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Productivity Spillovers from the Global Frontier and Public Policy: Industry-Level Evidence

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By Alessandro Saia, Dan Andrews and Silvia Albrizio

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ABSTRACT/RÉSUMÉ

Productivity Spillovers from the Global Frontier and Public Policy: Industry-Level Evidence

For much of the second half of the twentieth century, labour productivity grew rapidly in most OECD economies, fuelled by the adoption of a large stock of unexploited existing technologies. However, the slowdown in productivity growth over the past decade underscores the idea that as economies converge toward the global technological frontier, the ability to capitalise on new innovations developed at frontier becomes more important. Using industry level data for 15 countries over the period 1984-2007, this paper augments the neo-Schumpeterian framework to identify the relevant channels and policies that shape an economy's ability to learn from the global productivity frontier. An economy's ability to benefit from frontier innovation is a positive function of its degree of international connectedness, ability to allocate skills efficiently and investments in knowledge based capital, including managerial capital and R&D. Productivity growth, via more effective learning from the global frontier, is supported by a policy framework that promotes efficient resource allocation – including lower barriers to entrepreneurship, efficient judicial systems and bankruptcy laws that do not overly penalise failure – and fosters the creation of markets for seed and early stage finance. Innovation policies that support basic research and facilitate the absorption of external knowledge for firms – including via university-industry R&D collaboration – also enhance spillovers from the global productivity frontier, and consequently, productivity growth.

JEL Classification: C23; L5; L16; O43; O57.

Keywords: productivity, growth, catch-up, spillovers from the frontier.

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Retombées des technologies de pointe et politiques publiques: ce que montrent les données sectorielles

Durant la majeure partie de la seconde moitié du XXème siècle, la productivité du travail a augmenté rapidement dans la plupart des économies de l'OCDE, alimentée par l'adoption d'un grand nombre de technologies existantes mais encore inexploitées. Toutefois, le ralentissement de la croissance de la productivité au cours de la dernière décennie corrobore l'idée selon laquelle au fur et à mesure que les économies convergent vers la frontière technologique mondiale, la capacité à capitaliser sur les innovations développées à la pointe de la technologie augmente. À partir de données sectorielles couvrant 15 pays sur la période 1984-2007, cet article complète le modèle de croissance néo-schumpétérien afin d'identifier les canaux et les politiques qui affectent la capacité d'une économie à apprendre de la frontière de la productivité mondiale. La capacité d'une économie à bénéficier de l'innovation dans les technologies de pointe est une fonction croissante de son degré d'ouverture internationale, de sa capacité à allouer efficacement les compétences et les investissements aux actifs fondés sur la connaissance, y compris le capital managérial et la R & D. La croissance de la productivité, via un apprentissage plus efficace à partir de la frontière technologique mondiale, est soutenue par un cadre politique qui favorise une allocation efficace des ressources - y compris la réduction des barrières à la création d'entreprises, l'efficacité des systèmes judiciaires et les lois sur la faillite qui ne pénalisent pas trop l'échec - et qui favorise la création de marchés du capital d'amorçage et du capital-risque. Les politiques d'innovation qui soutiennent la recherche fondamentale et facilitent l'assimilation des connaissances extérieures par les entreprises - y compris via des collaborations entre les universités et les entreprises en matière de R & D– renforcent également les retombées de la frontière de la productivité mondiale, et par conséquent, la croissance de la productivité.

Classification JEL: C23; L5; L16; O43; O57.

Mots-clés: productivité, croissance, rattrapage, retombées des technologies de pointe.

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PRODUCTIVITY SPILLOVERS FROM THE GLOBAL FRONTIER AND PUBLIC POLICY: INDUSTRY-LEVEL EVIDENCE

By Alessandro Saia, Dan Andrews and Silvia Albrizio[1]

1. Introduction

1. For much of the second half of the twentieth century, labour productivity grew rapidly in many OECD economies, fuelled by a process of catch-up driven growth centred on the adoption of a large stock of unexploited existing technologies. From the mid-1990s, productivity growth accelerated in the United States – the global productivity leader – largely reflecting the large productivity gains associated with rapid diffusion in information and communication technologies (ICT). While these benefits were also partly realised in other English speaking and Nordic countries, some economies – particularly in Europe – began to fall behind and the process of productivity convergence halted. One explanation is that, as economies converge toward the frontier, the ability to capitalise on new innovations in the most advanced countries – such as ICT – becomes more important (Acemoglu et al., 2006). In turn, this brings into sharper focus the type of policy environment that is conducive to the adoption of cutting edge technologies and business practices.

2. Neo-Schumpeterian growth theory has become the workhorse model to investigate productivity growth. This model predicts that a country's productivity growth depends on its: *i)* distance to the global productivity frontier (the catch-up effect) and *ii)* ability to learn from the global productivity frontier (the pass-through effect) (Acemoglu et al., 2006; Aghion and Howitt, 2006). The catch-up effect refers to the ability of countries to adopt *existing* technologies and converge towards the global industry frontier. The pass-through effect (or learning/spillovers from the frontier) is a more dynamic concept, referring to countries' ability to benefit from *new* innovations at the frontier. Empirical models have provided extensive evidence of cross-country conditional convergence of growth rates, identifying the channels and the policies affecting the catching-up process (for example Nicoletti and Scarpetta, 2003; Griffith et al., 2004; Conway et al., 2006; Arnold et al, 2006; and Bourlès et al., 2013). However, the mechanisms that shape technological pass-through and enable countries to capitalise on innovation-led growth at the global frontier remain unexplored.

3. In earlier studies, learning from the frontier has been assumed to be uniform across countries, such that all countries benefit indiscriminately from the leader's innovation. From this perspective, this channel has been perceived as the free lunch of productivity growth. However, this paper shows that the process of technological learning from the global frontier is not a *fait accompli* and a lot can go wrong along the way. More specifically, econometric analysis based on data for 15 OECD countries over the period 1984-2007 shows that the magnitude of the learning from the frontier effect is found to be an increasing function of some key structural factors, including the degree of: *i)* international connectedness (e.g. trade with the frontier country); *ii)* efficiency of resource allocation; and *iii)* investment in knowledge-based capital (e.g. computerised information, innovative property and economic competencies). To the best of our knowledge, this is the first paper to augment the neo-Schumpeterian framework to explore the

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heterogeneous impact of frontier technological progress and innovation on laggard countries' productivity growth.

4. At the same time, a number of policies emerge as being relevant for the ability of countries to learn from the frontier via these channels. With respect to efficient resource allocation, bankruptcy laws that do not excessively penalize business failure, low entry barriers to entrepreneurship and an efficient judicial system are associated with higher global learning spillovers. Higher investment in basic research and policies that promote firm-university collaboration are found to be effective tools that increase the capability of countries to absorb external knowledge and technologies. Moreover, the results highlight the importance of well-developed capital markets and markets for seed and early stage finance in the diffusion of innovations from the frontier, thus reinforcing findings of previous research that showed the role of young firms in the commercialization of radical innovations. From a broader perspective, these findings are consistent with a recent OECD research agenda, which links the significant variation in productivity performance observed across countries to differences in the policy environment (Nicoletti and Scarpetta, 2003; Andrews and Criscuolo, 2013).

5. The remainder of the paper is structured as follows. The next section highlights the increasing relevance of learning from the frontier for productivity growth, while Section 3 describes the different channels that facilitate global learning spillovers. Section 4 describes the data and the empirical framework utilised in the analysis. Section 5 presents the empirical results on: *i*) the relevance of different structural drivers for learning from the frontier; and *ii*) how policies can improve the ability to learn from the frontier. Section 6 concludes.

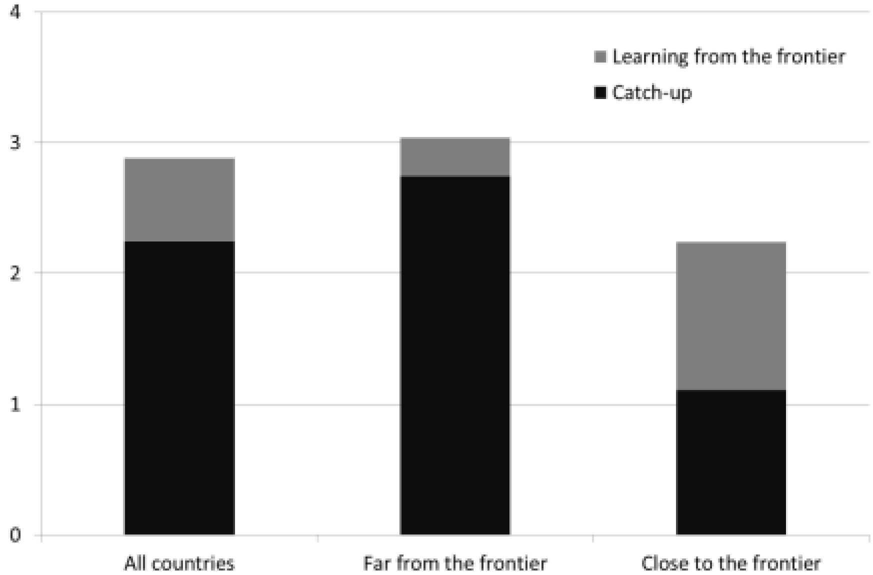
2. Learning from the frontier varies with distance to the frontier

6. By way of introduction, Figure 1 uses aggregate-level data to illustrate how the relative contribution of catch-up and learning from the frontier to aggregate labour productivity growth varies with a countries' distance to the frontier. In the traditional of the neo-Schumpeterian model (Aghion and Howitt, 2006), a country's productivity growth at time *t* is assumed to be a function of its lagged productivity gap (in levels) with the frontier economy in *t-1* (*i.e.* catch-up) and the contemporaneous rate of productivity growth of the frontier economy a time *t*. Using the full sample, the estimates suggest that the adoption of existing technologies (*i.e.* catch-up) accounts for most of the labour productivity growth observed over the period 1950-2013. The aggregate estimates, however, hide the fact that the effect of catch-up and learning from the frontier varies for different values of the distance to frontier. While for countries far from the frontier, most of the growth in labour productivity is due to the catch-up effect (second bar), technological learning from the frontier is a much more important source of productivity growth for countries close to the frontier (third bar).

7. The difference between the estimated effects for these two country groupings suggest that the convergence of productivity levels due to the gradual diffusion of the best practice existing technologies, which has been a relevant factor in the past, may become less important in the future, as convergence progresses (Braconier et al., 2014). Put differently, since the importance of the catch-up process is projected to decrease the closer a country gets to the global frontier, the focus for converging countries must shift on how to best harness productivity spillovers from the global frontier – a source of productivity growth that have received less attention to date. This is significant in light of the possibility that the policies required to facilitate learning from the frontier may differ from those that matter for catch-up (Acemoglu et al., 2006; Aghion et al., 2013).

Figure 1. Learning from the frontier is a more important source of growth closer to the frontier

Average contribution of catch-up and learning to average annual growth in labour productivity, 1950-2013



Notes: The figure shows how the average contribution from catch-up and learning from the frontier varies with an economy's distance from the frontier. *Close to the frontier* is defined as those country*year observations in the bottom quartile of the distance from the frontier distribution, while *Far from the frontier* refers to all other country*year observations. The estimates are calculated from a regression of growth in labour productivity on frontier growth and lagged distance from the frontier, where the United States is the frontier economy and is thus excluded from the regression. The data are averages over 5-year intervals and the regression also controls for country fixed effects and 5-year time fixed effects. The estimation is based on an unbalanced panel of 60 countries over the period 1950-2013. Corresponding regressions are reported in Appendix B (Table B1).

Source: Authors calculations based on the Conference Board Total Economy Database.

3. Channels that facilitate learning from the frontier

8. This section explores four broad mechanisms expected to shape an economy's ability to absorb frontier innovation and technology and, consequently, the magnitude of the learning from the frontier effect: *i)* openness to trade, and more specifically interconnectedness with the global frontier and the participation in global value chains (GVCs); *ii)* the ability to allocate resources efficiently; *iii)* investment in knowledge-based capital (KBC); and *iv)* well-functioning capital markets, particularly those that underpin the growth of young firms.

3.1 International trade

9. Trade is a well-established vehicle for technological and R&D spillovers (Coe and Helpman, 1995; Keller, 2001), reflecting the fact that trade intensifies a firms' exposure to market competition and information flows related to foreign technologies. Within the trade channel, the previous literature has focused on exporting as one of the main channel for productivity spillovers. Baldwin and Gu (2004) identify three mechanisms through which export-market participation affects productivity: *i*) product specialisation to exploit economies of scale; *ii*) exposure to international competition; and *iii*) learning by exporting. Firms may learn from foreign markets both directly, through buyer-seller relationships, and indirectly, through increased competition from foreign producers (De Loecker, 2013). Learning by exporting involves a variety of mechanisms that may lead to improved products, services, marketing and capacity utilisation (Kneller and Pisu, 2010).

10. Another trade-related mechanism relevant for productivity spillovers is participation in global value chains (GVCs). A key feature of globalisation has been the fragmentation of production processes and re-location of different stages of production across countries. This geographical re-organisation has led to R&D collaboration with foreign buyers/suppliers, product diversification, economics of scale and/or scope and specific investments to meet foreign standards and tastes. These effects suggest that GVCs can help create a dynamic environment where firms can take advantage of spillovers from the frontier easier and faster.

11. With this in mind, an acceleration of the growth at the global productivity frontier could be expected to translate into higher MFP growth, via the spillover channel, in economies that trade more intensively with the frontier country or with higher participation in GVCs for two main reasons:

- *Interconnectedness with the global frontier*: The exposure to good practices and ideas may enhance the formation of organisational and managerial capital, which is complementary to technological adoption (Bloom et al., 2012). Realising the full productivity benefits from new technologies (such as ICT) entails significant organisational restructuring, which requires considerable managerial skill. Moreover, connectedness entails the creation of know-how and learning capabilities which allow countries to quickly familiarise with and adopt new technologies (Alvarez et al., 2013). For instance, GVC linkages may enhance countries' absorptive capacity due to the exposure to frontier technologies and practices in the other stages of the chain.

- *Competition*: Trade with the leader is likely to engender more intense productivity-enhancing reallocation. The consequent expansion of the most productive firms and the downsizing or exit of inefficient firms, create resource capacity to take advantage from new innovations at the frontier. The resulting increase in the efficiency of resource allocation will raise the returns to investing in new technologies (Andrews and Criscuolo, 2013). Furthermore, GVCs pose additional competitive pressure on firms, increasing their incentives to keep abreast of new technological developments to maintain their productivity and cost advantages.

3.2 Investments in knowledge-based capital

12. Learning from the frontier also requires complementary investments in knowledge-based capital (KBC). Some aspects of new technologies are difficult to codify and require practical investigation before they can be properly incorporated into production processes. In this respect, domestic R&D activity is essential for countries' ability to benefit from new discoveries by facilitating the adoption of foreign technologies (Griffith et al., 2004).

13. At the same time, the composition of R&D investment has an impact on the absorption and implementation of new ideas, with an appropriate balance between basic and applied research essential. According to the Frascati Manual (OECD 2002), basic research is "experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundation of phenomena and observable facts, without any particular application or use in view". Applied research is also "original investigation undertaken in order to acquire new knowledge but is directed primarily towards a specific practical aim or objective". The importance of basic research for firms' productivity growth is long established (Mansfield, 1980 and 1981; and Link, 1981), while more recently, Akcigit et al. (2014) have argued that basic research results in significantly larger spillovers than applied research. This could be due to the fact that innovation from basic research has a larger domain of application – *i.e.* it often cuts across industries, as opposed to being industry-specific – and thus creates scope for technological process across a broad range of industries (Nelson, 1959; Rosenberg, 1990; Dasgupta and David, 1994).

14. Firms need to absorb external knowledge in order to create and maintain the capability to take advantage of frontier growth. For example, several papers highlight the positive correlation between connectedness with the scientific and academic community and firm performance (Cockburn and Henderson, 1998; Simeth and Cincera, 2013). Collaboration between universities and industry constitutes one of the main channels for the transmission of technology and knowledge from research hubs to production units. On the one hand, university researchers might be more closely connected to the global knowledge frontier, which provides a direct source of new knowledge and may increase the speed of technological diffusion. Moreover, financial support from industry can contribute to the expansion of research possibilities and international collaboration, facilitating exchange of ideas and spillovers. On the other hand, industry-based financing might constrain the scope of the basic research activities of universities due to the focus of private firms on creation of applied knowledge that can be leveraged for profit creation (Dasgupta and David, 1994).

3.3 Efficient resource allocation

15. An economy’s potential to learn from the global frontier might also be affected by its ability to reallocate scarce resources – including capital, labour and skill – to their most productive use. Efficient resource allocation underpins the growth of the most innovative and productive firms (Andrews and Criscuolo, 2013), thus raising the incentives to incorporate new technologies and best practices. Policies can facilitate conditions that promote efficient reallocation, by creating an innovation-friendly environment; or they can distort the reallocation mechanism by imposing barriers to experimentation and penalising failed entrepreneurs or new-entrants.

16. Previous studies have shown that low barriers to entry and exit (Andrews and Cingano, 2014; Andrews et al., 2014) and judicial efficiency (Beck and Levine, 2002; Andrews et al, 2014) have a strong impact on the efficiency of resource allocation. Less severe bankruptcy legislations are also associated with more rapid technological diffusion and catch-up with the global frontier (Westmore, 2013). In contrast, regimes that force early liquidation or those that penalise future ability to restart a business have an adverse effect on the willingness to take risks (de Serres et al., 2006).

17. The increasing relevance of knowledge in sustaining productivity growth and in adopting new technologies highlights the importance of an efficient allocation of human capital. Recent OECD research provides evidence of how the significant incidence of skill mismatch (*i.e.* the mismatch between workers' skills and those required for their job) observed in many OECD countries is harmful for aggregate productivity, since it constrains the ability of the most productive firms to grow (Adalet McGowan and Andrews, 2015a). In this regard, well-designed framework conditions that promote reallocation of resources play a crucial role in reducing skill mismatch (Adalet McGowan and Andrews, 2015b).

3.4 Financial and risk capital markets

18. Well-developed capital markets provide higher liquidity and credit possibilities, which not only stimulate technological innovation (King and Levine, 1993a, 1993b; Levine, 1997; Brown, et al., 2009; Hsu, Tian and Xu, 2014; Comin and Nanda, 2014), but also change the trajectory of innovation. For example, Nanda and Nicholas (2014) find that a sharp reduction of the available external finance to firms moves innovation away from more experimental, radical innovations.

19. Well-developed financial markets are even more important for young firms, which play a crucial role in promoting innovation and growth (Andrews and Criscuolo, 2013). Young firms have an advantage in adopting frontier technologies since in contrast to incumbents, they are not weighed down by an existing business structure. However, they face stricter financing constraints since they have limited internal funds and lack a track record to signal their “quality” to investors. Indeed, when asymmetric information

problems are large, a "missing markets" problem may emerge where many of the innovations associated with young start-up firms may never be commercialised. This financing gap is partly bridged by venture capitalists or business angels, who address informational asymmetries by intensively scrutinising firms before providing capital and monitoring them afterwards (Hall and Lerner, 2009). Hence, early stage seed financing and well-developed stock markets might provide young firms with the adequate financial support to sustain the "creative destruction process", where new entrants build on incumbents' ideas and business models.

4. Data and empirical methodology

4.1 Data

20. The analysis utilises data from Bourlès et al. (2013), which include industry-level data for 15 OECD countries (Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Italy, the Netherlands, Norway, Spain, Sweden and the United States) and 20 industries over the period 1984-2007.

21. The industry-level productivity and the distance to frontier are measured by a multi-factor productivity (MFP) index. MFP growth is calculated as follows:

$$\Delta \ln MFP_{cs,t} = \Delta \ln VA_{cs,t} - \alpha_s * \Delta \ln L_{cs,t} - (1-\alpha_s) * \Delta \ln K_{cs,t}$$

where subscripts *c*, *s*, and *t* indicate country, industry and year, respectively. VA is value-added (at constant prices), α is the elasticity of labour, proxied by the labour share in value-added, L indicates the total number of workers employed and K is the net capital stock (at constant prices). Data on value-added and total employment were sourced from the OECD, STAN database and net capital stocks were sourced from the OECD, Industry Productivity Database (PDBi). MFP levels are calculated for a base year (2000) and then extended over the entire sample, using MFP growth values computed above.

4.2 Empirical methodology

22. This section outlines the empirical methodology used to analyse the channels and policies that facilitate learning from the frontier. First, the baseline model is introduced and then augmented to test the hypothesis regarding the key structural channels (see Section 3) that shape spillovers from the global productivity frontier. Second, the model is further enriched to investigate the extent to which policies that are related to the aforementioned channels may shape the technology transfer from the productivity leader. Finally, some caveats concerning identification are outlined.

4.2.1 Baseline model

23. The empirical specification adopted in the paper is derived from the estimation of the neo-Schumpeterian growth framework of Aghion and Howitt (1998). Following Nicoletti and Scarpetta (2003), Aghion et al. (2004), Griffith et al. (2006) and more recently Bourlès et al. (2013), MFP growth follows an ADL (1,1) process of the form:

$$\Delta \mathrm{MFP}_{cs,t} = \beta_1 \Delta \mathrm{MFP\ Frontier}_{s,t} + \beta_2\, \mathrm{gap}_{cs,t-1} + \beta_3\, \mathrm{PMR}_{cs,t-1} + \delta_s + \delta_{ct} + \varepsilon_{cs}$$

where the subscripts *c*, *s*, and *t* indicate country, industry and year, respectively. $\Delta\,\mathrm{MFP\ Frontier}_{s,t}$ represents the MFP growth of the country-sector with the highest level of MFP at time *t*, $\mathrm{gap}_{cs,t-1}$ is the productivity gap, modelled as the distance in the level of MFP between each country and the leader, and $\mathrm{PMR}_{cs,t-1}$ are the knock-on effects of upstream product market regulation on downstream industries. The last term is included to control for the potential effect of anticompetitive regulations on intermediate goods (see Bourlès et al., 2013). The model is estimated using country-time fixed effects, to control for country-specific trends, and industry dummies to control for industry-specific characteristics. Standard errors are clustered at the country-industry level.

24. To investigate the heterogeneity of the spillover effect with respect to the structural factors that may contribute to shape a country's absorptive capacity, as explained in the Section 3, the model is augmented with the relevant interaction terms.[2] For example, in order to explore whether investment in R&D has an impact on the spillovers from the global frontier, the frontier growth variable is interacted with the R&D investment term:

$$\Delta MFP_{cs,t} = \beta_1 \Delta\, MFP\ Frontier_{s,t} + \beta_2 gap_{cs,t-1} + \beta_3 PMR_{cs,t-1} + \beta_4 RD_{cs,t} * \Delta MFP\ Frontier_{s,t} + + \beta_5\, RD_{cs,t} * gap_{cs,t-1} + \delta_s + \delta_{ct} + \varepsilon_{cs} \qquad (1)$$

where the coefficient β_4 provides an estimate of the effect of investment in R&D on the magnitude of the spillover effect. In order to interpret β_1 and β_2 as the mean effect on MFP growth, the technology gap and the frontier growth terms are centred on their respective sample means.

25. If β_4 is statistically different from zero, it would provide evidence against the homogeneity in the learning from the frontier effect. The working hypothesis is that the higher the investment in R&D, for example, the more likely the economy is to absorb innovation from the frontier ($\beta_4 > 0$). Similar results are expected with respect to other measures of KBC (e.g. managerial quality), international trade and participation in the GVCs, and efficient resource allocation.

4.2.2 Identifying the role of public policies

26. To investigate the extent to which different policies play a role in shaping the technology transfer from the productivity leader, a difference-in-difference specification is adopted. This approach, popularised by Rajan and Zingales (1998), is based on the assumption that there exist industries that have 'naturally' high exposure to a given policy (*i.e.* the treatment group), and such industries – to the extent that the policy is relevant to the outcome of interest – should be disproportionally more affected than other industries (*i.e.* the control group). In other words, identification will be based on comparing the differential MFP growth between highly exposed industries and marginally exposed industries in countries with different levels of a given policy.

27. The empirical model will thus take the form:

$$\Delta MFP_{cs,t} = \beta_1 \Delta\, MFP\ Frontier_{s,t} + \beta_2 * gap_{cs,t-1} + \beta_3 * PMR_{cs,t-1} + \textstyle\sum_j \beta_4^j * (P_{ct-1}^j * E_s^j) + \sum_j \beta_5^j * (P_{ct-1}^j * E_s^j) * \Delta\, MFP\ Frontier_{s,t} + \sum_j \beta_6^j * (P_{ct-1}^j * E_s^j) * gap_{cs,t-1} + \delta_s + \delta_{ct} + \varepsilon_{cs} \qquad (2)$$

where P_{ct-1}^j is policy *j* in country *c* and E_s^j is the industry *s* exposure to policy *j*. The parameter of interest is β_5^j, which provides estimates of how different policies shape countries' capacity to absorb spillovers from the frontier country. It is important to remember that it is not possible to directly interpret the coefficients of the exposure variable as the average effect of the policy of interest. For example, if P_{ct-1}^j corresponds to barriers to entrepreneurship (BE), a negative estimate of β_5^j implies that less stringent BE enhances spillovers from the frontier relatively more strongly in exposed industries compared to non-

2 The structural variables are included one at a time in the baseline specification. Hence, some caution is warranted in the interpretation of the results. Nevertheless, the results are broadly robust to including several structural variables together (Table B10).

exposed industries. In order to provide a more direct estimate of the impact of framework policies on the size of spillover effect, the methodology proposed by Guiso et al. (2004) is also adopted (see Box 1).

Box 1. A methodology to assess the size of spillovers from the frontier

To provide a sense of the economic significance of the results, a modified version of the methodology proposed by Guiso et al. (2004) is adopted.[1]

For example, assume that the aim is to assess the impact of barriers to entrepreneurship (BE) on the size of the spillovers from the frontier in country *c*. Using the estimated coefficients from Table 4 and the level of BE in country *c*, it is possible to provide an estimate of the impact of spillovers from frontier growth as follows:

$$\Delta\,\widehat{MFP}_c = \frac{\sum_{i=1}^{2}(\widehat{\beta}_1 * \,\Delta Frontier\ Growth_t + \widehat{\beta}_5 * USturn_i * (BE_c) * \,\Delta Frontier\ Growth_t)}{2}$$

where β_1 represents the impact of MFP growth in the frontier leader, $\widehat{\beta_5}$ is the coefficient of the interaction between the frontier growth and the level of BE, $\mathrm{Frontier\ Growth_t}$ represents the MFP growth in the frontier leader in year *t* and $USturn_{1/2}$ denote the highest and the lowest level of exposure, respectively. The firm turnover rate is used as the relevant exposure variable, since policies affecting firm entry and exit will matter more in industries where firm turnover is higher.

Two points are worth noting. First, the methodology presented above departs from Guiso et al. (2004) by computing the unweighted average rather than the weighted average (where weights correspond to the value-added shares). Second, the formula uses the average between those sectors with the highest and the lowest exposure rather than the average for all sectors. This paper departs from the usual methodology in order to avoid biased results arising from the fact that in our sample, industry coverage is not homogenous. Consider, for example, two countries (A and B) with the same level of BE but different industry coverage, where data on services industries are available only for country A. Incomplete industry coverage could bias the simulation since, even if the two countries have the same level of barriers, the estimated gains for country A would be higher since the exposure values are higher in services industries.

1. See Bassanini et al. (2009) for a discussion of the caveats associated with this methodology.

28. Table 1 shows the country-level policies and the relative industry-level exposure variables used in the differences-in-differences estimation. Exposure variables are taken from previous work exploiting the same methodology to investigate the relevance of country-level policies on different economic outcomes (See Section 5.2 for more details on the choice of the exposure variables). The exposure indices are computed from US data to the extent that United States is generally perceived to be a country with a low level of regulation intensity (*i.e.* “frictionless”). Accordingly, the United States is excluded from the analysis.[3]

29. Before proceeding, it should be noted that the coverage of countries and industries varies depending on the policy variable and thus, the number of observations varies throughout the analysis. It is reassuring, however, that changes in sample composition have a negligible effect on the estimated coefficients of catch-up and spillover effects. This indicates that the findings are not driven by the different samples used throughout the analysis.

3 It is worth noting, however, that the results are broadly robust to the inclusion of the United States in the sample.

Table 1. Structure of the differences-in-differences estimation and data sources

Variable	Country-level variable	Industry-level exposure variable
Framework policies	Barriers to entrepereneurship (BE) Overall Closing a business: Cost (% of estate) Trial length (OECD) Modified appeal rate before the second instance (number of incoming cases in second instance as a percentage of population) (Doing Business measure)	Firm turnover rate (defined as the entry rate + exit rate) at the industry level in the United States. Sourced from Bartelsman et al. (2008).
Innovation-related policies	Government Intramural Expenditure on R&D (% GDP) Higher education R&D as a percentage of GDP Higher education R&D financed by industry as a percentage of GDP. B-Index for Large Firms Each variable is sourced from the OECD Main STI Indicators.	Sectoral R&D intensity (R&D/value added) for the United States.
Seed Capital Indicators and Financial Market Development	Early Stage Deal Amount (log) Number of Policy Programmes (e.g. fiscal incentives and government equity financial instruments) Stock Market Capitalization as a percentage of GDP (source OECD) See Appendix 3 of Andrews and Criscuolo (2013) for data sources.	Sectoral ICT intensity: the share of ICT capital compensation in total capital compensation for the United States.

4.2.3 Identification concerns

30. There are several caveats that should be kept in mind when interpreting the results:

- The paper documents a series of cross-country empirical regularities and does not directly address the issue of causality. For example, the positive correlation at time *t* between frontier growth and the dependent variable might reflect a simultaneous increase in the level of R&D investment in the industry, rather than spillovers from the frontier. Given this possibility, as a robustness check, the analysis was also conducted using an alternative specification estimated with country-time and industry-time fixed effects to control for industry specific time-varying unobserved factors. The results are robust to this specification and are presented in Appendix B (Tables B3-B5).

- This paper does not claim a causal link among structural variables and technology spillovers. For example, it could be the case that more productive industries are more involved in GVC participation. Unfortunately, finding exogenous variation or good instruments to establish a causal link in cross-country studies is challenging. The identification strategy adopted in the paper relies on a set of country-time and industry fixed effects, hence unobserved country-specific factors that vary over time can be accounted for only by exploiting variation within the same country. Moreover, to limit possible reverse causality, lagged values of explanatory variables are used where possible, instead of contemporaneous values.

- Concerns about reverse causality might be less salient when employing the differences-in-differences specification. However, one could still argue that, for example, lobbying could be a potential source of endogeneity. For example, it can be the case that an industry with structurally-high turnover lobbies for lowering barriers to entrepreneurship (BE). This would typically happen in countries where spillovers are low relative to what they would be if BE were reduced, *i.e.* a positive cross-country correlation between spillovers and BE in exposed industries. This plays against the hypothesis that spillovers and BE should be negatively correlated across countries in exposed industries. In this case, this form of endogeneity tends to underestimate the true effect.

5. Empirical results

31. This section investigates the heterogeneity of frontier spillovers in the context of the various channels highlighted in Section 3. Section 5.1 establishes a link between structural factors and learning from the productivity leader. Section 5.2 focuses on a set of related policies that may be relevant for a country's ability to learn from the frontier, while the final subsection presents some robustness checks.

5.1 Structural drivers of learning from the frontier

32. Results presented in Table 2 suggest that the ability to learn from the frontier is positively related to the proximity to the global frontier.[4] Spillovers from the frontier are stronger in economies that are more connected with the global frontier via trade (Column 1), as measured by the intensity of trade with the productivity leader in each manufacturing industry. The same is true with respect to the degree of integration in GVCs (Column 2).[5] The results are consistent with the idea that higher international connectedness facilitates information flows and allows firms to more quickly adopt leading-edge technologies. Moreover, due to the increasing potential market size, firms are exposed more to market competition (Melitz, 2003), which may raise incentives to adopt new technologies.

33. The efficiency with which human resources are allocated is also relevant. Using skill mismatch indicators from the recent *OECD Survey of Adult Skills* (PIAAC) (see Adalet McGowan and Andrews, 2015a), the results in Table 2 (Column 3) suggest the existence of a negative relationship between the percentage of workers who are either over- or under-skilled and the size of the spillover effect. Indeed, adoption of frontier technologies is only possible if there are adequate resources to complement it. Moreover, in line with previous research (Andrews and Westmore, 2014), higher managerial capital as measured in the PIAAC survey (Adalet McGowan and Andrews, 2015a), is also associated with higher frontier spillovers (Column 4), possibly by facilitating the adoption and the implementation of new innovation.

4 The results are broadly robust to including the interaction of the regulatory burden indicator with the gap and frontier terms (Table B6).

5 GVC participation seems to have both a direct effect (participation in GVCs enhances productivity) and an interactive effect with frontier growth (higher GVC participation is associated with higher technology transfer from the productivity leader of the industry). While causality is unclear, the economic magnitude of this effect is explored in Appendix B (Figure B1), by simulating the gains to MFP growth from increasing GVC participation to the highest level in each industry.

Table 2. Learning from the frontier is shaped by key structural factors

	Structural Drivers					
	(1) Trade with the Frontier*	(2) Participation in GVCs	(3) Skill Mismatch	(4) Managerial Quality	(5) Business R&D	(6) E-government Readiness Index
Growth at the frontier (t)	0.136***	0.119***	0.121***	0.120***	0.120**	0.118***
	(0.0348)	(0.0252)	(0.0240)	(0.0242)	(0.0384)	(0.0234)
Gap with frontier (t-1)	0.0637***	0.0338***	0.0395***	0.0399***	0.0427***	0.0378***
	(0.00798)	(0.00626)	(0.0088)	(0.008)	(0.0101)	(0.00710)
Regulatory Burden Indicator (t-1)	-0.130	-0.0911	-0.0410	-0.031	-0.0814	-0.0567
	(0.163)	(0.0697)	(0.066)	(0.069)	(0.128)	(0.0636)
Relevant Structural Driver (t-1)	-0.00379	0.00133***	-0.0001	0.0000	-0.0001	
	(0.0127)	(0.000385)	(0.0002)	(0.0001)	(0.0005)	
Relevant Structural Driver (t-1) * Growth at the frontier (t)	0.223*	0.0117*	-0.0062*	0.0023**	0.0117***	0.00149**
	(0.132)	(0.00683)	(0.0034)	(0.001)	(0.002)	(0.000661)
Relevant Structural Driver (t-1) * Gap with frontier (t-1)	-0.00916	0.000931	-0.0006	-0.00004	0.000007	0.0000754
	(0.027)	(0.00182)	(0.0004)	(0.002)	(0.001)	(0.000118)
Country*year fixed effects	yes	yes	yes	yes	yes	yes
Industry fixed effects	yes	yes	yes	yes	yes	yes
Observations	2177	3953	4047	4026	1702	4629
R-squared	0.328	0.251	0.245	0.2466	0.3436	0.2504

Notes: The standard errors are clustered at country*industry cells. The full sample covers all non-frontier industries for the years 1984-2007. Changes in the number of observations are due to data availability. Details about the variables are presented in Appendix A. The asterisk indicates that the sample in Column (1) covers only manufacturing industries. The model in Column (1) includes the variable *% Trade with High MFP Countries* (and the interaction with the Frontier and Gap terms) that is defined as the % of total trade flows of country-industry *cs* with all non-frontier country-industry pairs with high productivity at time *t* (see Table B2 in Appendix B). A country-industry is defined as high productivity if its level of MFP is above the median observed in industry *s*. The main effect of E-government Readiness Index is not computed since data are observed at country level for one year. Additional results are reported in Appendix B.

34. As discussed in Section 3, the adoption of new technologies might also depend on a domestic framework that allows countries to be more reactive to frontier innovation. Consistent with this hypothesis, higher investment in R&D (Column 5) and ICT readiness – as proxied by the E-government readiness index[6] (Column 6) – contribute to creating such capability and are found to be positively associated with higher spillovers from the productivity leader of the industry.

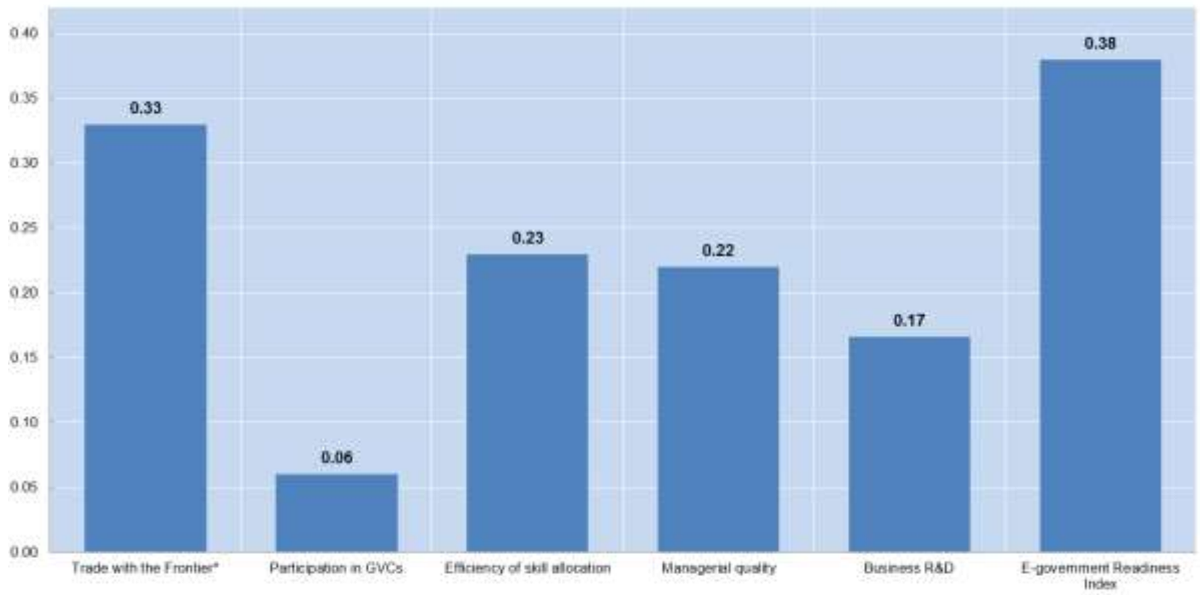
35. In order to provide a sense of the economic significance of these results, Figure 2 reports how the magnitude of the estimated frontier spillovers differs between the maximum and minimum level of each structural factor considered in our analysis. For example, assuming a 2% acceleration in MFP growth at the frontier – roughly equivalent to the ICT-induced acceleration in the mid-1990s - the estimated gain to annual MFP growth would be around 0.33 percentage points (pp) higher in a country which trades very intensively with the frontier economy (e.g. Canada), than in one where such trade flows are lower, such as Austria (Figure 2, bar 1).[7] This effect is sizeable given the average MFP growth observed in OECD countries over the period 1995-2007 at around 0.5%.

6 Due to data availability, the E-government Readiness Index is used as a proxy for the level of ICT infrastructure. Results are robust to using the Network Readiness Index (World Economic Forum, 2012), which captures how ICT friendly a country is, as a proxy for ICT infrastructure.

7 The learning effect associated with trade with the frontier is higher than that associated with participation in GVCs since the former refers to the level of direct exposure with the frontier industry while the latter is

Figure 2. Learning from the frontier is shaped by key structural factors

% difference in learning effect between maximum and minimum value of each structural variable, assuming 2% MFP growth at the frontier



Notes: Trade with the global frontier (Minimum: Austria, Maximum: Canada). The asterisk indicates that the sample in Column (1) covers only manufacturing industries. GVC Participation: OECD, TiVA database (Minimum: Canada, Maximum: Belgium). Efficiency of skill allocation (Minimum: Italy, Maximum: Belgium) and managerial quality (Minimum: Italy, Maximum: Finland) are derived from the OECD Survey of Adult Skills (2012). Business R&D is defined as the ratio of business R&D expenditures to value added and sourced from OECD, Main Science and Technology Indicators (Minimum: Australia, Maximum: Sweden). E-government readiness index (Minimum: Greece, Maximum: the Netherlands) is from OECD, Internet Economy Outlook 2012.

5.2 Public policies and learning from the frontier

36. This section investigates the relevance of public policies in shaping learning from the frontier. It exploits cross-industry cross-country data and a differences-in-differences specification accounting for country-time varying unobserved characteristics as explained in Section 4.2. Ideally, we would like to explore the impact of trade restrictions on learning from the frontier, but data restrictions make this difficult.[8] However, additional results (see Appendix C), highlight the importance of a well-functioning services sector, and the adverse effect of policy-induced rigidities in domestic services markets, as proxied by regulation in professional services.[9] The subsequent analysis is conducted along three different sets of factors and policies: *i*) policies that promote entry, efficient exit and civil justice efficiency; *ii*) selected innovation policies; and *iii*) capital and financial risk markets.

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a more indirect measure of connectedness. Moreover, the observed difference is also due to the fact that trade data are available only for manufacturing industries, where spillover effects are higher than those observed for service industries.

8 Liberalisation of trade increases market competition as well as availability of advanced technologies (Alvarez et al., 2013). Therefore, barriers to free movement of goods and service may pose a substantial obstacle to frontier spillovers (Bas et al., 2015). This is particularly true for several complementary services (e.g. telecommunication services and logistics services) that are indispensable in global production activities.

9 Policies that enhance the efficiency in the domestic services – i.e. less cumbersome regulation on professional services - allow economies to capitalise more on the productivity benefits of GVC participation (Table C1 in Appendix C).

5.2.1 Framework policies that promote resource allocation facilitate learning from the frontier

37. Policies can create conditions that promote efficient reallocation and provide an innovation-friendly environment by removing barriers to experimentation and lowering penalties for failed entrepreneurs or new-entrants. Accordingly, this section explores the extent to which low entry barriers, bankruptcy laws that do not excessively penalise business failure and efficient judicial systems shape the technology and innovation transfer from the productivity leader.

38. Table 3 reports the baseline estimates of Equation (2), where firm turnover rate is used as the relevant exposure variable, since policies affecting firm entry and exit will matter more in sectors where there is higher firm turnover. The coefficients of the triple interaction terms, *Framework policy*Turnover*Frontier Growth*, are estimated to be negative and significant in all specifications, providing evidence that framework policies which promote efficient entry and exit can support productivity growth via more effective learning from the frontier. The key results are as follows:

- Less stringent barriers to entrepreneurship (Column 1) and less punishing bankruptcy costs (Column 2) are associated with stronger productivity spillovers from the global frontier in industries with high firm turnover rates, relative to other industries.

- Higher civil justice efficiency, measured by trial length (Column 3) and less uncertainty about the final verdict (Column 4), are associated with stronger productivity spillovers from the global frontier in industries with high firm turnover rates, relative to other industries.

Table 3. Framework policies and productivity spillovers from the frontier

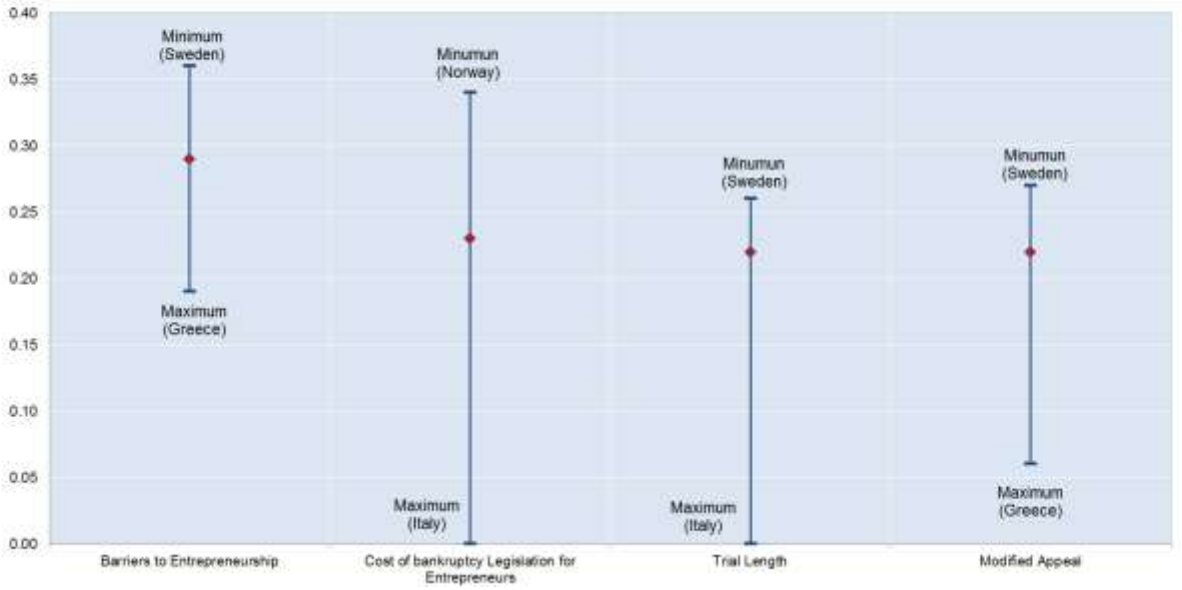
	Entry and Efficient Exit		Civil Justice Efficiency	
	(1)	(2)	(3)	(4)
	Barriers to Entrepreneurship	Cost of bankruptcy Legislation for Entrepreneurs	Trial Length	Modified Appeal
Growth at the frontier (t)	0.108*** (0.0260)	0.107*** (0.0228)	0.0964*** (0.0272)	0.0797*** (0.0235)
Gap with frontier (t-1)	0.0317*** (0.00641)	0.0363*** (0.00694)	0.0145 (0.00890)	0.0355*** (0.00983)
Regulatory Burden Indicator (t-1)	-0.128 (0.0783)	-0.0891 (0.0643)	-0.102 (0.0936)	-0.0795 (0.0791)
Framework Policy (t-1) * Turnover	-0.000370 (0.000445)	-0.0000455 (0.0000322)	0.000251 (0.000329)	-0.00217 (0.00150)
Framework Policy (t-1) * Turnover * Growth at the frontier (t)	-0.00358** (0.00175)	-0.000481*** (0.000141)	-0.00305** (0.00120)	-0.0156** (0.00660)
Framework Policy (t-1) * Turnover * Gap with frontier (t-1)	-0.000699* (0.000370)	-0.0000765** (0.0000358)	-0.000722** (0.000335)	-0.000885 (0.00204)
Country*year fixed effects	yes	yes	yes	yes
Industry fixed effects	yes	yes	yes	yes
Observations	3632	4449	1618	2997
R-squared	0.247	0.251	0.351	0.264

Notes: The standard errors are clustered at country*industry cells. The full sample covers all non-frontier industries for the years 1984-2007. The United States is excluded from the regressions since it is the benchmark country for Firm Turnover Rates. Changes in the number of observations are due to data availability. See Table B7 for further results including the interaction of the regulatory burden indicator with the gap and frontier terms.

39. To illustrate the economic significance of these results, Figure 3 simulates the impact of higher frontier growth on domestic productivity growth for different levels of public policy settings (see Box 1 for details). For example, assuming a 2% increase in MFP growth at the global frontier, the estimated gain to annual MFP growth would be around 0.2% higher – or almost twice as large – in a country where administrative entry barriers are relatively low (e.g. Sweden), than in an economy where the burden of administrative entry barriers is relatively high (e.g. Greece).

Figure 3. Well-designed framework policies facilitate learning from the global frontier

Estimated frontier spillover (% per annum) associated with 2% point increase in MFP growth at the global frontier



Notes: The chart shows how the sensitivity of MFP growth to changes in the frontier leader growth varies with different levels of framework policies and institutional environment. The diamond refers to the estimated frontier spillover effect associated with a 2% MFP growth at the frontier around the average level of the policy. The label "Minimum" (Maximum) indicates the country with the lowest (highest) value for the given policy indicator in a given reference year.

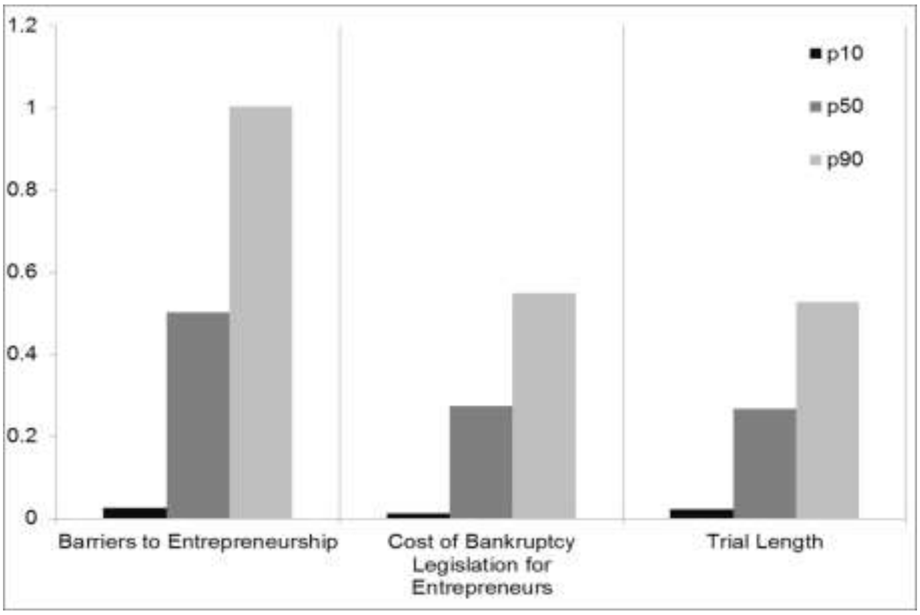
40. Interestingly, these policies also affect the economy's ability to absorb existing technologies. Consistent with some previous research (Nicoletti and Scarpetta, 2003, and Conway et al., 2006), the negative coefficient on the interaction term, *Framework policy*Turnover*gap,* indicates that the burden of these policies is stronger for country-industry pairs that are further away from the global frontier. One possible explanation is that inefficient framework conditions, by reducing the incentive to absorb existing technologies, reduce the speed of catch-up to the productivity leader. This effect is stronger for countries with low levels of productivity since the number of unexploited technologies is larger for these countries with the largest potential for catch-up.[10]

41. Figure 4 shows the effect of a policy improvement for different levels of distance to the frontier. The positive effect of a policy reform is stronger for countries that are far from the frontier and this effect is particularly strong for the impact of barriers to entrepreneurship (BE). The estimated gain in MFP

10 These results are not inconsistent with those of Bourlès et al., 2013 (i.e. the impact of intermediate goods market imperfections is stronger for observations that are close to the productivity frontier). Anticompetitive regulations (in upstream sectors) should disproportionally affect the most productive firms, while barriers to entry and exit induce exit from the bottom of the distribution. The positive correlation between distance to the frontier and the fraction of low productivity firms in an economy could help explain these results.

growth for a one unit decrease in the indicator of BE (roughly equivalent to moving policy settings from Greece to Denmark) would be around 1 percentage point in a country far from the frontier (*i.e.* observations in the top decile of the distance from the frontier distribution), while in a country close to the frontier (*i.e.* the bottom decile of the distribution), the estimated catch-up effect is less than 0.3%.

Figure 4. Simulated effects of changes in framework conditions for different levels of distance to the frontier



Notes: The chart shows the sensitivity of a policy improvement for different levels of distance to the frontier. The label "p10" (p90) indicates observations in the bottom (top) decile of the distance from the frontier distribution. The first column reports the estimated impact of a one unit decrease in the indicator of barriers to entrepreneurship. The second column reports the estimated impact of a five unit decrease in the indicator of cost of bankruptcy legislation for entrepreneurs. The last column considers a 500 days decrease in trial length.

5.2.2 Innovation policies improve learning from the frontier

42. Given the positive relationship between R&D and the size of the frontier spillovers, this section explores the potential role of innovation-related policies. The focus is on a selected set of potentially relevant policies. including: development of basic research, higher education expenditure, R&D collaboration between firms and universities and R&D tax incentives.

43. Table 4 reports the baseline estimates of Equation (2). If positive, the coefficients of the triple interaction terms, *Innovation policy*R&D*growth at the frontier,* will provide evidence of the influence of the considered policy on the size of the spillover. The key results are as follows:

- In more R&D intensive industries, higher expenditure in government intramural expenditure on R&D (i.e. public basic research) (Column 1) and greater collaboration between industry and university (Column 3) are associated with stronger productivity spillovers from the global productivity leader of the industry, relative to other industries.

- In more R&D intensive industries, higher R&D expenditure in the higher education sector (Column 2) is associated with higher productivity growth, partly via quicker catch up, but the interaction with frontier growth is insignificant, pointing to no effects on learning from the frontier.

- Results provide little evidence that more generous R&D tax subsidies are associated with higher MFP growth (Column 4). This is consistent with previous research that does not uncover clear evidence of a positive link between R&D tax incentives and productivity growth (Brouwer et al., 2005; Lokshin and Mohnen, 2007; Westmore, 2013).

Table 4. Innovation policies and learning from the frontier

	Innovation Policies			
	(1)	(2)	(3)	(4)
	Government Intramural Expenditure on R&D (% GDP)	HERD (% GDP)	HERD financed by Industry (% GDP)	B-Index
Growth at the frontier (t)	0.0830*** (0.0193)	0.0859*** (0.0189)	0.0861*** (0.0201)	0.0889*** (0.0193)
Gap with frontier (t-1)	0.0373*** (0.00666)	0.0381*** (0.00633)	0.0402*** (0.00651)	0.0375*** (0.00646)
Regulatory Burden Indicator (t-1)	-0.0656 (0.0689)	-0.0333 (0.0632)	-0.0538 (0.0649)	-0.0716 (0.0691)
Framework Policy (t-1) * R&D	-0.0569 (0.253)	0.306** (0.150)	0.919 (1.417)	-0.275 (0.208)
Framework Policy (t-1) * R&D * Growth at the frontier (t)	2.260** (1.038)	1.061 (0.0661)	21.14*** (6.384)	0.405 (0.261)
Framework Policy (t-1) * R&D * Gap with frontier (t-1)	0.245 (0.290)	0.267* (0.154)	5.556* (3.104)	0.136 (0.0868)
Country*year fixed effects	yes	yes	yes	yes
Industry fixed effects	yes	yes	yes	yes
Observations	4449	4449	4449	4449
R-squared	0.250	0.250	0.252	0.249

Notes: The standard errors are clustered at country*industry cells. The full sample covers all non-frontier industries for the years 1984-2007. The United States is excluded from the regressions since it is the benchmark country for R&D Intensity. Policy variables expressed as average values observed over the period. See Table B8 for further results including the interaction of the regulatory burden indicator with the gap and frontier terms.

44. Taken as a whole, these results indicate that R&D tax subsidies are not the panacea. In contrast, innovation policies supporting basic research (*i.e.* government intramural expenditure), which is more prone to market failure than applied research, as well as other innovation policies that promote collaboration between firms and universities are more relevant for enhancing productivity spillovers.[11]

11 Additional results provide evidence of a positive effect of direct government support in business enterprise expenditure on R&D and learning from the frontier. A possible explanation is that, unlike R&D tax incentives, direct support might be more beneficial for young firms, since young firms are more likely to be financially constrained. These results are also related with previous OECD research that shows that R&D tax incentives may contribute to slowing down the reallocation process, while direct support appears to have a more neutral impact (Bravo-Biosca et al.,2012).

45. Using the coefficients of Table 4, it is possible to provide an estimate of the economic significance of the results. For example, assuming a 2% increase in MFP growth at the frontier, the associated increase in productivity growth for the country with the highest rate of government intramural expenditure on R&D (as % of GDP) is around 0.4%, while in the country with the lowest level of government intramural expenditure, the spillover is less than 0.2% (Figure 5).

Figure 5. Innovation policies and learning from the global frontier

Estimated frontier spillover (% per annum) associated with 2% point increase in MFP growth at the global frontier

Notes: The chart shows how the sensitivity of MFP growth to changes in the frontier leader growth varies with different levels of innovation policy variables. The diamond refers to the estimated frontier spillover effect associated with a 2% MFP growth at the frontier around the average level of the policy. The label “Minimum” (Maximum) indicates the country with the lowest (highest) value for the given policy indicator in a given reference year.

5.23 Well-developed financial and risk capital markets enhance learning from the frontier

46. By providing risk-taking firms with access to credit, well-developed financial markets and various types of venture capital (VC) financing might enhance productivity spillovers from the global frontier. In this section, ICT intensity is used as the relevant exposure variable, since sectors characterised by higher rates of risky investments (e.g. in ICT or intangible assets) might be more likely to benefit from a system where financing constraints, due to asymmetric information problems, are bridged by venture capitalists (see Andrews and Criscuolo, 2013).[12]

47. Table 5 reports the baseline estimates of Equation (2). The coefficients of the triple interaction terms, *Framework policy*ICT*growth at the frontier,* are estimated to be positive and significant in all specifications. The key results can be summarised as follows:

- In more ICT intensive industries, higher VC activity, measured by the amount invested in early stage deals (Column 1) are associated with higher spillovers from the productivity leader of the industry, relative to other industries.

- In more ICT intensive industries, increases in the number of policy programmes (i.e. tax and equity instruments) designed to nurture the market for seed and early stage venture capital is associated in with a higher rate of spillovers, relative to other industries.

12 The results are robust to using firm turnover rate as an alternative exposure variable.

- Column 3 explores the impact of stock market capitalisation on the spillover effect. The positive and significant coefficient on the triple interaction term suggests that in more ICT intensive industries, higher stock market capitalisation is associated with higher technology transfer from the productivity leader of the industry, relative to other industries.

Table 5. Financial and risk capital markets and learning from the frontier

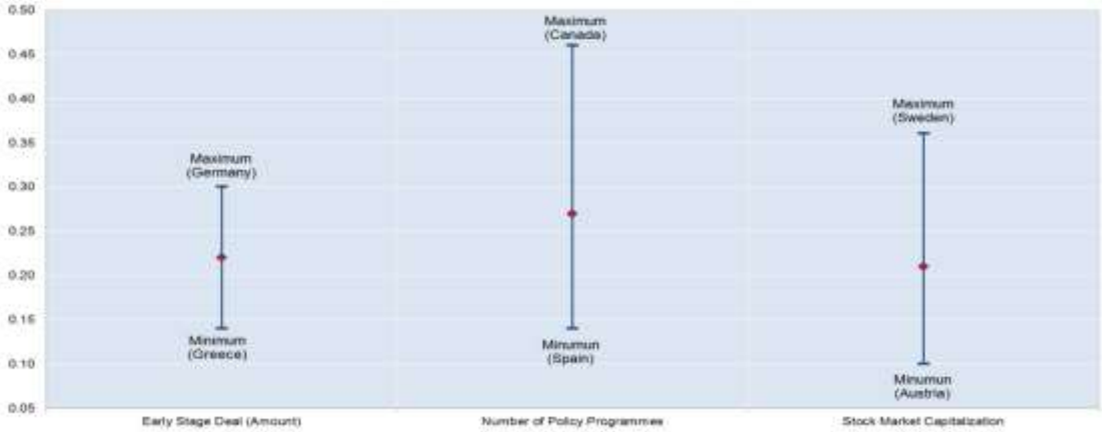
	Seed Policies and Developed Financial Markets		
	(1) Early Stage Deal (Amount)	(2) Number of Policy Programmes	(3) Stock Market Capitalization
Growth at the frontier (t)	0.0997*** (0.0258)	0.107*** (0.0250)	0.0895*** (0.0214)
Gap with frontier (t-1)	0.0343*** (0.00823)	0.0294*** (0.00659)	0.0297*** (0.00681)
Regulatory Burden Indicator (t-1)	-0.148* (0.0802)	-0.110 (0.0728)	-0.114 (0.0742)
Framework Policy (t-1) * ICT	0.00872 (0.0133)	0.00517 (0.00425)	0.0350 (0.0242)
Framework Policy (t-1) * ICT * Growth at the frontier (t)	0.235** (0.0928)	0.0998* (0.0542)	0.603*** (0.202)
Framework Policy (t-1) * ICT * Gap with frontier (t-1)	-0.0168 (0.0185)	-0.00947 (0.00709)	-0.0242 (0.0441)
Country*year fixed effects	yes	yes	yes
Industry fixed effects	yes	yes	yes
Observations	2514	3632	3632
R-squared	0.248	0.247	0.251

Notes: The standard errors are clustered at country*industry cells. The full sample covers all non-frontier industries for the years 1984-2007. The United States is excluded from the regressions since it is the benchmark country for ICT Intensity. Changes in the number of observations are due to data availability. See Table B9 for further results including the interaction of the regulatory burden indicator with the gap and frontier terms.

48. To illustrate the economic significance of these results, Figure 6 presents the estimated spillover effects associated with different levels of public policy settings. For example, assuming a 2% increase in MFP growth at the frontier, the estimated gain to annual MFP growth would be around 0.35 percentage points higher in a country with a higher number of programmes, such as tax incentives and government equity finance instruments (e.g. Canada), than in a country where the number of such policies is lower (e.g. Spain).

Figure 6. Financial and risk capital markets and learning from the global frontier

Estimated frontier spillover (% per annum) associated with 2% point increase in MFP growth at the global frontier



Notes: The chart shows how the sensitivity of MFP growth to changes in the frontier leader growth varies with different levels of framework policies and institutional environment. The diamond refers to the estimated frontier spillover effect associated with a 2% MFP growth at the frontier around the average level of the policy. The label “Minimum” (Maximum) indicates the country with the lowest (highest) value for the given policy indicator in a given reference year.

5.3 Robustness tests

49. The baseline results are generally robust to a number of common sensitivity tests, including: *i*) dropping one country and one industry at a time to ensure that the results are not driven by the inclusion of any particular country/industry; *ii*) using an alternative specification which includes country-time and industry-time fixed effects (Tables B3-B5); and *iii*) including the interaction of the regulatory burden indicator with the gap and frontier terms (Tables B6-B9).

50. The results are also broadly robust to including multiple structural drivers (Table B10) and policy interactions (Table B11) in the same model. For example, the role of basic research and R&D collaboration remains statistically significant when all innovation policies are included (Column 1) and some key framework policies are also controlled for (Columns 3 and 5). Moreover, the impact of barriers to entrepreneurship (Columns 2 and 4) and bankruptcy law (Columns 3 and 5) on frontier spillovers remain statistically after controlling for selected innovation policies and capital market indicators.

6. Conclusion

51. For much of the second half of the twentieth century, labour productivity grew rapidly in most OECD economies, fuelled by the adoption of a large stock of unexploited existing technologies. However, the slowdown in productivity growth over the past decade underscores the idea that as economies converge toward the global technological frontier, the ability to capitalise on new innovations developed at frontier becomes more important. Using industrylevel data for 15 countries over the period 1984-2007, this paper augments the neo-Schumpeterian framework to identify the relevant channels and policies that shape an economy’s ability to learn from the global productivity frontier. The ability to learn from the global frontier is stronger in economies that are more connected with the global frontier via trade; are more integrated in GVCs; allocate skills more efficiently and invest more in knowledge-based capital, such as R&D and managerial capital, and ICT infrastructure.

52. This paper identifies a set of policies relevant to maximising spillovers from the global productivity frontier including: *i*) policies that promote entry, efficient exit and civil justice efficiency; *ii*)

innovation policies; and *iii*) capital and financial risk markets. A number of relevant policy issues are identified. With respect to efficient resource allocation, bankruptcy laws that do not excessively penalize business failure, low entry barriers to entrepreneurship and an efficient judicial system are associated with higher global learning spillovers. Higher investment in basic research and policies that promote firm-university collaboration are found to be effective tools that increase the capability of countries to absorb external knowledge and technologies. Moreover, the results highlight the importance of well-developed capital markets and markets for seed and early stage finance in the diffusion of innovations from the frontier, thus reinforcing findings of previous research that showed the role of young firms in the development and adoption of radical innovations.

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APPENDIX A: DATA DESCRIPTION

- **Trade with the global frontier** is based on the OECD, STAN Database and represents the % of total trade flows (observed in our dataset) of country-industry *cs* with the country-industry leader at time *t*. Trade data is available only for manufacturing industries. Estimates presented in Table 2 are obtained using data over the period 1990-2007.

- **Participation in GVCs** is based on the OECD TiVA database, and is defined as the sum of the share of imported inputs in the overall exports of a country and of its exported goods and services used as imported inputs to produce other countries' exports. GVC data are available only for the years 1995, 2000 and 2005. Estimates presented in Table 2 are obtained using data over the period 1990-2007.

- **Skill Mismatch** is defined as the percentage of workers who are either over- or under- skilled and **Managerial Quality** refers to the average of proficiency scores (in literacy) of managers. Both measures are derived from the *OECD , Survey of Adult Skills* (2012). Cross-section data are at country*industry level.

- **Business R&D** is defined as the ratio of business R&D expenditures to value added and sourced from OECD, Main Science and Technology Indicators. Panel data are available at country*industry level.

- **E-government readiness index** is a combined indicator of the supply of, potential demand for and the maturity of e-government services from OECD, Internet Economy Outlook 2012. Cross-section data are at country level.

APPENDIX B: ADDITIONAL EMPIRICAL RESULTS

Table B1. Heterogeneous impact of learning from the frontier

	Close to the Frontier	Far from the Frontier
Growth at the frontier (t)	.468**	0.092
	(0.198)	(0.259)
Gap with frontier (t-1)	0.263***	0.0646**
	(0.059)	(0.025)
Country Fixed effects	yes	yes
Time fixed effects (5 years period)	yes	yes
Observations	159	369
R-squared	0.6576	0.4716

Notes: The standard errors are clustered at country level. The estimates are calculated from a regression of growth in labour productivity on frontier growth and lagged distance from the frontier, where the United States is the frontier economy and is thus excluded from the regression. The sample covers 60 countries over the period 1950-2013 and the data are averages over 5-year intervals Close to the frontier is defined as those country*year observations in the bottom quartile of the distance from the frontier distribution, while Far from the frontier refers to all other country*year observations.

Table B2. Trade and learning from the frontier

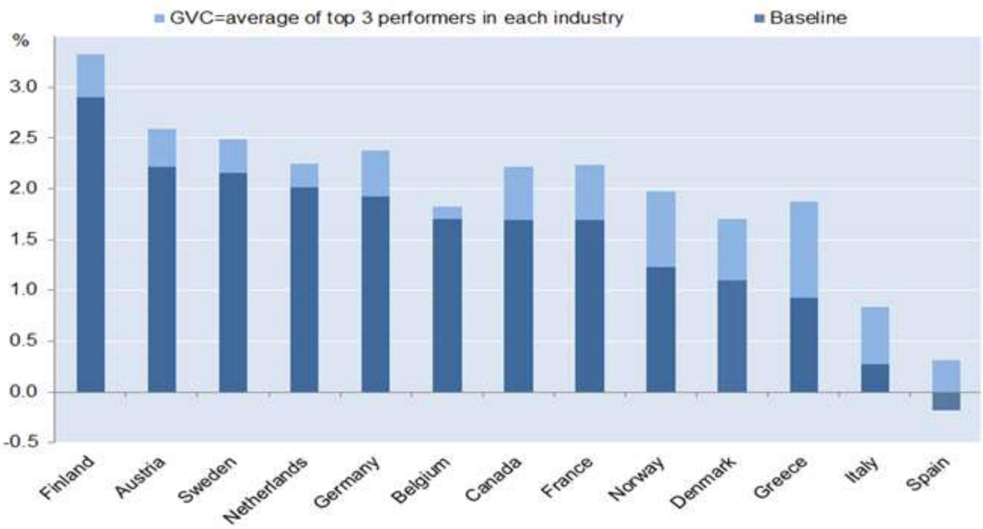
	(1)	(2)	(3)
Dependent Variable	Δ MFP	Δ MFP	Δ MFP
Growth at the frontier (t)	0.128***	0.136***	0.136***
	(0.0354)	(0.0352)	(0.0348)
Gap with frontier (t-1)	0.0619***	0.0632***	0.0637***
	(0.00809)	(0.00810)	(0.00798)
Regulatory Burden Indicator (t-1)	-0.114	-0.137	-0.130
	(0.158)	(0.163)	(0.163)
% Trade with High MFP Countries		-0.0141	
		(0.00999)	
% Trade with High MFP Countries * Growth at the frontier (t)		0.239**	
		(0.108)	
% Trade with Frontier Country			-0.00379
			(0.0127)
% Trade with High MFP Countries (excluding FT)			-0.0169
			(0.0104)
% Trade with % Trade with Frontier Country * Growth at the frontier (t)			0.223*
			(0.132)
% Trade with High MFP Countries (excluding FT) * Growth at the frontier (t)			0.268*
			(0.150)
Country*year fixed effects	yes	yes	yes
Industry fixed effects	yes	yes	yes
Observations	2177	2177	2177
R-squared	0.325	0.327	0.328

Notes: The standard errors are clustered at country*industry cells. The sample covers all non-frontier manufacturing industries for the years 1990-2007. % Trade with Frontier Country is defined as the % of total trade flows (observed in the sample) of country-industry *cs* with the industry leader in industry *s* at time *t*. % Trade with High MFP Countries is defined as the % of total trade flows of country-industry *cs* with all non-frontier country-industry pairs with High productivity at time *t*. A country-industry is defined as high productivity if its level of MFP is above the median observed in industry *s*.

Direct links between GVC participation and productivity

1. Participation in GVCs has a direct effect on MFP growth and an indirect effect by increasing the spillovers from the productivity leader in an industry. In order to show the potential direct productivity effects from increasing participation in GVCs, we simulate the MFP gains from raising the level of participation in GVCs in each industry. Figure B1 projects the predicted average MFP growth (baseline based on actual GVC participation) and a counterfactual average MFP growth based on raising GVC participation in each country to the average GVC participation for the top 3 performers in each industry for any given year for the manufacturing sector. Industry level productivity is aggregated using country-specific industry value-added shares. The results are derived from the estimates presented in Table 2.

Figure B1. Estimated gains to MFP growth associated with raising GVC participation



Source: OECD calculations based on OECD, TiVA database.

2. Tables B3-B5 replicate the results presented in Tables 3-5 using an alternative specification including country-time and industry-time fixed effects. For the sake of brevity, only the coefficients of the triple interaction terms of interest are reported.

Table B3. Framework policies and learning from the frontier: robustness checks

	Entry and Efficient Exit		Civil Justice Efficiency	
	(1)	(2)	(3)	(4)
	Barriers to Entrepreneurship	Cost of bankruptcy Legislation for Entrepreneurs	Trial Length	Modified Appeal
Framework Policy (t-1) * Turnover * Growth at the frontier (t)	-0.0034 (0.0027)	-0.0004*** (0.0001)	-0.0003** (0.0001)	1.358** (0.681)
Country*year fixed effects	yes	yes	yes	yes
Industry*year fixed effects	yes	yes	yes	yes
Observations	3632	4449	1618	2997
R-squared	0.3511	0.036	0.5688	0.3979

Notes: The standard errors are clustered at country*industry cells. The full sample covers all non-frontier industries for the years 1984-2007. The United States is excluded from the regressions since it is the benchmark country for R&D Intensity. Changes in the number of observations are due to data availability.

Table B4. Innovation policies and learning from the frontier: robustness checks

	Innovation Policies			
	(1)	(2)	(3)	(4)
	Government Intramural Expenditure on R&D (% GDP)	HERD (% GDP)	HERD financed by Industry (% GDP)	B-Index
Framework Policy (t-1) * R&D * Growth at the frontier (t)	5.524*** (2.171)	4.399** (2.108)	31.96*** (9.669)	0.0431 (0.0685)
Country*year fixed effects	yes	yes	yes	yes
Industry*year fixed effects	yes	yes	yes	yes
Observations	4449	4449	4449	4449
R-squared	0.3605	0.3615	0.3615	0.3597

Notes: The standard errors are clustered at country*industry cells. The full sample covers all non-frontier industries for the years 1984-2007. The United States is excluded from the regressions since it is the benchmark country for R&D Intensity.

Table B5. Financial and risk capital markets and learning from the frontier: robustness checks

	Seed Policies and Developed Financial Markets			
	(1)	(2)	(3)	(4)
	Early Stage Deal (Amount)	Cross-Border Early Stage Deal (Count)	Number of Policy Programmes	Stock Market Capitalization
Framework Policy (t-1) * ICT * Growth at the frontier (t)	0.287**	0.006**	0.1183*	0.8018***
	(0.136)	(0.003)	(0.063)	(0.272)
Country*year fixed effects	yes	yes	yes	yes
Industry*year fixed effects	yes	yes	yes	yes
Observations	2514	2774	3632	3632
R-squared	0.3746	0.3857	0.3522	0.3548

Notes: The standard errors are clustered at country*industry cells. The full sample covers all non-frontier industries for the years 1984-2007. The United States is excluded from the regressions since it is the benchmark country for ICT Intensity. Changes in the number of observations are due to data availability.

Table B6. Structural factors and spillovers from the frontier: robustness checks

	Structural Drivers					
	(1) Trade with the Frontier*	(2) Participation in GVCs	(3) Skill Mismatch	(4) Managerial Quality	(5) Business R&D	(6) E-government Readiness Index
Growth at the frontier (t)	0.213***	0.121***	0.128***	0.124***	0.160***	0.121***
	(0.0456)	(0.025)	(0.0242)	(0.024)	(0.0438)	(0.0231)
Gap with frontier (t-1)	0.0774***	0.0378***	0.0485***	0.048***	0.0425***	0.0433***
	(0.0104)	(0.0054)	(0.0059)	(0.005)	(0.00892)	(0.00513)
Regulatory Burden Indicator (t-1)	-0.135	-0.093	0.026	-0.180**	-0.0417	-0.0692
	(0.159)	(0.071)	(0.070)	(0.074)	(0.129)	(0.0654)
Relevant Structural Driver (t-1)	-0.00613	0.0013***	-0.0000	-0.00001	-0.000297	0.00399
	(0.0125)	(0.0003)	(0.0001)	(0.0001)	(0.000529)	(0.00363)
Relevant Structural Driver (t-1) * Growth at the frontier (t)	0.0767	0.01374*	-0.00601*	0.0024**	0.0101***	0.00142**
	(0.136)	(0.0072)	(0.0033)	(0.0009)	(0.00249)	(0.000651)
Relevant Structural Driver (t-1) * Gap with frontier (t-1)	-0.0199	0.00000	-0.0008*	0.0002	-0.000914	0.000239*
	(0.0266)	(0.0015)	(0.0004)	(0.0001)	(0.00107)	(0.000143)
Regulatory Burden Indicator (t-1) * Growth at the frontier (t)	-2.313***	-0.457	-0.0189	0.0001	-1.144	-0.0773
	(0.815)	(0.353)	(0.3089)	(0.311)	(0.733)	(0.294)
Regulatory Burden Indicator (t-1) * Gap with frontier (t-1)	-0.321**	0.175**	0.3515***	0.351***	0.272**	0.267***
	(0.131)	(0.074)	(0.0695)	(0.067)	(0.126)	(0.0755)
Country*year fixed effects	yes	yes	yes	yes	yes	yes
Industry fixed effects	yes	yes	yes	yes	yes	yes
Observations	2177	3953	4047	4026	1702	4629
R-squared	0.338	0.255	0.2569	0.2575	0.351	0.2576

Notes: The standard errors are clustered at country*industry cells. The full sample covers all non-frontier industries for the years 1984-2007. Changes in the number of observations are due to data availability.

Table B7. Framework policies and productivity spillovers from the frontier: robustness checks

	Entry and Efficient Exit		Civil Justice Efficiency	
	(1)	(2)	(3)	(4)
	Barriers to Entrepreneurship	Cost of bankruptcy Legislation for Entrepreneurs	Trial Length	Modified Appeal
Growth at the frontier (t)	0.112***	0.112***	0.104***	0.0924***
	(0.0260)	(0.0231)	(0.0260)	(0.0230)
Gap with frontier (t-1)	0.0349***	0.0402***	0.0260***	0.0405***
	(0.00534)	(0.00524)	(0.00713)	(0.00728)
Regulatory Burden Indicator (t-1)	-0.122	-0.0907	-0.0820	-0.0890
	(0.0799)	(0.0655)	(0.104)	(0.0833)
Framework Policy (t-1) * Turnover	-0.000286	-0.0000423	0.000000262	-0.209
	(0.000453)	(0.0000302)	(0.000000358)	(0.151)
Framework Policy (t-1) * Turnover * Growth at the frontier (t)	-0.00326*	-0.000443***	-0.00000328***	-1.071
	(0.00171)	(0.000139)	(0.00000113)	(0.676)
Framework Policy (t-1) * Turnover * Gap with frontier (t-1)	-0.000679*	-0.000111***	-0.00000137***	-0.300
	(0.000376)	(0.0000313)	(0.000000358)	(0.186)
Regulatory Burden Indicator (t-1) * Growth at the frontier (t)	-0.417	-0.317	-0.0717	-0.616*
	(0.352)	(0.315)	(0.312)	(0.368)
Regulatory Burden Indicator (t-1) * Gap with frontier (t-1)	0.130	0.257***	0.297***	0.247**
	(0.0807)	(0.0710)	(0.0790)	(0.0963)
Country*year fixed effects	yes	yes	yes	yes
Industry fixed effects	yes	yes	yes	yes
Observations	3632	4449	1618	2997
R-squared	0.249	0.259	0.361	0.273

Notes: The standard errors are clustered at country*industry cells. The full sample covers all non-frontier industries for the years 1984-2007. The United States is excluded from the regressions since it is the benchmark country for Firm Turnover Rates. Changes in the number of observations are due to data availability.

Table B8. Innovation policies and learning from the frontier: robustness checks

	Innovation Policies			
	(1)	(2)	(3)	(4)
	Government Intramural Expenditure on R&D (% GDP)	HERD (% GDP)	HERD financed by Industry (% GDP)	B-Index
Growth at the frontier (t)	0.0877***	0.0901***	0.0913***	0.0913***
	(0.0193)	(0.0188)	(0.0202)	(0.0195)
Gap with frontier (t-1)	0.0407***	0.0411***	0.0434***	0.0406***
	(0.00544)	(0.00520)	(0.00530)	(0.00530)
Regulatory Burden Indicator (t-1)	-0.0728	-0.0409	-0.0556	-0.0764
	(0.0677)	(0.0623)	(0.0644)	(0.0678)
Framework Policy (t-1) * R&D	0.0271	0.282*	3.608**	-0.186
	(0.194)	(0.148)	(1.432)	(0.182)
Framework Policy (t-1) * R&D * Growth at the frontier (t)	2.541**	1.193*	23.38***	0.507*
	(1.028)	(0.667)	(6.366)	(0.277)
Framework Policy (t-1) * R&D * Gap with frontier (t-1)	-0.180	0.0595	2.483	0.00298
	(0.275)	(0.148)	(3.050)	(0.0866)
Regulatory Burden Indicator (t-1) * Growth at the frontier	-0.630*	-0.585*	-0.600*	-0.647*
	(0.322)	(0.333)	(0.313)	(0.347)
Regulatory Burden Indicator (t-1) * Gap with frontier (t-1)	0.238***	0.225***	0.231***	0.229***
	(0.0700)	(0.0678)	(0.0669)	(0.0703)
Country*year fixed effects	yes	yes	yes	yes
Industry fixed effects	yes	yes	yes	yes
Observations	4449	4449	4449	4449
R-squared	0.257	0.258	0.259	0.256

Notes: The standard errors are clustered at country*industry cells. The full sample covers all non-frontier industries for the years 1984-2007. The United States is excluded from the regressions since it is the benchmark country for ICT Intensity. Changes in the number of observations are due to data availability.

Table B9. Financial and risk capital markets and learning from the frontier: robustness checks

	Seed Policies and Developed Financial Markets		
	(1) Early Stage Deal (Amount)	(2) Number of Policy Programmes	(3) Stock Market Capitalization
Growth at the frontier (t)	0.0989***	0.0903***	0.118***
	(0.0246)	(0.0208)	(0.0257)
Gap with frontier (t-1)	0.0411***	0.0334***	0.0331***
	(0.00771)	(0.00539)	(0.00512)
Regulatory Burden Indicator (t-1)	-0.132	-0.0943	-0.0968
	(0.0813)	(0.0746)	(0.0731)
Framework Policy (t-1) * ICT	-0.000869	0.0196	0.00228
	(0.00891)	(0.0177)	(0.00361)
Framework Policy (t-1) * ICT * Growth at the frontier (t)	0.290***	0.601***	0.0771
	(0.0862)	(0.153)	(0.0552)
Framework Policy (t-1) * ICT * Gap with frontier (t-1)	-0.00495	0.00612	-0.00737
	(0.0170)	(0.0409)	(0.00787)
Regulatory Burden Indicator (t-1) * Growth at the frontier	-0.224	-0.228	-0.324
	(0.348)	(0.318)	(0.347)
Regulatory Burden Indicator (t-1) * Gap with frontier (t-1)	0.212**	0.139*	0.137*
	(0.0941)	(0.0790)	(0.0824)
Country*year fixed effects	yes	yes	yes
Industry fixed effects	yes	yes	yes
Observations	2650	3768	3768
R-squared	0.258	0.256	0.252

Notes: The standard errors are clustered at country*industry cells. The full sample covers all non-frontier industries for the years 1984-2007. The United States is excluded from the regressions since it is the benchmark country for ICT Intensity. Changes in the number of observations are due to data availability.

Table B10. Including several structural variables together: robustness checks

	(1)	(2)	(3)
Particiation in GVCs * Growth at the frontier (t)	0.0112*	0.0117*	0.0104
	(0.00661)	(0.00682)	(0.00672)
E-Government Readiness Index* Growth at the frontier (t)	0.00134*		
	(0.000725)		
Skill Mismatch * Growth at the frontier (t)		-0.00490	
		(0.00364)	
Managerial Quality * Growth at the frontier (t)			0.00264**
			(0.00109)
Country*year fixed effects	yes	yes	yes
Industry fixed effects	yes	yes	yes
Observations	3953	3426	3409

Notes: The standard errors are clustered at country*industry cells. The full sample covers all non-frontier industries for the years 1984-2007. Changes in the number of observations are due to data availability. Regressions include the variable Structural Driver and interactions between Structural Driver and Gap.

Table B11. Including several policies together: robustness checks

	(1)	(2)	(3)	(4)	(5)
Government Intramural Expenditure on R&D (% GDP) * R&D * Growth at the frontier (t)	3.650*	0.686	1.961**		
	(1.991)	(1.000)	(0.987)		
HERD financed by Industry (% GDP) * R&D * Growth at the frontier (t)	22.91*			9.485	17.64***
	(11.64)			(6.111)	(5.413)
B-Index * R&D * Growth at the frontier (t)	-1.439				
	(0.907)				
HERD (% GDP) * R&D * Growth at the frontier (t)	1.159				
	(1.566)				
Barriers to Entrepreneurship (t-1) * Turnover * Growth at the frontier (t)		-0.00361**		-0.00336*	
		(0.00171)		(0.00176)	
Stock Market Capitalization (t-1) * ICT * Growth at the frontier (t)		0.530***		0.505**	
		(0.193)		(0.210)	
Cost of Bank. Leg. For Entrep. (t-1) * Turnover * Growth at the frontier (t)			-0.000328**		-0.000287*
			(0.000160)		(0.000159)
Number of Policy Programmes (t-1) * ICT * Growth at the frontier (t)			0.0495		0.0502
			(0.0443)		(0.0487)
Country*year fixed effects	yes	yes	yes	yes	yes
Industry fixed effects	yes	yes	yes	yes	yes
Observations	4449	3632	3632	3632	3632
R-squared	0.258	0.253	0.252	0.255	0.254

Notes: The standard errors are clustered at country*industry cells. The full sample covers all non-frontier industries for the years 1984-2007. Regressions include interactions Framework Policy * Exposure Variable and Framework Policy * Exposure Variable* Gap. The United States is excluded from the regressions since it is the benchmark country for exposure indicators. Variables where selected in order to have a similar coverage of countries and industries.

APPENDIX C: SERVICES, PRODUCTIVITY AND LEARNING FROM THE FRONTIER

Efficiency of the services sector and GVC participation

1. An efficient domestic services sector enhances the benefits of participation in GVCs, and hence facilitates the diffusion of new technologies. This box explores the extent to which policy factors magnify the positive effects of GVCs by looking at the case of regulation in services sector.

2. The impact of professional services regulation on productivity is explored using the following model:

$$\Delta\, \mathrm{MFP}_{cs,t} = \beta_1 \Delta\, \mathrm{MFP\ Frontier}_{s,t} + \beta_2 * \mathrm{gap}_{cs,t-1} + \beta_3 * (\mathrm{PSR}_{ct-1} * \mathrm{GVC}^{j}_{usa}) + \delta_s + \delta_{ct} + \varepsilon_{cs}$$

where PSR_c represents the professional services regulation in country c. To gain within country variation, the policy variable of interest is interacted with industry-level GVC participation in industry j using US data (GVC^{j}_{usa}). The intuition behind this approach is that more stringent regulation should disproportionally affect those sectors that rely more on service inputs (i.e. characterized by high GVC participation).

Table C1. Professional services regulation and productivity growth

	(1)	(2)
Growth at the frontier (t)	0.108***	0.108***
	(0.0265)	(0.0265)
Gap with frontier (t-1)	0.295***	0.0296***
	(0.0067)	(0.0066)
Professional Service Regulation (t-1) * GVC USA		-0.000876*
		(0.000497)
Country*year fixed effects	yes	yes
Industry fixed effects	yes	yes
Observations	3632	3632
R-squared	0.244	0.245

Notes: The standard errors are clustered at country*industry cells. The full sample covers all non-frontier industries for the years 1984-2007. The United States is excluded from the regressions since it is the benchmark country for GVC participation.

3. In line with the mechanism described in the main text, the results in Table C1 provide evidence of the negative correlation between professional services regulation and productivity growth in industries highly exposed to GVCs. For example, reducing professional services regulation from the high level in Germany to the lower level in Denmark would increase the differential in annual MFP growth between an industry with high GVC participation (e.g. electrical and optical equipment) and a low participation industry (e.g. construction) by around 0.3 percentage points.

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