DO PRODUCT MARKET REGULATIONS IN UPSTREAM SECTORS CURB PRODUCTIVITY GROWTH? PANEL DATA EVIDENCE FOR OECD COUNTRIES

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Abstract—We identify the impact of intermediate goods markets imperfections on productivity downstream. Our empirical specification is based on a model of multifactor productivity (MFP) growth in which the effects of upstream competition can vary with distance to frontier. This model is estimated on a panel of fifteen OECD countries and twenty industries over 1985 to 2007. Competitive pressures are proxied with industry product market regulation data. We find evidence that anticompetitive upstream regulations have significantly curbed MFP growth over the past fifteen years, and more strongly so for observations that are close to the productivity frontier.

I. Introduction

COMPETITION—and policies affecting it—has been found to be an important determinant of productivity growth in recent empirical research. Firm-level evidence has generally supported the idea that competitive pressures are a driver of productivity-enhancing innovation and adoption (Geroski, 1995a, 1995b; Nickell, 1996; Nickell, Nicolitsas, & Dryden, 1997; Blundell, Griffith, & Van Reenen, 1999; Griffith, Redding, & Simpson, 2002; Aghion et al., 2004; Haskel, Pereira, & Slaughter, 2007), especially for incumbent firms that are close to the technological frontier (Aghion et al., 2005; Aghion, Blundell et al., 2009). Further evidence has also been provided at the industry level (Nicoletti & Scarpetta, 2003; Inklaar, Timmer, & van Ark, 2008; Buccirossi et al., 2009; Griffith, Harrison, & Simpson, 2010) and for aggregate productivity measures (Conway et al., 2006; Aghion, Askenazy, et al., 2009) generally based on cross-country panels.[1]

[1] Theoretically, the link between competition and productivity growth has been traced to three main factors: innovation, technology adoption, and reallocation across heterogeneous firms. While some early models of endogenous technical change (Romer, 1990; Grossman & Helpman, 1991; Aghion & Howitt, 1992) would predict competition to curb innovation in line with Schumpeterian theory, more recent analyses (sometimes called neo-Schumpeterian) predict positive or hump-shaped effects of competition on innovation (Aghion et al., 2001; Aghion & Schankerman, 2004). Firm heterogeneity plays an important role in both the neo-Schumpeterian theories and in models that focus on the positive impact of low market frictions and competitive pressures on reallocation from low- to high-productivity firms (Melitz, 2003; Bernard et al., 2003; Melitz & Ottaviano, 2008; Restuccia & Rogerson, 2008). Parente and Prescott (1994, 1999) have highlighted more specifically the negative effects of barriers to competition on technology adoption.

Most empirical studies of the competition-growth link have focused on competitive conditions within each industry (or market) as drivers of firm- or industry-level productivity enhancements. Yet to the extent that expected rents from innovation or technology adoption are underlying efforts to improve efficiency relative to competitors, focusing on within-industry competition misses an important part of the story. Indeed, these rents, and the corresponding within-industry incentives to improve productivity, may be reduced by lack of competition in industries that sell intermediate inputs necessary to production. In other words, if there is market power in these upstream industries and if firms in downstream industries have to negotiate terms and conditions of their contracts with suppliers, part of the rents expected downstream from adopting best-practice techniques will be grabbed by intermediate input providers. This in turn will reduce incentives to improve efficiency and curb productivity in downstream industries even if competition is thriving there. Moreover, lack of competition in upstream industries can also generate barriers to entry that curb competition in downstream industries as well, further reducing pressures to improve efficiency in these industries. For example, tight licensing requirements in retail trade or transport can narrow access to distribution channels.

The influence of competition in upstream industries for productivity improvements downstream is likely to be particularly relevant in developed countries where most industries are increasingly involved in global competition. In industries or markets exposed to trade, direct competitive pressures from rival firms (both incumbents and new entrants) are often strong and provide the expected incentives for efficiency improvement. By contrast, several nonmanufacturing industries are often protected from extensive trade pressures by the need for proximity or the fact that service provision occurs through national physical networks. With these nonmanufacturing industries accounting for rising shares of total intermediate inputs, the effects of lack of competition there propagate throughout the economy. As the returns to efficiency improvements are higher for firms that compete neck-and-neck with rivals that are close to the technological frontier, lack of competition upstream is likely to reduce downstream incentives to improve efficiency more markedly when distance to frontier is short, as it is often the case in increasingly globalized markets.

Our paper focuses on the influence of upstream competition for productivity outcomes in downstream industries. To our knowledge, only a few papers have looked at this issue so far, and only in static cross-section analyses (Allegra et al., 2004; Faini et al., 2006; Barone & Cingano, 2011) or single-country investigations (Forlani, 2010;

Arnold, Javorcik, & Mattoo, 2011, on France and Czech Republic, respectively). By contrast, we use panel data on fifteen OECD countries and twenty industries over the 24-year period 1984 to 2007 to estimate a stylized version of the dynamic neo-Schumpeterian model (Acemoglu, Aghion, & Zillbotti, 2006). In this model, rent-seeking efficiency improvements are driven by both improvements at the frontier and the speed of catch-up to this frontier. This makes it possible to differentiate the potential downstream effects of lack of upstream competition depending on the distance to the technological frontier.[2] We measure industry-level efficiency improvements and distance to frontier through a multifactor productivity (MFP) index, using OECD industry statistics, and we proxy competition upstream with detailed time series information on policies, rules, and regulations that generate entry barriers in key nonmanufacturing industries (henceforth called upstream industries).

Our identification strategy is straightforward. The impact of upstream regulations on downstream productivity should be growing with the intensity of use of intermediate inputs from the regulated upstream industries. Therefore, we build an indicator of regulatory burden by crossing the upstream regulatory indicators with the intensity of use of intermediate inputs calculated from input-output matrices. We also introduce industry and country-year fixed effects in the empirical specifications to account for various unobserved factors. Thus, we estimate the (across-industry and within-country) average differential impact of upstream regulations on different downstream industries.[3]

We find clear evidence that anticompetitive regulations in upstream industries curb MFP growth downstream. Consistent with the neo-Schumpeterian framework, these effects are nonlinear and depend on distance to frontier. They are strongest for observations (country-industry-period triads) that are close to the global technological frontier measured as the highest MFP in each period, but remain generally negative for a large share of our data. Interestingly, the share of observations whose MFP growth suffers from anticompetitive regulations increased over time, with the negative indirect effects of regulations affecting virtually all observations over the past fifteen years. This could be due to the increased integration of the world economy in the context of the diffusion of new technologies. With competition correspondingly becoming tougher downstream and adoption becoming more compelling, erosion of innovation rents by

regulated upstream industries is increasingly more damaging for incentives to enhance productivity. According to our estimation results, if each country's regulations were aligned on the most procompetitive ones actually observed in the OECD area, yearly gains in MFP growth would be nearly as high as 1% on average over the medium term. Our results are robust to the introduction of variables controlling for the direct (within industry) effects of regulations, changes in the way MFP is constructed, the use of different input-output tables for measuring the burden of upstream regulation on downstream industries, variations in the sample of countries and industries, and modifications in the set of fixed effects used to account for unobservables.

The paper is organized as follows. Section II details the channels through which lack of competition in upstream industries can affect efficiency growth in downstream industries. We present the econometric model in section III that we used to test this conjecture. We describe the main features of our MFP and regulation data in section IV. We discuss in section V our identification strategy, empirical results, and the related robustness checks. In this context, we provide in section VI illustrative simulations of the potential effects of making upstream markets more competitive. A few reflections on links to previous literature, open issues, and directions for future research conclude the paper in section VII.

II. Upstream Market Competition and Downstream Productivity

A. The Channels

A large and growing body of research has studied the effects of competition on growth. While competition can affect economic performance through various channels, this line of research has usually focused on the direct effects of lack of competition in an industry on its productivity performance.[4] In this paper, we focus on the effects of regulations that curb market competition in upstream industries, such as legal barriers to entry in some nonmanufacturing markets (henceforth, anticompetitive upstream regulations), on the productivity performance of downstream industries.[5]

We highlight two main channels through which lack of competition in upstream industries can generate trickle-down effects that affect the productivity performance of other industries.[6] First, if markets for intermediate inputs are imperfect, downstream firms may have to negotiate with (and can be held up by) suppliers. In this case, regulations that increase suppliers' market power can reduce incentives to

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[2] Our work is related to the industry-level analysis of Nicoletti and Scarpetta (2003) and Conway et al. (2006). However, these authors did not distinguish between effects of competition in upstream and downstream industries.

[3] We also controlled for the direct impact of regulations. To this end, we used different sets of indicators build by the OECD: the domestic nonmanufacturing regulation indicators used to describe regulations in upstream industries, indicators of foreign direct investment (FDI), and indicators of trade barriers. Controlling for the within-industry direct effects of regulations did not alter our estimates of the indirect effects of regulations in other industries via input-output linkages.

[4] For recent surveys, see Griffith and Harrison (2004), Aghion and Griffith (2005), Schiantarelli (2005), Crafts (2006), and Nicoletti and Scarpetta (2006).

[5] Note that such downstream industries include the nonmanufacturing industries themselves to the extent that they are consumers of intermediate inputs originating from other regulated industries.

[6] These channels are illustrated formally in the endogenous growth model developed in Lopez (2010) and reported in Bourlès et al. (2010).

improve efficiency downstream, as part of the (possibly temporary) rents that downstream firms expect from such improvements will have to be shared with suppliers of the intermediate inputs that are necessary for downstream production. Second, anticompetitive regulations in an upstream industry can reduce competition downstream if access to downstream markets requires using intermediate inputs produced upstream, particularly in the case of services inputs where import competition is limited. For example, if restrictive licensing or business conduct regulations in trade or transport services hinder the development of open, efficient, and innovative distribution channels, market access by downstream firms can suffer, with negative repercussions for productivity growth.

The main resulting conjecture is that weak upstream competition can curb efficiency growth in downstream firms. The remainder of this paper tests this conjecture by means of an econometric specification that accounts for both this upstream regulation–downward efficiency link and some of the other determinants of efficiency growth already highlighted in the literature (the technological pass-through and the technological catch-up), and that controls for unobserved factors by means of fixed effects.

B. The Effect of the Distance to the Technological Frontier

Recent models of endogenous growth often include the feature that, with technology flows unfettered across countries, productivity growth in follower countries or industries is a positive function of growth at the world technological frontier and of the gap between this frontier and the productivity level of the follower country or industry (Acemoglu et al., 2006; Aghion & Howitt, 2006). In other words, countries and industries lagging behind the technological frontier can boost their productivity by benefiting from the positive spillovers of innovation at the frontier (the technological pass-through phenomenon) and by adopting leading technologies available on the market (the technological catch-up phenomenon). Thus, productivity growth depends on both the ability to catch up and the ability to benefit from the innovation drift, with the importance of the latter increasing as the country or industry gets closer to the world frontier (Aghion & Howitt, 1998).[7] According to this line of research, anticompetitive regulations mainly influence the productivity of existing firms by curbing incentives to adopt the leading technologies available in the market and innovate.

Interestingly, in these models, the aggregate impact of (domestic or foreign) competition on productivity can be nonlinear and depends on the characteristics of incumbent firms (for example, on the degree of firm heterogeneity). Two sets of effects influence the behavior of productivity in each market: the escape competition (or escape entry) effect and the Schumpeterian (or discouragement) effect. The pre-

valence of one set of effects over the other will affect the link between competition and productivity. In turn, this prevalence is determined, among other things, by the average distance to frontier of firms in the market.[8]

III. Empirical Model

Our empirical analysis accounts for the different effects on productivity just considered. It uses regulation measures that are explicitly designed to account for the trickle-down effects of anticompetitive upstream regulations on the productivity performance of downstream industries, and we use an econometric specification of productivity that allows for the effects of regulation to depend on distance to the technological frontier. The empirical model also allows for persistent heterogeneity in productivity levels and growth across countries and industries, with productivity levels and growth in country-industry pairs driven by both developments at the global technology frontier and changes in product market policies affecting competitive pressures in upstream markets. Productivity growth in country-industry pairs is a function of both the productivity growth at the frontier and the catch-up to the productivity level at the frontier, whose speed depends on distance to frontier and, hence, ultimately on policies that affect the level of productivity. The model can therefore be thought of as an empirical implementation of the neo-Schumpeterian growth framework we have described. It has been used extensively in recent empirical research on the determinants of productivity growth at both the firm level (Aghion et al., 2005) and industry level (Nicoletti & Scarpetta, 2003; Griffith et al., 2004, 2010; Conway et al., 2006).

Our empirical model is specified as the following ADL(1,1) autoregressive distributed lag process in which multifactor productivity (MFP) for the country-industry pair cs at time t (MFP_{cst}) is co-integrated with the multifactor productivity of the frontier country-industry pair Fs (MFP_{Fst}). Formally, we can write the following linear regression in logarithms:

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\begin{aligned}
mfp_{cs,t} = {} & \alpha_0 . mfp_{cs,t-1} \\
& + \alpha_1 \times mfp_{Fs,t} + \alpha_2 \times mfp_{Fs,t-1} \\
& + \alpha_3 \times REG_{cs,t-1} + \alpha_4 \times REG_{cs,t-1} \times gap_{cs,t-1} \\
& + \gamma_s + \gamma_{c,t} + \varepsilon_{cs,t},
\end{aligned}
\tag{1}
$$

where the logarithms of the MFP levels of nonfrontier pairs cs and frontier country-industry pairs Fs at time t are noted in lowercase letters as, respectively, $mfp_{cs,t}$ and $mfp_{Fs,t}$;

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[7] Griffith et al. (2004) show that follower countries that invest in R&D reap a double dividend: they improve their ability to both innovate and incorporate frontier technologies into the production process.

[8] For instance, the positive "escape competition" effect on firms' efforts to improve productivity is likely to be stronger in markets where a large proportion of firms is neck-and-neck and close to the frontier than in markets where a large proportion of firms have a wide technological gap to fill (Aghion et al., 2004, 2006). Indeed, in markets dominated by firms that are far enough from the world frontier, the Schumpeterian or discouragement effects due to an increase in competition can be strong enough to deter any innovation activity.

$REG_{cs,t}$ is the indicator of the trickle-down effects of anticompetitive upstream regulations in each industry-country-period triad (see below for details); $gap_{cs,t} = mfp_{Fs,t} - mfp_{cs,t}$ is the country-industry pair distance (in logarithm) from the country-industry frontier; γ_s, $\gamma_{c,t}$ are industry and country-year fixed effects, proxying for industry-specific characteristics (such as technology or skills) and country-specific trends (such as overall technical progress or deregulation waves), respectively; and $\varepsilon_{cs,t}$ denotes the random regression error term. As in Griffith et al. (2004), the ADL(1,1) equation (1) can be rewritten as the following error correction model (ECM) representation, equation (2), under the assumption of long-run homogeneity ($\alpha_0 + \alpha_1 + \alpha_2 = 1$):

$$\Delta mfp_{cs,t} = \alpha_1 \times \Delta mfp_{Fs,t} + (1 - \alpha_0) \times gap_{cs,t-1}$$
$$+ \alpha_3 \times REG_{cs,t-1} + \alpha_4 \times REG_{cs,t-1} \times gap_{cs,t-1}$$
$$+ \gamma_s + \gamma_{c,t} + \varepsilon_{cs,t}. \tag{2}$$

This ECM representation has many attractive statistical properties and a straightforward interpretation. Productivity growth of country-industry pair cs is expected to increase with productivity growth of the industry frontier Fs and with the country-industry pair distance from the industry frontier.[9] The model implies heterogeneity in equilibrium MFP levels because the innovation potential of each country-industry pair is assumed to be only a fraction of the innovation potential at the frontier, and convergence to the frontier takes time. In keeping with the neo-Schumpeterian view of the effects of competition on productivity growth, our regressions also allow for a nonlinear effect of anticompetitive upstream regulation on different country-industry pairs by crossing the regulation variable with distance to frontier.

Throughout our analysis, the focus is on the total effects of anticompetitive upstream regulations, $\alpha_3 + \alpha_4 gap$. It should be stressed that regulation has negative effects on productivity growth that are increasing with distance to the frontier if $\alpha_3 < 0$ and $\alpha_4 < 0$ and decreasing with distance to the frontier if $\alpha_3 < 0$ and $\alpha_4 > 0$. In other words, only in the latter case would results be consistent with the neo-Schumpeterian view that lack of competition is less damaging for industries far from the frontier than for industries that are close to it and that compete neck-and-neck with their global rivals.

For a better interpretation of the model, it is useful to consider its steady-state properties. If we assume that the frontier MFP growth ($\Delta mfp_{Fs,t}$), the distance to the technological frontier ($gap_{cs,t-1}$), the anticompetitive regulation indicator ($REG_{cs,t-1}$), and the effects of technical progress

($\gamma_{c,t}$, $\gamma_{F,t}$) are constant while the shocks $\varepsilon_{cs,t}$ are null, we can see that the industry MFP growth rates for the follower countries $\Delta mfp_{cs,t}$ are also constant and equal to growth at the frontier, $\Delta mfp_{Fs,t}$. Moreover, the technological distance and the MFP growth rates depend on only the levels of anticompetitive regulations REG and the effects of technical progress ($\gamma_{c,t}$, $\gamma_{F,t}$).

More precisely we can delete the t and ($t-1$) subscripts in the ECM equation (2) and after some algebraic computation derive from it three steady-state relations: the first one for the frontier country (by also imposing $GAP_{Fs,t} = 0$) that shows that Δmfp_{Fs} is constant; the second one for the follower countries implying that gap_{cs} is constant; and the third one, as a direct consequence of the two previous ones, implying that Δmfp_{cs} is equal to Δmfp_{Fs} and hence also constant. Finally, we can write more simply:

$$gap_{cs} = \frac{1}{(1 - \alpha_0 + \alpha_4 \cdot REG_{cs})}$$
$$\times [-\alpha_3 \cdot (REG_{cs} - REG_{Fs}) - (\gamma_c - \gamma_F)]$$
$$\Delta mfp_{cs} = \Delta mfp_{Fs} = \frac{\alpha_3}{1 - \alpha_1} \times REG_{Fs} + \frac{\gamma_s + \gamma_F}{1 - \alpha_1}, \tag{3}$$

where the first relation shows that the distance of the follower countries to the technological frontier is decreasing with the difference between the country and the frontier effect of the technical progress ($\gamma_c - \gamma_F$), and if $\alpha_3 < 0$ is increasing, as we can expect with the difference between the country and the frontier regulation level ($REG_{cs} - REG_{Fs}$), while the second relation shows that the industry MFP growth for the frontier country and the follower countries depends positively on the industry and country/time-specific technical progress effects (γ_s, γ_F), and if $\alpha_3 < 0$ negatively on the effects of anticompetitive regulations in upstream industries (REG_{Fs}).

IV. Data

We need data on MFP and the extent of anticompetitive regulation in a subset of industries that we define as upstream. Our identification strategy also requires measures of the importance of the upstream industries as suppliers of intermediate inputs. Merging different sources, we were able to assemble a cleaned, unbalanced panel of 4,629 observations for fifteen countries and twenty industries over the 1984–2007 period.[10] The data sources and specific calculations are presented in the following sections.

A. Productivity Variables

We measure industry-level efficiency improvements and distance to the frontier by means of MFP indicators in growth rates but also in levels, which we constructed using

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[9] Notice that even though it is estimated with MFP growth as the dependent variable, the ECM representation remains an equation in levels including the industry fixed effects as the underlying ADL(1,1) model. It is not an equation written in first differences (or log-growth rates) in which these fixed effects are wiped out. See Bond et al. (2003).

[10] We explain in the online appendix the rules we have followed to clean the data. Note that the observations for the country-industry frontier are excluded from the estimation sample in each period.

OECD industry statistics. The MFP growth rates are calculated as follow:

$$\Delta mfp_{cs,t} = \Delta va_{cs,t} - \alpha_s \times \Delta l_{cs,t} - (1 - \alpha_s) \times \Delta k_{cs,t},$$

where va is the logarithm of the value added in constant price; α the output elasticity of labor, approximated by the labor share on value added; l the logarithm of the total employment in number of persons; and k the logarithm of the net capital stock in constant price. The value added and total employment come from the STAN database for industrial analysis and the net capital stock from the OECD productivity database by industry (PDBi).[11]

The distance-to-frontier variable (GAP), defined in each period as the ratio of the leading country-industry MFP to that of the follower countries ($GAP_{cs,t} = MFP_{Fs,t}/MFP_{cs,t}$), depends on MFP levels. These levels are calculated for a base year (2000) and then extended over the sample period using data on MFP growth. To ensure comparability across countries, we have converted the value-added and capital stock levels into prices denominated in a common currency using OECD aggregate purchasing power parities (PPP), and we have used a common labor share, the industry-specific average share over all countries and periods. Estimates are robust to the choice of other proxies for the labor shares and the use of industry-specific PPPs for value added. Another comparability issue is raised by the value-added prices of the electrical and optical equipment industry, which include communication and computing equipment. Prices in this industry for the United States are extensively based on the hedonic price method and therefore are not comparable to those of other countries that do not apply this method. This can have an important impact on measures of productivity growth. We therefore replaced U.S. hedonic prices in this industry by total manufacturing value-added prices (see the supplementary online appendix for the corresponding sensitivity analysis).

Figure 1 presents the box plots of the resulting MFP growth and GAP variables in selected years. Panel A shows that MFP growth is widely dispersed with a small median value of about 0.8% per year, and panel B that GAP is also widely dispersed and that its median value has remained stable at about 1.55 over the period.

B. Product Market Regulation Indicators

Empirical research on the effects of competition on productivity has used a variety of approaches to measure competitive pressures. These include indicators of market structure or market power, survey-based assessments of the

business environment, and indicators of product market policies. The indicators of product market regulations drawn from the OECD international product market regulation database used in this paper try to address three major issues: minimize endogeneity bias, account for the trickle-down effects of competitive pressures in upstream industries on downstream industries, and provide a link with policies that affect competition.[12]

Addressing the endogeneity of competition measures has been one of the main empirical challenges in trying to identify the impact of competition on innovation or productivity outcomes. Traditional indicators of product market conditions, such as markups or industry concentration indices, can hardly be treated as exogenous determinants of economic outcomes.[13] Entry of new (possibly foreign) firms is also most likely not exogenous to productivity outcomes. Moreover, research shows that some widely used indicators of market structure or market power are not univocally related to product market competition.[14] Finally, these indicators do not provide a direct link to policy or regulation.

To address these concerns, our empirical analysis is based on some of the potential policy determinants of competition rather than on direct measures of it. Aghion, Askenazy, et al. (2009) and Griffith et al. (2010) have taken a similar approach. However, while these authors rely on EU indicators about antimonopoly cases and the implementation of the Single Market Programme, we use the OECD indicators of product market regulations, focusing on the nonmanufacturing regulation (NMR) indicators and the trickle-down effects of inappropriate regulations in these industries on all industries of the economy as measured by the so-called regulatory burden indicators REG (see below).[15] The nonmanufacturing sector is undoubtedly the most regulated and sheltered part of the economy, while few explicit barriers to competition remain in markets for manufactured goods of OECD economies.

Nonmanufacturing regulation indicators. The OECD NMR indicators measure to what extent competition and

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[11] The construction of the PDBi net capital stocks series is described in the online appendix, and more information is available in the OECD "PDBi Methodological Notes" (http://www.oecd.org/std/productivity statistics). It might seem preferable to calculate MFP using data on hours worked and capital services, but at the time of writing, such data were available only for the aggregate economy, not at the country-industry level.

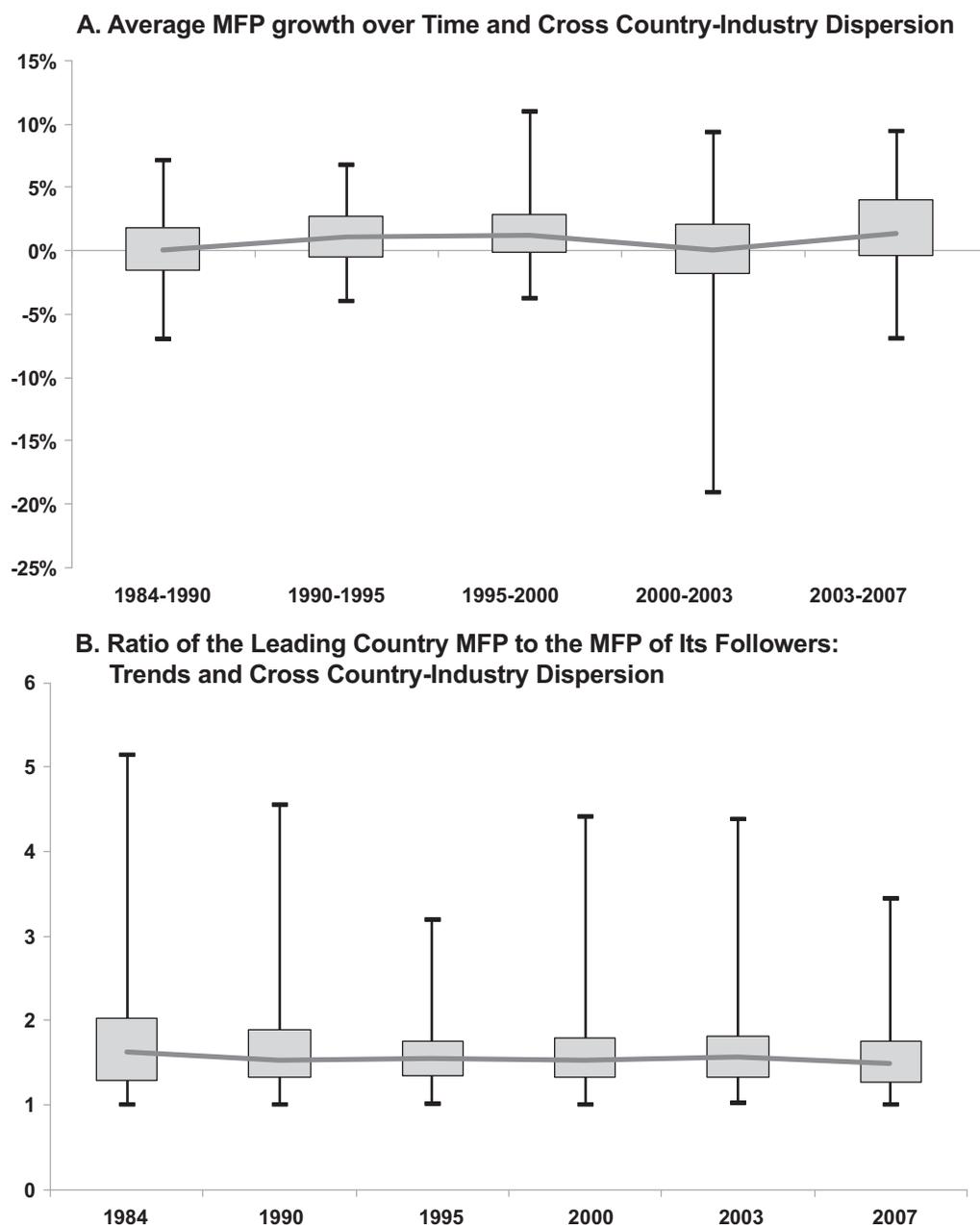[12] This database is publicly available at www.oecd.org/eco/pmr.

[13] Among the very few cross-country studies that explore the role of competition for productivity, Cheung and Garcia Pascual, (2004) use markups and concentration indexes. At the single-country level, Nickell (1996), Nickell et al. (1997), Blundell et al. (1999), and Disney, Haskel, and Heden (2003) use a variety of market indicators to capture competitive pressures. The potential problem of endogeneity of market shares and markups is even more serious at firmlevel as firms that have high productivity may gain market share and enjoy innovation rents. Additional problems specific to market shares and concentration indices are that they depend on precise definitions of geographic and product markets (the relevant market where competition unfolds) and tend to neglect potential as well as international competition.

[14] Boone (2000a, 2000b) suggests that there may be a hump-shaped relationship between competition and markups. Some authors have addressed this issue by using related indicators of relative profits and profit persistence (Creusen, Minne, & van der Wiel, 2006; Greenhalgh & Rogers, 2006).

[15] Similar constructs were also used, in different contexts and with different characteristics, by Faini et al. (2006), Conway et al. (2006), and Barone and Cingano (2011).

FIGURE 1.—MFP GROWTH AND LEVELS

A. Average MFP growth over Time and Cross Country-Industry Dispersion

B. Ratio of the Leading Country MFP to the MFP of Its Followers: Trends and Cross Country-Industry Dispersion


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, rules, and market and industry settings and cover energy (gas and electricity), transport (rail, road, and air) and communication (post, fixed, and cellular telecommunications), retail distribution, and professional services, with country and time coverage varying across industries. In addition, this study uses the indicator of restrictions to competition in banking constructed by De Serres et al. (2006).

The main advantages of using the NMR indicators in empirical analysis are that they can be held to be exogenous to productivity developments and are directly related to underlying policies, a feature that measures of competition based on market outcomes and business survey data do not have.[16] Another advantage is that they vary over countries,

[16] Of course, endogeneity cannot be completely ruled out with these indicators if, for instance, policies are affected by productivity outcomes through political economy channels. On the relative advantages of policy-based and survey-based composite indicators, see Nicoletti and Pryor (2006).

FIGURE 2.—NONMANUFACTURING REGULATION TRENDS AND CROSS-COUNTRY DISPERSION
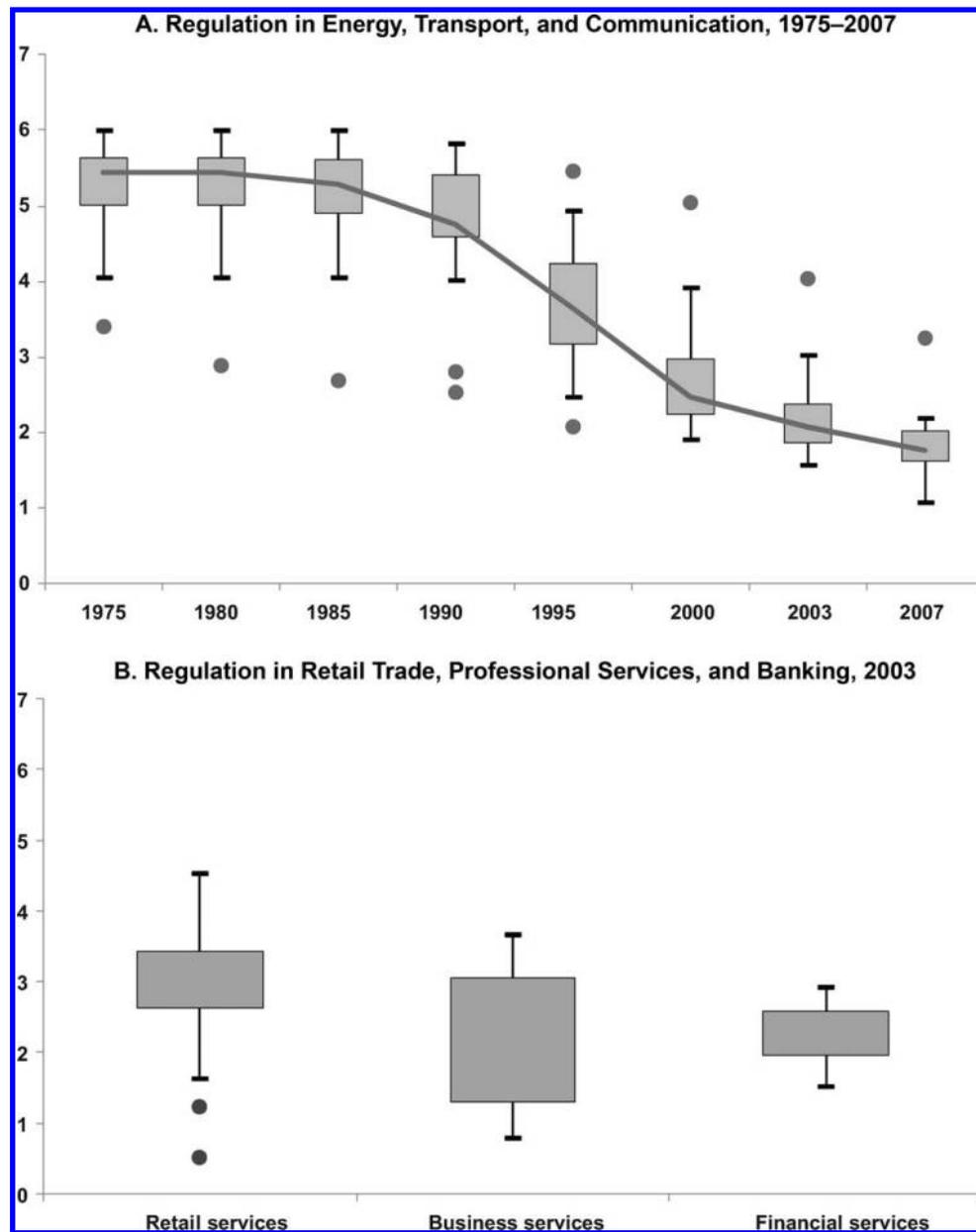
Scale of 0–6 from Least to Most Restrictive of Competition.

industries, and time, though full-time variability is currently limited to a subset of nonmanufacturing industries.[17]

Figure 2 illustrates the patterns of NMR across countries and industries, and, when data are available, over time. Panel A shows the cross-country dispersion and the evolu-

[17] Indicators for energy, transport, and communication cover thirty OECD countries over the 1975–2007 period; the indicators for retail distribution and professional services cover thirty OECD countries for 1998, 2003, and 2007; the indicator for banking covers thirty OECD countries for 2003. As a result, while in the cross-section dimension the indicators cover most of the regulated industries and countries, the time variability of the indicators originates mostly in policy changes in the energy, transport, and communication industries.

tion over time of regulation in energy, transport, and communication. All indicators take continuous values on a scale going from least to most restrictive of competition. The box plot suggests relatively low time variability over the 1975–1985 period, with a marked downward trend and increased variability over the subsequent period. The cross-country dispersion is narrower at the beginning and end of period and increases over the 1985–2003 period. Relatively restrictive regulations prevailed at the beginning of the period in most countries and industries; a movement toward deregulation started at the beginning of the 1980s, but at different paces in different countries and industries, and a marked convergence in policies characterized the end of period.

Panel B shows that in 2003, the cross-country dispersion in regulation was higher in retail distribution and professional services than in banking, reflecting the effects of two decades of financial liberalization.

Regulatory burden indicators. In spite of their advantages, the NMR indicators tend to be multicollinear, and for parsimony as well as for identification (as explained in section V.A), they cannot be used directly as explanatory variables in our econometric model. They have to be aggregated in a composite indicator using appropriate weights. Since our basic identifying assumption is that the impact of upstream regulations on downstream productivity should be growing with the importance of upstream regulated industries as suppliers of intermediate inputs (see below), we have chosen to weight the NMR indicators accordingly, based on information from OECD input-output tables. We have thus used composite indicators called "regulatory burden" ("REG indicators" for brevity), which are computed in each period t in the following way for the country–industry pair cs:

$$REG_{cs,t} = \sum_{j \neq s} NMR_{cj,t} \times w_{cjs} \text{ with } 0 < w_{cjs} < 1,$$

where $NMR_{cj,t}$ denotes the NMR indicator for upstream industry j of country c at time t, and the weight w_{cjs} is the total input requirement of downstream industry s in country c for intermediate inputs from upstream industry j (see the online appendix for details). Note that we exclude intraindustry intermediate consumption when computing REG to focus exclusively on inter-industry effects. Note also that we compute REG not only for the downstream (manufacturing) industries but also for the upstream (nonmanufacturing) industries.

Panels A and B of figure 3 show the sample averages of REG by country in 1985, 2000, and 2007 and by industry in 2000 and 2007, respectively. They also show the corresponding averages of REG restricted to the three lowest levels of REG among the fifteen countries in the sample that we call "lightest-practice" regulation indicator for brevity and we use in section VI to perform simple simulations of the estimated effects of product market reforms on MFP. The figures highlight large decreases in REG reflecting the effects of deregulation policies over time in the different countries and industries, but they also show that in spite of convergence in these policies, important cross-country differences remained in 2007.

V. Identification Strategy and Empirical Results
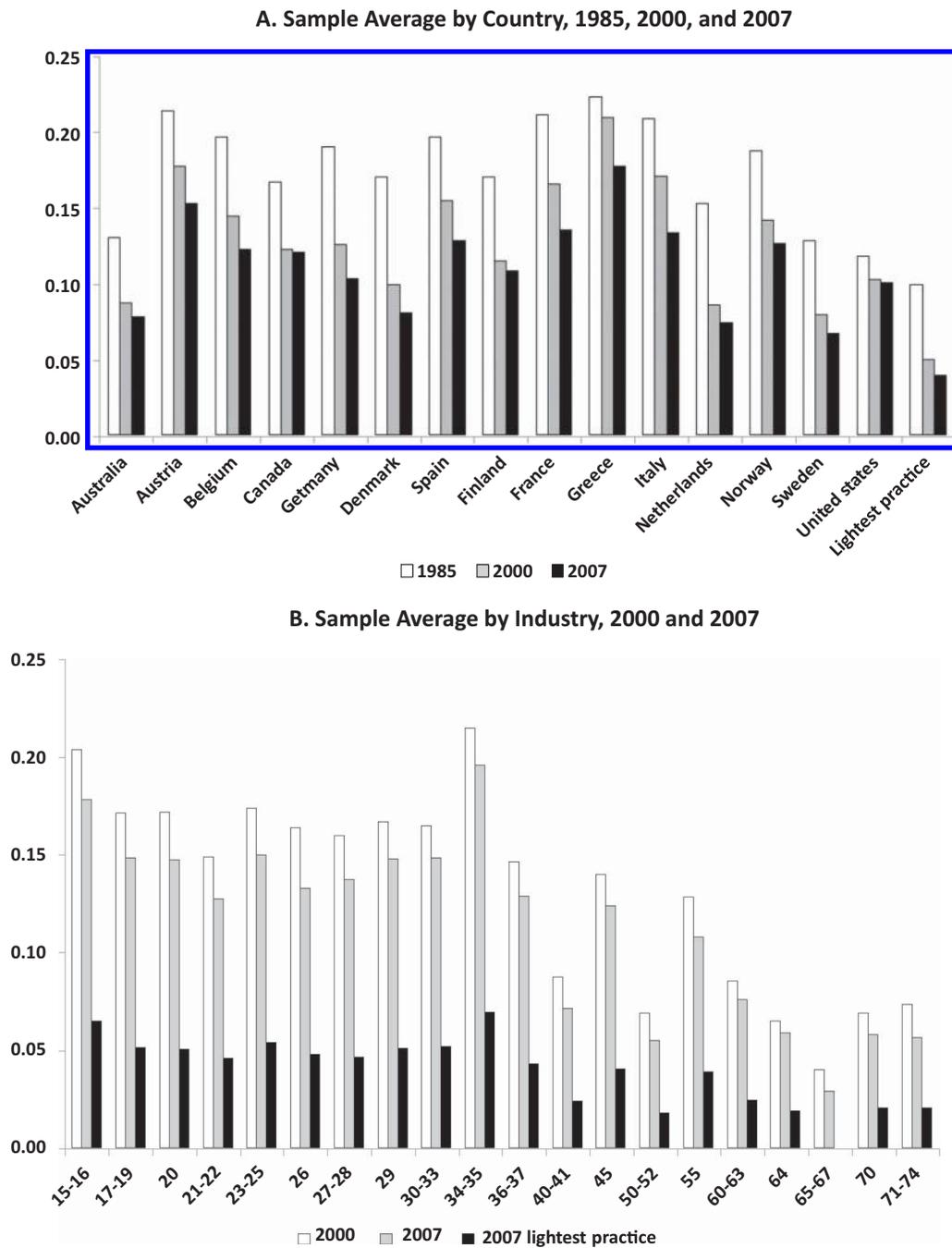
A. Identification Strategy

Our empirical specification is a variant of the Rajan and Zingales (1998) difference-in-difference approach. Indeed, the NMR indicators are crossed with an industry-specific characteristic—the intensity of use of regulated intermediate inputs—and country-year fixed effects account for the possibly endogenous average effects of regulations (see the

next paragraph). Therefore, we identify the effects of regulation on productivity using only the differences of impact between industries. The main deviation from the Rajan and Zingales (1998) approach is the assumption of an equal impact of the six NMR indicators implied by the aggregation into the regulatory burden indicator, which we impose to avoid excessive collinearity in estimation. To minimize endogeneity issues and measurement error, the indicators of regulatory burden used in empirical analysis are based on the 2000 U.S. input-output table (we set $w_{cjs} = w_{USjk}$ for any c). Ideally, to fully control for endogeneity, the input-output table should come from a country not included in the sample and without any anticompetitive regulation in non-manufacturing industries. The sensitivity analysis shows that estimation results are robust to the exclusion of the United States from the sample or the use of the input-output table of the United Kingdom, a country missing from our sample and where regulation is estimated by the OECD indicators to be most procompetitive in a majority of non-manufacturing industries (see the online appendix).

There are two main potential sources of estimation bias that must be discussed. First, if there are country waves of deregulation, the estimated impacts of changes in regulatory burden indicators may capture the direct (within industry) effect of changes in the regulation of downstream industry themselves. To avoid the related omission bias, we therefore controlled for the within-industry impact of regulations relying on OECD indicators of (a) domestic regulations in nonmanufacturing industries, (b) barriers to foreign direct investment in all industries, and (c) barriers to trade in manufacturing industries (indicators of such border barriers are described in the online appendix). There is no OECD indicator available on domestic regulations in the manufacturing industries, but one should note that most changes in policies over the period covered in the sample have occurred either by deregulation in the nonmanufacturing industries or elimination of border barriers: there was little need for domestic deregulation in manufacturing industries that were already largely open to competition. Surprisingly, none of the within-industry effects were estimated to be significant. This probably reflects the presence of country-year fixed effects, precisely because concomitance of deregulation or trade and investment liberalisation across industries results in policy waves at the country level that may be captured by such effects, which makes their separate identification difficult. Because the coefficients of the direct effects of regulations and border barriers did not turn out to be significantly different from 0, these indicators were dropped from the main empirical specifications. However, the estimated impacts of upstream regulation identified through our differences-in-differences estimation strategy are robust to this specification choice (sensitivity analysis to controlling for the within-industry regulation effects is provided in the online appendix).

Second, lobbyism could make policies endogenous (Li & Xu, 2002). For instance, low productivity growth of firms in certain industries could provide incentives for firms in such

FIGURE 3.—VARIABILITY OF THE REGULATORY BURDEN INDICATORS AND LIGHTEST PRACTICE

A. Sample Average by Country, 1985, 2000, and 2007

□ 1985   ▨ 2000   ■ 2007

B. Sample Average by Industry, 2000 and 2007

□ 2000   ▨ 2007   ■ 2007 lightest practice

Scale 0–1 from Least to Most Restrictive. For industries see table A1.

industries to exert political pressures for raising anticompetitive regulations, thereby protecting firms' rents. In this case, the direct effects of an industry's regulation on productivity in the same industry would be overestimated. However, our estimation results are not affected by this bias because we are not concerned with within-industry effects of regulation on productivity.[18] Our results, however, could be biased if

downstream industries that use regulated (upstream) intermediate inputs, and whose productivity growth is low as a result, were to lobby for and obtain upstream deregulation either because they anticipate that this would raise their productivity or in order to reduce the market power of upstream firms and preserve their rents. In both cases, one would expect that firms in downstream industries that use the regulated upstream inputs most intensively would lobby more strongly and obtain deeper upstream deregulation. This, however, would play against the conjecture that we test in

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[18] This is another argument to exclude intraindustry intermediate consumption when computing the regulatory burden indictor.

TABLE 1.—MAIN ESTIMATION RESULTS
DEPENDENT VARIABLE: GROWTH IN MULTIFACTOR PRODUCTIVITY

	1985–2007		1985–1994	1995–2007
MFP growth for the technology leader$_t$ ($\Delta mfp_{Fs,t}$)	0.113***	0.114***	0.065*	0.122***
	[0.016]	[0.016]	[0.033]	[0.019]
Gap in MFP levels$_{t-1}$ ($gap_{cs,t-1}$)	0.037***	0.041***	0.065***	0.032***
	[0.003]	[0.004]	[0.006]	[0.005]
Regulatory burden indicator$_{t-1}$ ($REG_{cs,t-1}$)	−0.064	−0.067	0.044	−0.124**
	[0.048]	[0.047]	[0.091]	[0.062]
Effect of gap on the regulation impact$_{t-1}$ ($REG_{cs,t-1} \times gap_{cs,t-1}$)		0.240***	0.375***	0.132**
		[0.040]	[0.064]	[0.054]
Time × Country fixed effects ($\gamma_{c,t}$)	Yes	Yes	Yes	
Industry fixed effects (γ_s)	Yes	Yes	Yes	
Tests of joint significance of variables' coefficient (p-values)				
$\quad gap_{-1} = REG_{-1} = gap_{-1} \times REG_{-1} = 0$		0,000	0,000	0,000
$\quad REG_{-1} = gap_{-1} \times REG_{-1} = 0$		0,000	0,000	0,011
Test of equality across both periods (p-values)				
$\quad$ Joint for gap_{-1}, REG_{-1}, and $gap_{-1} \times REG_{-1}$			0,000	
Observations	4,629	4,629	1,691	2,938
R^2	0.25	0.25	0.27	

Standard errors in brackets. Significant at *10%, **5%, and ***1%. The estimated equation corresponds to relation (2). The gap in MFP levels is defined as $gap_{cs,t} = \ln(MFP_{Fs,t}) - \ln(MFP_{cs,t})$.

this paper because it would entail an underestimation bias of the negative effects of upstream regulation on downstream productivity. Therefore, at worst, the empirical results presented in the following paragraph could be interpreted as a lower-bound effect of upstream regulations, conditional on downstream lobbying.[19]

B. Empirical Results

Table 1 presents OLS regression results for different specifications of our regression model.[20] The first column reports results omitting the interaction between the gap and the regulatory burden indicator, while the second column is the estimate of our baseline equation (2), including the interaction term. The last two columns report results from the same equation splitting the sample into two subperiods. To compare specifications with and without the interaction term more easily and always interpret the coefficient on each variable as the mean effect on MFP growth (even in the presence of the interaction term), the technology gap variable and the indicator of regulatory burden are centered on the sample mean.[21] As already argued, to reduce omitted variable bias and control for idiosyncratic country-wide factors, we always include industry and country-year fixed effects. For example, country-time fixed effects account for (possibly time-varying) country-specific characteristics of

technological progress, labor, product, or financial markets (including possibly deregulation waves), while industry effects account for (time-invariant) structural differences in technology or skills across industries.

MFP growth in the global productivity leader of the industry is always found to have a positive and highly significant influence on productivity growth in less productive countries and industries, indicating a significant rate of technological pass-through. In addition, the coefficient of the technology gap variable is estimated to be positive and significant in all specifications, suggesting that within each industry, countries that are further behind the technological frontier experience higher rates of productivity growth. In other words, catch-up is found to play an important role as a driver of productivity growth, consistent with previous empirical research in this area.

Turning to our main result, the indicator of regulatory burden is found to curb MFP growth and increasingly so the closer MFP is to the technological frontier. When estimated at its mean, our regulatory burden indicator seems to have no significant effect on downstream productivity growth. However, when this effect is conditioned on distance to the frontier (via its interaction with the gap), this lack of significance appears to come mainly from a composition effect. Regressions including the interaction term indeed show that the burden of anticompetitive regulation in upstream industries has a significant effect on MFP growth downstream (as reflected in the tests of joint significance). Moreover, since the coefficient of the interaction term is generally positive and significant ($\alpha_4 > 0$), the depressing effect of anticompetitive upstream regulation on MFP growth is significantly stronger for country-industry-period triads that operate close to the technological frontier of our sample. Figure 4 illustrates this point. It presents the estimated impact on MFP growth of a unit increase of the regulatory burden indicator (REG) depending on the dis-

[19] For this reason and in view of the intrinsic limitations of our data, we do not investigate further empirically the issue of endogeneity in the paper.

[20] We assume that the level of MFP is cointegrated with the level of MFP of the leading country. We use Pedroni's cointegration tests to investigate this assumption: four of the seven tests reject the noncointegration null hypothesis. This uncertain result could be explained by the relatively short temporal dimension of our data.

[21] If the variables were not centered, the coefficient on the regulatory burden indicator would correspond—when the interaction term is present—to the effect of regulation at the frontier (when the technology gap is null).

Figure 4.—Impact on Downstream MFP Growth of a One Unit Increase in the Indicator of the Burden of Upstream Regulations for Downstream Industries
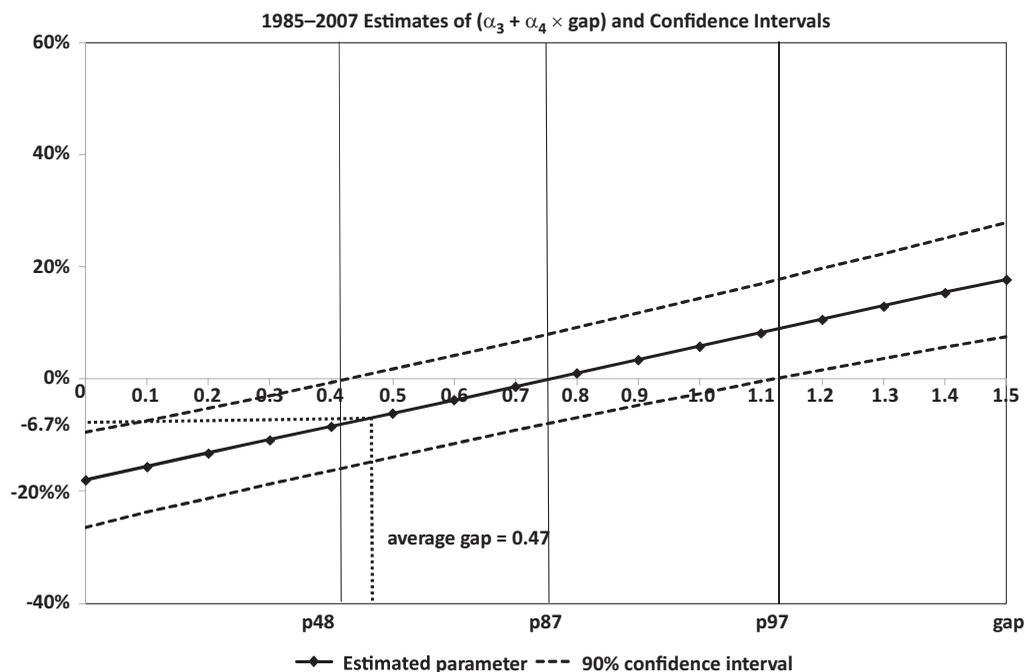
tance to the frontier ($\alpha_3 + \alpha_4 \times$ gap), as well as the 10% confidence interval of this estimate. This impact is purely hypothetical, as in reality, REG varies between 0.015 and 0.348 in our estimation sample, but it serves the purpose of illustrating the results graphically (the economic significance of the estimates is discussed in the next section). For 87% of the observations, the impact of REG on productivity is negative, and for 48% of the observations, namely, those that are closer to the technological frontier, the negative impact is also statistically significant. For the remaining 39% of observations ($= 87 - 48$) the negative impact is not significant, including for observations at the average gap (0.47), reflecting the results in the second column of table 1.

The estimated effects of easing anticompetitive upstream regulation, as measured by reductions in the indicator of regulatory burden, are consistent with our priors based on neo-Schumpeterian models. Indeed, when regulation restricts competition in industries that supply intermediate inputs, the incentives to improve efficiency are weaker in downstream industries the more intensively these industries use the regulated products. Moreover, the positive effect of competition on efficiency improvement is strongest for observations that are close to the global technological frontier. In other words, the "escape competition" effect dominates close to the frontier, whereas this effect is weakened by a "discouragement" effect far from the frontier, consistent with Aghion and Howitt (2006).

To further illustrate these results, figure 5 plots the impact of our indicator of regulatory burden on MFP growth (y-axis) against the level of the technology gap (we

show values of the gap expressed in both log-differences and percentage MFP ratios) at different points of the distribution of the regulatory burden indicator. As the impact depends on the level of regulation, we represent this relationship for three regulatory settings in nonmanufacturing industries corresponding to the first, fifth, and last deciles of the distribution of our indicator of regulatory burden. The slope of these "iso-regulation" lines flattens out as regulation becomes more procompetitive (the line coincides with the horizontal axis when there are no anticompetitive regulations at all). Therefore, the distance between the lines and the horizontal axis can be interpreted as the average productivity effect of completely removing anticompetitive upstream regulations at each distance to frontier. Panel A illustrates results for the whole sample period, while panels B and C illustrate those for the two subperiods. Measured at the average gap (64% of MFP of the technology leader) and average level of regulation (a value of 0.15 for our regulatory burden indicator), the effect of increasing competition in upstream industries by instantaneously eliminating all anticompetitive regulations is to increase MFP growth by over 1% per year, according to the estimates on the whole period.

Interestingly, regulatory burdens appear to have played an increasingly damaging role for MFP over time, with the strongest damage being observed over the most recent period. When the sample is split into two subperiods (table 1, third and fourth columns) the share of observations for which MFP growth suffers from anticompetitive regulation in upstream industries is estimated to increase substantially

FIGURE 5.—THE IMPACT OF UPSTREAM REGULATION ON DOWNSTREAM MFP GROWTH DEPENDING ON DISTANCE TO
FRONTIER AND REGULATORY SETTINGS
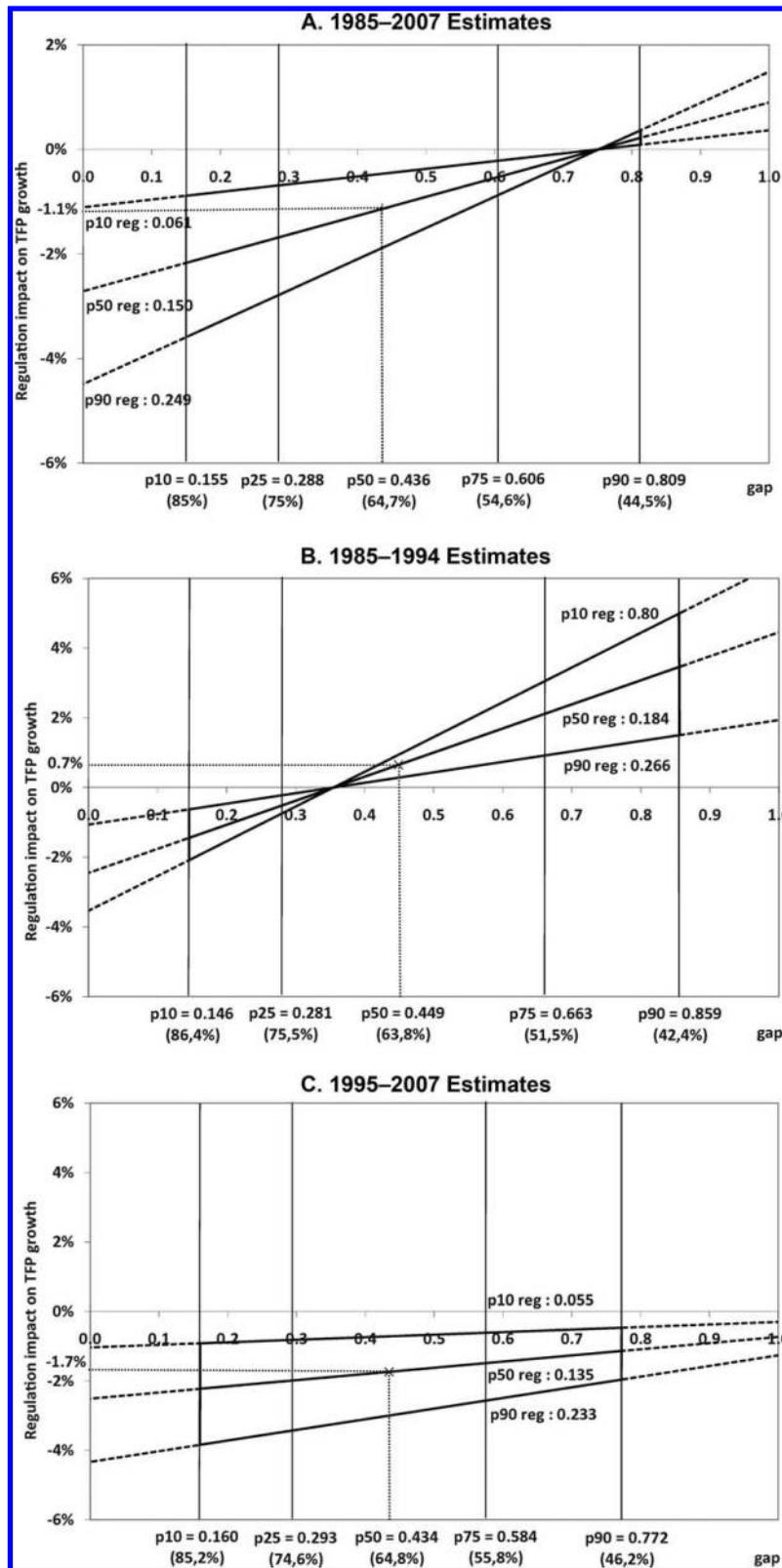
The impact of the regulatory burden indicator (REG) on MFP growth depends on the country-industry pair distance from the industry frontier and on the level of regulation. The first conditioning factor is intro-
duced through the variable GAP, which is the logarithm of the ratio of the industry MFP leader to the MFP of its followers. The quartiles as well as the first and last deciles of the GAP are indicated on the panels (the
corresponding percentage ratios of follower MFP to frontier MFP are in brackets).

Concerning the second conditioning factor, the three curves represent iso-regulation lines depicting regulatory settings that correspond to different percentiles of the sample distribution of REG. The quadrangle
included between, on the one hand, the first and last deciles of the regulatory burden indicator, and on the other, the corresponding deciles for the GAP includes around 60% of the observations in the sample.

over time. Indeed, while the average impact of the regulatory burden indicator is estimated to be positive and nonsignificant in the 1985–1994 period, it becomes negative and significant over the period 1995 to 2007. At the same time, the attenuating effect of the gap on the MFP impact of regulatory burdens is more than halved in the most recent period. These results from splitting the sample into two subperiods translate graphically into a substantial flattening of the relationship between the impact of regulation on MFP growth and the technology gap at each level of the regulatory burden on figure 5, panels B and C. In other words, while regulation could have had a positive effect on MFP for a large part of the sample (63%) over the first subperiod (but significantly so for only 17% of the observations), it has had a negative effect for virtually all observations (99%), and significantly so for 73% of the observations over the 1995–2007 period. During this period, an easing of regulatory burdens from their average level (0.14) to 0 (by eliminating all anticompetitive regulations in upstream industries) would have increased the MFP growth of a country with an average MFP gap of 65% by up to 1.7 percentage points per year. We stress that these estimated effects are purely illustrative, as they would correspond to radical and sudden changes in regulatory settings that are unlikely to be politically implementable in practice. More realistic simulation scenarios are described in the next section.

The increasingly negative impact of regulation on MFP growth over time needs to be investigated further, but one interpretation is related to two sources of structural change affecting the global economy during this period: globalization and the diffusion of new technologies. With increased integration of the world economy in the context of the diffusion of new technologies, competition has become tougher downstream and ICT adoption and the corresponding reorganization of production processes have become more compelling for maintaining market shares. At the same time, new entry by innovative firms has become a more important source of productivity improvements. Thus, the erosion of returns from efficiency improvements by regulated upstream industries is increasingly more damaging for incentives to enhance productivity, and possible barriers to entry generated by regulation in upstream industries are increasingly reflected in a drag on industry-level productivity performance. It is important to note that these different effects of regulation depending on the period studied should not be understood as coming from different levels of development (for example, from smaller average distance to frontier) as the effects appear to change over time at each given level of technological gap. They therefore necessarily originate from structural changes in the global economy.

Both our baseline estimates of the MFP growth equation and our empirical findings concerning the effects of upstream regulation are robust to changes in data coverage and va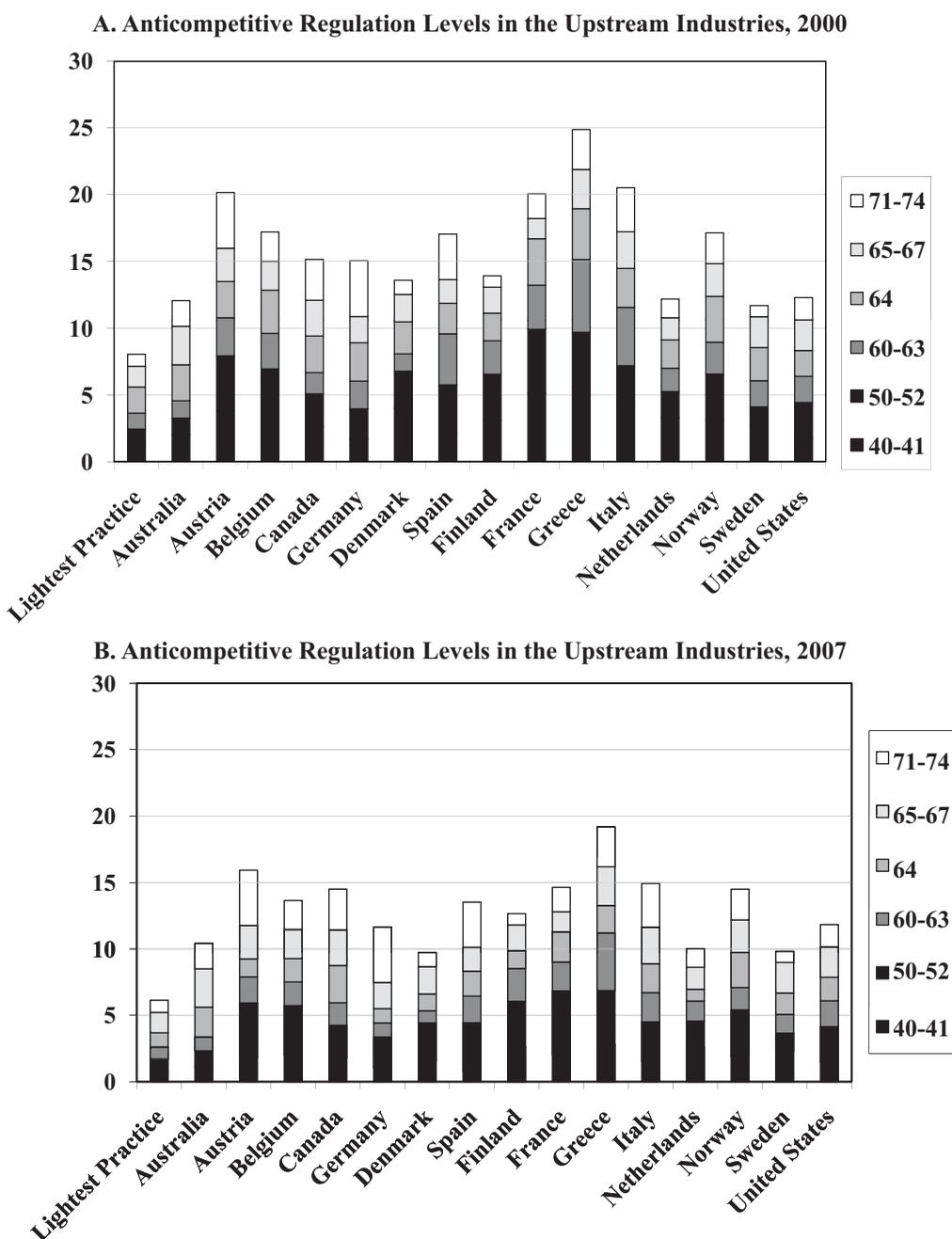riable definitions. The main sensitivity checks included (a) dropping industries or countries one by one, (b) basing computation of the REG indicator on the I-O matrix of a different country (or country-specific I-O matrices) (c) introducing measures of within-industry regulations (domestic and border barriers to trade and foreign direct investment), and (d) changing assumptions in the construction of the MFP index. Variants in MFP construction included applying industry instead of national PPPs and using different measures for the labor share. We also adjusted the MFP index for possible bias in the computation of productivity originating from cross-country differences in employment rates and working time (Bourlès & Cette, 2007) and replicated most of the results using labor productivity growth instead of MFP as the dependent variable (and a measure of capital deepening as an additional regressor). Finally, we checked robustness to changes in the definition of prices in the electrical and optical equipment (ISIC 30-33) industry, where changes in quality were particularly important over the estimation period. The online appendix reports detailed results obtained through these robustness analyses. Overall, the size and significance of coefficient estimates are not much affected.

VI.   Estimated Impact on MFP Growth of Easing Regulation in Upstream Industries

To further illustrate the influence of regulatory burdens on MFP performance, we propose a calculation of the MFP gains in the nonfarm business industry from adopting, in the year 2000, the "lightest practice" regulation observed in upstream industries in 2007. For the purposes of this exercise, *lightest practice* is defined in each upstream industry as the average of the three lowest levels of anticompetitive regulation observed among the countries in the data set (overall lightest practice corresponds to lightest practice in all upstream industries). A switch to lightest practice means a pervasive and important easing of anticompetitive regulations in every nonmanufacturing industry covered in our data set. It is therefore an extreme example of structural policy reform.

Figure 6, panel A suggests that in 2000, the degree of anticompetitive regulation in upstream industries differed considerably among countries. Regulation was friendliest to competition in Sweden, Australia, the Netherlands, and the United States and most restrictive in France, Austria, Italy, and Greece, with cross-country differences originating mainly from the transport (ISIC 60-63) and utilities (ISIC 40-41) industries. Seven years later (see panel B), cross-country differences persisted despite some convergence, with Denmark, Sweden, the Netherlands, and Australia now being the four countries where regulation was friendliest to competition and France, Italy, Austria, and Greece continuing to be the most restrictive. From 2000 to 2007, easing of anticompetitive regulations was widespread in the utility industries and in post and telecommunications (ISIC 64),

FIGURE 6.—ANTICOMPETITIVE REGULATION LEVELS IN THE UPSTREAM INDUSTRIES, 2000 AND 2007

A. Anticompetitive Regulation Levels in the Upstream Industries, 2000

B. Anticompetitive Regulation Levels in the Upstream Industries, 2007

Industries: 40–41, Electricity, Gas and Water Supply; 50–52, Wholesale and Retail Trade, Repairs; 60–63, Transport and Storage; 64, Post and Telecommunications; 65–67, Financial Intermediation; 71–74, Rental of Material and Equipment and Other Business Activity. All industry indicators have a 0–6 range from least to most restrictive.

with remaining differences across countries in 2007 concentrated essentially in the regulation of transport, business services (ISIC 71-74), and wholesale and retail trade (ISIC 50-52). The gap with our measure of overall lightest practice remained sizable in all countries over the whole period, though it declined over time.

To calculate the potential productivity effects from adopting lightest practice regulations, we use estimates of equation (2) as reported in the last column of table 1 (the estimates over the 1995–2007 period). In these calculations, the

indicator of regulatory burden (REG) is based on domestic input-output matrices, so as to take into account the differences across countries in the intensity of downstream intermediate consumption of products from regulated upstream industries.[22] Each country-industry MFP is projected dyna-

[22] If downstream industries reduce their intensity of use of regulated intermediate inputs, the productivity effects would be underestimated by our calculations. The sensitivity of our evaluations to the choice of domestic input-output matrices is shown in Table 2.

FIGURE 7.—SIMULATION OF ANNUAL GAINS IN MFP GROWTH IN SELECTED COUNTRIES FROM ADOPTING IN 2000 THE LIGHTEST PRACTICE OBSERVED IN 2007 IN THE UPSTREAM INDUSTRIES
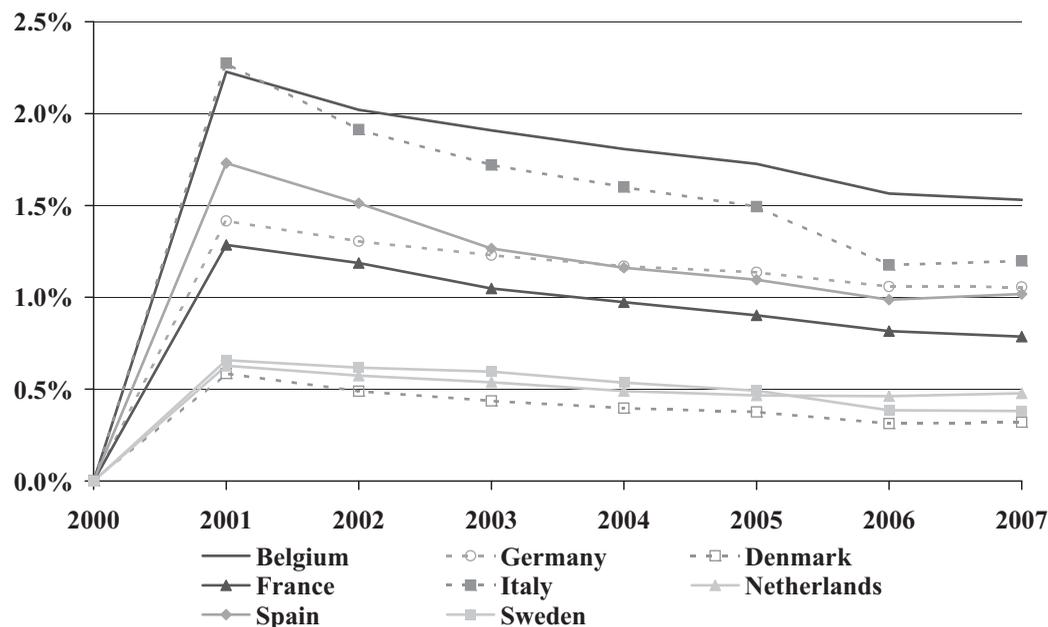
mically over time: the MFP impact of deregulation results from the initial decrease in the indicator of regulatory burden obtained by adopting lightest practice regulations in upstream industries and on the subsequent reductions in distance to frontier (GAP) that this initial policy shock sets off over the projection period.[23]

Figure 7 shows annual MFP gains that are generally decreasing overtime, with a peak in 2001.[24] The subsequent decline in annual gains reflects the declining catch-up effect on MFP, as well as, to a smaller extent, the reduction of the regulatory burdens during the 2000–2006 period in the baseline situation (see figures 2 and 6). Annual gains vary widely across countries, but are on average sizable. In 2007, as shown in figure 8, panel A, the simulated MFP gains (in the nonfarm business industry) from reforms that were assumed to be made in 2000 are very high, ranging from around 3 to around 13 percentage points relative to baseline depending on the country. Looking at the impact of adopting lightest practices in each upstream industry, we see that the highest productivity gains originate from reforms in retail trade and the professional services, while the lowest gains are obtained from adopting lightest prac-

tices in financial intermediation and communication, where the country regulatory practices were already closer in the year 2000. In figure 8, panel B, the simulated differences in MFP gains resulting from aligning regulation on lightest practice simultaneously in all upstream industries rather than adopting them one by one in each of the upstream industries are minor.[25]

The cross-country differences in the simulated MFP gains reflect four factors: (a) the excess regulatory burden relative to lightest practice in each upstream industry, (b) the initial distance to the frontier of productivity in downstream industries, (c) the intensity of intermediate consumption of products from regulated upstream industries, and (d) the composition effect due to differences in industry structure across countries (as reflected in differences in value added shares of downstream industries). Table 2 presents an estimation of the separate contributions of each of these four factors in the different countries relative to their contributions in the United States, which is taken as the benchmark in this exercise.[26] It isolates the contribution of the adoption of upstream industries' lightest practices (NMR in column 3) from their overall amplification or attenuation effects due to the country differences in MFP levels and industrial structure (in column 4), and it decomposes the latter into the three components arising respectively from

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[23] For this calculation, a measurement of the gap in MFP in each country-industry-year triad is necessary. Since our data set is unbalanced due to some missing data points for capital stocks, the missing gaps in MFP were estimated in the following way: gaps in MFP, when available, were regressed on labor productivity gaps, and the missing gaps in MFP were estimated using these regression results and the labor productivity gaps, which are available for all country-industry-year triads in our sample. The regression was carried out by OLS, with fixed effects for years, industries, and countries ($R^2 = 0.60$).

[24] No gains are obtained in 2000, since we assume in the model that regulations have an impact on MFP growth with a one-year lag.

[25] These differences come from the fact that adopting the lightest practice in one upstream industry modifies distance to the frontier (the MFP gap) in the following years, which modifies the MFP gains obtained by adopting the lightest practice in other upstream industries.

[26] See the footnote to table 2 for a detailed explanation of how these contributions are defined and assessed.

FIGURE 8.—SIMULATION OF MFP GAINS IN THE NONFARM BUSINESS INDUSTRY IN 2007 FROM ADOPTING IN 2000 THE LIGHTEST PRACTICE OBSERVED IN 2007 IN THE UPSTREAM INDUSTRIES

A. Decomposition of the MFP Gains in 2007 by Upstream Industry
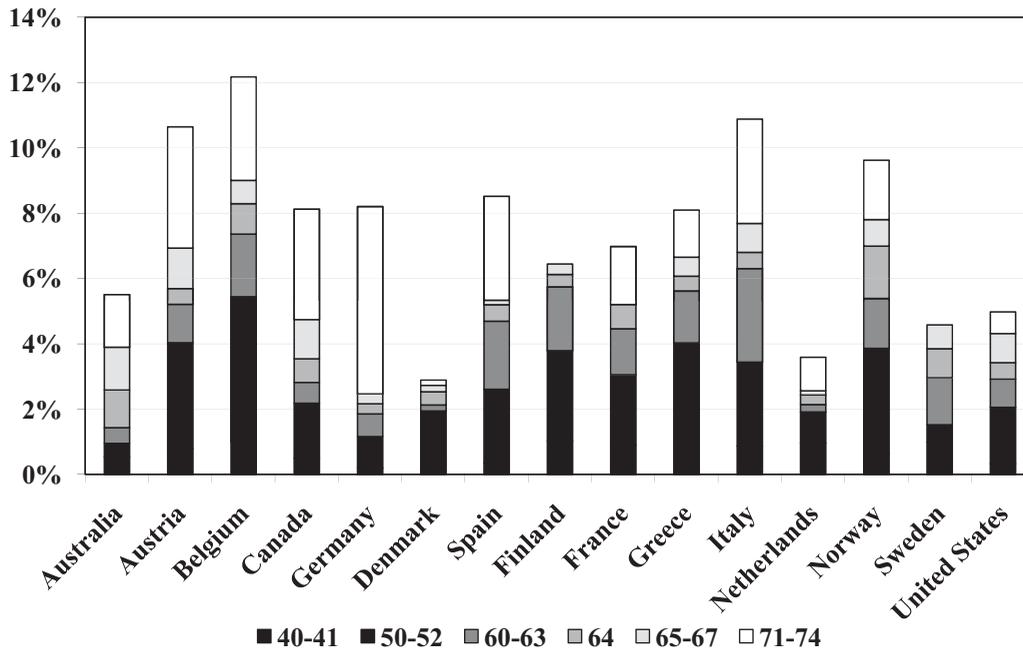
B. MFP Gains in 2007; Alternative and Simultaneous Reforms
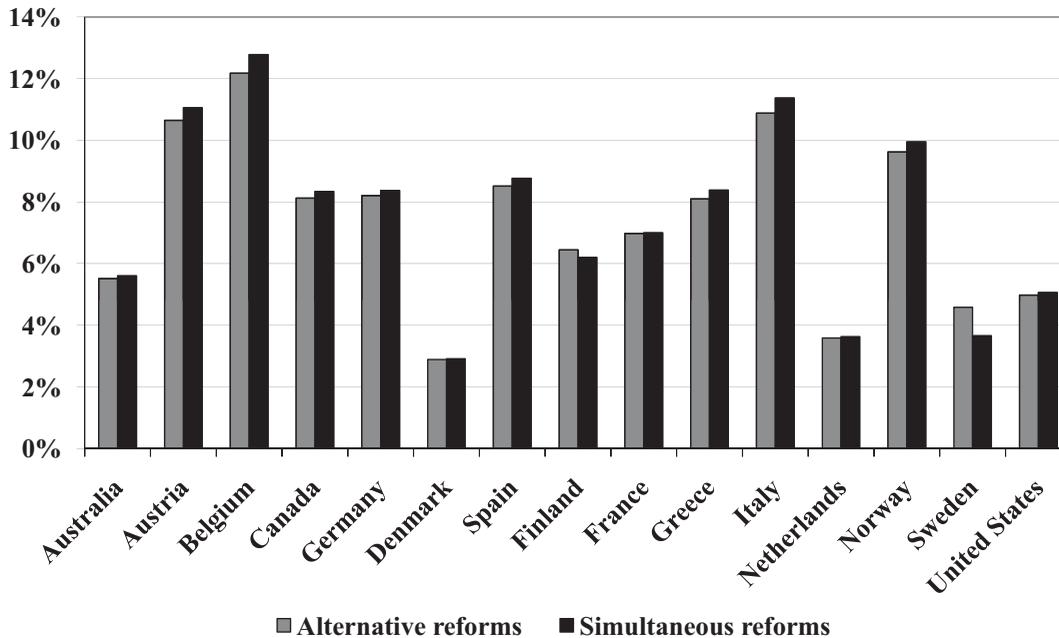
For panel A: Industries—40–41, Electricity, Gas and Water Supply; 50–52, Wholesale and Retail Trade, Repairs; 60–63, Transport and Storage; 64, Post and Telecommunications; 65–67, Financial Intermediation; 71–74, Rental of Material and Equipment and Other Business Activity. Panel B: The impact of one reform depends on the implementation of other reforms via their effects on the distance to the frontier. Thus, the addition of MFP gains calculated for each reforms as if there were no other changes differs from the impact of reforms taken simultaneously (noted "alternative" and "simultaneous" reforms, respectively)

differences in MFP (GAP in column 5), upstream industry intermediate consumption (domestic input-output table in column 6), and value-added composition (VA in column 7). Interestingly, the magnitude of the contribution of adopting NMR lightest practices is on average larger than the magnitude of overall transmission effects (1.7% versus 0.8%).

This partly results from compensation between the MFP gap effects and the intermediate consumption composition effects: the first are all negative, averaging −1.8%, while the second are all positive with the exception of Greece, and the average is 2.0%. The value-added composition effects are generally much smaller, averaging 0.5%.

TABLE 2.—SIMULATION OF MFP GAINS IN THE NONFARM BUSINESS INDUSTRY IN 2007 FROM ADOPTING IN 2000 THE LIGHTEST PRACTICE OBSERVED IN 2007 IN THE UPSTREAM INDUSTRIES: DECOMPOSITION INTO THE EFFECTS OF THE FOUR MAIN UNDERLYING FACTORS

Country	MFP Gains (2) + 5.06% (1)	Relative to United States (3) + (4) + (5) + (6) (2)	Originating from Differences in			
			NMR (3)	GAP (4)	I-O Table (5)	VA (6)
Sweden	3.66%	−1.4%	−1.83%	−0.44%	0.63%	0.25%
Netherlands	3.63%	−1.43%	−1.76%	−0.79%	0.94%	0.18%
Denmark	2.91%	−2.15%	−1.18%	−1.3%	0.29%	0.05%
Australia	5.6%	0.54%	−0.73%	−0.87%	1.83%	0.31%
United States	5.06%	0.00%	0.00%	0.00%	0.00%	0.00%
Finland	6.2%	1.14%	0.45%	−2.15%	2.00%	0.85%
Germany	8.37%	3.31%	1.16%	−1.84%	3.51%	0.48%
Canada	8.34%	3.28%	1.92%	−1.04%	1.87%	0.53%
Belgium	12.78%	7.72%	2.42%	−2.4%	6.72%	0.99%
Spain	8.77%	3.71%	2.63%	−2.59%	2.31%	1.37%
Norway	9.94%	4.88%	2.75%	−1.73%	4.31%	−0.45%
France	7,00%	1.94%	3.48%	−1.71%	0.13%	0.04%
Italy	11.37%	6.31%	4.15%	−3.21%	4.41%	0.95%
Austria	11.05%	5.99%	4.94%	−2.42%	1.91%	1.56%
Greece	8.38%	3.32%	7.3%	−4.98%	−0.15%	1.15%
Average	7.54%	2.48%	1.71%	−1.83%	2.05%	0.55%

The four main factors of country differences in simulated MFP gains correspond to country differences respectively in (a) the importance of nonmanufacturing regulations (NMR), (b) the MFP distance to the frontier (GAP), (c) the intensity of intermediate consumption from downstream industries as computed on the basis of country input-output coefficients (Domestic I-O Table), and (d) the industry composition as measured in terms of value-added (VA). The contributions of these four factors to the simulated MFP gains in a country are assessed by simulating the variation in MFP gains corresponding to the sequential alignment of their values to that of another country taken as benchmark. These contributions sum up to the difference between the overall country MFP gains and that of the benchmark country, but they can differ to some extent with the sequence of simulations adopted. The order adopted here from the factors seems natural. For illustrative purposes, we chose the United States as a benchmark.

By construction, the estimates shown in the different columns of the table are such as: (1) = (2) + 5.06% (i.e. + US total gains); (2) = (3) + (4) + (5) + (6). Total MFP gains (1) are already shown in figure 7, panels A and B (simultaneous reforms). The countries are ranked in the table in terms of increasing contributions of adopting NMR lightest practice in column 3.

VII. Conclusion

Regulations that bridle access to otherwise competitive markets and unnecessarily constrain business operations can be a drag on productivity growth. While most analyses of this issue have focused on the effects of these regulations on the productivity of the firms or industries directly concerned, the main point of this paper is that such regulations can also have powerful indirect depressing effects on the productivity of other industries through input-output linkages. We described the main channels through which these effects happen: reduced access to key intermediate inputs that curb competition downstream and rent seeking by intermediate input providers, both reducing incentives to improve productivity downstream. We then tested the existence and estimated the magnitude of such effects on an industry-level panel of OECD countries over the past two decades, proxying upstream market imperfections with indicators of anticompetitive product market regulations. Although our empirical productivity specification cannot distinguish among the various channels at work, we find that differences in regulation of nonmanufacturing industries providing intermediate inputs are indeed quite relevant in explaining the variance of multifactor productivity growth rates in our sample, with upstream regulation curbing such growth rates significantly in a large share of observations. Moreover, we showed that the closer that MFP is to the technological frontier, the higher is the estimated negative impact of upstream regulation on productivity growth. Interestingly, the estimated negative impact has increased over time with deepening globalization and diffusion of ICT.

Simulations based on our most robust estimates suggest that all countries could expect important MFP growth gains from structural reforms that consist of adopting the lightest regulation practices in industries that are important providers of intermediate inputs to the economy. However, these MFP growth gains are different across countries. The differences stem from four factors: (a) the excessive regulatory burden relative to lightest practice in upstream industries, (b) the intensity of linkages between upstream and downstream industries, (c) the weight of different downstream industries in the economy, and (d) the distance of productivity in those industries to the global productivity frontier. The larger the excess regulatory burden, the higher the intermediate consumption of regulated products, the greater the value-added weight of industries burdened by upstream regulations, and the smaller the distance to the productivity frontier, the stronger the gains in productivity from aligning regulations in upstream industries with lightest international practice.

More work needs to be done to check the economic and statistical significance of our econometric results. Although they appear rather robust, our results should be qualified on at least two grounds. First, anticompetitive regulations on product markets could be influenced by other variables that affect industry productivity and are omitted in our analysis. It is thus not unlikely that our estimates correspond not only to the impact on MFP growth of changes in upstream product market regulations, but may also reflect the changes of these other variables. The econometric soundness of our results thus needs to be confirmed by further investigation, and the economic mechanisms underlying them have to be much better understood. In particular, it would be desirable

to better identify statistically some of the channels linking upstream regulation to productivity, which are highlighted in our discussion. Second, the illustrative simulations we consider are of course extremely drastic: a policy of adopting the "lightest regulation practices" in all upstream industries over a short period (here one year) would be overly ambitious and politically difficult to implement. Therefore, the normative implications of our analysis should be discounted.

Progress to bridge better and more precisely the gap between our results and policy implications could be made in the two interrelated dimensions of data and empirical modeling. The data dimension is perhaps the more important. In this paper we have taken advantage of the updated OECD database of regulation indicators and can expect further progress from this source of information, in particular as its coverage is extended, as well as by careful comparison with other existing databases and sources of relevant information. For modeling, more detailed research, ranging from econometric analysis to case studies, investigating the various channels through which specific regulations affect firm behavior is necessary. As our results suggest, significant links between regulation and productivity over the past fifteen years, focusing on the consequences of ICT diffusion in the context of worldwide globalization and exploring what could be the aftermath of the current economic crisis, would also be essential to deepen our economic understanding of such links.

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