variables of our productivity, ICT and R&D regressions, both in levels and annual growth rates. We can see in particular that on average for our sample over the twenty year period 1987-2007 REG has been reduced at a rate of 3.3% per year while the MFP gap with the USA has been slowly decreasing by 0.2% per year. In parallel, ICT capital intensity has been very rapidly increasing at a rate of 11.3% per year, while its gap with the USA has been slowly augmenting by 0.3% per year. R&D capital intensity has also been increasing at a rapid rate of 5.8% per year, while its gap with the USA has been widening very significantly by 1.5 % per year. Similarly we observe that our measures of the ICT and R&D labor cost ratios have respectively been decreasing at very high rates of about 10% and 5.8% per year, which largely reflects the actual use of quality-adjusted hedonic prices for ICT and of overall manufacturing prices for R&D for lack of more appropriate prices.

Table 1: Simple descriptive statistics

	Levels in logs except for REG				Annual log growth rate in % also for REG			
	Q1	Median	Q3	Mean	Q1	Median	Q3	Mean
Regulatory burden indicator REG	0.40	0.65	0.89	0.65	-4.75	-2.62	-1.17	-3.33
MFP gap	-0.55	-0.39	-0.25	-0.42	-4.06	-0.20	3.59	-0.20
ICT capital intensity gap	-1.10	-0.75	-0.27	-0.73	-5.22	-0.13	5.30	0.28
R&D capital intensity gap	-1.28	-0.54	-0.04	-0.62	-4.94	1.01	7.02	1.55
ICT capital intensity	5.30	5.96	6.74	6.01	5.93	10.39	15.55	11.34
ICT - labor cost ratio	-0.18	0.18	0.61	0.24	-16.20	-9.11	-2.94	-9.98
R&D capital intensity	5.63	6.52	7.65	6.54	1.06	5.12	10.22	5.85
R&D - labor cost ratio	-0.07	0.03	0.18	0.05	-7.18	-3.10	0.73	-3.28

All statistics are computed for the complete study sample (i.e., 2612 observations for levels and 2430 for growth rates), except for the R&D variables computed for the subsample without industries with low R&D intensity (i.e., 1478 observations for levels and 1366 for growth rates).

Table 2 summarizes the results of an analysis of variance for all the variables of our analysis in terms of separate country, industry and year effects θ_c, θ_i and θ_t , as well as a sequence of two ways interacted effects θ_{ct} , (θ_{ct} and θ_{it}) and (θ_{ct} , θ_{it} and θ_{ci}). The first column documents the variability of the variables lost in terms of “first step” R2 in first step when we include in the regressions of our model the three one-way effects separately, as a basic control for the usual sources of specification errors, such as omitted (time invariant) country and industry characteristics. The three following columns document what is the additional variability lost in terms of “second step” R2 when we also include interacted two-way effects, in order to control for other potential sources of specification errors to be discussed in the next Section on identification and estimation. They are ordered in a sequence going from the most plausible source of endogeneity (2nd column), to the next plausible source (3rd column) and to a third one (4th column) that we will argue is very unlikely.

Table 2: Analysis of variance

	First step R^2	Second Step R^2		
	Separate country, industry and year effects	Country*year	Country*year and industry*year	Country*year, industry*year and country*industry
	(1)	(2)	(3)	(4)
Regulatory burden indicator REG	0,938	0.196	0.520	0.959
MFP gap	0,471	0,083	0.235	0.840
ICT capital intensity gap	0,458	0,093	0.209	0.915
R&D capital intensity gap	0,606	0,017	0,112	0,937
ICT capital intensity	0,824	0.095	0.1620	0.9120
ICT - labor cost ratio	0,837	0.4470	0.507	0.801
R&D capital intensity	0,790	0,018	0,070	0,9360
R&D - labor cost ratio	0,758	0,217	0,265	0,690

All statistics are computed for the complete study sample, except for the R&D variables computed for the subsample without industries with low R&D intensity.

We see that the three country, industry and year effects taken alone already account for large shares of variability of the eight variables of our model which are ranging from 45-60% for the MFP, ICT and R&D gap variables of the productivity regression, to 75-85% for the ICT and R&D capital intensity and labor cost ratio variables, and to nearly 95% for our central explanatory variable REG. We see that the shares of left variability accounted by interacting country and year effects alone is at most of 45% (for the ICT-labor cost ratio but much less for the other variables), and by interacting also industry and year effects at most of 50% (for REG and the ICT-labor cost ratio but much less for the other variables). Interacting in addition the country and industry effects account in total up to a minimum share of 70% for all eight variables and of 90-95% for five of them.

Focusing on REG, the share of its variability in total variability, which is left to estimate the regulatory impact parameters of interest in the productivity, ICT and R&D regressions, decreases from 7.2% with separate country, industry and year effects, to 5.0% adding country-year effects, 3.% adding also industry-year effects, and 0.3% adding finally country-industry effects. It is good that the absolute total variability of REG is large enough so that even a share of a few percent is enough to obtain estimates which are statistically significant as we shall see in Section V. It is also fortunate that there are both strong and *a priori* reasons for considering that it is very likely that the country-industry component of the data, contrary to the country-year and industry-year components, is indeed an appropriate source of exogenous variability for the estimation of our model.

IV. Identification and Estimation

In order to estimate consistently the long term impacts of REG in the productivity, R&D and ICT demand regressions (3) and (4), we have to take into consideration intricately related potential sources of specification errors, mainly: (i) inverse causality, when governments reacting to economic situations and political pressures implement changes in product market regulations; (ii) direct effects of such changes, in so far as they can be correlated over time within-country and across-industry as well as within- industry and across-country; (iii) omitted variables such as country specific and/or industry specific technical progress and changes in international trade, etc… We will explain in a first sub-section how we can take care of such specification errors by including country*year and industry*year effects in our regressions and thus largely mitigate the biases they potentially generate. We will also argue to the contrary that there no need to control for country*industry effects, and that we can rely on the country*industry variability of the explanatory variables in our regressions to identify and estimate consistently the upstream regulatory impact parameters of interest.

To be fully confident that we are estimating long term parameters, we have also to corroborate that our regressions are cointegrated. We have also to make sure that short term correlations between the idiosyncratic errors in the regressions and our variables are not another possible source of biases for our estimates, in particular those of the elasticities of ICT and R&D capital intensities and relative user costs. To deal with this issue we implement the Dynamic OLS (DOLS) estimators proposed by Stock & Watson (1993). In a second sub-section we will thus briefly report on the cointegration tests we have performed showing that by and large we can accept that our model is cointegrated, and on the Hausman specification tests of comparison of the OLS and DOLS estimates showing that the former are biased and the later are indeed to be preferred.

Specification errors and country, industry and year interacted effects

Firms' political pressures to change regulations are an important potential source of econometric specification errors. In particular, if firms respond to negative productivity shocks by "lobbying" for raising anticompetitive regulations, thereby protecting their rents, inverse causality would entail negative correlations between productivity and product market regulation indicators. Therefore, the negative impacts of anticompetitive regulations on productivity could be overestimated. Obviously, such biases could also arise and eventually be larger when estimating the regulatory impacts on the demand for R&D and ICT. However, we can distinguish three cases depending on whether such productivity shocks and lobbying reactions occur over time at the country level across industries, and/or they occur at the industry level across countries, and/or they are country and industry specific.

The first case appears the most likely, because of imitation behavior by government and decisions or recommendations taken at the international level (in particular by the EU, the OCDE or the World Trade Organization). Including country*year interacted effects in our regressions will take care of the corresponding endogeneity biases in this case.

The second case is very similar to the first. Although probably less prevalent than the first case, it may concerns particularly upstream industries as energy, transport, communications and banking, in which international agreements and regulations are widespread. Likewise, including industry*year effects in our model will take care of the resulting endogeneity biases.[7]

The last case of potential occurrence of biases arising from lobbying and productivity shocks at specific country-industry levels would apply if we were concerned by assessing the impacts of existing regulations in industries on the productivity and ICT and R&D of these industries themselves, but not in the present analysis in which we focus on estimating the impacts of regulations in upstream industries on other downstream industries. Actually although we are

7 When industry*year fixed effects are introduced, our empirical investigation tests actually that the impact of NMR indicators is growing with the intensity of use of regulated inputs. Therefore, our approach presents similarities with the 'difference-in-difference' approach, as highlighted in Appendix D.

estimating average impacts of upstream regulations over all industries by keeping upstream industries in our sample, we are abstracting from the possible regulatory impacts of upstream industries on their own productivity and ICT and R&D, by being careful to impute a value of zero for upstream industries own to intermediate consumption ($w_J^j = 0$) in measuring REG in these industries.[8]

Besides that they can correct for or at least alleviate potential endogeneity biases, it is also important to stress that country*year fixed effects and industry*year either alone or taken together can act as good proxies for a variety of omitted variables. In particular they can take into account differences between countries and/or industries in technical progress, in the change of international trade conditions, in the evolution of proportions of skilled and highly educated labor force, etc…

To wrap-up, in view of the inherent difficulties and uncertainties of our study, rather than choose one preferred model econometric specification, we have thought proper to keep two that provide a range of plausible consistent estimates. The first one with only interacted country*year effects takes care of the endogeneity and omitted variables specification errors that we consider most likely and gives generally higher negative estimates (in absolute values) of the upstream regulatory impact parameters that can be viewed as upper bound estimates. The second with both interacted country*year and industry*year effects takes care more fully of such specification errors and give estimates that can be deemed as lower bound estimates. In the next two sections we will center the discussion of our estimation results and simulations on these two types of estimates. But we also document in Appendix B estimates of our model for econometric specifications with other choices of two-ways interacted country, industry and year effects, thus allowing the interested readers to judge the differences they entail.

Cointegration and DOLS estimators

To support our long term interpretation of our estimation results and our reliance on the DOLS estimators, we have to test the cointegration of our model. Precisely, we have to test that: i) MFP, R&D and ICT capital intensity and relative user cost variables stocks and their relative costs are integrated of order 1 (I(1)); (ii) MFP is cointegrated with the leading country

8 It can be noted in this regard that the estimated negative impacts of REG are significantly higher in absolute value if we did not take such precaution than when we do, which can be taken as a confirmation of an endogeneity bias.

We have performed Levin, Lin and Chu (2002) and Im, Pesaran and Shin (2003) panel data unit-root tests and Pedroni (1999, 2004) panel data cointegration tests. All the unit-root tests confirm that the MFP, R&D and ICT capital intensities and user costs variables are I(1), whereas the cointegration tests are somewhat less clear-cut, four out of seven of them rejecting the no-cointegration null hypothesis. However, it is important to stress that our unit-root and panel cointegration tests have necessarily a relatively weak power because of the short time dimension of our panel data sample (maximum 20 years but in average about half since it is seriously unbalanced).

In principle when non-stationary variables are cointegrated, the Ordinary Least Squares (OLS) estimators are convergent under the standard assumptions (Engle and Granger, 1987). However, there are reasons to suspect that the OLS estimates of the elasticities of ICT and R&D capital intensities and relative user costs (γ and δ) and (σ_d and σ_k) in the productivity regression and the demand regressions may be biased, because of short term correlations between these variables and regression idiosyncratic errors. The DOLS estimators get rid of these correlations by including in the regressions leads and lags of the first differences of the potentially endogenous explanatory variables if they are non-stationary.[9] The Hausman specification tests implemented on the three regressions show that the OLS and DOLS estimates differ quire significantly, confirming clearly our preference for the latter.

V. Estimation results

We comment successively the estimation results of the production function (relation 2) and of the R&D and ICT factor demand functions (relation 3). In all estimates, country, year and industry fixed effects are included. For the reasons developed above, we presents results with and without country*year and industry*year fixed effects. For brevity, we call sometimes option A the introduction of country*year fixed effects but no industry*year fixed effects, option B the introduction of both and option O their absence. Generally, the estimated coefficients are not statistically different whatever the fixed effects interactions included (except the direct impact of the regulatory burden indicator, see further). However, these statistical results come from quite large standard errors of the coefficient estimators in many

9 Given that the time dimension of our sample is already short, we have only included one lead and one lag. Our estimates are practically unaffected when we add one or two more leads and lags.

cases. In other words, the lack of statistically significant differences should not hide the important economic differences between the estimated coefficients values.

Production function (relation 2)

Table 2 presents DOLS regression results for the production function. Columns 1, 3 and 5 report estimation results of the relation 2, while column 2, 4 and 6 present results for specifications omitting the ICT capital intensity gap and the R&D capital intensity gap. In columns 1 and 2, country*year fixed effects are included (option A), in columns 3 and 4, country*years and industry*year fixed effects are included (option B) and in columns 5 and 6, no fixed effect interactions are included (option O).

Table 2: **Production function**
Dependent variable: MFP gap with the US

	(1)	(2)	(3)	(4)	(5)	(6)
Gap in ICT capital intensity	0.052*** [0.009]		0.074*** [0.009]		0.048*** [0.008]	
Gap in R&D capital intensity	0.078*** [0.007]		0.069*** [0.007]		0.083*** [0.007]	
Regulatory burden indicator$_{-1}$	-0.234*** [0.055]	-0.253*** [0.057]	-0.064 [0.067]	-0.155** [0.071]	-0.226*** [0.050]	-0.212*** [0.051]
Fixed effects:						
Country, industry, year	Y	Y	Y	Y	Y	Y
Country*year	Y	Y	Y	Y	N	N
Industry*year	N	N	Y	Y	N	N
Observations	2612	2612	2612	2612	2612	2612
R-squared	0.565	0.518	0.646	0.596	0.526	0.474
RMSE	0.1821	0.1911	0.1720	0.1835	0.1818	0.1910

*** significant at 1%; ** significant at 5%; *significant at 10% - Standard errors between brackets
DOLS estimations with one lag and one lead (their coefficients are not presented)

As the MFP gap is calculated without taking into account ICT and R&D impacts, the estimation results of relation 2 indicate that the Value Added elasticity to ICT capital stock is between 4.8% and 7.4%, and the elasticity to R&D capital stock between 6.9% and 8.3%. These results are consistent with the empirical literature. They support excess return on R&D but not on ICT capital stock, as their average capital cost shares are, according to our calculations, of 6.4% and 6.3% (on the relevant industries, i.e. 8 industries for R&D and 13 for ICT).

The estimates of the relation 2 indicate also that a 0.1 increase of the regulatory burden indicator would contribute to decrease the MFP by around 2.34 points, according to column 1. This result appear robust to the omission of the country*year fixed effect (columns 5 and 6), but the impact of the regulatory burden indicator reduces strongly when industry*year fixed effects are included in the estimates (columns 3 and 4). It keeps even significantly different from zero only when ICT and R&D gaps indicators are both omitted (column 4).[10] An interpretation of this result is that, in our dataset, the variance of the regulatory burdens has an important industry*year dimension (see table 1) and the remaining variance would be too close of white noise shocks to estimate the parameters. In the following, we consider that the impact of the regulatory burden indicator is between the two estimates with and without the industry*year fixed effects (columns 1 and 3).

Note that the appendix B presents another interpretation by distinguishing the impact of the regulatory burden indicator between industries investing or not in R&D (see table B1). When industry*year fixed effects are introduced, the impact of the regulatory burden indicator remain significant for the industry not investing in R&D. We come back to this point after presenting the results on R&D and ICT demands.

Chart 3 presents the impact of the regulatory burden indicator on MFP according to the estimates of Table 2 column 1 and 3, i.e. option A and B. If we consider the distribution of our regulatory burden indicator, these results mean that in comparison with the situation without any anticompetitive NMR, the regulatory burdens decrease the MFP by at least 11.7 points for 50 % of the observations according to option A and 3.2 points according to option B.[11]

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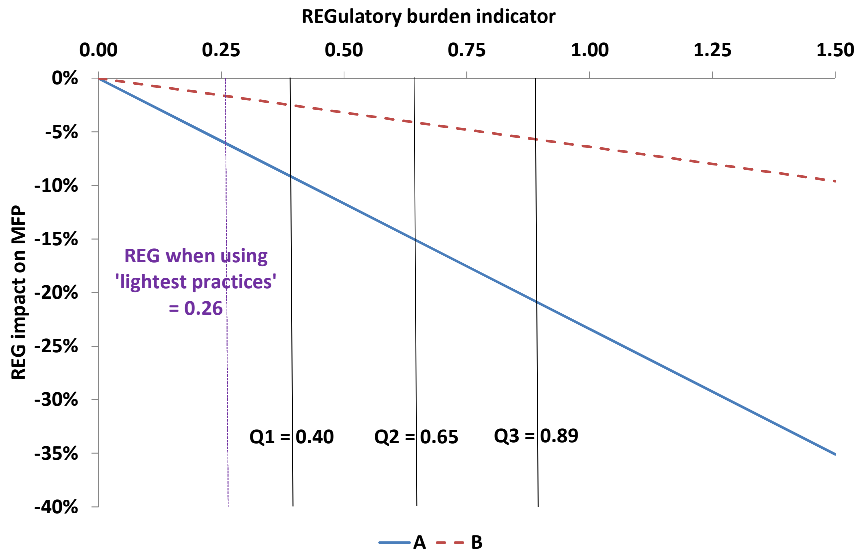
10 Therefore, this is only the impact of upstream regulations not explained by the R&D and ICT channels that is questioned by this result.

11 As a country without any anticompetitive NMR doesn’t exist, chart 3 presents also another basis for comparison: a value of the regulatory burden indicator calculated on lightest practices. The lightest practices are defined, in each upstream industry, as the average of the three lowest levels of regulation observed in 2007 among the countries in the dataset. These lightest practices are mobilized by the next section simulation. The REG indicator values are calculated at the industry level and chart 3 presents the unweighted average of the industry values for the REG indicator on lightest practices. Relatively to this average value, the regulatory burdens decrease the MFP by at least 5.6 points for 50 % of the observations according to option A and 1.5 points according to option B.

Chart 3: **Long-term impact of the REG indicator on MFP**



Factor demand functions (relation 3)

Tables 3 and 4 present DOLS regression results for R&D and for ICT demand. In the two tables, columns 1, 3 and 5 report estimation results of the relation 3 while column 2, 4 and 6 present results corresponding to a Cobb-Douglas specification, with substitution elasticities between every factor couples constrained to be equal to one. As in the previous table 2, in columns 1 and 2, country*year fixed effects are included (option A), in columns 3 and 4, country*years and industry*year fixed effects are included (option B) and in columns 5 and 6, no fixed effects interactions are included (option O).

Table 3: **R&D demand**
Dependent variable: R&D capital intensity
The price elasticity is constraint to unity in column (2), (4) and (6)

	(1)	(2)	(3)	(4)	(5)	(6)
R&D capital cost	-0.628*** [0.128]	-1	-0.619*** [0.135]	-1	-0.607*** [0.108]	-1
Regulatory burden indicator$_{-1}$	-1.395*** [0.385]	-1.563*** [0.382]	-0.868** [0.425]	-1.051** [0.424]	-0.717** [0.283]	-0.831*** [0.283]
Fixed effects: Country, industry, year Country*year Industry*year	 Y Y N	 Y Y N	 Y Y Y	 Y Y Y	 Y N N	 Y N N
Observations	1478	1478	1478	1478	1478	1478
R-squared	0.801	0.763	0.810	0.746	0.796	0.787
RMSE	0.6599	0.6624	0.6776	0.6855	0.6242	0.6273

*** significant at 1%; ** significant at 5%; *significant at 10% - Standard errors between brackets
DOLS estimations with one lag and one lead (their coefficients are not presented)

Table 4: **ICT demand**
Dependent variable: ICT capital intensity
The price elasticity is constraint to unity in column (2), (4) and (6)

	(1)	(2)	(3)	(4)	(5)	(6)
ICT capital cost	-0.758*** [0.041]	-1	-0.728*** [0.045]	-1	-0.507*** [0.032]	-1
Regulatory burden indicator$_{-1}$	-0.263** [0.125]	-0.166 [0.125]	-0.342** [0.164]	-0.251 [0.166]	-0.089 [0.115]	0.059 [0.120]
Fixed effects: Country, industry, year Country*year Industry*year	 Y Y N	 Y Y N	 Y Y Y	 Y Y Y	 Y N N	 Y N N
Observations	2612	2612	2612	2612	2612	2612
R-squared	0.863	0.845	0.871	0.837	0.842	0.824
RMSE	0.4139	0.4169	0.4220	0.4277	0.4252	0.4450

*** significant at 1%; ** significant at 5%; *significant at 10% - Standard errors between brackets
DOLS estimations with one lag and one lead (their coefficients are not presented)

According to the estimation results of the relation 3, the elasticities to the relative user cost of capital are significantly smaller than 1, in absolute value, for R&D and ICT demands, whether or not country*year or industry*year fixed effects are included. According to these estimates, a 1 % increase of the relative factor cost would decrease the factor intensity by around 0.6 % in the case of R&D and between 0.51% and 0.76 % in the case of ICT.

The coefficient of the regulatory burden indicator is negative and generally significant for both ICT and R&D demands equations. These estimates are sensible to the introduction of fixed effect interactions and to the Cobb-Douglas constraint. These differences are not statistically significant, mainly because of quite large standard errors. However, the differences of the estimated coefficient values are economically important differences, so the next section simulation takes these differences into account.

According to the estimates of relation 3, a 0.1 increase of our regulatory burden indicator would decrease the factor intensity by around 14.0 % for R&D when option A is preferred (column 1). However, this effect is much smaller, almost divided by 2, according to option B or O estimates (columns 3 and 5). Concerning ICT, there are also important differences. According to option A estimates, a 0.1 increase of our regulatory burden indicator would decrease the factor intensity by around 2.6 % for ICT (column 1), but this value goes up to 3.4% when industry*year fixed effects are introduced (column 3). Moreover, this impact is much smaller when country*year fixed effects are omitted and the estimated coefficient is even no more significant (column 5). The estimated impact of regulatory burden on R&D is more robust to the hypothesis of a Cobb-Douglas specification, whereas the sensibility on ICT is quite the same than for the introduction of fixed effect interactions. However, beyond the sensibility of the coefficient, it appears clearly that the impact of regulatory burdens is by a lot higher on R&D capital intensity than on ICT capital intensity.

As for the productivity equation, appendix B distinguishes the impact of the regulatory burden indicator between industries investing or not on R&D. It shows the contrary than for the impact on MFP: the impact of the regulatory burden indicator on ICT demand is significant only for the industry investing on R&D. Therefore, there is an interesting ‘story’ when industry*year fixed effects are included: the R&D and ICT channels capture the whole upstream regulations impact on productivity for the R&D industries whereas these impact goes through other channels for the no-R&D industries.

Some previous studies showed also an important impact of upstream anticompetitive regulation on downstream industry productivity growth (see, among others, Bourlès *et al.*, 2010, Barone and Cingano, 2011). In our knowledge, our estimates are the first to support the idea that at least part of this impact come through the effects of upstream regulations on R&D and ICT capital intensity. It appears important to take into account both these different channels to appreciate the possible impact of a decrease of anticompetitive regulation on the productivity growth.

VI. Simulations

To further illustrate the influence of regulatory burdens on MFP performance, we propose an evaluation of the MFP gains at the national level from adopting in 2007 the observed lightest practice of anticompetitive regulation. First, we present the calculation methods and results. Then, we break down the important MFP gains differences between countries into their various sources. Finally, a retrospective simulation completes the analysis by measuring the MFP gains on the 1987-2007 period resulting of the observed reforms in order to put things into perspective.

MFP gains from adopting the lightest practice

The lightest practice is defined, in each upstream industry, as the average of the three lowest levels of regulation observed in 2007 among the countries in the dataset, and the global lightest practice corresponds to the lightest practice in all upstream industries. Chart 1 and 2 show that the degree of anticompetitive regulation in upstream industries differs considerably among countries.

The evaluation of the MFP gains from the adoption of the lightest practice of anticompetitive regulation is realised in two steps. The first step corresponds to the evaluation of the impact of this adoption on the R&D and the ICT capital intensities. For this, we use the estimate results of the relation 3. The second step corresponds to the evaluation of the impact of this adoption through a direct channel (the direct impact of regulations on MFP) and through an indirect one (the impact from the change of R&D and ICT capita intensities). For this, we use the estimate results of the relation 2. The industry MFP gains are then aggregated at the national level according to the 2007 Value Added share of each industry in the GDP, assuming no impact on the industries excluded from our analysis (on average, the 13 mobilized industries represent 53.8 % of the GDP).

As explained before, the evaluation of the regulatory burden indicator included in our empirical specifications is realised using national input-output table. To evaluate national specific R&D, ICT and MFP impacts of the adoption of the best anticompetitive regulation practices in upstream industries, we use in our simulations for each country its own input-output table. However, we present below the influence of this choice on the MFP impact evaluation.

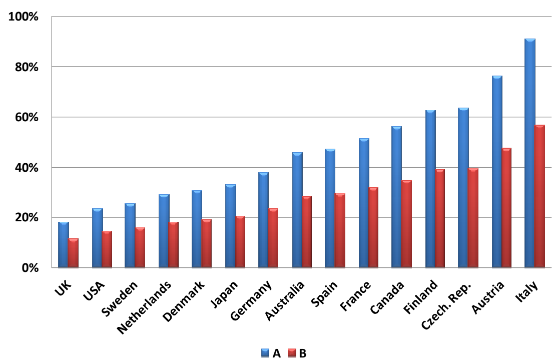
Furthermore, we showed in the previous section that relation 2 and 3 estimate results change importantly if we integrate or not industry*year fixed effects among the explanatory variables. For this reason, we present two sets evaluation of the impact of adopting the best anticompetitive regulation practices: the Option A corresponds to the estimate results obtained without industry* year fixed effects (we use for this the estimate results reported at the first column of the tables 2, 3 and 4), and the Option B corresponds to the estimate results obtained with industry*year fixed effects (we use for this the estimate results reported at the column 3 of the tables 2, 3 and 4).

Charts 3 represent the impact in the different countries of the dataset of the adoption of the best anticompetitive regulation practices on R&D capital level and on ICT capital level. The main results are the following:

- The impact is strongly higher with the Option A than with option B on R&D capital (around 50% more) and slightly higher with the Option B than with the Option A on ICT capital (around 25% more);
- The impact is strongly higher on R&D capital than on ICT capital (around four times for the Option A and 3 times for the Option B);
- The UK and the US are the two countries where the impact is the lowest, their anticompetitive regulation being also the lowest. The impact is around 15% (Option B) to 20% (Option A) for R&D capital and around 5% for ICT capital;
- At the other extremity, Austria and Italy are the two countries where the impact is the highest, their anticompetitive regulation being also the highest. The impact is around 50% (Option B) to 80% (Option A) for R&D capital and around 15% (Option A) to 20% (Option B) for ICT capital;
- The other countries are between these two extremes, Sweden, Netherlands and Denmark closer to the US-UK one and the Czech Republic, Finland and Canada closer to the Austria-Italy one.

Charts 3: **Long-term impact of product market reforms**

Impact on R&D capital accumulation



Impact on ICT capital accumulation

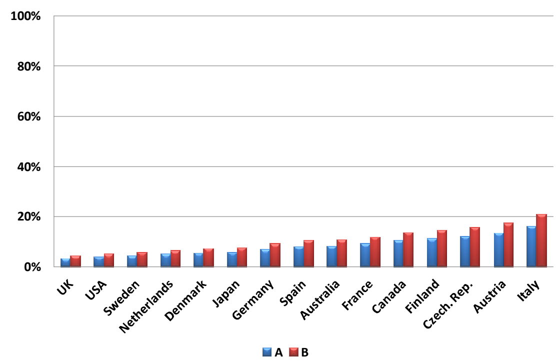
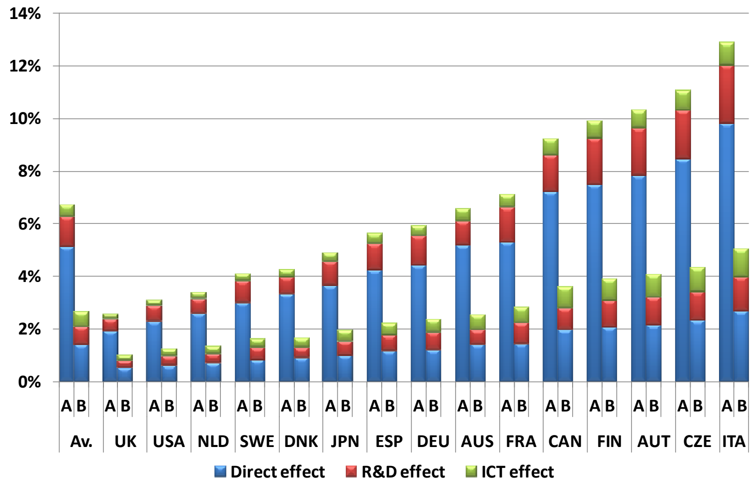


Chart 4 represents the MFP impact in the different countries of the dataset of the adoption of the best anticompetitive regulation practices. This impact is composed of a direct component, calculated with the coefficient of the regulatory burden indicator from the relation 2, and of two indirect components which intervene through R&D and ICT impact commented above, calculated with the coefficients of R&D capital intensity gap and ICT capital intensity gap indicator from the relation 2. The main results are the following:

- The global impact is strongly (by a factor around 2.5) always higher with the Option A than with the Option B. This difference comes mainly from the direct effect and slightly from the indirect one through R&D capital intensity;
- The direct impact is more important than the sum of the two indirect ones, this difference being by a lot higher in the Option A (around 4 time) than in the Option B (around 25% more);
- The UK and the US are the two countries where the impact is the lowest, their anticompetitive regulation being also the lowest. The impacts are around 1% (Option B) to 2.5% and 3% (Option A), respectively;
- At the other extremity, the Czech Republic and Italy are the two countries where the impact is the highest, their anticompetitive regulation being also the highest. The impact is around 4%-5% (Option B) to 11%-13% (Option A);
- The other countries are between these two extremes, Netherlands, Sweden and Denmark closer to the US-UK one and Canada, Finland Austria closer to the Austria-Italy one;
- In average over the 15 countries of the dataset, the impact is around 2.5% (Option B) to 6.5% (Option A).

Chart 4 **: Impact on productivity**



Break down of MFP gains country differences

In the results presented above, national input-output matrixes and Value Added shares were used for each country to calculate its regulatory burden indicator the impact of its adoption of lightest practice anticompetitive regulation. Another choice could have been to use the US input-output matrix and VA shares, the US being the referential country to evaluate the R&D and the ICT capital intensity gaps. It seems interesting to evaluate the effect of this choice on our evaluation. It underlines the importance of the differences input-output matrix and industry structure to explain the MFP gains.

The table 6 compares the MFP global impact of the adoption of the best anticompetitive regulation practices with different choices concerning the input-output matrix and VA shares. This comparison is proposed for the two possible choices concerning the year*industry fixed effects: Option A and Option B (respectively without and with these year*industry fixed effects). Columns 1 and 4 correspond to the MFP impact presented above, columns 2 and 5 to the impact when the US input-output matrix is used, columns 3 and 6 when the US input-output matrix and VA shares are used.[12] The main results are the following:

- The choice of the input-output matrix (to calculate the regulatory burden indicator of each country) has a consequent influence on the evaluated MFP impact of the adoption of lightest practice regulation. As the intensity of use regulated intermediate inputs is low in the US, the choice of the US matrix decreases the impact, from a proportion of 20% (for

12 Thus, the columns 3 and 6 allow comparing with the US the differences of MFP gains induced by the differences of excess regulations “all other things being equal”.

Netherlands, for example) to a proportion of 45% (for the Czech Republic). Nevertheless, the impact stays consequent in all countries;

- The choice of the domestic or US VA shares has no sensible influence on the MFP impact of this policy. This influence can be positive or negative, and in absolute proportion value the highest influence is observed for Finland where the choice of the US matrix decreases the MFP impact by 15%.

All these results give a strong confirmation to the diagnosis that anticompetitive regulation in the upstream industries contributes to restrict MFP gains. This influence comes through different channels: a direct one and two indirect through R&D and ICT capital intensity, the direct channel being the most important. Adopting the best anticompetitive regulation practices would support strongly the growth strategies implemented in the countries of our dataset, and consequently their public finance consolidation strategies.

Table 6: **Simulated MFP gains from reforms, depending on I-O tables and industry weights**

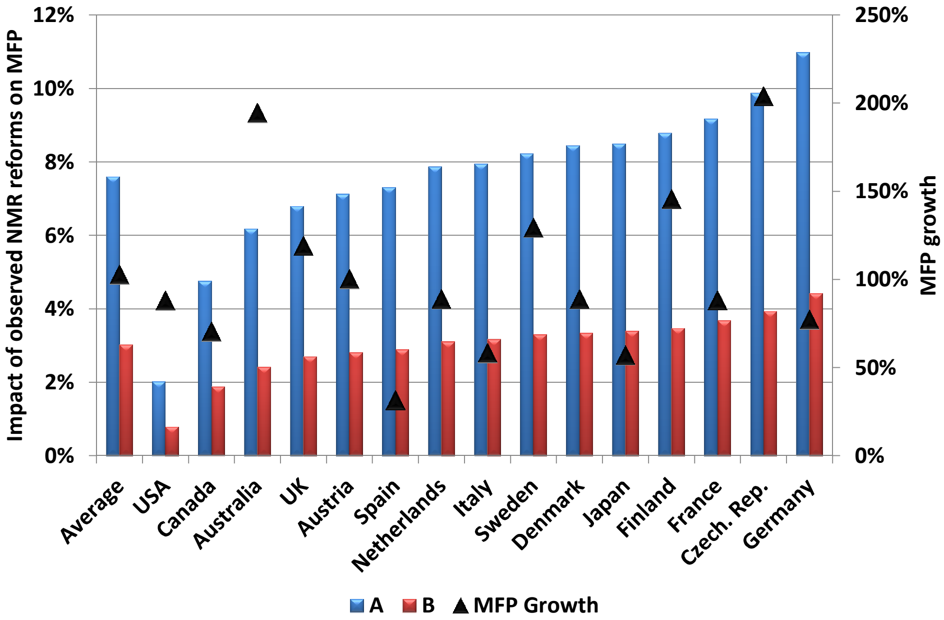
	(1)	(2)	(3)	(4)	(5)	(6)
UK	2,6%	1,7%	1,7%	1,0%	0,7%	0,6%
USA	3,1%	3,1%	3,1%	1,2%	1,2%	1,2%
Netherlands	3,4%	2,8%	2,8%	1,3%	1,1%	1,1%
Sweden	4,1%	3,0%	2,7%	1,6%	1,2%	1,0%
Denmark	4,3%	3,6%	3,5%	1,6%	1,4%	1,3%
Japan	4,9%	3,8%	3,5%	1,9%	1,5%	1,4%
Spain	5,6%	3,8%	4,2%	2,2%	1,5%	1,6%
Germany	5,9%	4,4%	3,5%	2,4%	1,7%	1,4%
Australia	6,6%	4,6%	4,9%	2,5%	1,7%	1,9%
France	7,1%	5,7%	5,4%	2,8%	2,2%	2,1%
Canada	9,2%	7,5%	7,2%	3,6%	2,9%	2,8%
Finland	9,9%	6,8%	5,8%	3,9%	2,6%	2,2%
Austria	10,3%	7,6%	7,6%	4,1%	2,9%	2,9%
Czech. Rep.	11,1%	5,9%	5,4%	4,3%	2,2%	2,0%
Italy	12,9%	7,2%	7,2%	5,0%	2,8%	2,8%
Average	6,7%	4,8%	4,6%	2,6%	1,8%	1,7%
I-O table	Domestic	US	US	Domestic	US	US
Industry weights	Domestic	Domestic	US	Domestic	Domestic	US
Specification	A	A	A	B	B	B

Retrospective analysis

Chart 1 shows large reductions of the value of the REG indicator over the sample period. Therefore, it is interesting to complete the previous simulation by the calculation of the MFP gains on the 1987-2007 period induced by the observed NMR reforms. The calculation method is the same as previously. In particular, we use of domestic input-output matrix and value added shares and the estimated coefficients without industry*year fixed effects (option A) or with these fixed effects (option B).

Chart 5 shows the MFP gains induced by the NMR reforms (on the left axis) as well as the observed MFP growth (on the right axis) on the same period. These last are unweighted averages of the industry level estimation sample MFP growth.[13] The country average MFP gains from observed NMR reforms over the whole period are 7.60% (0.35% per year) when using the option A estimated coefficients, and 3.02% (0.14% per year) with the option B. These gains are sensible. The comparison with the observed MFP growth over the same period put things into perspective. Indeed, the country average MFP growth is 102.55% (3.30% per year), so much more than the impact of NMR reforms.

Chart 5: **MFP gains over the 1987-2007 period from observed NMR reforms**



13 The MFP gains of NMR reforms are calculated on the whole 1987-2007 period and the 13 industry, whereas the country MFP growth are observed on the unbalanced estimation sample. This unbalanced panel has an important impact on MFP growth differences between countries. Moreover, as the estimations and simulations are also done on a small number of industries, a comparison with national accounting MFP growth is hardly possible.

VII. Conclusion

We have investigated the R&D and ICT investment possible channels through which upstream industry anticompetitive regulations impact productivity. To our knowledge, it is the first attempt to try out this characterization. For this, we have estimated a production function where productivity depends directly on upstream regulations and also on R&D and ICT capital, as well as two factor demand functions, where R&D and ICT accumulation depends also on upstream regulations. From this approach, it has been possible to distinguish direct and indirect impacts of regulations on productivity. The empirical investigation has been realized on a country-industry unbalanced panel dataset, including 2612 observations on 14 OECD countries and 13 manufacturing and market service industries over the 1987-2007 period.

From the estimation results, it has been possible to evaluate the long term national level MFP gains from adopting the observed lightest practice of anticompetitive regulations. The lightest practice is defined, in each upstream industry, as the average of the three lowest levels of regulations observed in 2007 among the countries in the dataset. Two evaluations have been proposed: one (Option A) corresponds to the estimate results obtained without industry*year fixed effects and the other one (Option B) corresponds to the estimate results obtained with industry*year fixed effects. It has appeared that the direct impact of regulations is always larger than the sum of the two indirect ones (25% to 3 three times more). The main results are that: (i) The global impact is strongly (by a factor around 2.5) always higher with Option A than with Option B. This difference comes mainly from the direct effect and only slightly from the indirect one through R&D capital intensity; (ii) The UK and the US are the two countries where the impact is the lowest, their anticompetitive regulations being also the lowest. The global impact goes from around 1% (Option B) to 2.5% and 3% (Option A), respectively. At the other extremity, the Czech Republic and Italy are the two countries where the impact is the highest, their anticompetitive regulation being also the highest. The impact goes from around 4%-5% (Option B) to 11%-13% (Option A). The other countries lie between these two extremes.

All these results give a strong confirmation to the diagnosis that anticompetitive regulations in the upstream industries contribute to restricting MFP gains. This influence comes through different channels: a direct and two indirect through R&D and ICT capital intensity, the direct channel being the larger. These results give scope for policies aiming to substantially raise productivity and GDP growth through a decrease of the upstream industry anticompetitive regulations. In the current period, these types of structural reforms could help the fiscal consolidation implemented in numerous countries to decrease sovereign debt, in terms of GDP percentage.

Nevertheless, our estimates do not take into account other regulations which could also impact productivity growth, as for example labour market ones. Several studies (see among others Aghion *et al.* 2009) showed that labour market regulations could impact productivity either directly or through an interaction with product market regulations, as upstream industry regulations taken into account in this study. The large direct impact of the upstream industry regulations on productivity could also act, by a substantial proportion, from labour market regulations. Our results open the way for future studies trying to go further in the analysis of the impact of regulations on productivity growth.

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APPENDIX A: DATA PRESENTATION

This appendix presents the data and calculation methods in more detail than section III. The first part focuses on capital stocks and the Multi-Factor Productivity (MFP) index whereas the second part improves understanding of the OECD anticompetitive Non-Manufacturing Regulation indicators (see Conway and Nicoletti (2006) for a more detailed presentation of these indicators).

Multi-Factor Productivity

Data required by the MFP calculations come from the OECD and EU KLEMS databases: (i) data on value added, Purchasing Power Parities, employment in number of person engaged and labor compensation come from the OECD STAN database; (ii) R&D investments data come from the OECD ANBERD database; (iii) the breakdown of R&D investments between intermediate consumptions, physical investments and R&D employment come from various OECD databases; and (iv) physical investments values and prices come from the EU KLEMS database. To avoid double counting of the R&D investments and thus to treat symmetrically the ICT and R&D production factors, the value added is increased by the amount of R&D intermediate consumptions whereas the R&D employment level and compensations are deducted from the total employment level and compensation.[14]

We merge data for 18 manufacturing and service industries, covering the whole market industry except 3 industries: 'Agriculture, hunting, forestry and fishing', 'Mining and quarrying' and 'Real Estate activity'.[15] The list of these 18 industries is presented on Table A1 as well as their ICT and R&D investments coefficients (i.e., the ratio of investment over value added) on average over the 2001-2005 period. For the 5 industries greyed out, Table 1 shows very low ICT and R&D coefficients, respectively 1.08% and 0.62% on average, against 3.05% and 3.63% for the 13 other industries. As we are interested on the impact of 'upstream' regulations on ICT and R&D, these 5 industries are excluded from the estimation sample. Among the 13 remaining industries, all are investing sensibly in ICT but 5 are almost not investing in R&D. Indeed, for these 5 industries, presented in italics, the average R&D

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14 Because of the lack of data availability, the R&D expenses in physical investments are not deducted from the total physical investments.

15 These 18 industries represent the maximum level of disaggregation available when using our data sources. This number of industries is smaller than in Bourlès *et al.* (2010) as some industries are aggregated together because of R&D expenses data availability.

investment coefficient is of 0.57% against 5.54% for the 8 others industries. Therefore, these 5 industries are excluded from the sample when estimating the R&D demand. The choices of excluding some industries but not others are sometimes arbitrary; however our estimation results are robust to these choices.

Table A1: **ICT and R&D investment coefficients sample averages on the 2001-2005 period**
The investment coefficients are the ratio of ICT investments over value added in current prices

INDUSTRIES	ISIC rev. 3 code	ICT coef.	R&D coef.
FOOD PRODUCTS, BEVERAGES AND TOBACCO	*15-16*	*1,61%*	*1,10%*
TEXTILES, TEXTILE PRODUCTS, LEATHER AND FOOTWEAR	17-19	1,23%	1,16%
WOOD AND PRODUCTS OF WOOD AND CORK	20	1,13%	0,38%
PULP, PAPER, PAPER PRODUCTS, PRINTING AND PUBLISHING	*21-22*	*2,80%*	*0,64%*
CHEMICAL, RUBBER, PLASTICS AND FUEL PRODUCTS	23-25	1,78%	8,05%
OTHER NON-METALLIC MINERAL PRODUCTS	26	1,43%	1,37%
BASIC METALS AND FABRICATED METAL PRODUCTS	27-28	1,48%	1,33%
MACHINERY AND EQUIPMENT, N.E.C.	29	2,20%	5,06%
ELECTRICAL AND OPTICAL EQUIPMENT	30-33	4,30%	16,01%
TRANSPORT EQUIPMENT	34-35	2,24%	10,28%
MANUFACTURING NEC; RECYCLING	36-37	1,37%	1,41%
ELECTRICITY GAS AND WATER SUPPLY	40-41	2,72%	0,40%
CONSTRUCTION	45	0,74%	0,14%
WHOLESALE AND RETAIL TRADE; REPAIRS	*50-52*	*2,09%*	*0,24%*
HOTELS AND RESTAURANTS	55	0,95%	0,00%
TRANSPORT, STORAGE, POST AND TELECOMMUNICATIONS	*60-64*	*6,64%*	*0,54%*
FINANCIAL INTERMEDIATION	*65-67*	*5,65%*	*0,32%*
RENTING M&EQ AND OTHER BUSINESS ACTIVITIES	72-74	4,70%	1,85%

Industries with almost no ICT and R&D investments (then excluded from the estimation sample) are greyed out
Industries with almost no R&D investments (but some in ICT) are in italics
The industries which are also 'upstream' are underlined

Physical investments in constant prices are computed using national level deflators. To calculate the ICT investment deflator, the USA use extensively hedonic methods relatively to other countries and, therefore, we prefer to use the USA ICT investment relative prices for all the countries.[16] Because of the lack of data availability, we use the manufacturing deflator as a proxy for R&D investment prices. Capital stocks are calculated with the Permanent Inventory Method (PIM), investment taking place in final-period and assuming geometric rates of depreciation. The EU KLEMS database distinguishes between 3 ICT and 3 non-ICT assets. We compute the capital stocks for each of these 6 assets and then we aggregate them into non-ICT and ICT capital stocks. It allows us to consider different depreciation rates for the assets: 5 % for non-residential structures, 10 % for transport and other non-ICT

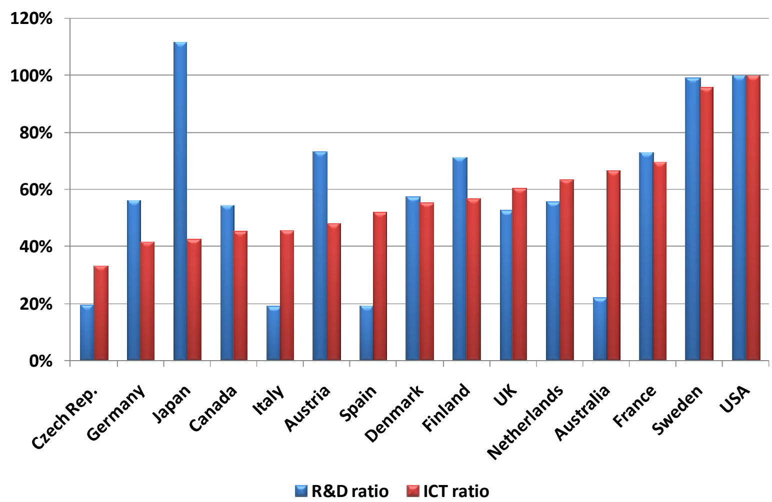
16 Note that for the same reasons we have modified the value added prices of the "Electrical and optical equipment" industry, which include communication and computing equipment. Prices in this industry for the USA are extensively based on the hedonic price method and, therefore, are not comparable with those of other countries that do not apply this method. This can have an important impact on measures of productivity growth. As for ICT investments, we therefore substitute USA hedonic value added prices for domestic prices in this industry.

equipments, 15 % for communication equipments, 25 % for R&D and 30 % for hardware and software.

Physical investments data are available from 1970 but the R&D investments are available only since 1987 at the industry level. The issue of computing the initial R&D capital stock is therefore important. We first calculate an R&D capital stock at the aggregate level, using data starting in 1981, and then this stock is shared between industries according to their share in total R&D expenses to proxy for the initial R&D capital stock. To compute the initial capital stocks K_0 of aggregate R&D or non-ICT physical capital we use the formula $K_0 = I_0^q/(\delta + g)$ with I_0^q the investment in constant price the first year available, δ the depreciation rate and g the value added growth rate over the previous decade. Regarding ICT capital stocks, we assume an initial capital stock of zero in 1971.

Chart A1 shows the country average ratio of domestic over USA R&D and ICT capital intensity (i.e., ratios of R&D or ICT capital stocks over employment). The estimation sample is strongly unbalanced, but less on the 2001-2005 period, therefore we compute the ratios on this period. Chart A1 shows important differences between countries. Moreover, the ranking of countries is very different for R&D and ICT capital intensities.

Chart A1: **R&D and ICT capital intensity ratio with the US, country sample 2001-2005 average**



The MFP index mobilized in our estimations takes into account of labor and the non-ICT physical capital stocks but omit the R&D and ICT capital stocks:

$$mfp_{ci,t} = (y_{ci,t} - l_{ci,t}) - \tilde{\alpha}_i(c_{ci,t} - l_{ci,t})$$

With small letters for logarithms, c, i and t the country, industry and time indices, respectively, Y the value added, L the labor, C the non-ICT physical capital stock and $\tilde{\alpha}$ the non-ICT capital elasticity, assumed equal to its share in total costs computed on the US data over the whole estimation period. Chart A2 shows the country average ratio of this MFP index over its USA value on the 2001-2005 period: every country is quite far from the USA MFP.

Chart A2: **MFP ratio with the US, country sample 2001-2005 average**

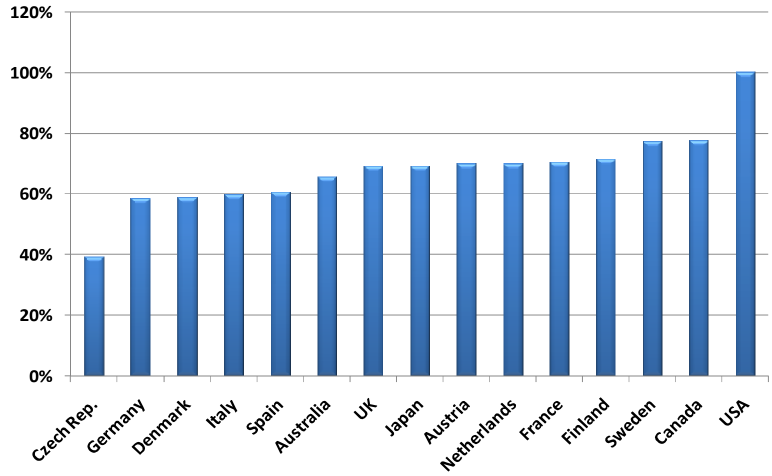


Table A2 presents the estimation sample quartiles and averages in level and annual growth rates of each variable mobilized in the 3 estimated equations as well as the two components of the MFP index, i.e. the labor productivity and the non-ICT capital intensity, which are. On average, the MFP and ICT intensity gaps with the USA are stable over time, whereas the R&D intensity has converged by 1% per year. The relative cost of ICT capital has decreased strongly, leading to a huge increase in capital intensity of 11.34% per year on average. There is also an important growth rate of R&D intensity, but this rate is two time smaller on average than for ICT intensity (5.85%).

Table A2: **Descriptive statistics**

	Level (b)				Annual growth rate (in %) (c)			
	Q1	Median	Q3	Mean	Q1	Median	Q3	Mean
Regulatory burden indicator	0.40	0.65	0.89	0.65	-4.75	-2.62	-1.17	-3.33
MFP gap	-0.55	-0.39	-0.25	-0.42	-4.06	-0.20	3.59	-0.20
ICT capital intensity gap	-1.10	-0.75	-0.27	-0.73	-5.22	-0.13	5.30	0.28
R&D capital intensity gap (a)	-1.28	-0.54	-0.04	-0.62	-4.94	1.01	7.02	1.55
ICT capital intensity	5.30	5.96	6.74	6.01	5.93	10.39	15.55	11.34
ICT capital relative cost	-0.18	0.18	0.61	0.24	-16.20	-9.11	-2.94	-9.98
R&D capital intensity (a)	5.63	6.52	7.65	6.54	1.06	5.12	10.22	5.85
R&D capital relative cost (a)	-0.07	0.03	0.18	0.05	-7.18	-3.10	0.73	-3.28
Labor productivity	4.41	5.51	7.24	6.54	-3.10	2.65	6.24	3.61
Non-ICT capital intensity	1.80	2.35	3.89	2.98	-0.29	2.08	4.65	2.46

(a): the low R&D industries are excluded from the sample
(b): the variables are in logarithm, except the ‘regulatory burden’ indicator
(c): annual growth rates in difference of logarithm, including for the ‘regulatory burden’ indicator

Product market regulation indicators

The OECD anticompetitive Non-Manufacturing Regulations (NMR) indicators measure to what extent competition and firm choices are restricted where there are no a priori reasons for government interference, or where regulatory goals could plausibly be achieved by less coercive means. They are based on detailed information on laws and rules. This information is the raw material allowing calculating the aggregate indicators, as presented by Diagram 1. For each NMR indicator, the detailed information is first aggregated into 5 sub-level indicators: public ownership, public control on business activity, legal barriers to entry, market structure and industry structure (these 5 sub-level indicators are not calculated systematically for each upstream industry as they are not always relevant). Then, these sub-level indicators are aggregated into one indicator for each upstream industry. The step distinguishing between 'state control' and 'barriers to entrepreneurship' is not used by the OECD to calculate the aggregated indicators. We present this step because these two 'mid-level' indicators are used in appendix B. Indeed, as it would be discuss, we could expect different impact of 'state control' and 'barriers to entrepreneurship' on economic activity of downstream industries.

Diagram 1: **Aggregation of the detailed information on anticompetitive regulations**

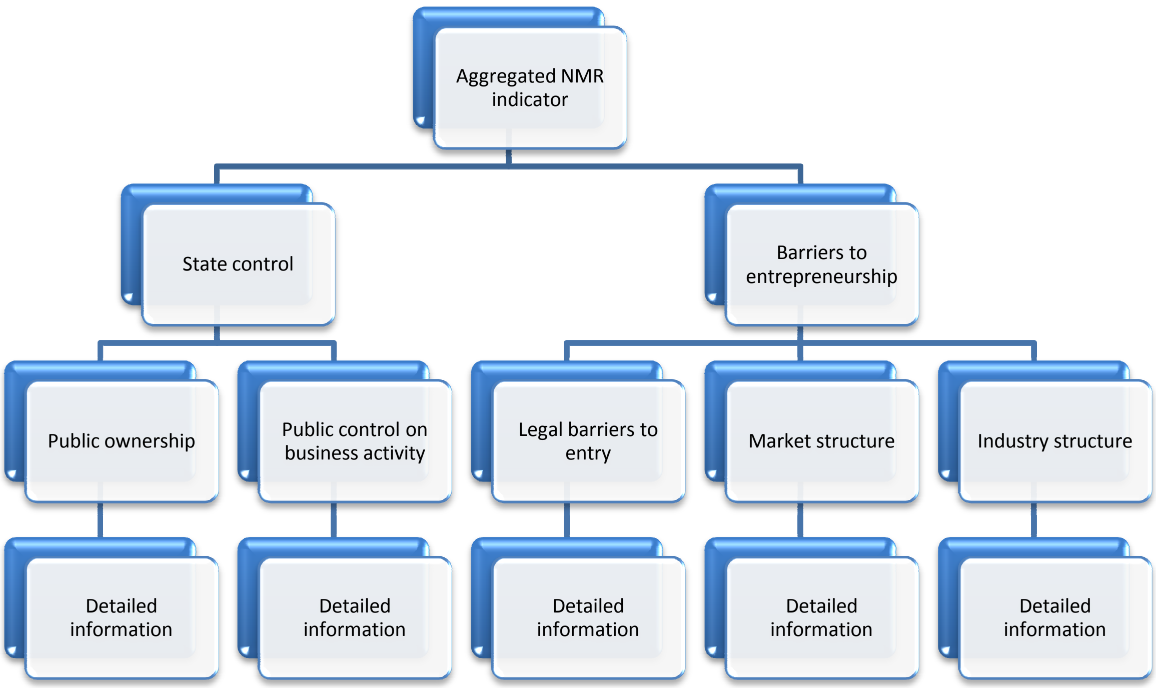


Table A3 shows the questionnaire used to calculate the 'legal barriers to entry' sub-indicator for professional services, as well as the coding of the answers and their weights for the aggregation. This example could help improve understanding of what is really measured by the OECD NMR indicators. Obviously, it is impossible to show each questionnaire, but this one is quite typical (all the questionnaires are available on the OECD "Indicators of Product Market Regulation Homepage").

Table A3: **The questionnaire on 'legal barriers to entry' for professional services**
Scale 0-6, 0 for the most pro-competitive regulations

	Weights by theme (b_j)	Question weights (c_k)	Coding of data				
Licensing:	2/5						
How many services does the profession have an exclusive or shared exclusive right to provide?		1	0 0	1 1,5	2 3	3 4,5	>3 6
Education requirements (only applies if Licensing not 0):	2/5						
What is the duration of special education/university/or other higher degree?		0.33	equals number of years of education (max of 6)				
What is the duration of compulsory practice necessary to become a full member of the profession?		0.44	equals number of years of compulsory practice (max of 6)				
Are there professional exams that must be passed to become a full member of the profession?		0.22	no 0			yes 6	
Quotas and economic needs tests	1/5						
Is the number of foreign professionals/firms permitted to practice restricted by quotas or economic needs tests?		1	no 0			yes 6	

The coding of data is indicated under each possible answer.

APPENDIX B: SENSITIVITY ANALYSIS

Section V shows the main estimation results and their sensitivity to the introduction of various fixed effects and, for the factor demands, to the Cobb-Douglas production function assumption that the elasticity of substitution between all factors is equal to one. The main estimates are robust to most of these first sensitivity analyses, except the direct impact of upstream regulations on productivity. Indeed, this impact is no more statistically significant when industry*year fixed effects are introduced. Therefore, section VI presents policy simulation calculated according to the parameters estimated when the industry*year fixed effect are omitted (option A) and alternative simulations using the estimation results including these fixed effects (option B).

This appendix continues the sensitivity analyses. First, we investigate how much the impact of upstream regulations differs between industries investing or not on R&D (called R&D and no-R&D industries thereafter). Then, we study the robustness with respect to the constraints on return to scale and on non-ICT capital elasticity. Next, we investigate the introduction of a catch-up term in the production equation and its omission in the factor demand specifications. Then, we allow the impacts of barriers to entrepreneurship and of state control to differ. Finally, we complete the section V sensitivity analyses with respect to the fixed effects by the introduction of country*industry fixed effects in the estimated specifications.

Impact of upstream regulations in R&D and no-R&D industries

Whereas all industries in the estimation sample are investing on ICT, only 8 industries are investing on R&D (“Chemicals Products”, “Other Mineral Products”, “Metal Products”, “Machinery and Equipment”, “Electric Equipment”, “Transport Equipment” and “Energy”) and 5 industries are not (“Food Products”, “Wood Products”, “Manufacturing NEC”, “Construction” and “Hotels and Restaurants”). We investigate whether the impact of upstream regulations on MFP index and on ICT demand differ between both industry groups.[17]

17 We focus here on the coefficient of the REG indicator. However, the R&D and ICT capital elasticity can also differ between industries. Indeed, when the R&D and ICT capital intensity gaps in the productivity equation are interacted with their respective cost shares (calculated on the US and averaged on the 1987-2007 period), these interaction terms are positive and significant. In other words, the industries investing substantially on R&D or ICT are also the industries benefiting the most, per unit, of these investments.

Table B1 presents the impact of upstream regulations on productivity (B1.1) and on ICT demand (B1.2), with or without industry*year fixed effects, for all industries as in section V (col. (1) and (3)), or separately for R&D and no-R&D industries (col. (2) and (4)). According to the estimation results, the impact of upstream regulations on productivity and ICT demand are statistically different between the 2 industry groups only when industry*year fixed effects are included in the estimated specification (col. (4)). In this last case, the negative impact of upstream regulations on ICT demand is statistically significant only for the R&D industries whereas, on the contrary, the 'direct' impact of upstream regulations on productivity is statistically significant only for the no- R&D industries. To sum up, there is an interesting 'story' when industry*year fixed effects are included: the R&D and ICT channels capture the whole upstream regulations impact on productivity for the R&D industries whereas this impact goes through other channels for the no-R&D industries.

Table B1: **Upstream regulation impacts of industries investing or not on R&D**

B1.1 Production function
Dependent variable: MFP gap with the US

		(1)	(2)	(3)	(4)
Gap in ICT capital intensity		0.052*** [0.009]	0.053*** [0.009]	0.074*** [0.009]	0.073*** [0.009]
Gap in R&D capital intensity		0.078*** [0.007]	0.077*** [0.008]	0.069*** [0.008]	0.071*** [0.008]
Regulatory burden indicator$_{-1}$	All industries	-0.234*** [0.054]		-0.064 [0.062]	
	R&D industries		-0.250*** [0.055]		-0.044 [0.062]
	no-R&D industries		-0.187*** [0.067]		-0.188*** [0.073]
Fixed effects: Country, industry, year Country*year Industry*year		 Y Y N	 Y Y N	 Y Y Y	 Y Y Y
Reg impact equality test (p-values)			0.2037		0.0029
Observations		2612	2612	2612	2612
R-squared		0.565	0.566	0.646	0.647
RMSE		0.1821	0.1821	0.1720	0.1718

*** significant at 1%; ** significant at 5%; *significant at 10% - Standard errors between brackets
DOLS estimations with one lag and one lead (their coefficients are not presented)

B1.2 ICT demand
Dependent variable: ICT capital intensity

		(1)	(2)	(3)	(4)
ICT capital costs		-0.741*** [0.041]	-0.732*** [0.042]	-0.712*** [0.044]	-0.723*** [0.045]
Regulatory burden indicator$_{-1}$	All industries	-0.281** [0.126]		-0.368** [0.165]	
	R&D industries		-0.245* [0.128]		-0.398** [0.166]
	no-R&D industries		-0.417*** [0.154]		-0.144 [0.210]
Fixed effects: Country, industry, year Country*year Industry*year		 Y Y N	 Y Y N	 Y Y Y	 Y Y Y
Reg impact equality test (p-values)			0.1253		0.0866
Observations		2612	2612	2612	2612
R-squared		0.862	0.862	0.870	0.870
RMSE		0.4163	0.4162	0.4237	0.4235

*** significant at 1%; ** significant at 5%; *significant at 10% - Standard errors between brackets
DOLS estimations with one lag and one lead (their coefficients are not presented)

Robustness with respect to the constraints on return to scale and non-ICT capital elasticity

To estimate more conveniently the productivity equation, we assume constant return to scale and we calibrate the non-ICT capital elasticity by its share on total costs. We show in this section that our estimation results are robust to these assumptions.

To relax both assumptions leads to estimate the following productivity equation:

$$lp\_gap_{ci,t} = \pi l\_gap_{ci,t} + \alpha c\_gap_{ci,t} + \gamma d\_gap_{ci,t} + \delta k\_gap_{ci,t} - \mu \, REG_{ci,t-1} + u_{ci,t}$$

with: $lp\_gap_{ci,t} \equiv (y_{ci,t} - l_{ci,t}) - (y_{\bar{c}i,t} - l_{\bar{c}i,t})$, $c\_gap_{ci,t} \equiv (c_{ci,t} - l_{ci,t}) - (c_{\bar{c}i,t} - l_{\bar{c}i,t})$, $l\_gap_{ci,t} \equiv l_{ci,t} - l_{\bar{c}i,t}$ and $\pi \equiv \alpha + \gamma + \delta + \beta - 1$

Constant return to scale induces $\pi = 0$, whereas the non-ICT capital elasticity α is calibrated to around 0.19 on industry average (note that the calibration is industry specific). Table B2 presents DOLS regression results, with and without industry*year fixed effects, for this empirical specification (col. (4) and (8)) as well as for relation 3 (col. (1) and (5)) and when the variables lp_gap or l_gap are omitted (col. (2), (3), (6) and (7)).

The estimated impacts of labor and non-ICT capital intensity gaps are close to their expected values: π is next to zero whereas the non-ICT capital elasticity is slightly smaller than its calibrated value. The introduction of the non-ICT capital intensity gap reduces the R&D

capital elasticity, whereas the estimated ICT capital elasticity and the impact of upstream regulations are always robust.

Table B2: **Sensibility to the production function assumptions**

Dependent variable	MFP gap		LP gap		MFP gap		LP gap	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Gap in labor		-0.012 [0.013]		-0.026** [0.013]		-0.024* [0.013]		-0.043*** [0.013]
Gap in non-ICT capital intensity			0.151*** [0.012]	0.161*** [0.013]			0.145*** [0.012]	0.158*** [0.013]
Gap in ICT capital intensity	0.052*** [0.009]	0.060*** [0.009]	0.046*** [0.009]	0.048*** [0.009]	0.074*** [0.009]	0.079*** [0.009]	0.064*** [0.009]	0.066*** [0.009]
Gap in R&D capital intensity	0.078*** [0.007]	0.077*** [0.007]	0.040*** [0.007]	0.038*** [0.007]	0.069*** [0.007]	0.068*** [0.007]	0.037*** [0.006]	0.034*** [0.006]
Regulatory burden indicator$_{-1}$	-0.234*** [0.055]	-0.240*** [0.055]	-0.205*** [0.051]	-0.203*** [0.051]	-0.064 [0.067]	-0.078 [0.067]	-0.050 [0.063]	-0.034 [0.064]
Fixed effects: Country, industry, year Country*year Industry*year	 Y Y N	 Y Y N	 Y Y N	 Y Y N	 Y Y Y	 Y Y Y	 Y Y Y	 Y Y Y
Observations	2612	2612	2612	2612	2612	2612	2612	2612
R-squared	0.565	0.577	0.627	0.631	0.646	0.653	0.688	0.692
RMSE	0.1821	0.1797	0.1686	0.1679	0.1720	0.1705	0.1614	0.1607

*** significant at 1%; ** significant at 5%; *significant at 10% - Standard errors between brackets
DOLS estimations with one lag and one lead (their coefficients are not presented)

Robustness with respect to catch-up terms

Our main empirical productivity specification assumes that the relationship between the MFP of the follower and the leader country is bounded (for given fixed effects). In other words, we assume that the coefficient of the cointegrated long term relationship between the MFP indexes is equal to one in equation 1 (see section II). On the contrary, catch-up term are omitted into the factor demand specifications, assuming that cross-country common changes are already taken into account by the price effects and the years fixed effects. In the following paragraphs, we investigate the sensitivity of the main estimates to these assumptions and show the robustness of the results.

Relaxing the assumption of a bounded relationship leads to the following empirical productivity specification:

$$mfp_{ci,t} = cst + \rho\left(mfp_{\bar{c}i,t} - \gamma\left(d_{\bar{c}i,t} - l_{\bar{c}i,t}\right) - \delta\left(k_{\bar{c}i,t} - l_{\bar{c}i,t}\right)\right) + \gamma\left(d_{ci,t} - l_{ci,t}\right) + \delta\left(k_{ci,t} - l_{ci,t}\right) - \mu\, Reg_{ci,t-1} + u_{ci,t}$$

If $\rho = 1$ then this equation is equivalent to our main empirical specification. Note that this equation introduces constraints between the coefficients, as we assume that the capital elasticities are identical across countries in order to ensure the comparability of followers and leaders MFP. Table B3 presents the estimation results of this specification (col. (2)) and of our main specification (col. (1)).[18] According to the estimation results, the catch-up coefficient $\rho = 0.869$ is smaller than expected, but the estimated ICT and R&D capital elasticity as well as the impact of upstream regulations are robust.

Table B3: **Robustness of the productivity equation estimates with respect to catch-up**

Dependent variable	**MFP gap**	**MFP**
	(1)	(2)
Gap in ICT capital intensity	0.052*** [0.009]	0.046*** [0.008]
Gap in R&D capital intensity	0.078*** [0.007]	0.077*** [0.007]
Regulatory burden indicator$_{-1}$	-0.234*** [0.055]	-0.180*** [0.051]
MFP US		0.869*** [0.016]
Fixed effects: Country, industry, year Country*year Industry*year	 Y Y N	 Y Y N
Observations	2612	2612
R-squared	0.565	0.562
RMSE	0.1821	0.1709

*** significant at 1%; ** significant at 5%; *significant at 10% - Standard errors between brackets
DOLS estimations with one lag and one lead (their coefficients are not presented)

To investigate the robustness of ICT and R&D demand estimates with respect to catch-up, we introduce the ICT and R&D capital intensities of the leader country, respectively. Table B4 presents the estimation results. The estimated coefficient of the catch-up variable is not statistically different from 0 for the ICT demand and is statistically significant but small, relatively to the productivity equation, for the R&D demand. The estimated coefficients of the relative capital costs and, more importantly, the impact of upstream regulations are strongly robust to the addition of these catch-up variables.

18 Note that when the industry*year fixed effects are introduced they already take into account of the leader variables and both equations are equivalents.

Table B4: **Robustness of the demand factors estimates with respect to catch-up**

B4.1: **R&D demand**
Dependent variable: R&D capital intensity

	(1)	(2)
R&D capital costs	-0.628*** [0.128]	-0.615*** [0.128]
Regulatory burden indicator$_{-1}$	-1.395*** [0.385]	-1.383*** [0.389]
R&D capital intensity US		0.252*** [0.096]
Fixed effects: Country, industry, year Country*year Industry*year	 Y Y N	 Y Y N
Observations	1478	1478
R-squared	0.801	0.802
RMSE	0.6599	0.6585

B4.2: **ICT demand**
Dependent variable: ICT capital intensity

	(1)	(2)
ICT capital costs	-0.758*** [0.041]	-0.759*** [0.042]
Regulatory burden indicator$_{-1}$	-0.263** [0.125]	-0.278** [0.129]
ICT capital intensity US		-0.091 [0.073]
Fixed effects: Country, industry, year Country*year Industry*year	 Y Y N	 Y Y N
Observations	2612	2612
R-squared	0.863	0.864
RMSE	0.4139	0.4135

*** significant at 1%; ** significant at 5%; *significant at 10% - Standard errors between brackets
DOLS estimations with one lag and one lead (their coefficients are not presented)

Barriers to entrepreneurship and state control impacts

The industry anticompetitive product market regulation indicators are made up of two main regulatory areas: state control and barriers to entrepreneurship. The former mobilizes information on public ownership of leader firms and on public control on business activity (mainly price control). The last takes into account of legal barriers to entry, market structures and industry structure. The purpose of state control may be to internalize market externalities or provide public services, and then may not lead to increase the upstream rents, unlike the barriers to entrepreneurship. Therefore, according to our theoretical motivations, the impact of these two regulatory areas on efficiency improvement incentives could be qualitatively different.

We investigate this possibility by computing two different regulatory burden indicators, one using the indicators on state control and the second using data on barriers to entrepreneurship (the main regulatory burden indicator is equal to the sum of these two indicators). We introduce these regulatory burden indicators into the estimated specifications and then test the assumption of coefficient equality, with or without industry*year fixed effects. Table B5 presents the results. The assumption of the coefficient equality cannot be rejected, even at 10%, for the productivity equation (col. (1) and (2)) and the ICT demand (col. (5) and (6)), but the coefficients of the two regulatory burden indicators are statistically different for the R&D demand (col. (3) and (4)).

Table B5: **Equality tests of the impacts of the of state control and barriers to entrepreneurship regulatory burden indicators (p-values)**

	Productivity equation		R&D demand		ICT demand	
	(1)	(2)	(3)	(4)	(5)	(6)
Equality test (p-value)	0.825	0.407	0.000	0.000	0.122	0.186
Fixed effects:						
Country, industry, year	Y	Y	Y	Y	Y	Y
Country*year	Y	Y	Y	Y	Y	Y
Industry*year	N	Y	N	Y	N	Y
Observations	2612	2612	1478	1478	2612	2612

Tests based on the DOLS estimates with one lag and one lead

Table B6 presents these R&D demand estimates (col. (2) and (6)), the main estimation results (col. (1) and (5)) as well as the results when only one of the two different regulatory burden indicators is introduced. The coefficient of the regulatory burden indicators of barriers to entrepreneurship is statistically significant, negative and stronger than the coefficient of the main regulatory burden indicator, whereas the coefficient of state control is positive and statistically significant. A possible explanation is that downstream firm incentives to improve efficiency are higher when there is state control of upstream firms if these last are not grabbing part of the innovative rents.

Table B6: **Impact of direct state control on R&D demand**
Dependent variable: R&D capital intensity

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
R&D capital costs		-0.628*** [0.128]	-0.547*** [0.126]	-0.618*** [0.125]	-0.511*** [0.129]	-0.619*** [0.135]	-0.547*** [0.133]	-0.627*** [0.132]	-0.512*** [0.135]
Regulatory burden $indicator_{-1}$	All regulations	-1.395*** [0.385]				-0.868** [0.425]			
	All but state control		-4.156*** [0.546]	-3.824*** [0.540]			-3.649*** [0.604]	-3.324*** [0.601]	
	State control		2.242*** [0.642]		1.389** [0.646]		2.535*** [0.678]		1.946*** [0.681]
Fixed effects:									
Country, industry, year		Y	Y	Y	Y	Y	Y	Y	Y
Country*year		Y	Y	Y	Y	Y	Y	Y	Y
Industry*year		N	N	N	N	Y	Y	Y	Y
Observations		1478	1478	1478	1478	1478	1478	1478	1478
R-squared		0.801	0.808	0.806	0.799	0.810	0.816	0.814	0.810
RMSE		0.6599	0.6475	0.6504	0.6621	0.6776	0.6661	0.6699	0.6764

*** significant at 1%; ** significant at 5%; *significant at 10% - Standard errors between brackets
DOLS estimations with one lag and one lead (their coefficients are not presented)

Robustness with respect to the introduction of country*industry fixed effects

Section IV motivates the set of interacted fixed effects included in the estimated specifications in addition to the separate country, industry and year fixed effects. Indeed, the simultaneous introduction of all the interacted fixed effects would take into account of most of the data variability (see Table 1), thus the identification of the coefficients of interest would be almost impossible. Therefore, we must add to the separate fixed effects only the interactions preventing from the most important sources of bias. We assume that country*year fixed effects are the most relevant, as they take into account of country shocks, potential lobbyism, between industry correlations of regulation changes within country and of various omitted variables. Section V shows the estimates when these fixed effects are included and the sensitivity of these estimates to the introduction of industry*year fixed effects, these lasts taking into account of important industry specific changes as well as catch-up effects (making our estimates fully independent of the choice of leading country).

The country*industry fixed effects are not included in section V specifications. These fixed effects are important when estimating the impact of regulations within industries, as omitted country*industry specific factors may explain both economic activity and regulations, but we investigate the impact of regulations in one industry on the economic activity of other industries. Thus, these fixed effects seem less relevant. However, in order to be more comprehensive, Table B7 shows the robustness of the estimates with respect to the introduction of country*industry fixed effects.

Table B7 first two columns show the estimates when the country*industry fixed effects are omitted, without or with country*year fixed effects, as in section V specifications (see Table 2, 3 and 4 col. (1) and (5)), whereas the country*industry fixed effects are added to the estimated specifications of the two other columns. These last estimates confirm the smaller value of the estimated coefficient of the regulatory burden indicator when country*year fixed effects are omitted (which could be interpreted as underestimation according to section IV motivations). Mainly, the estimates are robust with respect to the introduction of country*industry fixed effects, particularly when country*year fixed effects are also included. On the other hand, the R&D and ICT elasticities are very sensitive, leading to estimated values unlikely, according to the abundant literature on these topics, which may be explained by the lack of remaining data variability.

To sum up, the direct effects of upstream regulations on productivity, R&D intensity and ICT intensity are robust with respect to the inclusion of country*industry fixed effects, but not the indirect impact on productivity through the R&D and ICT channels, as the estimated R&D and ICT elasticities are very sensitive. However, elasticity values very different from section V estimations are unlikely.

Table B7: **Robustness with respect to the country*industry fixed effects**

B7.1: **Production function**

Dependent variable: MFP gap with the US

	(1)	(2)	(3)	(4)
Gap in ICT capital intensity	0.048*** [0.008]	0.052*** [0.009]	0.008 [0.010]	-0.047*** [0.013]
Gap in R&D capital intensity	0.083*** [0.007]	0.078*** [0.007]	0.125*** [0.011]	0.125*** [0.014]
Regulatory burden indicator$_{-1}$	-0.226*** [0.050]	-0.234*** [0.055]	-0.145*** [0.035]	-0.179*** [0.055]
Fixed effects:				
Country, industry, year	Y	Y	Y	Y
Country*year	N	Y	N	Y
Industry*year	N	N	N	N
Country*industry	N	N	Y	Y
Observations	2612	2612	2612	2612
R-squared	0.526	0.565	0.823	0.861
RMSE	0.1818	0.1821	0.1168	0.1064

*** significant at 1%; ** significant at 5%; *significant at 10% - Standard errors between brackets
DOLS estimations with one lag and one lead (their coefficients are not presented)

B7.2: **R&D demand**

Dependent variable: R&D capital intensity

	(1)	(2)	(3)	(4)
R&D capital cost	-0.607*** [0.108]	-0.628*** [0.128]	-0.249*** [0.052]	0.037 [0.063]
Regulatory burden indicator$_{-1}$	-0.717** [0.283]	-1.395*** [0.385]	-0.238* [0.125]	-1.168*** [0.238]
Fixed effects:				
Country, industry, year	Y	Y	Y	Y
Country*year	N	Y	N	Y
Industry*year	N	N	N	N
Country*industry	N	N	Y	Y
Observations	1478	1478	1478	1478
R-squared	0.796	0.801	0.980	0.984
RMSE	0.6242	0.6599	0.2008	0.1959

*** significant at 1%; ** significant at 5%; *significant at 10% - Standard errors between brackets
DOLS estimations with one lag and one lead (their coefficients are not presented)

B7.3: **ICT demand**

Dependent variable: ICT capital intensity

	(1)	(2)	(3)	(4)
ICT capital cost	-0.507*** [0.032]	-0.758*** [0.041]	-0.316*** [0.018]	-0.479*** [0.026]
Regulatory burden indicator$_{-1}$	-0.089 [0.115]	-0.263** [0.125]	0.105 [0.078]	-0.406*** [0.077]
Fixed effects:				
Country, industry, year	Y	Y	Y	Y
Country*year	N	Y	N	Y
Industry*year	N	N	N	N
Country*industry	N	N	Y	Y
Observations	2612	2612	2612	2612
R-squared	0.842	0.863	0.967	0.982
RMSE	0.4252	0.4139	0.2006	0.1557

*** significant at 1%; ** significant at 5%; *significant at 10% - Standard errors between brackets
DOLS estimations with one lag and one lead (their coefficients are not presented)

APPENDIX C: DIFFERENCES WITH BOURLÈS *ET AL.* (2014)

Our productivity equation analysis differs slightly from Bourlès *et al.* (2014). First, concerning the data mobilized, the MFP definition is more detailed and, as a consequence, the estimation sample is smaller than in Bourlès *et al*. (2014). Second, the Dynamic Ordinary-Least-Square (DOLS) estimation approach is preferred to an Error Correction Model. This Appendix motivates these choices and shows the robustness of the estimates.

Data differences

Labor productivity and regulation data are the same in the two papers, as well as the capital elasticity calibration method.[19] However, the investigation of the R&D and ICT channels leads to three main differences: (1) the single asset mobilized in Bourlès *et al.* (2014) is decomposed between ICT and non-ICT physical capital and the MFP index omit the former (see section II); (2) value added, total employment level and compensation data are changed in order to avoid R&D 'double counting'; and (3) we focus on a limited number of industries that actually invest in R&D, thus reducing the estimation sample.

These changes are sizeable. Nevertheless, Table C1 shows the robustness of the estimates. The first two columns present the results on our estimation sample, without and with the industry*year fixed effects, whereas the two others present the estimates on the Bourlès *et al.* (2014) data. The ICT and R&D channels are not specified, thus the first two columns of table C1 correspond to the columns (2) and (4) of table 2. The comparisons of columns (1) with (3) and (2) with (4) show the robustness of the estimated impact of the regulatory burden indicator to the differences between the estimation samples.

19 More precisely, there are two differences concerning these data: (1) labor productivity data have been updated; (2) the scale of the regulatory burden indicator has been changed to be between 0 and 1 in Bourlès *et al.* (2014), but not in our paper. Note that the Bourlès *et al.* (2014) scale is used for all Table C2 estimates and never for Table C1, in order to allow for direct comparison with the already presented results in each case.

Table C1: **Production function sensibility to the Bourlès *et al.* (2014) data**
Dependent variable: MFP gap with the US

Data	Cette, Lopez and Mairesse		Bourlès *et al.*	
	(1)	(2)	(3)	(4)
Regulatory burden indicator$_{-1}$	-0.253*** [0.057]	-0.155** [0.071]	-0.243*** [0.046]	-0.209*** [0.052]
Fixed effects:				
Country, industry, year	Y	Y	Y	Y
Country*year	Y	Y	Y	Y
Industry*year	N	Y	N	Y
Observations	2612	2612	4346	4346
R-squared	0.518	0.596	0.477	0.546
RMSE	0.1911	0.1835	0.2087	0.2032

*** significant at 1%; ** significant at 5%; *significant at 10% - Standard errors between brackets
DOLS estimations with one lag and one lead (their coefficients are not presented)

Estimation method

The identification strategies of the two papers are the same, based on a variant of the 'difference-in-difference' approach, but their estimation methods differ. Following Griffith *et al.* (2004), Bourlès *et al.* (2014) use an Error Correction Model (ECM), thus allowing distinguishing between short and long-term impacts of the explicative variables. On the contrary, our analysis doesn't specify the dynamic of the relationship. This choice is motivated by our interest on the long-term relationship as well as by the dimension of our sample. Indeed, the average time dimension of series is 15.5 years, making hard to separate long-term and short-term impacts.

Formally, the DOLS estimator differs from an ECM by the introduction in the estimated specification of leads of the explanatory variables and by the lack of lags of the dependent variable. Our results are robust to the omission of the former, but the introduction of lags of the dependent variable induces an important increase of the standard errors of the estimated coefficient (see further Table C2). In other words, the important difference is that Bourlès *et al.* (2014) take into account of the persistence of the MFP parametrically, through its lags, whereas we treat indirectly for this persistence by correcting the estimated standard errors for the resulting persistence of the error terms through the non-parametric Newey-West method.

Table C2 shows the estimation results when using the Bourlès *et al.* (2014) ECM specification. The first two columns present the estimation results on Bourlès *et al.* (2014) data, column (1) without industry*year fixed effects included in the estimated specification, therefore these results are the same as in column (1) Table 1 of Bourlès *et al.* (2014), column (2) with these fixed effects included. Columns (3) and (4) show the estimates on our estimation sample, again with and without industry*year fixed effects.

Table C2: **Production function ECM estimations**
Dependent variable: MFP growth

Data	Bourlès et al.		Cette, Lopez, Mairesse	
Period	1985-2007		1987-2007	
	(1)	(2)	(3)	(4)
Frontier MFP growth	0.113*** [0.021]		0.254*** [0.029]	
MFP gap_{-1}	0.037*** [0.004]	0.038*** [0.005]	0.047*** [0.009]	0.055*** [0.009]
Regulatory burden $indicator_{-1}$	-0.063 [0.049]	-0.041 [0.056]	-0.094 [0.090]	-0.132 [0.107]
Fixed effects: Country, industry, year Country*year Industry*year	 Y Y N	 Y Y Y	 Y Y N	 Y Y Y
Observations	4629	4629	2277	2277
R-squared	0.249	0.358	0.453	0.572
RMSE	0.0483	0.0468	0.0537	0.0500

*** significant at 1%; ** significant at 5%; *significant at 10% - Standard errors between brackets
DOLS estimations with one lag and one lead (their coefficients are not presented)

The catch-up coefficients, taken into account by the impacts of the frontier MFP growth and the MFP gap, are statistically significant and of the expected sign: a positive shock on the frontier MFP increases the MFP of the domestic country. The coefficients of the regulatory burden indicator are negative and of the same order but are not statistically significant. According to Bourlès *et al.* (2014), this result is explained by a composition effect: the impact of regulations is statistically significant only for the observations close to the technological frontier. However, the lack of precision of the estimates could also be explained by the difficulty to distinguish between the short and long-term effects.

The last two columns of Table C2 allow comparing the ECM estimation results with the DOLS estimates of Table A1. This comparison required to calculate the long-term impacts implied by the ECM estimates, i.e. the ratio of the regulatory burden estimated coefficient over the gap coefficient (which is the opposite of the loading factor). Thus, the long-term impact of the regulatory burden indicator is -0.411 and -0.493 according to column (3) and (4) estimates, respectively.[20] These impacts are higher than with the DOLS results, respectively -0.253 and -0.155. The small value of the estimated gap coefficient could explain these differences. Indeed, according to column (3) estimates, the long-run impact of a product market reforms would require more than 48 years to be almost fully achieved (exactly, 90% of the impact of the reform would be achieved after 48.8 years).

20 Note also that, in order to compare with the DOLS results, we need to take into account of the rescaling of the regulatory burden indicator.

APPENDIX D: A COMPARISON OF OUR APPROACH WITH THE DIFFERENCE-IN-DIFFERENCE MODEL

We investigate the impact of anticompetitive regulations of non-manufacturing industry on the productivity of the other industries – or in the same way on their R&D and ICT capital intensity. In order to do this, a very simple specification would be to regress the industry productivity index directly on the NMR indicator and the other covariates. However, the estimates could be biased because of reverse causality from productivity to regulations and/or omission bias, as already mentioned in section IV. Therefore, we prefer to test the proposition that the impact of NMR is growing with the intensity of use of the regulated intermediate inputs. This approach leads to an empirical specification which is a variant of the difference-in-difference model.

This appendix presents the similarities and differences with the diff-in-diff approach in order to provide a deeper understanding of our empirical specification. We present the genuine representation of the diff-in-diff model, and then we show that under certain conditions our specification would be an application of this genuine representation. Finally, we underline the differences with our specification as well as their consequences.

First, assume the genuine representation of the diff-in-diff model:

$$Y_{it} = G_i + T_t + \beta . G_i * T_t + \epsilon_{it}$$

With Y_{it} the dependent variable of the individual i at time t, G_i and T_t dummy variables equal to one if, respectively, the individual i is in the treatment group and the time t is in the post-treatment period, and zero otherwise. Therefore, the OLS estimation of the coefficient β converges to the average treatment effect under the assumption that the counterfactual trend of the treatment group is the same as the trend of the control group.

Now, assume that our analysis focuses on the impact of one upstream regulation reform in one country and that there is only two groups of downstream industries, one using the regulated intermediate inputs (the treatment group) and the other not (the control group). This is leading to the following equation:

$$Y_{it} = \theta_i + \theta_t + \beta. G_i * T_t + \sum_j \alpha_j . X_j + \epsilon_{it}$$

With Y_{it} one of our three dependent variable ($Y_{it} = \{mfpgap_{it}; (d-l)_{it}; (k-l)_{it}\}$), X_j the j[th] covariate, θ_i and θ_t individual and time fixed effects and the other variables being the same as previously. We see that the only difference with the genuine representation would be the introduction of covariates and the industry and time fixed effects taking into account of the G_i and T_t dummy variables and further. Therefore, the estimated impact of the reform is given by the difference of evolutions between the two industries.

Coming back to our empirical specification, we conclude from the last paragraph that a first difference with the genuine diff-in-diff model is that our estimates are based on continuous variables: (i) there is no treated and control group but groups with 'degrees of treatment' (depending of the intensity of use of intermediate inputs) and; (ii) there is not only one treatment but regulation changes almost every years. More importantly, another difference is that there is a country dimension in our panel. If country*industry fixed effects were introduced, the estimated impact would be a weighted average of the diff-in-diff estimations on each country. However, as we introduce industry and country fixed effects separately, because of the lack of data variability (see table 1), our estimates are identified using also within-country-industry differences.

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