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Regulation, Allocative Efficiency and Productivity in OECD Countries: Industry and Firm-Level Evidence

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ABSTRACT/RESUME

Regulation, Allocative Efficiency and Productivity in OECD Countries: Industry and Firm-Level Evidence

This paper relates diverging productivity performances across OECD countries over the past fifteen years to differences in the stringency of regulations in the product market. We first summarize industry-level evidence linking these diverging patterns to delays in service markets reforms in the wake of the ICT shock. The evidence we survey suggests that, especially in continental EU countries, tight regulation of services has slowed down growth in ICT-using sectors, which use intermediate service inputs intensively. Based on harmonised cross-country firm-level data, we then provide new evidence that one of the key channels through which inappropriate service regulations affect productivity growth is by hindering the allocation of resources towards the most dynamic and efficient firms. At the industry level, resources were allocated less efficiently across firms in countries where service regulations are less market-friendly. Firm-level econometric estimates confirm that anti-competitive service regulations hamper productivity growth in ICT-using sectors, with a particularly pronounced effect on firms that are catching up to the technology frontier and that are close to international best practice. In other words, regulations hurt in particular those firms that have the potential to excel in domestic and international markets.

JEL Codes: D24, E23, K23, L11, L51
Keywords: productivity; product market regulation; allocative efficiency; firm-level data

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Réglementation, allocation des ressources et productivité dans les pays de l'OCDE: évidence empirique au niveau des secteurs et des entreprises

Cette étude établi un rapport entre trajectoires divergentes de productivité dans les pays OCDE pendant les dernières 15 années, et différences dans la rigidité de la réglementation sur les marchés des biens. La première partie du papier résume les résultats empiriques existants au niveau des industries sur le rapport entre productivité et réglementation dans les secteurs de services, ainsi que son rapport avec le choc technologique dans les technologies de l'information et de la communication (TIC). L'évidence empirique que nous examinons suggère qu'en particulier dans les pays d'Europe continentale la réglementation rigide a ralenti la croissance dans les secteurs «utilisateur des TIC», qui utilisent de manière intensive les services réglementés. Sur la base de données harmonisées au niveau des entreprises, ce papier présente ensuite des résultats nouveaux qui montrent que l'effet de la réglementation sur la croissance de la productivité se transmet principalement à travers des obstacles à l'allocation des ressources vers les entreprises les plus dynamiques et efficientes. L'allocation des ressources au sein de chaque industrie est moins efficiente dans les pays ayant une réglementation plus rigide dans les secteurs des services. Nos estimations économétriques au niveau des entreprises montrent ensuite que la réglementation des services réduit la croissance de la productivité dans les secteurs « utilisateur des TIC », avec un effet particulièrement prononcé sur les entreprises qui sont proches de la frontière technologique et y convergent rapidement. Autrement dit, la réglementation nuit surtout aux entreprises qui ont le plus haut potentiel de succès dans les marchés nationaux et internationaux.

Codes JEL: D24, E23, K23, L11, L51
Mots clé: productivité, réglementation dans les marchés des biens; efficience dans l'allocation de ressources; données individuelles d'entreprise

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REGULATION, ALLOCATIVE EFFICIENCY AND PRODUCTIVITY IN OECD COUNTRIES: INDUSTRY AND FIRM-LEVEL EVIDENCE

Jens Arnold, Giuseppe Nicoletti and Stefano Scarpetta[1]

Introduction

1. The past decade has witnessed major changes in the growth performance of OECD countries. Some of them – including the United States, Australia and a number of smaller European economies - have managed to reverse the long-standing slowdown in productivity growth.[2] Other countries, including most continental European ones (as well as Japan), have been lagging behind, with stagnating or decelerating productivity growth. As a result, the income gap of the EU as a whole worsened relative to the United States, even discounting the effects of German unification. This reversal in the historical process of economic convergence among OECD countries is puzzling because it coincided with a period of policy convergence in many areas, such as macroeconomic stabilisation, trade and product market liberalisation and greater financial integration. The dichotomy between growth performances and policy convergence over the past decade has been related to the different ability of OECD countries to harness the potential benefits of a new general-purpose technology – the information and communication technology (ICT).[3] It was originally thought that cross-country growth divergence was only temporary – associated to the technology shock in ICT-producing industries (*e.g.* Oliner and Sichel, 2000; Gordon, 2000). But, in fact – productivity and output growth differentials have persisted well into the new millennium, further widening the gap in living standards between the United States and many EU countries. The industry sources of these divergent growth paths have also evolved, with a greater role played by productivity acceleration in ICT-using industries (*e.g.* Triplett and Bosworth, 2004; Basu and Fernald, 2006).[4]

2. A number of theoretical and empirical studies have tried to explain the growth disparities of the past decade. Many have indicated that, despite some convergence in policy settings, there remain major

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1. OECD Economics Department. This paper was prepared for the ECB-Banque de France-Conference Board Conference on "The Creation of Economic and Corporate Wealth in a Dynamic Economy" (Frankfurt, 16-17 January 2008). We thank conference participants, and in particular the two discussants, Juan Jimeno and Donald Coletti, as well as Jean-Luc Schneider, Bart van Ark, John van Reenen and Paul Conway for their insightful comments, and Irene Sinha for editorial assistance.The views expressed in this paper are those of the authors and should not be taken to represent those of the OECD member countries.

2. Among smaller European economies, there were starkly contrasting developments: productivity continued to grow fast in Ireland, some Nordic countries, Portugal and Greece, while its growth remained disappointing in the Netherlands, Spain and, especially, Switzerland.

3. Some early studies have emphasised the significant acceleration in multifactor productivity in computer and semiconductor production and its effects on IT investment in other sectors of the economy (Oliner and Sichel, 2000; Jorgenson, Ho and Stiroh, 2000; Gordon, 2000; and the survey by Anderson and Kliesen, 2006). More recently, other studies have emphasised the strong acceleration of MFP in service sectors, resulting from both organisational changes related to IT and a better allocation of resources in service industries (Basu and Fernald, 2006; Triplett and Bosworth, 2004; Bosworth and Triplett, 2007a; Bosworth and Triplett, 2007b).

4. See Annex 2 for the classification of ICT-producing, ICT-using and non-ICT using industries adopted in this paper.

differences in the business environment of the OECD countries, with significant effects on the incentives to innovate and adopt new technologies.[5] Indeed, the past decade was seen as a sort of "natural experiment": OECD countries with different policies and institutions were exposed to the rapid diffusion of a new general-purpose technology that required a business environment encouraging experimentation and fast reallocation of resources across sectors and firms to accommodate and make the best use of technological developments. [6,7] Empirical research in this field has rapidly moved from aggregate analyses to sectoral and, more recently, firm-level studies: cross-country gaps in aggregate growth performances were shown to depend to a large extent on the performance of key ICT-"intensive" sectors (*e.g.* Triplett and Bosworth, 2004; van Ark *et al.* 2003, 2007) and on the ability, within these sectors, to nurture technology adoption and innovation through the entry of new firms and the retooling of existing businesses (Bartelsman *et al.* 2004*;* Brynjolfsson and Hitt, 2000).

3. The list of policy and institutional factors that are likely to promote experimentation and efficient resource reallocation across sectors and firms is long. A substantial literature has examined the impact of credit constraints on firm dynamics and technology adoption (*e.g.* Rajan and Zingales, 1998; Beck *et al.* 2004*;* Klapper *et al.* 2006; Aghion *et al*. 2007). A more limited number of studies have looked at the role of labour market regulations in influencing labour reallocation and the adaptability of firms to technological shocks (Haltiwanger *et al*. 2006; Micco and Pagés, 2006). More recently, the empirical literature has increasingly been focusing on regulations in the product market, especially those that affect competitive pressures. Interest in competition as one of the main drivers of efficiency improvements, was revived by so-called neo-Schumpeterian theories of growth, which focused on the effects of new entry and rivalry among incumbents on technology adoption, innovation and productivity growth. Some studies have focused on policy-induced entry barriers (*e.g.* Scarpetta *et al*. 2002; Scarpetta and Tressel, 2002; Nicoletti and Scarpetta, 2003; Arnold *et al.* 2007, Desai *et al.* 2003*;* Fishman and Sarria Allende, 2004; Griffith *et al*. 2004; Conway *et al*. 2006), while others have used foreign entry to proxy for competitive pressure on domestic incumbents (*e.g.* Aghion *et al.* 2004; Griffith *et al.* 2006). This empirical research has also been motivated by the large cross-country variability in policy choices in this area and the sheer magnitude of reforms explicitly aimed at promoting competition and productivity growth in OECD countries.[8]

4. In this paper we take a fresh look at the relationship between competition policies and productivity growth focusing on the divide between relatively "deregulated" English-speaking countries and relatively "restrictive" continental European countries. Relying on both recent empirical results and new evidence at both the industry and firm levels, we argue that the relationship between the pace and

5. Studies on the links between competition and growth are surveyed by Aghion and Griffith (2005); Acemoglu et al. (2005) provided theoretical foundations. For cross-country empirical analyses see e.g. Scarpetta and Tressel, (2002); Nicoletti and Scarpetta (2003); Conway et al. (2006); Griffith, et al. (2006).

6. Resource reallocation is driven by incumbent firms adapting to market and technological changes, but also by firm dynamics – the entry of new firms, their expansion in the initial years of life and the exit of obsolete units. Interestingly, while the magnitude of firm demographics is fairly similar across US and EU countries with different institutional and policy settings, the characteristics of entrants and exiters, their growth performance and overall contributions to technological adoption and ultimately to productivity growth vary considerably (Foster et al. 2006; Bartelsman et al. 2004; Griffith et al. 2006).

7. Firm-level analyses have for long been largely concentrated in the United States, but in recent years a number of studies have focused on EU countries and some have even ventured in cross-country comparisons. The latter suggest that all market economies are characterised by a continuous process of reallocation of resources and that this process plays a major role for aggregate productivity and output growth (e.g. Olley and Pakes, 1996; Foster et al. 2002; Griliches and Regev, 1995; Bartelsman *et al.* 2004).

8. In an early attempt to relate reforms to growth, Koedijk and Kremers (1996) noted that policy changes in European product markets have sometimes been deeper than reforms in labour markets.

depth of product market reforms – and in particular reforms in those aspects of regulations more influential for firm dynamics and resource reallocation – and the timing of the ICT shock are important for understanding the growth divergence between these two groups of countries. In many of them, notably in continental Europe, product market reforms in key non-manufacturing sectors have indeed been slow and hesitant. These sectors are important both on their own right and because they provide key intermediate inputs to the ICT-using sectors that have driven productivity growth in many OECD countries over the recent past. Hence, our working hypothesis is that productivity growth in ICT-using sectors may have suffered from the lack of non-manufacturing reforms in three main ways: barriers to entry in some of them (*e.g.* retail trade and business services) reduced the scope of the creative destruction process -- the entry and exit of firms and reallocation among incumbents; the resulting low competitive pressures weakened incentives for incorporating and using efficiently ICT in production processes; and low quality and/or high costs of non-manufacturing inputs, in which ICT-using sectors are particularly intensive, limited the ability to reap the efficiency gains originating from the changes in the organisation of production that ICT allow.

5. To substantiate these claims we proceed in steps. We first show, by means of an original set of OECD indicators of the "knock-on" effects of non-manufacturing regulation, that the burden of inappropriate regulations has been disproportionately high in ICT-using sectors of many continental EU countries. Then, relying on existing industry-level econometric results, we show that these regulatory burdens have led to slower productivity growth in the ICT-using industries of these countries. Finally, using harmonised industry-level and firm-level data we provide new evidence on the relationship between regulation and the efficiency of resource allocation across sectors and firms in countries for which these data are available. This leads to several conclusions:

- First, there is a significant heterogeneity of productivity performance across sectors in OECD countries and, within each of them, across firms. This heterogeneity, in turn, highlights the importance of an efficient allocation of resources to promote aggregate productivity growth.

- Second, across industries (and especially within the ICT-using set) resources are allocated less efficiently where anti-competitive regulations are severe.

- Third, anti-competitive regulations tend to be associated with a weaker ability of sectors and countries to allocate resources to the most dynamic and productive firms.

- Finally, the negative effects of anti-competitive product market regulations on firm productivity are concentrated in ICT-using sectors, with a particularly pronounced effect on firms that are in the process of catching up to the technology frontier and that are not far from international best practice. In other words, regulations hurt in particular those firms that have the potential to excel in domestic and international markets.

6. The rest of the paper is organised as follows. In Section 2, we review the theoretical linkages between anti-competitive product market regulations, investment, resource reallocation, innovation and ultimately productivity growth. Relying on OECD indicators, we also briefly discuss how differences across countries in these regulations have evolved over time and hit differently ICT-using sectors. We then move in Section 3 to the evidence on the regulation-productivity linkage at the aggregate, sectoral and firm levels. After a brief reminder of cross-country growth patterns, we show how differences in regulation have interacted with the ICT supply shock to shape divergence in growth performances over the past two decades, focusing on ICT investment and the performance of ICT-using sectors. We then examine more in detail how differential growth performances have been affected by the ability of OECD economies to reallocate resources to fast growing sectors and firms. In this context, we present new econometric evidence on how product market regulations affect productivity performance of different firms in a sample of EU countries. Section 4 provides some concluding remarks.

II. The effects of product market regulation on productivity

II.1 How does regulation affect productivity?

7. Product market regulations, like other regulations, generally address public interest concerns about market failures, including monopoly conditions, externalities and asymmetric information. In this context, product market regulation can promote competition in certain industries by ensuring that market power in natural monopoly segments is not used abusively and by providing the correct incentives to market participants. However, regulatory frameworks may be flawed by several (possibly concurring) factors. Some regulations may drift away from their original public interest aims, resulting in the protection of special interest groups. Second, regulations (and their implementation) sometimes involve costs that exceed their expected benefits, leading to so-called "government failure". Third, technical progress, the evolution of demand and progress in regulatory techniques can make the design of regulations obsolete.

8. Inappropriate regulations can affect the productivity performance of an economy in many ways. They can influence the productivity of existing firms by altering the incentives to invest, adopt the leading technologies available in the market and innovate. They can raise entry costs, curbing competitive pressure and hindering the reallocation of resources across sectors producing different goods and services and, within each sector, across firms with different productivities. To the extent that a lack of competitive pressure results in higher prices, this can generate trickle-down effects into downstream sectors by raising the costs of intermediate inputs, particularly in services industries where import competition is limited. Regulation can also have differential effects on different industries and firms depending on specific technological and market factors as well as on their position relative to frontier production techniques.

9. Given the multiple channels and the potentially conflicting effects, it is hard to provide a single and exhaustive taxonomy of the regulation-productivity linkages.[9] This section briefly reviews some of the ways in which regulations that inappropriately raise barriers to entry and firms' costs can influence productivity under two main headings: the effects on incumbent firms and the effects through firm dynamics and the associated resource reallocation.[10] Needless to say, we cannot give justice to the vast theoretical literature linking product market competition and productivity and just refer to the studies most closely related to our subsequent empirical analysis.

Regulation and the productivity of incumbents

10. There are three main ways in which policies that ease regulatory burdens and restrictions to competition (where competition is viable) can affect the productivity performance of incumbent firms: they can contribute to eliminate the slack in the use of resources, enhance capital intensity and increase innovative efforts. In the following we will subsume into these efforts both the adoption of frontier technologies and more fundamental innovation activities.

Regulation and slack

11. Product market policies that promote entrepreneurship and competition contribute to productivity improvements by raising the efficiency with which inputs are used (see Winston, 1993, for a review).[11]

9. For two recent attempts, see Griffith and Harrison (2004) and Crafts (2006).

10. In other words, we concentrate on ways in which ill-designed regulations can harm productivity. We do not discuss the potential benefits of appropriate regulations for productivity.

11. A related channel is the elimination of the deadweight loss associated with regulatory burdens (see Crafts, 2006).

These policies help to eliminate organizational slack, particularly managerial slack or reduced work effort in situations of asymmetric information or moral hazard. For example, competition creates greater opportunities for comparing performance, making it easier for the owners or the market to monitor managers. Competition is also likely to raise the risk of losing market shares at any given level of managerial effort, inducing managers to work harder so as to avoid this outcome. Moreover, cost-reducing productivity improvements also generate a higher bang-for-the-buck in competitive environments in which the price elasticity of demand is higher.[12] To the extent that workers share product market rents with managers, more competition can also induce more worker effort (Haskel and Sanchis, 2000). Finally, business-friendly regulations may make it easier to implement efficiency improvements by reshuffling resources within and across establishments. [13]

12. It should be stressed that theoretical predictions of the effects of greater competition on managers' incentives are often subtle and ambiguous (Vickers, 1995; Schmidt, 1997). Models using explicit incentives under information asymmetry do not lead to clear-cut implications (see *e.g.* Holmström, 1982), while inter-temporal models using implicit (*i.e.* market-based) rewards suggest a positive link between competition and managerial effort only if productivity shocks are more correlated across competitors than managerial abilities (Meyer and Vickers, 1997). But, competition could also lead to more slack if managers are highly responsive to monetary incentives, as the scope for performance-related pay is reduced (Scharfstein, 1988; Martin, 1993).

Regulation, investment and technology adoption

13. In a recent study, Alesina *et al.* (2005) suggest that less red tape and lighter regulatory burdens lower the costs of adjusting the capital stock, thereby boosting the willingness of firms to react to changes in fundamentals by expanding their productive capacity. In their model an extension of the monopolistic competition model by Blanchard and Giavazzi (2003) to two factors of production a reduction in barriers to entry increases the number of firms, leading to a decrease in the mark-up of prices over marginal costs and, therefore, of the shadow cost associated with capital and output expansion by incumbent firms. In the long run, this is likely to expand activity levels and stimulate capital formation. Their empirical results show that restrictive regulations contribute to explaining the diverging patterns of investment rates in services on the two sides of the Atlantic over the past two decades.

14. However, the effects of regulation on productivity through capital deepening are not straightforward for a number of reasons. First and foremost, while labour productivity rises with higher capital-labour ratios, the relationship between capital deepening and multifactor productivity is ambiguous: to the extent that an increase in the capital-labour ratio is induced by policies or institutions that distort relative factor prices, multifactor productivity may suffer. For instance, Poschke (2007) argues that more costly regulations in Europe have tilted firms' technology choices towards higher capital intensity than in the United States, which reduced multifactor productivity by acting as an entry barrier that protects low-productivity incumbents.[14] Second, recent theoretical and empirical research (*e.g.* Blanchard and Giavazzi,

12. These channels are highlighted by Hart (1983), Lazear and Rosen (1981), Nalebuff and Stiglitz (1983); Aghion and Howitt (1998) and Nickell, Nicolitas and Dryden (1997).

13. For instance, Lagos (2006) provides a model that relates multifactor productivity to labour market regulations faced by entrepreneurs. The effects on growth trajectories of reforms that improve the efficiency in the use of inputs have been recently stressed by Bergoeing *et al.* (2002), among others.

14. Using a standard heterogeneous-firm model, Poschke (2007) shows that small differences in administrative entry costs can explain a significant proportion of US-EU differences in capital-output ratios and multifactor productivity. In his model, higher entry costs induce both a higher equilibrium capital intensity and a lower investment rate, due to less firm entry. Thus, his findings are consistent with the inverse relationship between regulation and investment rates found by Alesina *et al.* (2005).

2003; Griffith *et al.* 2007; Fiori *et al.* 2007) has shown that product market regulation also tends to lower employment. Hence, the net effect of these regulations on capital deepening is not clear a priori. Third, different types of regulations are likely to have different effects on capital formation. For instance, certain regulations, such as ceilings on the rate of return on capital, encourage firms to over accumulate capital in order to increase their overall remuneration – the so-called Averch-Johnson (1962) effect. Moreover, ill-designed de-regulation can fail to provide the right incentives to expand capacity.[15]

15. The effects of lighter product market regulation on productivity through technology adoption are more clear-cut. The opening up of markets and increased competitive pressures provide both opportunities and incentives for firms to upgrade their capital stock and adopt new technologies to reach frontier production techniques, though this may depend on their distance to frontier (see below). The role of regulatory barriers and monopoly rights in curbing or preventing technology adoption has been illustrated in a series of studies by Parente and Prescott (*e.g.*1994; 1999) who pointed out, using calibrated neo-classical growth models with technology adoption, that differences in such barriers could help explain persisting cross-country differences in GDP per capita levels. Another class of models has focused on the role of new technologically advanced entrants. Firms may come with new technology, often embodied in new capital stock, and this gives incumbents the opportunity to upgrade their capital through imitation. Aside from pure imitation, incumbents may also benefit from various kinds of externalities originating from affiliates of foreign multinationals such as exposure to foreign high-technology intermediate inputs (Rodríguez-Clare, 1996) and learning spillovers for the host-country labour force (Fosfuri *et al.* 2001).[16] While the empirical evidence is mixed, recent cross-country and micro-economic studies suggest that these effects are significant, especially in the developed countries and where absorptive capacity is high, indicating that an increase in the presence of foreign affiliates is likely to be associated with higher levels of multifactor productivity.[17]

16. Recent neo-Schumpeterian models of endogenous growth (*e.g.* Acemoglu *et al*. 2003) include the feature that, with technology flowing unfettered across countries, productivity growth in follower countries or industries is a positive function of the gap between the productivity level of the country or industry and the world technological frontier. In other words, countries and industries lagging behind the technological frontier can promote productivity also 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 innovate, with the importance of the latter increasing as the country or industry gets closer to the world frontier (Aghion and Howitt, 1998 Ch.8).[18] It should be stressed, however, that neo-Schumpeterian research finds the aggregate impact of (domestic or foreign) competition on productivity to be non-linear and to depend on the characteristics of incumbent firms (*e.g.* on the degree of firm heterogeneity). We discuss these issues below in the context of the effects of competition on innovation.

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15. In particular, certain sectors such as network industries have been subject to a re-design of price regulation (*e.g.* from rate of return to price caps or access pricing regimes), changes in industry structure (*e.g.* vertical separation of networks from service provision) and ownership structure (*e.g.* privatization), with uncertain effects on capital formation. Regulatory risk due to a frequently changing regulatory framework can also have implications for investment behaviour.

16. The role of "knowledge capital" in multinational enterprises, which provides the basis for spillovers to host-country firms, has recently been summarised by Markusen (2002).

17. This literature has been recently surveyed by Keller (2004) and Görg and Greenaway (2004). For studies finding positive spillovers, see for instance Haskel *et al.* (2002), Griffith *et al.* (2006), Javorcik (2004) and Arnold *et al.* (2007). Recently, the attention has been focused on the precise channels through which these spillovers occur (see, for instance, Crespi *et al.* 2007).

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

Innovation

17. Regulations that promote or hinder competition can influence innovative activities of incumbent firms through several channels. Research focusing on the effects of competition on innovation has a long history but theoretical and empirical studies have been growing rapidly over the past decade, as surveyed recently by Aghion and Griffith (2005). Here, we will just review some landmark results that will be useful in understanding our later empirical analysis, focusing on models that allow for an effect of competition on aggregate productivity growth through its effect on innovation. Two main effects are at work: the so-called "appropriability" effect that stresses the need for innovating firms (new entrants or incumbents) to expect a sufficient level of post-innovation rents; and the "escape competition" effect that stresses the need for incumbents to innovate in order to preserve their pre-innovation rents, when faced with the possibility that their rivals (new entrants or incumbents) may innovate.

18. Early analyses focused mainly on the appropriability effect and post-innovation rents (in the Schumpeterian spirit). In this framework, the main source of aggregate innovation originates from new entrants and the "creative destruction" process through which inefficient incumbents are replaced by new innovating firms. Because tighter competition reduces the expected post-innovation rents, a generally negative effect of increased competition on innovation efforts (and therefore productivity) of incumbents is expected, except under very special conditions (*e.g.* perfect protection of intellectual property rights).[19]

19. More recent "neo-Schumpeterian" analyses have questioned this view in several ways. First, they stressed that, as competitive pressures increase, what is relevant for incumbents' innovation incentives is their effect on the *difference* between pre and post-innovation rents or, equivalently, whether the escape competition effect dominates the appropriability effect (Aghion *et al*. 2005).[20] If the escape competition effect is sufficiently strong, incumbents will engage in innovation when faced with tougher competition.[21] These models therefore potentially allow innovation by both new entrants and incumbents. However, as competition becomes tough enough to substantially reduce post-innovation rents, the escape competition effect may not dominate anymore and incumbents may cease to innovate in response to increased competition. Thus, the relationship between aggregate innovation (and productivity) and competitive pressures is likely to be hump-shaped, with too little or too much competition being harmful for innovative efforts (for a given protection of intellectual property rights). Moreover, when entry of firms operating at the world technological frontier is explicitly accounted for, neo-Schumpeterian models imply that the positive escape competition effect on incumbents' innovative activities will be stronger for firms whose cost structure is close to that of their innovating rivals than for firms that have a large technological gap to fill (Aghion *et al*. 2004; Aghion *et al*. 2006). The reason is that a "discouragement" effect is at work: the innovation effort needed of firms that are "neck-and-neck" to maintain the lead over their rivals is smaller than the effort required from firms that are further back on the technology scale.[22] Indeed, for firms that are far enough from the world frontier, the discouragement effect due to an increase in entry (which can reflect competition in a market) can be strong enough to deter any innovation activity. This highlights the

19. Negative effects of competition on innovation by incumbents are a feature that is common to a wide variety of models of endogenous technical change in which entry of new firms is the only source of innovation (Romer, 1990; Aghion and Howitt, 1992; Grossman and Helpman, 1991).

20. This insight of neo-Schumpeterian theories is related to earlier analyses of the interplay between the "rent dissipation" effect and Arrow's (1962) "rent replacement" effect (Gilbert and Newbery, 1982; Fudenberg and Tirole, 1986).

21. A related effect of competition on incumbents' innovation incentives (the "restructuring" effect) had been previously unveiled by Aghion and Schankerman (2003) in a model with heterogeneous firms, in which competition would encourage high-cost firms to innovate in order to avoid losing market shares to low-cost rivals.

22. An early model with gradual innovation, in which neck-and-neck firms coexist with firms that lag further behind was proposed by Aghion *et al*. (1995).

importance of firm heterogeneity and reallocation of resources from low to high-productivity firms for assessing the impact of product market policies on aggregate productivity outcomes.

Regulation, reallocation and firm dynamics

20. The Schumpeterian view of the importance of creative destruction for promoting a better allocation of resources and productivity growth has gained further strength over the past decade, as the evidence of wide heterogeneity in firms' characteristics and performance in most market economies has grown.[23] This widespread heterogeneity highlights the limits of models based on the "*representative agent"* hypothesis or based on identical monopolistic competition firms, and suggests that the assessment of aggregate productivity may require knowledge of the cross-sectoral distribution of activity and changes at the firm level. The observed heterogeneity of firms is often associated with the idea that firms, whether new entrants or incumbents, are continuously evolving and testing new technologies (broadly defined to include the use of advanced technologies but also organizational structures) in order to gain market shares or simply survive.[24] Experimentation is directly related to firm dynamics. New firms replacing obsolete units represent a way in which the market evolves. Moreover, firm turnover may also be an important vehicle for the adoption of new technologies and indeed this may be particularly relevant in the case of ICT.[25] The latter often require significant changes in the organization of production and skill composition, and newcomers may have a comparative advantage in adopting them relative to existing firms in as much as they do not have to incur these adjustment costs. However, entering a new market always involves significant uncertainties, especially if this is associated with the adoption of a new, potentially more productive but also more uncertain, technology. The wider range of technology options available to entrant firms but also the greater uncertainty concerning the business plan explain the observed greater variance in the performance of young businesses compared with older incumbents.

21. The incentives for new firms as well as for incumbents to engage in experimentation and the associated reallocation of resources are likely to be influenced in different ways by product market regulations. It should be stressed that the links between firm heterogeneity and the degree of market experimentation on the one hand, and product market regulations, on the other, is not clear-cut. As stressed by Bartelsman *et al.* (2004), inappropriate regulations may affect the reallocation dynamics on different margins in a variety of ways. For example, high start-up costs are likely to reduce firm turnover and potentially lead to a less efficient allocation of resources, but those firms that finally enter the market may have a higher productivity than otherwise due to a tighter selection at entry. In turn, the average productivity of incumbents and exiting businesses will be lower. Similarly, certain market distortions might weaken the selection process at entry and exit leading to less systematic differences between entering, exiting and incumbent businesses. There is also an important time dimension related to the analysis of firm dynamics and economic performance. Market conditions that promote experimentation and trial and error processes, may be associated with more risk and uncertainty in the short run, leading to a lower immediate contribution from entry and exit to productivity, but a higher long-run contribution when the trial and error process of the experimentation has worked its way out (through learning and selection effects).

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23. The heterogeneity in firm's behavior, even within narrowly-defined industries or markets has been well documented (see e.g. Caves, 1998; Bartelsman and Doms, 2000; Bartelsman et al. 2004).

24. Different theoretical models and a growing empirical evidence support the idea that firms – both incumbents and new firms – are engaged in a continuous process of "experimentation" in which they choose whether to enter or stay in the market, and whether or not to expand and adopt new technologies that may have higher potentials but also run greater risks (see e.g. Sutton, 1997, Pakes and Ericson, 1998, and Geroski, 1995, for surveys)

25. Bartelsman et al. (2004) as well as Bartelsman (2005) indeed found that the entry of new firms plays a stronger role in boosting aggregate productivity in high-tech industries as compared with medium and low-tech industries.

22. A number of theoretical studies have tried to account for firm heterogeneity and modelled distortions to entry and exit as well as reallocation. For example, Bernard *et al.* (2003) and Melitz (2003) highlight the role of external barriers affecting the degree of competition in the product market, while building on models by Melitz and Ottaviano (2007) and Del Gatto *et al.* (2006), Corcos *et al.* (2007) find that lifting behind-the-border barriers may be even more important for productivity. In their models with heterogeneous firms, a lowering of trade barriers generates a reallocation of resources in favour of more productive firms. In particular, the exit of low productivity firms and the expansion in the domestic and foreign markets of more productive firms lead to an increase in aggregate productivity growth. Bergoeing *et al.* (2004) also allow for idiosyncratic differences in firm productivity and focus on the effect of a productivity shock on aggregate productivity when there are government-induced frictions in the reallocation of resources, which they assume to take the form of a subsidy to incumbents. Their simulations suggest that such subsidies lengthen the period in which output is below potential. A few additional studies have further developed models with adjustment frictions that prevent resources from immediately being allocated to the most productive firms (see *e.g.* Restuccia and Rogerson, 2007; Hsieh and Klenow 2006; Bartelsman *et al*. 2007). Static and dynamic frictions partly depend on market characteristics and technological factors but are also clearly related to inappropriate product market regulations. In particular, frictions may represent the costs of adjustment – either in the form of entry and exit costs, or adjustment costs in reallocating factors of production such as capital and labour.[26] In these models as well, both policy-induced entry costs and regulations that raise the adjustment costs to technological shocks reduce aggregate productivity.

Summing up

23. A number of theoretical models suggest that by easing the entry of new firms, increasing rivalry among incumbents and reducing frictions in the reallocation of resources, product market reforms are likely to promote aggregate investment, technology adoption, innovation and, ultimately productivity growth. However, offsetting factors and uncertainties inherent in the channels described above – *e.g.* the ambiguous effect on managerial incentives and the different response of firms with different characteristics indicate that the strength, if not the direction, of the link between product market competition and productivity performance remains an empirical issue. Recent research has focused on the sources of within-firm productivity improvements and on the role played by resource reallocation across heterogeneous firms for aggregate productivity developments. This research has helped reconcile theory with a number of stylized facts [27]– *e.g.* the fact that competitive pressures often provide both incumbents and new entrants incentives to innovate and the crucial role played by fast-growing firms and has significantly enriched the analysis of the link between product market policies and productivity. For instance, neo-Schumpeterian views shed light on the complementary roles of antitrust and patenting policies and the distinct roles played by international openness and domestic liberalisation. Moreover, Neo-Schumpeterian views and recent research on firm heterogeneity stressed the role that appropriate regulations can play in facilitating the reallocation of resources from low to high productivity incumbents in a competitive environment. In this paper, we will draw on both these strands of literature to analyse the effects of changes in product market regulations on productivity from a cross-country point of view. To this end, in the next sub-section, we first discuss ways to compare regulatory settings in different countries and then look at regulatory reforms that countries have undertaken over the past two decades.

26. The latter might involve a range of costs including the search and matching frictions that have been the focus of much of the recent literature on studying the dynamics of the labor market (see e.g. Davis et al. 1996; Restuccia and Rogerson, 2007; Hsieh and Klenow, 2006).

27. For instance, while attempts to test earlier theories of innovation against the data were not very successful (see Cohen and Levin, 1989, for a survey of these empirical studies), the predictions of neo-Schumpeterian models are generally supported by both industry-level and firm-level empirical analyses.

II.2 Has product market regulation changed?

Measuring regulation

24. Different approaches have been used in the literature to characterise the degree of competition in the product market and the role of policy and regulatory settings. Traditional indicators of product market conditions, such as mark-ups or industry concentration indices, cannot be treated as exogenous determinants of economic outcomes.[28] Entry of new (possibly foreign) firms is also obviously not exogenous to productivity outcomes. Indeed, addressing the endogeneity of competition measures has been one of the main challenges in trying to identify the impact of competition on innovation or productivity. Moreover, recent research shows that many of the market indicators of productivity are not univocally related to product market competition.[29] Finally, they fail to provide a direct link to policy or regulation.

25. To address these concerns, the empirical analyses reported in the next section are based on some of the potential policy determinants of competition, rather than on direct measures of it. Griffith *et al.* (2004) and Aghion *et al.* (2006) have recently taken a similar approach. However, while they focus on EU data on anti-monopoly cases and the implementation of the Single Market Programme, we use indicators of product market regulations drawn from the OECD international product market regulation database.[30] We focus on regulation in non-manufacturing industries and on the "knock-on" effects of inappropriate regulations in these industries on all sectors of the economy. The main reason for focusing on these indicators in the empirical analysis of productivity is that they capture regulations affecting key ICT-using sectors. The non-manufacturing 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. Moreover, even low-regulated industries suffer from regulation-induced inefficiencies in non-manufacturing because all industries are heavy intermediate consumers of non-manufacturing products. The indicators measure to what extent competition and firm choices are restricted where there are no *a priori* reasons for government interference, or where regulatory goals could plausibly be achieved by less coercive means. The indicators are constructed to measure regulation in a particular area, certain industries, or the overall economy. A detailed description of the indicators of non-manufacturing regulation and the knock-on indicators of "regulation impact" is provided in Conway and Nicoletti (2006). Annex 1 explains their main features.

26. In synthesis, the indicators of non-manufacturing regulation 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.[31] They

28. Amongst the very few cross-country studies that explore the role of competition for productivity, Cheung and Garcia Pascual (2001) use mark-ups and concentration indexes. At the single-country level, Nickell (1996), Nickell *et al.* (1997), Blundell *et al.* (1999) and Disney *et al.* (2000) use a variety of market indicators to capture competitive pressures. The potential problem of endogeneity of market shares and mark-ups is even more serious at firm-level as firms that have high productivity may gain market shares 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 (*i.e.* the relevant market where competition unfolds) and tend to neglect potential as well as international competition.

29. Boone (2000) suggests that there may be a hump-shaped relationship between competition and mark-ups. Some authors have addressed this issue by using related indicators of relative profits and profit persistence (Creusen *et al.* 2006; Greenhalgh and Rogers, 2006).

30. The data are publicly available at www.oecd.org/eco/pmr. The most recent observations are currently for 2003, but an update to 2007 will be available at the end of 2008.

31. In addition to the above industries, the indicator of regulation in banking constructed by de Serres *et al*. (2006) is also used to derive the "knock on" indicators of regulation impact. Indicators for energy, transport and communication cover 21 OECD countries over the 1975-2003 period; the indicators for retail distribution and professional services

focus on three main areas affected by sweeping reforms in OECD countries, with the aim of promoting entrepreneurship and competition: *i)* privatisation, *ii)* entry and business conduct in potentially competitive domestic markets, *iii)* pro-competitive regulation of natural monopoly markets (*e.g.* by regulating access to networks or unbundling them from the provision of services). Indicators for each of these areas are based on detailed information on laws, rules and market and industry settings. From these data, regulation impact indicators of the "knock on" effects of anti-competitive regulation for 39 sectors that use the outputs of these non-manufacturing industries as intermediate inputs are calculated for the 1975-2003 period. To the best of our knowledge, these indicators provide the broadest coverage of sectors and areas, and the longest time-series currently available for comparing product market regulation across OECD countries. They are complementary to indicators of economy-wide anticompetitive regulation already published by the OECD (Conway *et al.* 2005). All indicators take continuous values on a scale going from least to most restrictive of private governance and competition.

27. As already mentioned, the main advantages of using these indicators in empirical analysis is that they can be held to be exogenous to productivity developments and that they are directly related to underlying policies, a feature that business survey data do not have.[32] Another advantage is that, as they are composite constructs based on detailed information about policies, they address multicollinearity problems in estimation. At the same time, they make it possible to focus on the specific aspects of policies that are thought to be relevant for productivity. For instance, most of the analyses reported below focus on the barriers to entry and administrative burdens elements (and sometimes, separately, the public ownership one). Some analyses explicitly distinguish border and non-border policies that affect competition. Yet another advantage of the OECD indicators is that they vary over countries, industries and time, though full time variability is limited to a subset of non-manufacturing industries. Moreover, the regulation impact indicators of the knock-on effects of regulation in other sectors extend, with some limitations, time variability over 1975-2003 to most of the business industries.[33]

Reforms over the past two decades

28. In tune with a number of qualitative analyses of product market policy developments in the OECD area, the quantitative OECD indicators suggest that market-oriented reforms were extensive over the past two decades. Here we illustrate reforms in the non-manufacturing sectors of selected OECD countries and their implications for regulatory burdens on the manufacturing sector as well as for ICT and non ICT-intensive sectors (see Annex 2 for the classification of sectors into these two categories). For the purposes of this paper, we focus on four groups of countries that had widely different reform and productivity patterns: the United States, the United Kingdom, other English-speaking countries (Canada, Ireland, Australia and New Zealand), Nordic EU countries (Denmark, Finland and Sweden) and large

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cover 30 OECD countries for 1998 and 2003; the indicator for banking covers 30 OECD countries for 2003. As a result, while in the cross-section dimension the indicators cover most of the regulated sectors, the time variability of both the non-manufacturing and regulation impact indicators originates mostly in policy changes in the energy, transport and communication sectors.

32. Of course, endogeneity cannot be completely ruled out 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 (2005).

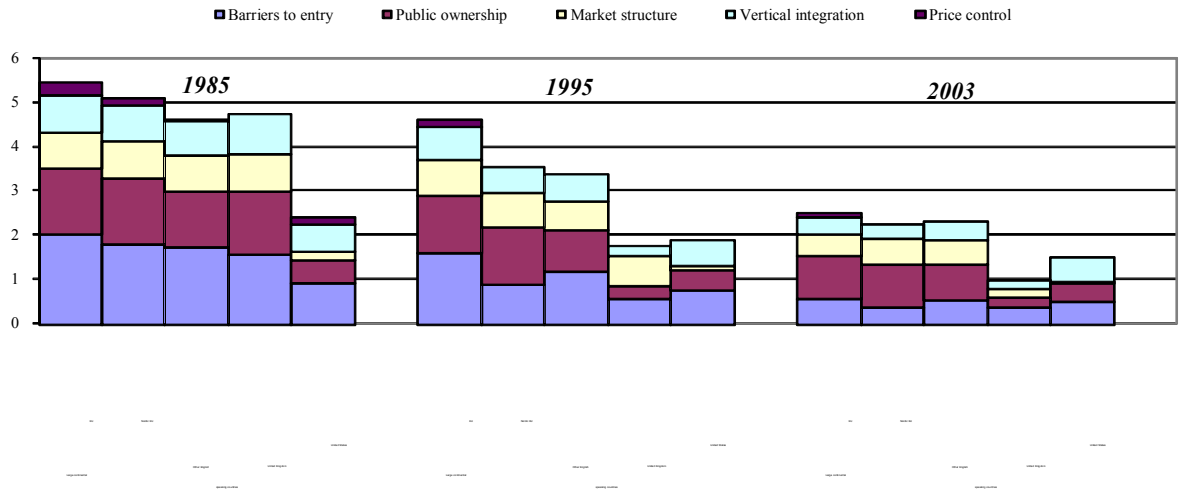
33. Griffith *et al*. (2006) formulate a number of criticisms concerning the OECD indicators, the most compelling being that their time dimension is limited to a subset of non-manufacturing sectors that they do not think are representative enough of economy-wide regulatory developments. The use of the regulation impact indicators partly addresses this concern. Besides, Conway and Nicoletti (2006) show that the OECD indicator of non-manufacturing regulation is closely correlated, both across countries and over time, with a popular indicator of economy-wide business regulation, the Economic Freedom of the World index by Gwartney and Lawson (2006). This is not surprising since most of OECD product market reforms have been implemented in the non-manufacturing industries over the past decades.

continental EU countries (France, Germany, Italy and Spain). Figure 1 shows developments in various areas of regulation in energy, transport and communication from 1985 to 2003 (Panel A) as well as developments in retail distribution and professional services from 1998 to 2003 (Panel B). It suggests that at least in energy, transport and communication, regulatory approaches have converged across countries over the past two decades. Product market regulations have become more conducive to market mechanisms as governments have liberalised potentially competitive markets, re-regulated natural monopoly markets by establishing pro-competitive regulations where possible, and privatised state owned enterprises. The shorter data for retail and business services also suggest a move to a more business-friendly environment, though cross-country differences remain large and action has been lesser, especially in large continental EU countries.

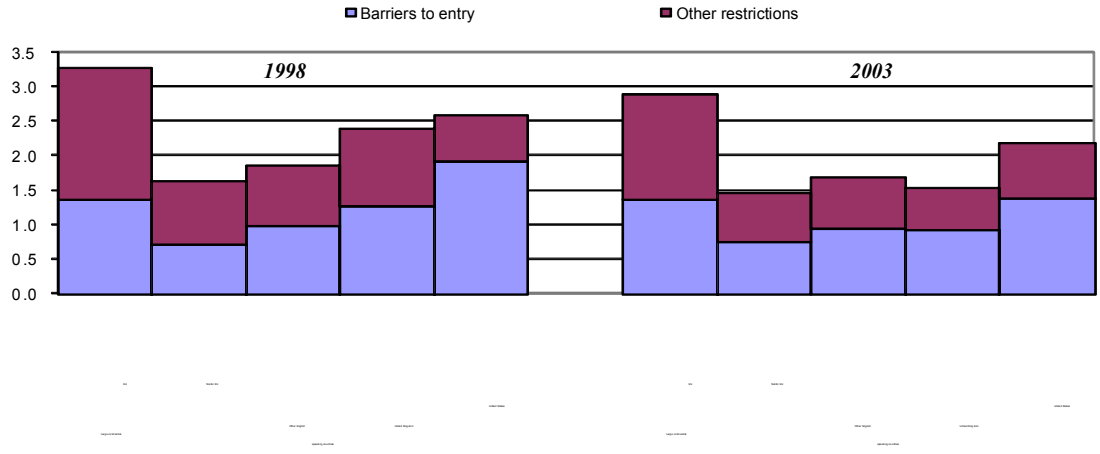
Figure 1. Product market regulation in non-manufacturing industries

OECD indicator, scale 0-6 from least to most restrictive

Panel A: Network industries



Panel B: Retail trade and professional services

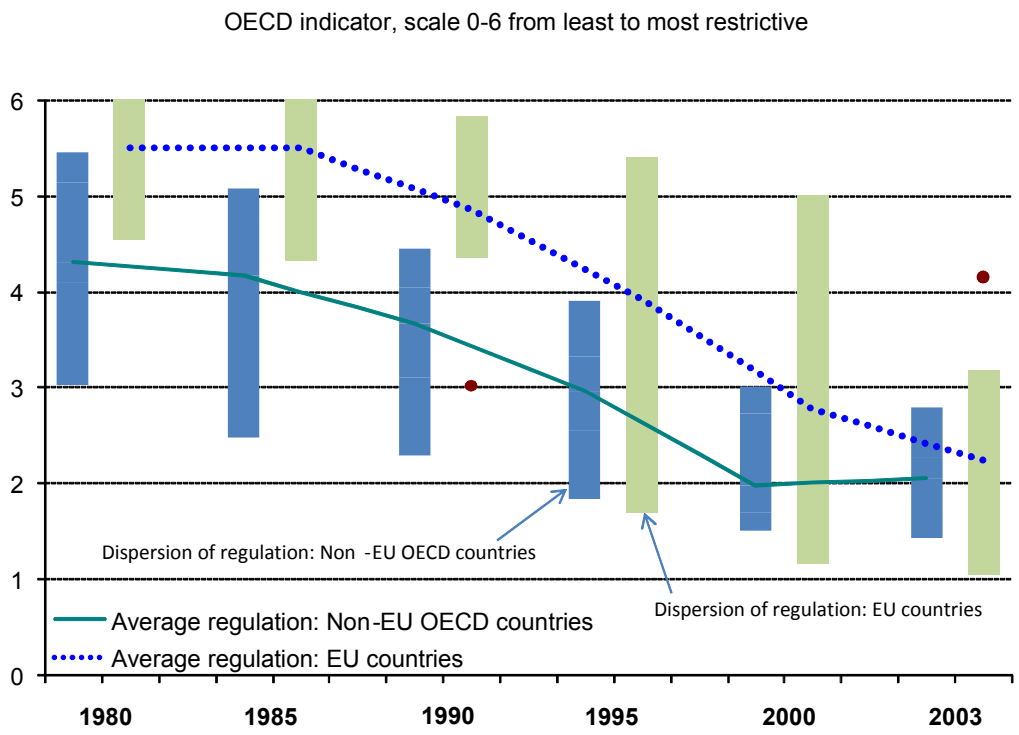


Source: Conway and Nicoletti (2006).

29. While the process of convergence towards more market-friendly regulations is widespread across OECD countries, the timing and depth of reforms differed dramatically across countries. The United States

was the first country to undertake wide-ranging reforms in the early 1980s. A number of other countries – notably the United Kingdom, Canada, New Zealand and the Nordic countries – launched reforms a little later, from the mid-1980s. But in most of the EU countries, and most notably in the large continental ones, the bulk of product market reform occurred much later, in the mid-1990s, and a number of them still had a relatively restrictive non-manufacturing environment at the turn of the millennium. As a result of these different starting points and reform patterns, regulations remained on average more restrictive in the EU than in the other countries. Moreover, the dispersion in regulatory approaches increased widely in the EU area over the 1990s, while regulations in other OECD countries kept becoming more homogeneous all along (Figure 2). It was only in the most recent years that EU countries also started to significantly converge in their regulatory settings, mainly because of the efforts made by some of the laggard EU countries of the 1990s. The working hypothesis that we develop in the next sections of our paper is that, by delaying regulatory reforms in key ICT-intensive sectors, many EU countries failed to create a favourable environment for absorbing the ICT shock that unfolded over the 1990s.

Figure 2. The evolution and dispersion in product market regulation in the EU and other OECD countries
Energy, transport and communication, 1980-2003[1]



1. Box chart of the cross-country dispersion of the aggregate indicators of regulation in transport, energy, and communications sectors across countries. The boxes show the dispersion of the indicator values across country groupings in each year. The dots represent outlier countries.

Source: Conway and Nicoletti (2006).

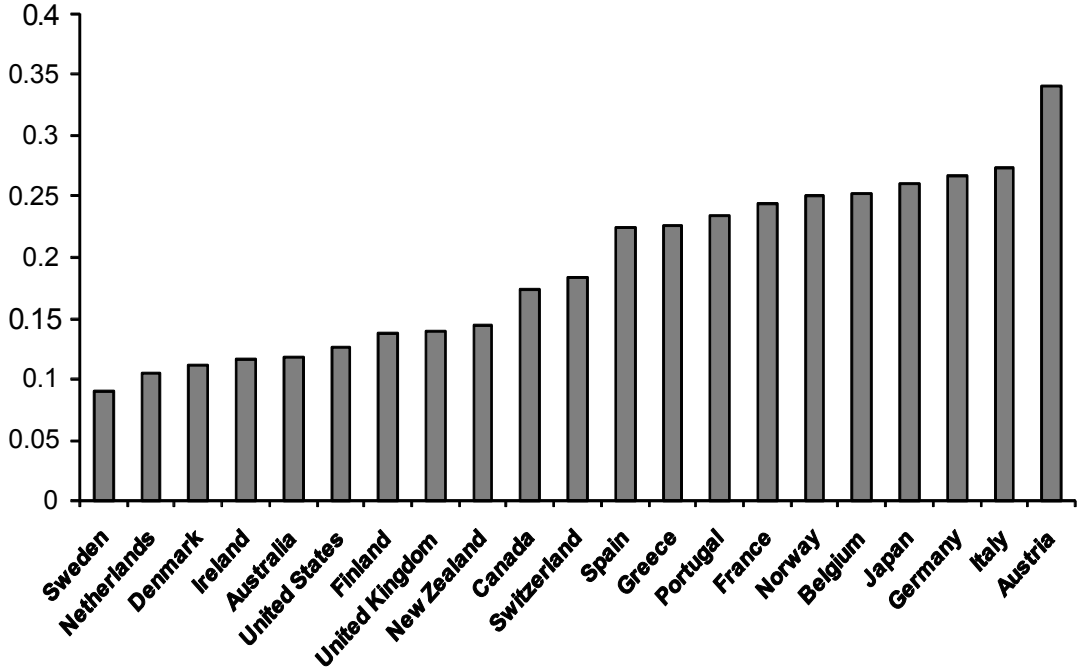
Regulatory burdens and intersectoral linkages

30. As mentioned earlier, inappropriate regulations in non-manufacturing industries have implications for other sectors through input-output interlinkages. The domestic business environment is likely to be particularly important for efficiency in utilities and service industries, where competition from abroad is weaker and a difficult balance has to be struck between regulations and market forces due to market imperfections (*e.g.* in network industries). To the extent that enhancing competition in these

industries encourages productivity growth, non-manufacturing reforms can provide a "double dividend" because they may increase both the direct contribution of non-manufacturing to overall productivity growth and contribute to overall productivity growth indirectly, via improvements in the productivity of industries that use non-manufacturing products as intermediate inputs.[34] The OECD indicators of regulation impact aim precisely at assessing these "knock-on" effects of non-manufacturing regulation on other sectors (see Annex 1 for a more detailed description of these indicators). To illustrate this, Figure 3 shows the burdens imposed in 2003 by non-manufacturing regulations on the manufacturing sector (Panel A) and on ICT and non ICT-intensive sectors (Panel B) of OECD countries. These depend on both the stringency of non-manufacturing regulations in different countries and the extent to which each sector use non-manufacturing products as intermediate products. As expected, the knock-on effects are largest in continental EU countries and lowest in Nordic and English-speaking countries. Cross-country differences are particularly pronounced when the focus is set on ICT-using industries.

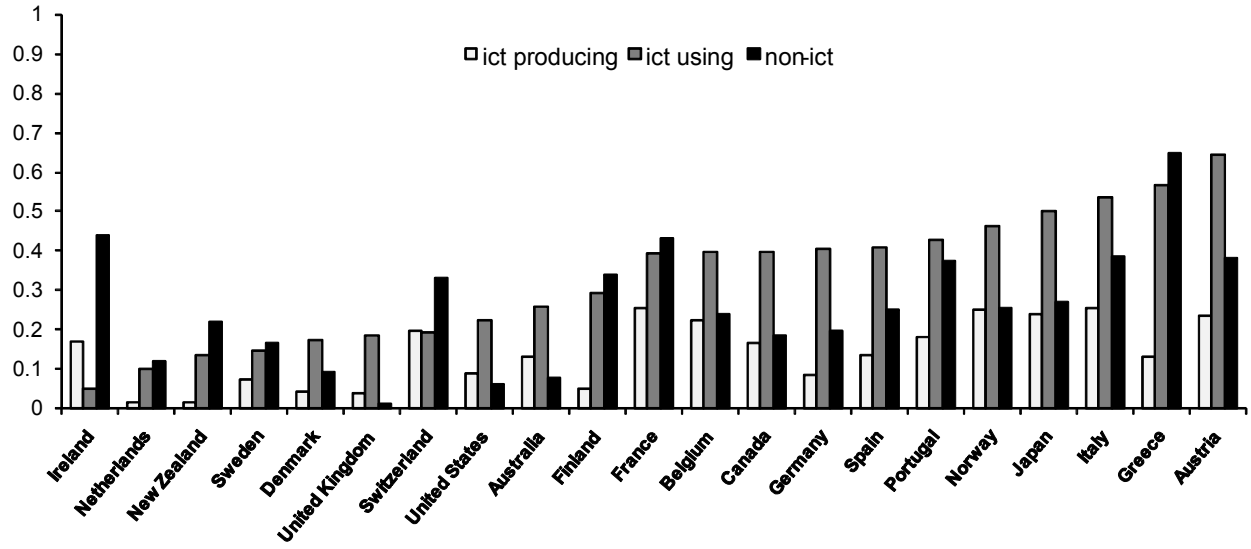
Figure 3. The burden of non-manufacturing regulation on the business sector, 2003[1]
(scale normalised to 0-1 from least to most burdensome)

Panel A. Manufacturing



34. The role of intersectoral input-output linkages in transmitting and amplifying the effects of product market reform has been recently stressed by Faini et al. (2004) and Conway et al. (2006).

Panel B. ICT and non-ICT sectors



1. These indicators reflect the 'knock-on' effects of anti-competitive regulation in non-manufacturing sectors on industries that use the output of these sectors as intermediate inputs into the production process. See Annex 1 for more details.
Source: Conway and Nicoletti (2006).

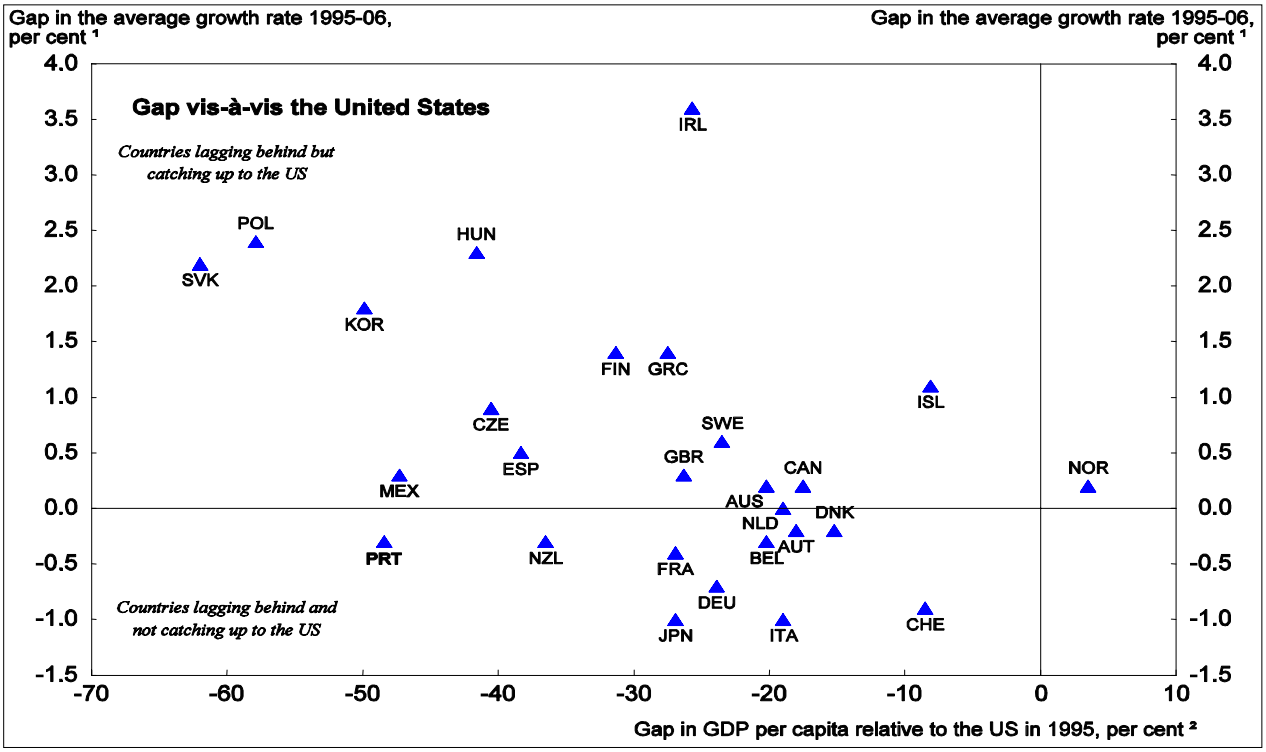
III. Evidence on product market policies and productivity

III.1 Aggregate productivity outcomes and GDP per capita growth

31. The traditional way to assess the process of convergence – or divergence – in GDP per capita is to plot the country GDP per capita growth rate over a given period of time against the initial GDP per capita levels: countries with lower GDP per capita levels have greater potential to grow by catching up to the levels of their wealthier counterparts.[35] This process of economic convergence, which characterized most of the post-WWII period, has come to a halt in the mid-1990s: relative to the United States, a number of countries with significant gaps in living standards have experienced low average output growth over the past decade – including most large continental EU countries (South-West quadrant in Figure 1). Rapid catch-up continued in the transition economies of Central and Eastern Europe, South Korea, Greece, some of the Nordic countries and, especially so, in Ireland (North-West quadrant in Figure 1).

35. It should be stressed at the outset that cross-country differences in business cycle conditions can significantly affect international comparisons of growth patterns. The option generally used in the literature is the comparison of average growth rates over sufficiently long time periods in order to minimise cyclical influences. However, this approach is problematic for analysing recent growth patterns, given the lack of synchronisation in countries' business cycles. In an attempt to tackle this issue, we rely on cyclically-adjusted series as opposed to actual series. The figure uses Kalman-filtered series for output, employment and productivity computed by the OECD in the context of the estimation of potential output. Computing trends using an extended version of the Hodrick-Prescott filter (Hodrick and Prescott, 1997) yields similar results. For a more extensive discussion on the calculation of trend series and on the consistency of results using different approaches, see Scarpetta et al. 2000).

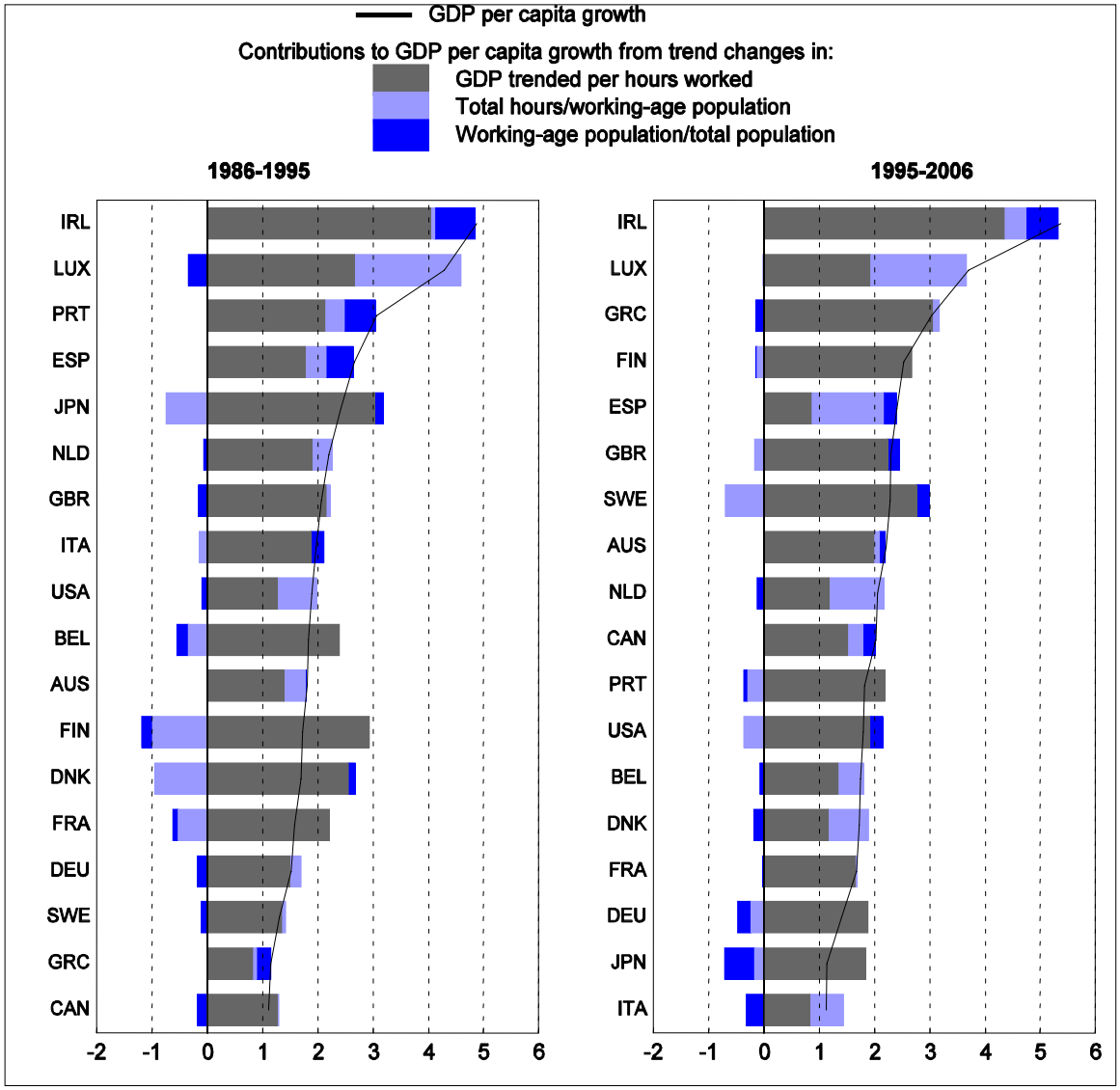
Figure 4. Convergence to US GDP per capita, 1995-2006: large continental EU countries are losing ground[1]



1. The average growth rate of GDP per capita is calculated on the basis of volumes data from national account sources. The level of GDP per capita is calculated on the basis of 1995 PPPs.
Source: OECD, National Accounts database; OECD, *Going for Growth* 2008.

32. From an accounting point of view, one way to decompose aggregate GDP per capita growth is to distinguish: *i)* a *demographic factor*, resulting from changes in the ratio of persons of working age (15-64 years) to the total population; *ii)* a *labour productivity factor*, resulting from changes in output per hour worked; *iii)* a *labour utilisation factor*, resulting from changes in the labour utilisation (total hours worked to working age population). This decomposition is presented in Figure 5 for a number of OECD countries over the 1990s and the most recent years.

Figure 5. Decomposition of GDP per capita growth, 1990-2006



Source: OECD Productivity database

33. Changes in GDP per capita growth have been largely driven by changes in labour productivity and utilisation. Significant increases in total hours worked in the Netherlands, Spain and Denmark contrast sharply with declines or weak growth in other Nordic countries (from very high employment rates) as well as in Germany, Portugal and the United States.

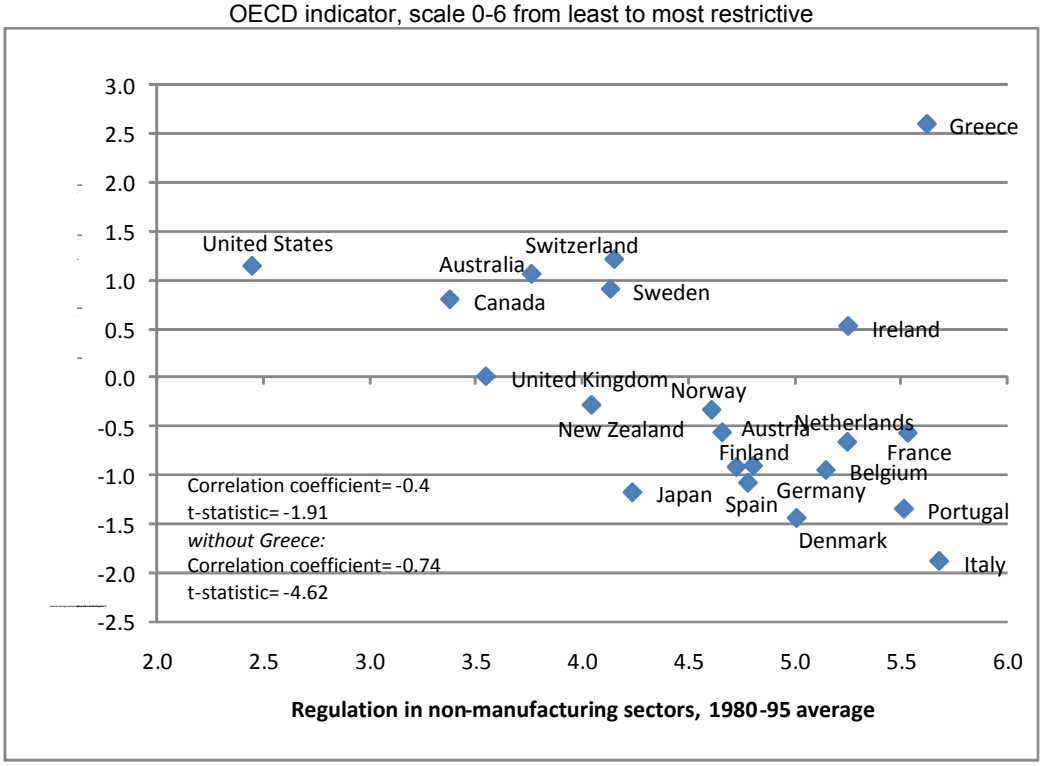
34. The growth of hourly labour productivity accounts for at least half of GDP per capita growth in most OECD countries and considerably more than that in some of them. A similar picture emerges if productivity is defined on a per worker basis. Compared with the 1985-95 period, hourly labour productivity growth picked up in a number of countries, including the United States, Finland, Australia, Canada, Ireland and Sweden. By contrast, growth decelerated in continental European countries – especially France, Italy and Spain – and barely changed in the United Kingdom. Formal tests, based on a variety of univariate and multivariate time-series models for hourly productivity, suggest that the US acceleration and the European (EU15) deceleration were "structural", and occurred around the mid-1990s.

Downward structural breaks appear to be particularly clear for the four large continental EU countries, while no such a break is generally found for the United Kingdom. [36]

35. To what extent have differences in product market regulations affected the productivity performance of the OECD countries? Figure 6 plots the acceleration in hourly labour productivity growth against the stringency of product market regulations in non-manufacturing industries for which we have matching time-series data. At first glance, countries with a relatively liberal approach to competition have tended to experience a greater acceleration in aggregate hourly labour productivity growth after 1995. The rest of this paper explores more in depth this suggestive cross-country evidence, looking at two main channels through which differences in product market policies may help explain aggregate productivity outcomes: their effects on incentives to adopt the most efficient technologies and their influence on the ability of OECD economies to allocate resources to their best use.

Figure 6. Product market regulation and hourly labour productivity acceleration

OECD indicator, scale 0-6 from least to most restrictive



Source: OECD Productivity Database and Conway and Nicoletti (2006)

III.2 The role of information and communication technology[37]

36. Recent industry-level empirical analyses suggest that it is not so much product market policies per se that mattered for explaining diverging cross-country performance patterns from the late-1990s, but rather the relationship between the timing of policy reforms and the timing of technological change (Conway *et al.* 2005; Conway and Nicoletti, 2007). As illustrated earlier, in many OECD countries, notably in continental Europe where growth performance was most disappointing, product market reforms

36. See Kahn and Rich (2006) for the US and Jimeno et al. (2006) for EU countries. The lack of acceleration in the United Kingdom has been referred to as the "UK productivity puzzle" by Basu *et al*. (2003).

37. This section draws extensively on Conway and Nicoletti (2007).

were slow and hesitant during most of the 1990s, a period during which the diffusion of information and communication technologies (ICT) was particularly intense. Moreover, key ICT-using sectors (such as retail trade and business services) remain relatively regulated. Delaying reforms may have made firms in these countries unable to fully capture the benefits of ICT, both in terms of incorporating them into new vintages of the capital stock and reaping the efficiency gains originating from the changes in the organisation of production that they allow. The negative repercussions on aggregate performance of the mismatch between the timing of reforms and the timing of technological change may have been amplified by the fact that ICT is a general-purpose technology that can be usefully employed in most sectors of the economy.

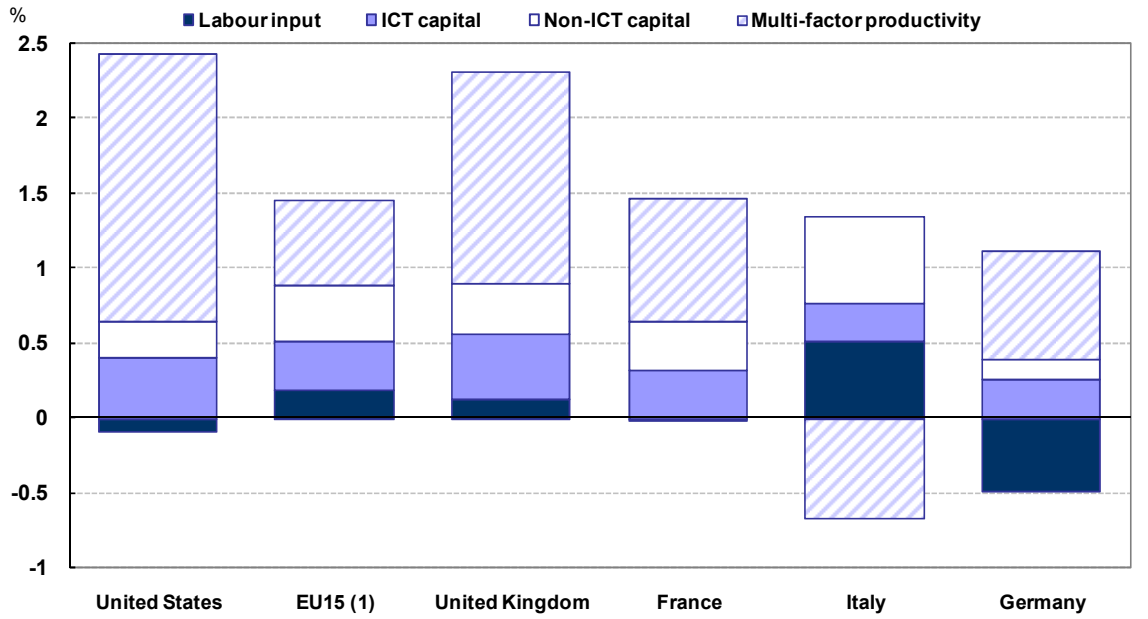
37. To begin assessing the role of ICT in promoting productivity and output growth, Figure 7 decomposes output growth over the 2000-05 period in: *i)* capital deepening – distinguishing between ICT capital and non-ICT capital; *ii)* labour input; and *iii)* technical progress, as measured by residual output growth once the contributions of labour and capital inputs have been subtracted (so called multifactor productivity, MFP).[38] It is important to note at this stage that, aside from the direct contribution of ICT capital to output growth, several key factors related to ICT are also embodied in the aggregate measure of MFP growth: the acceleration of productivity in ICT-producing sectors themselves, the growing share of these sectors in OECD economies and the spill-over effects of new technologies on productivity in ICT-using industries – largely high-tech manufacturing and, especially, some service industries. The figure clearly suggests that ICT capital deepening and MFP growth have driven output growth in the United States to a larger extent than in the EU. Among the large EU countries, only the United Kingdom has experienced similar growth contributions from ICT capital and MFP. In both France and Germany, ICT capital deepening and MFP growth contributed less. In Italy, MFP actually declined.

38. If anti-competitive regulations hinder the adoption and efficient use of ICT, their negative effects on productivity performance are likely to have been particularly strong in large continental EU countries since the mid 1990s. Recent empirical analyses explored this conjecture in two ways. Gust and Marquez (2004) and Conway *et al.* (2006) looked at the effect of regulation on one indicator of technology adoption and capital quality: the evolution of the share of ICT in gross fixed capital formation. [39] Nicoletti and Scarpetta (2003), Conway *et al.* (2006), Griffith *et al.* (2006) and Inklaar *et al.* (2008) investigated the possibility that the speed of catch up to best practice productivity may be curbed by anti-competitive regulation.

38. Depending on the way the growth of inputs is computed, different measures of MFP growth can be obtained, with different interpretations. In the figure we present the simplest measure – the Solow residual – that includes both embodied (in physical and human capital) technological progress and disembodied technological progress resulting from innovations, organisational change and, more generally, more efficient use of all inputs.

39. The share of ICT investment in total investment is typically used as a key indicator of ICT diffusion. There are, however, many other indicators that measure the pervasiveness (or otherwise) of ICT technology across countries (see, for example, OECD 2002). Most of these different indicators are closely correlated and tend to indicate a similar pattern of ICT diffusion.

Figure 7. ICT capital deepening and MFP growth are the two key drivers of output growth, 2000-2005

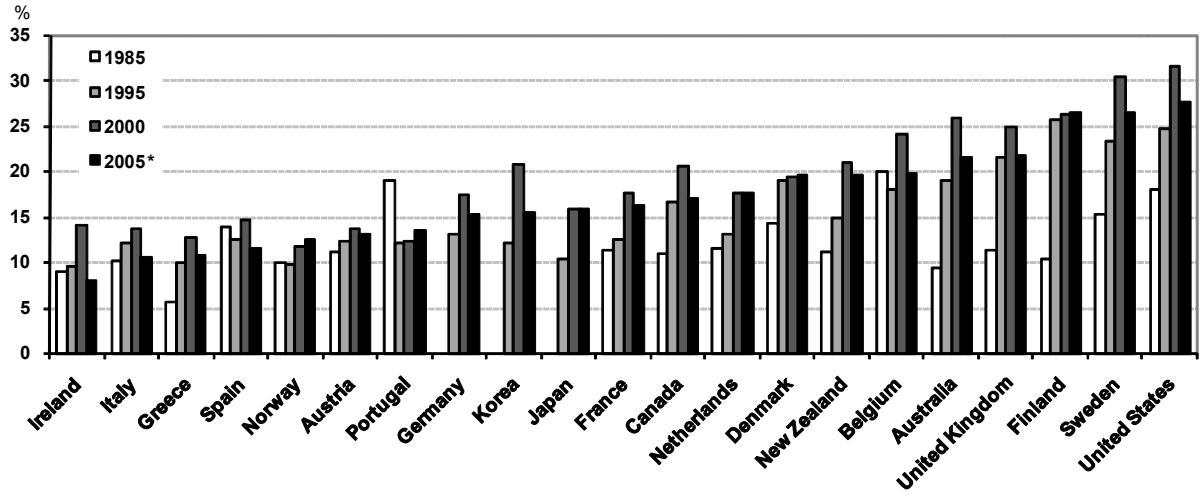


Source: Authors' calculations; OECD Productivity Database

Regulation and ICT adoption

39. Given its potential for enhancing productivity and rapid price declines over recent years - especially when adjusted for quality – ICT has spread rapidly in many OECD countries. However, consistent with the large variation in the productivity dividend from ICT investment, rates of ICT adoption have varied considerably across countries. In several English-speaking and Nordic countries the share of ICT in total investment has risen by around 10 percentage points between 1985 and 2005, while in other countries the increase has also been significant but smaller (Figure 8). In 2005, the share of ICT investment was particularly high in the United States, Sweden, Finland, the United Kingdom and Australia. In contrast, the ICT share in some continental European countries, Japan and, to a lesser extent, Canada was substantially lower. Several reasons can be envisaged for these differences, ranging from industry specialisation and first-mover advantage to gaps in workers' skills. However, given the wide availability of ICT and the relative homogeneity of industry features in the OECD area, cross-country differences in the pace of ICT uptake provide a useful 'natural experiment' with which to test whether restrictive regulations may have slowed down the adoption of this technology.

Figure 8. The diffusion of information communication technology
(share of ICT investment in total non-residential gross fixed capital formation in percent)



* Or latest available year
Source: OECD, Productivity Database

40. There are a number of potential reasons why this might be the case. As already mentioned, in a competitive environment with low barriers to entry the incentive to invest in ICT so as to increase productivity and retain market share may be stronger, at least for firms that are not too far from the technological frontier, than in a more restrictive regulatory environment where incumbents are sheltered from competitive processes. For example, investment in ICT may help firms increase productivity by allowing them to expand their product range, customise their services, and respond better to client demands. ICT may also help reduce inefficiencies in the production process by, for example, reducing inventories. In addition, as pointed out by Alesina *et al.* (2005) in the context of general-purpose fixed investment, the costs of adjusting the capital stock and firm structure and reorganising the production process, all of which are necessary if new technology is to be successfully integrated, will tend to be lower when the regulatory burden is lighter. Finally, a more competitive environment is likely to put stronger downward pressure on the cost of ICT, thereby promoting its diffusion. Casual evidence suggests that, on average over the past decade, ICT adoption has been stronger in countries where regulations were less burdensome and friendlier to competition (Figure 9).

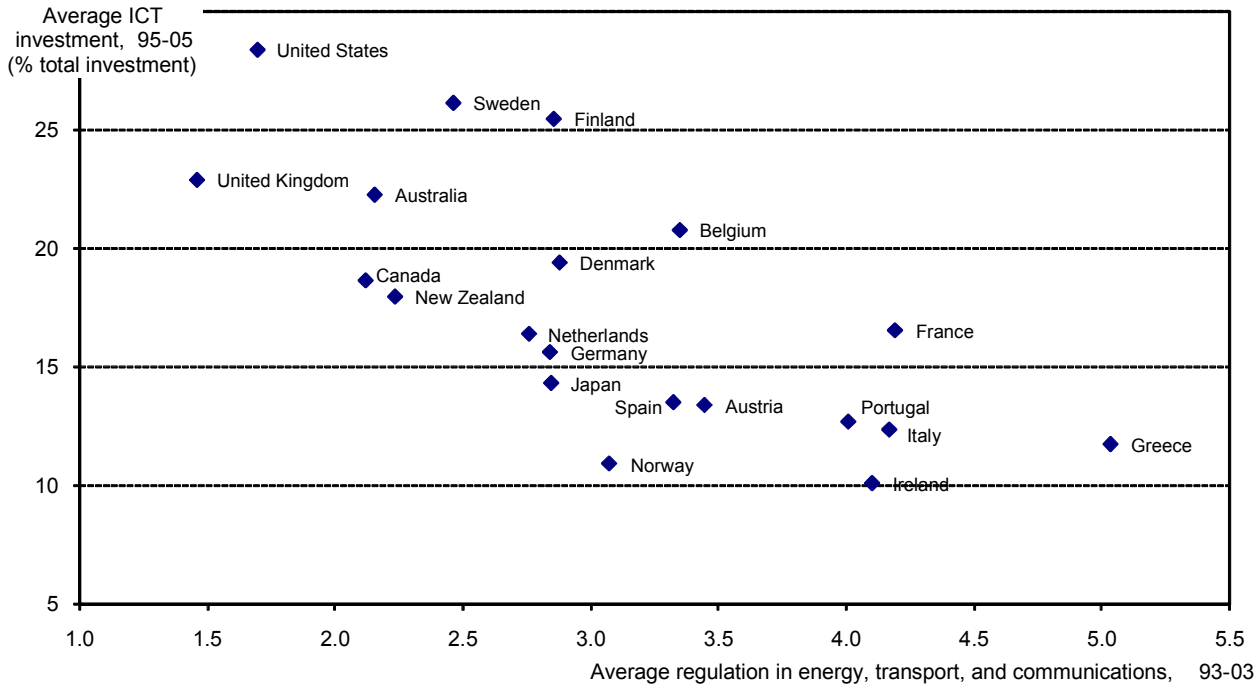
41. Panel regressions by Conway *et al*. (2006) and Gust and Marquez (2004) confirmed this bivariate evidence. Both these studies accounted for other (observed and unobserved) factors that could potentially affect ICT adoption such as workers' skills, industry composition and other country and/or industry specific characteristics. While Gust and Marquez (2004) looked mainly at the effects of labour market regulation on the aggregate ICT share, Conway *et al*. (2006) explicitly focused on the link between product market regulation and ICT investment at both the aggregate and industry levels.[40] At the aggregate level, regulation was proxied by the OECD indicator of anti-competitive regulation in energy, transport and communication, while at the industry level regulation was proxied by the OECD industry-level indicators of the knock-on effects of non-manufacturing regulation in all business sectors (see above). In both cases

40. Conway *et al*.'s analysis of aggregate ICT covered 18 countries over the period 1985-2003: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Italy, Ireland, Japan, Netherlands, Portugal, Spain, Sweden, the United Kingdom, and the United States. Industry-level regressions covered the period 1980-2001 for five countries for which data on industry-specific ICT investment were available at the time of the analysis: France, Germany, the Netherlands, the United Kingdom and the United States. Previous aggregate panel regressions by Gust and Marquèz (2004) used a smaller and shorter cross-country sample. Aside from labour market regulations, they also looked at the effect of a cruder measure of product market regulation.

domestic restrictions on competition were found to have a strong negative effect on ICT investment, with some evidence that these effects are concentrated in ICT-using and non-ICT intensive sectors, which are less exposed than ICT-producing sectors to foreign competition.[41] Interestingly, the largest negative effects were found for regulations that increase barriers to entry in domestic markets, while the presence of public-owned firms did not seem to affect ICT investment, perhaps because, especially in network industries, publicly-controlled firms have in some cases been found to over-invest in new technologies. For example, telecommunications companies have sometimes abandoned costly plans to expand digital or cable networks in the wake of privatisation.

Figure 9. Product market regulation and the diffusion of information communication technology[1]

OECD indicator, scale 0-6 from least to most restrictive



1. The indicator of regulation is the simple average of the OECD regulation indicators for seven non-manufacturing industries (see Annex 1 for details).

Source: Conway and Nicoletti (2007).

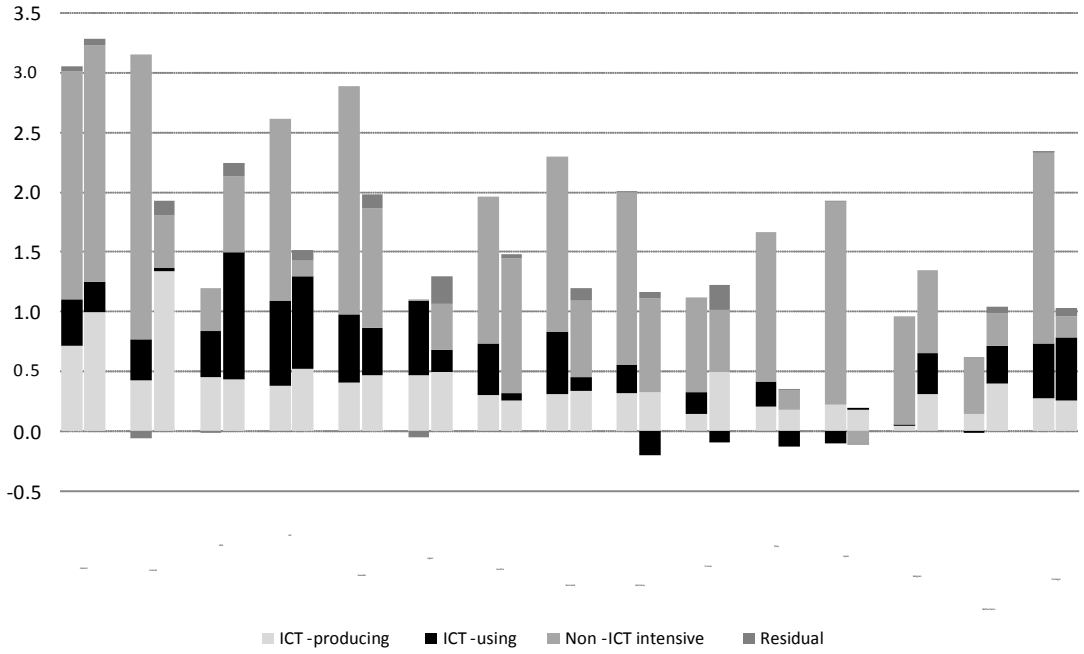
42. In sum, the results suggest that industries operating in a relatively liberal regulatory environment are more inclined to incorporate ICT into the production process than industries operating in an environment in which product market regulation is more restrictive. But to what extent does this effect explain observed differences in aggregate ICT investment across countries? Over the 1985-03 period, a relatively pro-competitive regulatory environment was found to increase the average share of ICT investment in total investment in the United States by more than four percentage points above the OECD average of 15%. In the United Kingdom, Canada, and Australia, the estimated contribution of product market policies to investment in ICT relative to the OECD average also appears to have been significant (between 2.5 and 3.5 percentage points), but less than in the United States. Conversely, in Greece, Italy, Portugal and France relatively restrictive regulations were estimated to have significantly dragged down ICT investment relative to other OECD countries (by 2.5 to 3.5 percentage points).[42]

41. Also, the development of ICT-producing industries often reflects factors that are unrelated to regulation, such as first-mover advantage or specialisation due to country-specific comparative advantages and/or agglomeration economies.

42. Overall, product market regulation were estimated to explain around 12% of the cross-country differences in ICT investment, with other factors such as human capital, the share of services in value-added and other country

43. The finding that ICT adoption was curbed by the lack of competitive pressures at home supports the idea that cross-country differences in the timing of product market reform may have had a particularly strong influence on productivity patterns over the 1990s, when technological innovation was advancing rapidly. There are two main ways in which unduly restrictive regulations may have interacted with the ICT shock to slow the speed of productivity growth in countries that delayed reforms. First, to the extent that anti-competitive regulations slow ICT adoption, productivity growth in sectors that are potentially ICT-intensive may have been lowered by a suboptimal level of investment (the "direct" productivity effect). This finding is particularly important in the light of recent results by Inklaar *et al*. (2008) who find few spill-over effects of ICT investment on "pure" MFP growth, thereby confining the effects of ICT on productivity to those of capital deepening. Second, a lack of competitive pressures and excessive regulatory burdens may have curbed the incentives to use embodied ICT technologies as efficiently as in more competitive and lightly regulated countries and thereby slowed the process of productivity convergence (the "indirect" effect). The consequence is that the contribution of key ICT-intensive sectors to productivity growth has differed significantly across countries. In the United States a large proportion of the increase in labour productivity in the second half of the 1990s originated in sectors that either produce or intensively use ICT (Figure 10). A few other countries – for example, Ireland, Finland, Belgium, the Netherlands, and the United Kingdom – also experienced accelerating productivity growth in these sectors in the second half of the 1990s. In a number of other countries, however, the contribution of ICT-producing or using sectors to productivity growth has typically been smaller than in the United States and even declined in several of them over the 1996-2004 period.[43]

Figure 10. Contributions to aggregate labour productivity growth, 1990-2004[1]



1. Annual average contributions to the growth of total value-added per person employed, in percentage points. The residual reflects adding up differences in aggregating from sectoral to the aggregate economy level. Countries are ordered according to labour productivity growth in the most recent period.
Source: Authors' computations from EU-KLEMS (March 2007) data

characteristics explaining the rest. Similar results were obtained at the industry level, with product market regulation now explaining more than 20% of the variance in ICT investment across countries and industries.

43. The role of ICT production and use is discussed in detail in Pilat and Wölfl (2004). Differences in the contribution of ICT-using sectors to productivity growth have been found to be important sources of productivity divergence between the United States and Europe. See, for example, van Ark *et al.*, (2002) and Gust and Marquez (2004).

44. With the direct and indirect effects of regulation on productivity at work, and in conjunction with the fact that regulatory burdens have tended to fall disproportionately on ICT-using sectors (as shown in Figure 3 above), the emergence of ICT over the 1990s may have amplified the influence of cross-country differences in the depth, scope and timing of product market reforms on productivity developments, despite the overall tendency of policies in this area to converge. This conjecture has been investigated in different ways by a number of recent cross-country empirical studies that focused explicitly on the policy determinants of productivity at the industry level.

Regulation, ICT and productivity growth

45. The direct and indirect effects of regulation on productivity growth have been explored by Nicoletti and Scarpetta (2003), Conway *et al*. (2006), Griffith *et al*. (2006) and Inklaar *et al.* (2008) within the framework proposed by Aghion and Howitt (2005). In their model, productivity growth in a given country (or sector) depends on the ability to keep pace with growth in the country (or sector) with the highest level of productivity (the leader) by either innovating or taking advantage of the best technology available. Productivity growth depends on how fast the leader is growing and the speed with which the productivity gap is closing. In turn, this speed is affected by the policy environment in the follower country (or sector). Following Aghion and Griffith (2005), empirical studies focused on the role of policies promoting firm rivalry and market entry in increasing incentives to enhance efficiency and lower the costs of reorganising production accordingly.

46. While the basic model used is similar, the various studies differ in data and coverage, control variables and, especially, in the measurement of product market policies: [44]

- *Data and coverage*. The analysis of Conway *et al*. (2006) focused on labour productivity per worker, and was performed at both the aggregate and industry levels using OECD ADB and STAN data for 39 manufacturing and service sectors in 21 countries over the past two decades. Nicoletti and Scarpetta (2003) had previously used similar OECD industry-level data for an earlier period, but focused on estimates of industry-level MFP (adjusted for cross-country differences in aggregate hours worked). Griffith *et al*. (2006) also rely on MFP estimates from the OECD industry-level database, but cover only nine EU countries and twelve manufacturing industries over a shorter time period. The industry-level study by Inklaar *et al*. (2008) used the new EU-KLEMS data set, from which a more sophisticated measure of MFP (adjusted for hours worked at industry-level) could be computed as the residual output growth once use of labour services (adjusted for labour composition), capital services (adjusted for asset composition) and intermediate inputs have been taken into account. However, their country coverage was limited to 10 EU countries, the United States and Japan, and the industry focus was on (a subset of) market services.

- *Control variables*. Besides the direct and indirect effects of regulation, Nicoletti and Scarpetta (2003), Conway *et al*. (2006) and, to a lesser extent, Griffith *et al*. (2006) also account for a number of unobserved characteristics that are country and/or industry specific as well as for global shocks over time and industry-specific trends in productivity.[45] Inklaar *et al*. (2006) only control for country and industry dummies.

44. The regression models used by Nicoletti and Scarpetta (2003), Conway *et al*. (2006) and Inklaar *et al*. (2008) are variants of that developed by Griffith *et al.* (2004) to test the effect of R&D expenditure on productivity growth.

45. The results of Conway *et al*. (2006) are also robust to accounting for industry-specific workers' skills and capital deepening.

- *Measurement of product market policies*. Conway *et al*. (2006) approximate regulatory burdens with the time-series of OECD industry-level indicators summarising the "knock on" effects of non-manufacturing regulations in individual business sectors (see above). This allows taking into account the effects of both entry barriers (especially in regulated service sectors) and the costs implied by regulation on all sectors of the economy. In a previous study, Nicoletti and Scarpetta (2003) related industry-level productivity outcomes to both the OECD time-series of the average regulatory burdens in (a subset of) non-manufacturing sectors and the OECD cross-section of industry-specific barriers to entry (in manufacturing and services sectors). Inklaar *et al*. (2008) use either the same OECD average time-series or the corresponding industry-level time-series for a subset of services sectors only.[46] Griffith *et al*. (2006) use EU anti-monopoly proceedings and dummies measuring the expected impact of the implementation of the Single Market Programme in different manufacturing sectors.

47. Given the above differences in data and specification, results from these studies are not easily comparable. However, a number of common conclusions emerge. To a different extent, regulations that restrict competition are found to curb productivity directly in all studies, though often only in some ICT-intensive industries. Moreover, Nicoletti and Scarpetta (2003) and Conway *et al*. (2006) find that an important channel through which restrictive regulations curb productivity growth across the board is by hindering the process of convergence to best practice productivity.

48. The findings by Conway *et al*. (2006) are worth mentioning in more detail in the context of this paper, because they look at both direct and indirect effects of regulation on productivity and focus explicitly on the split between ICT-intensive and other industries. The results can be summarised as follows. First, as expected, restrictive regulations have a direct negative influence on productivity growth in ICT-intensive (*i.e.* ICT-producing and ICT-using) sectors, implying that weak competition and regulatory burdens are particularly harmful for technology-driven productivity improvements in these sectors. No such direct impact could be detected on productivity growth in non-ICT sectors. Second, restrictive regulations also indirectly slow down productivity growth by curbing the speed of catch up to the productivity leader. The effect of catch up on productivity growth is generally found to be strong, reflecting a high degree of economic integration in the OECD area and the fact that technological innovation usually occurs in a given region or country.[47] However, catching up to best practice is found to be much harder in inappropriately regulated countries (or sectors) than in countries (or sectors) where regulations that promote competition have been put in place. Because relatively unproductive countries or sectors have the largest potential for catch up, the cost of inappropriate regulations, in terms of productivity gains foregone, is largest in countries or sectors with the widest productivity gaps. In other words, the cost of anti-competitive regulation increases the further a country (or sector) is from the world productivity frontier.

49. Conway *et al*.'s findings cannot determine if the indirect negative effect of restrictive regulations on productivity growth is due to inadequate diffusion, adoption or use of new technologies. But, keeping in mind the results found for the impact of regulation on the ICT share, it seems likely that a mixture of these three impeding factors is at work in inappropriately regulated countries (or sectors). In this respect, well-functioning and competitive product markets would seem to be an important condition for rapid productivity growth, because they increase the incentive to incorporate new technologies and lower the

46. These authors also perform panel regressions at the level of single service industries using the relevant OECD indicators of product market regulation. They find clear effects of regulation on productivity only in telecommunications.

47. Keller (2004) notes that "only a handful of rich countries account for most of the world's creation of new technology" and that in most countries "foreign sources of technology account for 90% or more of domestic productivity growth". Guellec and van Pottelsberghe de la Potterie (2001) make a similar point.

cost of making other necessary changes in the organisation of production to fully exploit these technologies. Product market regulation may also affect firms' ability to engage in co-invention or innovation in other areas, which often occur as part of the process of technological diffusion (Bresnahan and Greenstein, 1997). Under these conditions, it would seem, therefore, that a pre-requisite for taking full advantage of the diffusion of new technologies is to implement reforms that make product markets receptive to them and that countries that failed to do so before the ICT shock of the early 1990s, especially in sectors that provide intermediate inputs to crucial ICT-using sectors, may have been strongly disadvantaged in their quest for growth.

50. For example, Conway and Nicoletti (2007) use regression results to illustrate the "growth deficit" that would affect inappropriately regulated countries in the wake of a positive supply shock of a magnitude comparable to that experienced with the diffusion of ICT technologies. They estimate prudentially (*e.g.* taking into account only the indirect effect of regulations on the speed with which countries and sectors operating behind the world productivity frontier catch up to best practice) that, after five years from a one-off outward shift in the world productivity frontier of an equal size in all sectors, aggregate productivity in restrictive countries (such as Italy and, to a lesser extent, Germany) would increase only by a fraction of the response in a country where product market regulation is least restrictive of competition.[48] Moreover, in all countries, the detrimental effect of anti-competitive regulation is larger in ICT-intensive sectors given that, as discussed above, the regulatory burden is estimated to be higher in these sectors in comparison to non-ICT intensive sectors. The estimated gap in productivity catch-up in ICT-intensive sectors is particularly sizeable in Austria, Greece, Italy, Germany, Norway, and Belgium, all of which remain 30% to 40% below potential five years after the initial shock.

51. These experiments suggest that the dispersion of productivity levels across countries may have increased over time following the positive ICT supply shock as a result of differences in product market regulation. Moreover, the dispersion in productivity levels across countries may also have become larger in ICT-intensive sectors reflecting the larger cross-country heterogeneity of regulations in these (largely non-manufacturing) sectors. This provides indirect evidence that differences in regulation over the 1990s may have at least partly driven cross-country productivity divergence in the past decade.

III.3 Structural change and productivity performance

52. The discussion in previous sections relates widening gaps in productivity performances to cross-country differences in the ability to take full advantage of new widely available technologies. In turn, we have argued that such ability has differed due to differences in regulations that shape the business environment in crucial sectors. However, each country has industries and, within each industry, firms that perform well relative to world best practice. A well-functioning economy should naturally tend to reallocate resources towards these sectors and firms. In this section we take a closer look at factors affecting the cross-industry and cross-firm dispersion of productivity performances, and the role played by regulation in shaping such dispersion and the corresponding resource reallocation process.

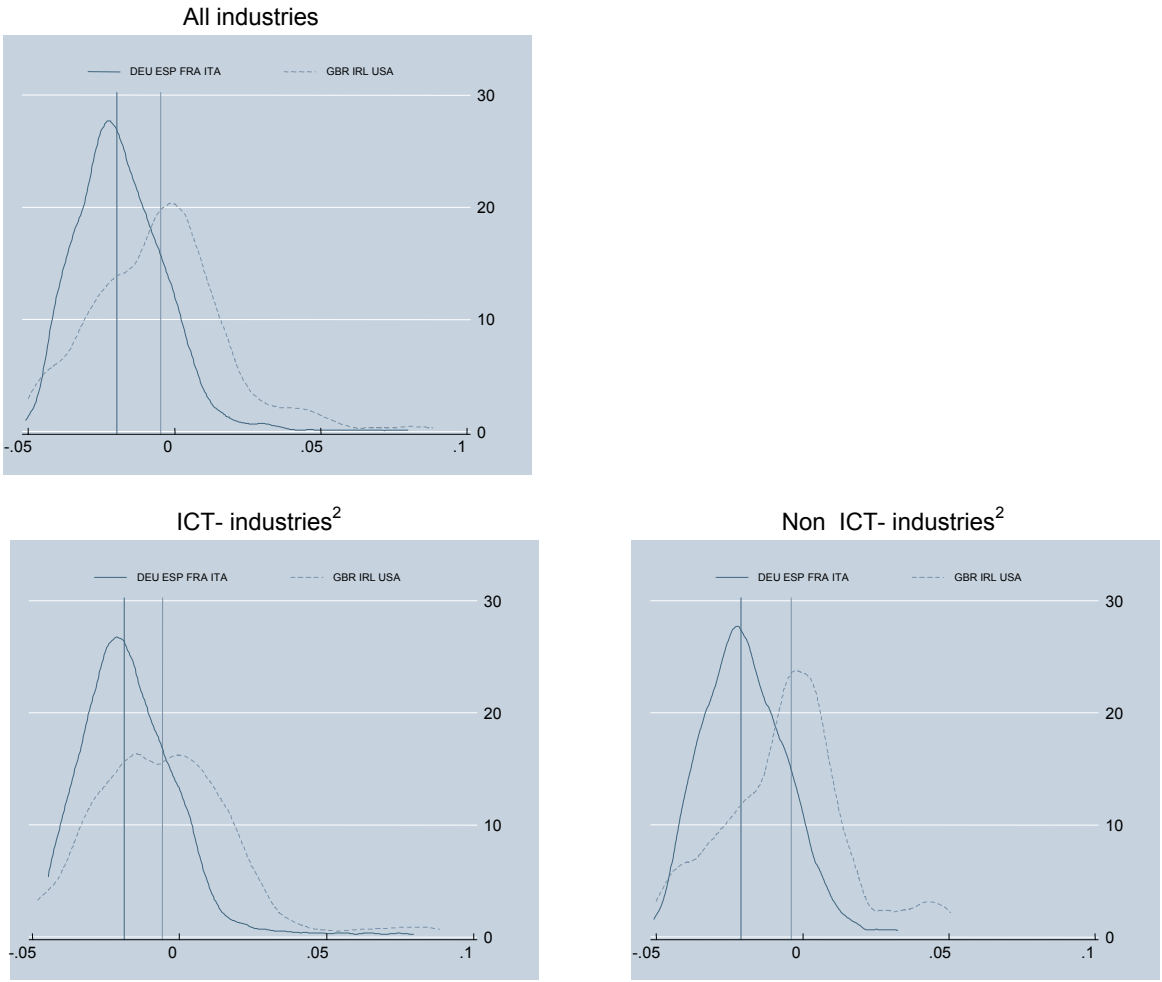
Regulation, industry heterogeneity and productivity

53. To begin exploring the dispersion of productivity growth rates, Figure 11 shows the cross-industry distribution of labour productivity growth rates over the 1995-2005 period in two groups of countries for which we have consistent data: three relatively "deregulated" English-speaking countries the United States, the United Kingdom and Ireland; and four relatively "restrictive" large continental and

48. To make country responses comparable and isolate the effect of product market regulation, this simulation assumes that, initially, the level of productivity in each sector is equal across all countries. Thus, the shock opens up the same sectoral productivity gap in all countries in the first year, which then closes at different speeds depending on the extent to which regulations restrict competition and hinder adjustment in different countries.

southern European countries Germany, France, Italy and Spain. For each group of countries, three distributions are shown: pooling all 39 industries and focusing on either ICT or non ICT industries. To abstract from short-term fluctuations, a Hodrick-Prescott filter has been applied to the series using all available years. In addition, the measure of labour productivity growth has been purged of idiosyncratic effects across countries and industries to make it possible to pool the productivity data meaningfully.[49] Therefore, values on the horizontal axis are not directly interpretable, while their dispersion (overall and in different industries) is.

Figure 11. Labour productivity growth distributions across countries, industries and time, 1995-2005[1]



1. Productivity growth purged of country, industry and period means.
2. See Annex 2 for the classification of sectors into ICT and non ICT.
Source: Authors' calculations based on EU-KLEMS, March 2007

54. Several features emerge. For both groups of countries, the overall distribution is skewed to the left, indicating prevalence towards weak productivity growth rates, but has a long right tail, indicating cases of high productivity growth. Interestingly, the right tail of fast growing industries is longer and thicker in English-speaking countries than in EU countries that have a higher concentration among

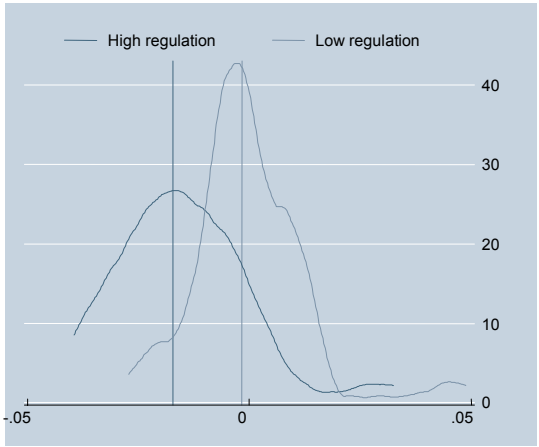
49. In other words, the figure shows the distribution of the residual of a regression of productivity growth rates on country and sector dummies after applying a Hodrick-Prescott filter and eliminating outliers (top and bottom percentile of the distribution). The resulting distributions are based on country-industry-year observations. The industry-level data are drawn from the EU-KLEMS database (March 2007, see Inklaar, Timmer and van Ark, 2007).

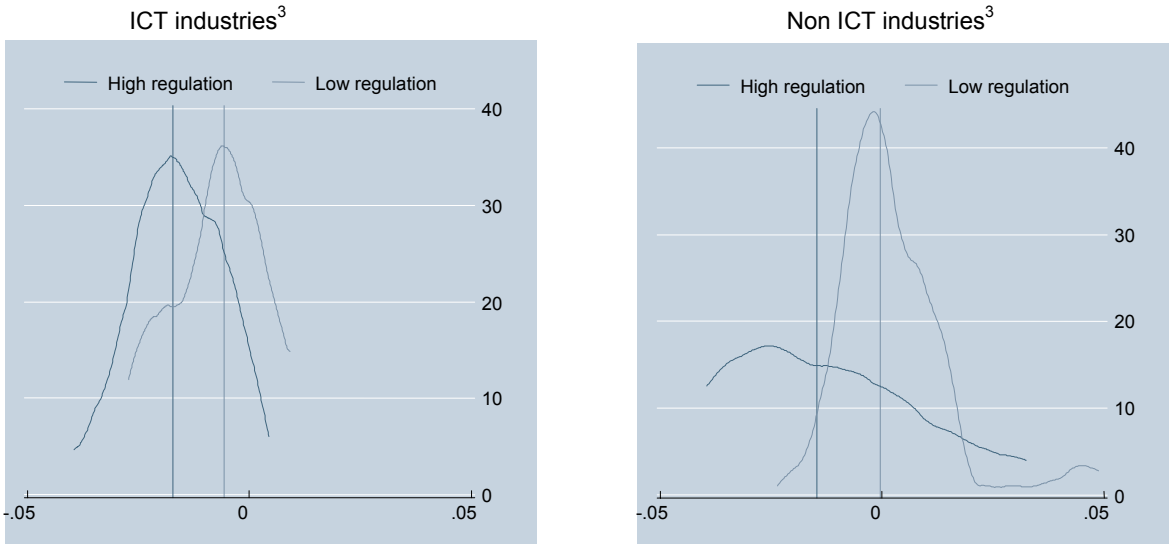
relatively slower-growing industries. As a consequence, English-speaking countries tend to have a higher median productivity growth than EU countries. The asymmetry between the two groups of countries is similar in both ICT and non ICT industries, but the dispersion of productivity growth rates is higher in the ICT-using industries of English-speaking countries. It would seem that above-median productivity growth, in the context of higher overall dispersion, is more common in the US, the United Kingdom and Ireland than in the large continental and southern European countries, especially in industries that are intensive in ICT.

55. In the light of our previous discussion, it is natural to relate these differences in productivity growth distributions to underlying product market policies that are more or less prone to help sustain fast growing firms within each industry. Before exploring this conjecture more in depth with firm-level data, it is useful to verify whether there is any association between differences in productivity growth distributions and our measures of the "knock-on" effects of restrictive non-manufacturing regulations at the industry level. To this end, Figure 12 replicates the three productivity growth distributions pooling together all countries, but now distinguishing between high and low-regulated cases (each observation being for a country/sector/period, purged as before from idiosyncratic factors), with the two sets of cases overlaid. High and low-regulated cases are defined as those falling in the first and fifth quintiles, respectively, of the distribution of the OECD indicator of the knock-on effects of non-manufacturing regulations in all business sectors (see Annex 1 for details).

56. The figure suggests that regulation plays a role in shaping the distribution of productivity growth rates. Where regulation encourages competition and does not impose excessive costs to businesses, median productivity growth is higher than where regulations are restrictive and costly. There are also noticeable differences in the productivity distributions of the ICT and non-ICT groups of industries. In the ICT group, low-regulated activities have a higher median productivity growth than the more heavily regulated ones but a similar shape of the density function. In the non-ICT group, strict regulations – by reducing entry and market contestability – seem to allow industries with relatively low productivity growth to continue lagging behind (e.g. fat left tail of the distribution). To shed more light on this issue, in the remainder of this paper we look at the possible impact of product market policies on the process of resource reallocation and firm growth using cross-country firm-level data.

Figure 12. Labour productivity growth distributions across countries, industries and time, 1995-2005[1]
High and low regulation[2]
All industries





1. Productivity growth, HP filtered and purged of country and industry means.
2. Observations are classified into low or high regulation if they fall in the first or last quintile, respectively, of the distribution of the regulation impact indicator. These indicators reflect the 'knock-on' effects of anti-competitive regulation in non-manufacturing sectors on industries that use the output of these sectors as intermediate inputs into the production process. See Annex 1 for details.
3. See Annex 2 for the classification of sectors into ICT-using and non ICT-using.
Source: Authors' calculations based on EU-KLEMS, March 2007, and Conway and Nicoletti (2006)

The role of reallocation across firms

57. Previous studies (see *e.g.* Van Ark, 1996; Scarpetta *et al.* 2000) have shown that, over the past two decades, aggregate productivity growth in OECD countries was largely due to efficiency improvements within broadly defined industries.[50] Nevertheless, there is evidence of large differences in productivity growth rates across industries at a finer level of disaggregation as well as over time. Reallocation across services industries appears to have played an increasingly important role in some countries (see *e.g.* Bosworth and Triplett, 2007, for the United States). Thus, the ability to reallocate resources to new dynamic industries may have played an important role in driving aggregate performance over the recent past.

58. The significant heterogeneity of industry-level productivity levels and growth rates is compounded by an even higher dispersion at the firm level within each industry and a continuous process of reallocation of resources through the entry of new firms, the exit of obsolete units and the expansion and contraction of incumbents. This continuous reallocation process was found to play a major role for aggregate productivity and output growth in a number of OECD countries (*e.g.* Olley and Pakes, 1996; Foster *et al.* 2002; Griliches and Regev, 1995; Bartelsman *et al.* 2004; and Aghion and Howitt, 2006). Resource reallocation is driven by incumbent firms adapting to market and technological changes, but also by firm dynamics – the entry of new firms, their expansion in the initial years of life and the exit of obsolete units. Firm dynamics is sizeable: several studies suggest that about 10 to 15% of all firms are either created or closed down every year in industrialized and emerging economies (see Caves, 1998;

50. A shift-and-share decomposition is generally used to assess the role of within-industry effects *vs.* effects due to reallocation of resources across sectors. In Scarpetta *et al.* (2000), the shift-share analysis is performed using 3-4 digit ISIC (Rev.3) industry breakdown for manufacturing, and 2-digit ISIC for services. This decomposition bears several limitations other than the lack of detail for services (Timmer and Szirmai, 1999). First, it focuses on labour productivity and not on multi-factor productivity. Second, it assumes that marginal productivity of factor inputs moving in or out of an industry is the same as average productivity. Finally, if output growth is positively related to productivity growth (the so-called Verdoorn effect), the impact of structural change may be underestimated, since part of the shift to rapid-growth sectors will be counted in the within-effect.

Bartelsman and Doms, 2000 and Bartelsman *et al.* 2004 for reviews). Many of the new firms that enter the market fail in the initial years of life, but those that survive tend to grow, often at a higher pace than incumbents firms (see *e.g.* Geroski, 1995; Sutton, 1997; Bartelsman *et al.* 2004).

59. Are there significant differences in the degree of firm heterogeneity, and thus in the scope for resource reallocation? To shed light on this issue we rely on the firm-level Amadeus database (a commercially available collection of company-level accounting data). Our version of the database includes about 1.5 million European companies, including large numbers of unlisted SMEs, and covers the years 1998-2004.[51] Available information allows for a detailed analysis of firm level performance at a fine sectoral disaggregation.

60. Although the data provider, Bureau Van Dijk, ensures that 95% of companies fulfilling the size criteria are indeed included in the database, a typical feature of firm level data sets such as Amadeus is that not all firms in the data report information on all relevant output and input variables. This reduces the effective size of the dataset significantly, and the remaining sample, in which only firms were retained for which both labour productivity and MFP could be measured, needs not be representative of the population distribution of firms across size classes, sectors, and countries. The Amadeus sample of firms was therefore aligned with the distribution of the true firm population. In a first step, population weights for every size-sector-country strata were calculated from the Eurostat *Structural Business Statistics* database for the year 2000. Then, random draws with replacement from each size-sector-country strata in the sample were taken until the weight of each strata corresponds to its population weight. Given that our version of Amadeus does not have a satisfactory coverage of firms below 20 employees, the resampling procedure targets the size-sector-country distribution of the true population of firms with 20 employees and more.[52]

61. Figure 13 shows the distribution of firm-level labour productivity over the 1998-2004 period for two countries –France and the United Kingdom – and for four representative sectors – two ICT-producing sectors, *electrical and optical equipment* (ISIC Rev.3 30-33) and *post and telecommunication* (64), one ICT-using industry, wholesale and retail trade (50-52), and a traditional manufacturing industry, *textile, clothing and footwear* (17-19). We focus on labour productivity at this stage because we want to take into account repercussions for productivity dispersion of both MFP improvements and capital deepening: indeed, cross-country and cross-sectoral differences in productivity distributions, and their developments over time, reflect differential abilities and/or opportunities for implementing innovative production techniques but also for investing in new technologies. For each year, industry and country we plot the distribution between the 5th and the 95th percentile of labour productivity. The upper bound of the grey bar represents the 75th percentile, the lower bound the 25th percentile and the line in the middle of each grey bar being the median.

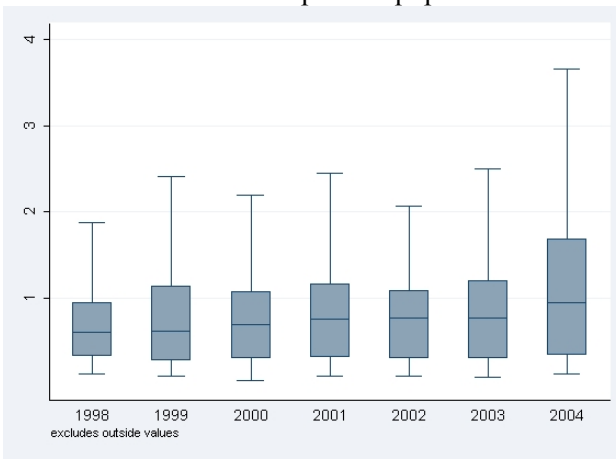
51. This database includes all companies that fulfil at least one of the following three size criteria: *i)* operating revenue equal to at least 1.5 million euros, *ii)* total assets equal to at least 3 million euros and *iii)* number of employees equal to at least 20. The provider of the Amadeus database is a private company, Bureau Van Dijk.

52. See Appendix 3 for more information on the resampling procedure. An additional question regards the harmonisation of the accounting items reported in the database across countries, as accounting standards and reporting regulations differ in details. In all our empirical analyses in this paper, we control for such cross-country differences by including country fixed-effects.

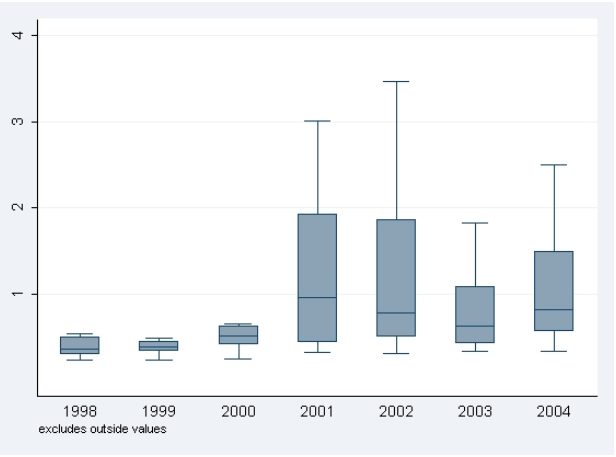
Figure 13. Evolution and dispersion of labour productivity: selected countries and sectors[1]

France

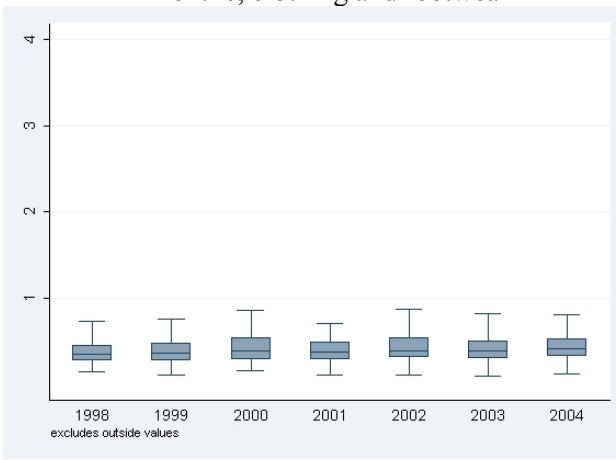
Electrical and optical equipment



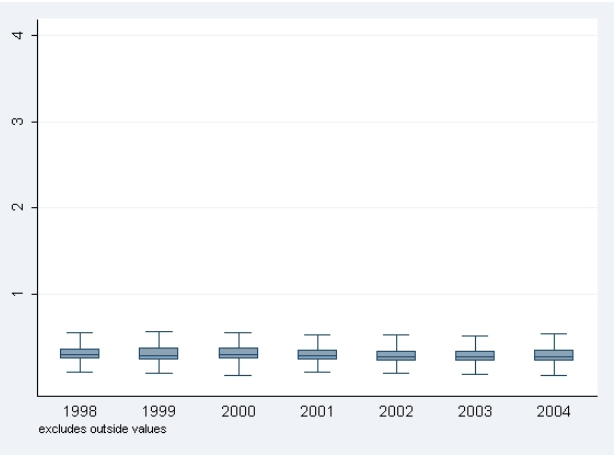
Telecommunications



Textile, clothing and footwear

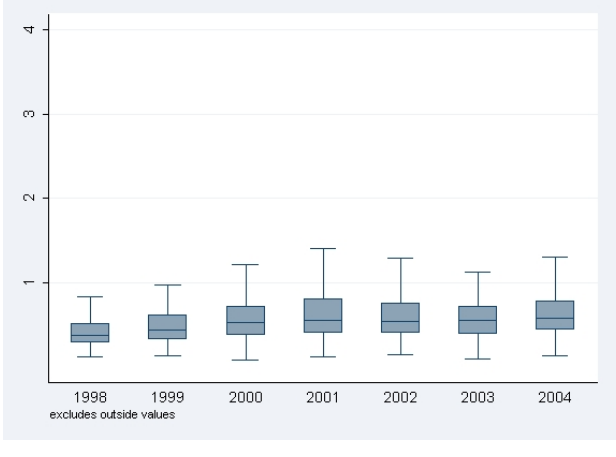


Wholesale and retail trade

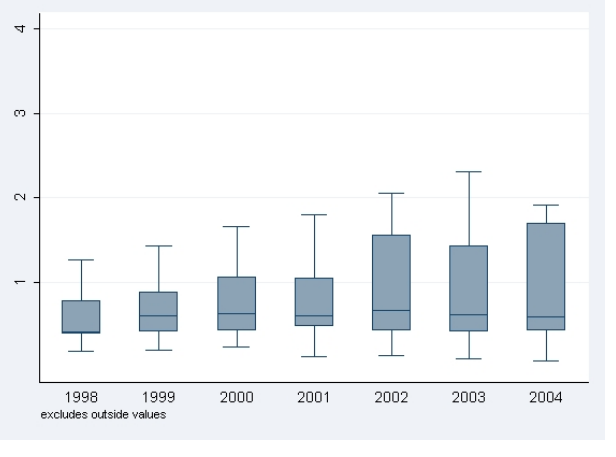


United Kingdom

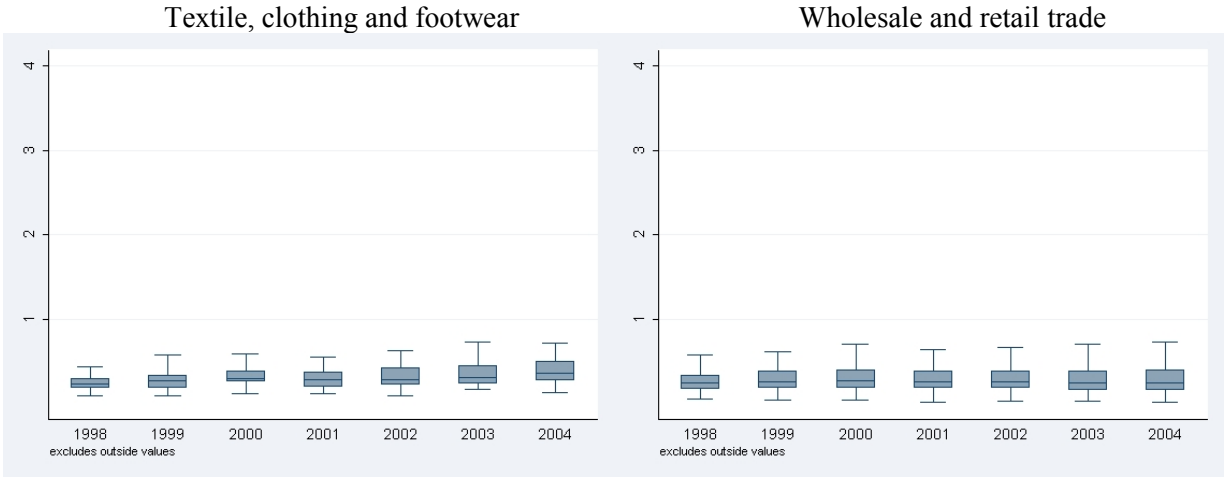
Electrical and optical equipment



Telecommunications



United Kingdom *contd.*



1. The figures present the distribution of labour productivity in each industry and year between the 5th and 95th percentiles. The upper bound of the grey bar represent the 75th percentile, the lower bound the 25th percentile and the line in the middle of each grey bar being the median. Labour productivity is measured as value-added per worker in 100 thousands of 1995 euros, using value-added deflators from EU KLEMS.
Source: Authors' calculations, Amadeus database.

62. All industries display persistent productivity dispersion confirming the fact that at any point in time all industries are characterised by a (more or less) wide heterogeneity in the performance of its firms, some of them being young businesses that are learning their way into the market, others being obsolete firms on their way out, but others again being firms undergoing significant investment and retooling. Interestingly, the degree of productivity dispersion varies significantly across sectors. In line with our discussion so far, the ICT-producing industries show a higher average productivity, but also a wider heterogeneity in productivity performance and, especially in the case of the telecommunication sector, an increase in dispersion over time largely because of the development of high productivity firms at the top of distribution.[53] The traditional manufacturing sector – textile, clothing and footwear – shows a much narrower distribution of productivity growth rates across firms as does the trade sector, especially in France, despite the potential for its firms to exploit the productivity bonus provided by ICT. Indeed, UK retail firms seem to experience – though on a much smaller scale – the same increase in productivity dispersion at the top as observed in ICT-producing sectors.

63. Given the wide dispersion in the firm-level productivity performance and the wider heterogeneity in the ICT sectors, the natural question is whether market forces tend to reallocate resources towards firms with higher efficiency levels. There are different ways to assess the importance of reallocation for productivity. A number of studies have focused on dynamic efficiency, assessing the role for productivity growth of reallocation among incumbents, as well as through the entry and exit of firms, (Foster *et al.* 2006; Griliches and Regev, 1995; Bartelsman *et al.* 2007). However, this analysis of dynamic efficiency, while inherently interesting, is fraught with interpretational and measurement difficulties mainly related to the comparability across countries of the entry and exit of firms. In an attempt to overcome these difficulties, these studies tend to exploit sectoral variations within countries and then, in turn, compare

53. Griffith, Redding and Simpson (2006) present a similar figure for the United Kingdom. focusing on the narrower office machinery and computer equipment industry and the footwear and clothing industry. Their data covers a much longer period – 1981-2000 – and suggest a significant acceleration in productivity in the office and computer sector with a widening of the dispersion as of the mid-1990s when the IC technology shock was fully unfolding, while the dispersion remained broadly constant in the traditional clothing and footwear sector.

such sectoral differences across countries – a difference-in-difference approach. They generally find a significant role of entry and exit for productivity growth in all countries and a stronger role of entry in dynamic industries, where new firms may better harness new technologies in production and organization processes.

64. A simpler way to assess the importance of reallocation for productivity is to ask the question – are resources allocated efficiently in a sector/country in the cross section of firms at a given point in time? To answer this question, the focus needs to be set on multifactor productivity, which is the appropriate measure of firm-level efficiency in the use of inputs. This approach is based upon a simple cross-sectional decomposition of multifactor productivity levels developed by Olley and Pakes (1996). They note that, in the cross section, the aggregate level of productivity for a sector at a point in time, *t*, can be decomposed as follows:

$$P_t = (1/N_t)\sum_i P_{it} + \sum_i (\theta_{it} - \bar{\theta}_t)(P_{it} - \bar{P}_t) \qquad (1)$$

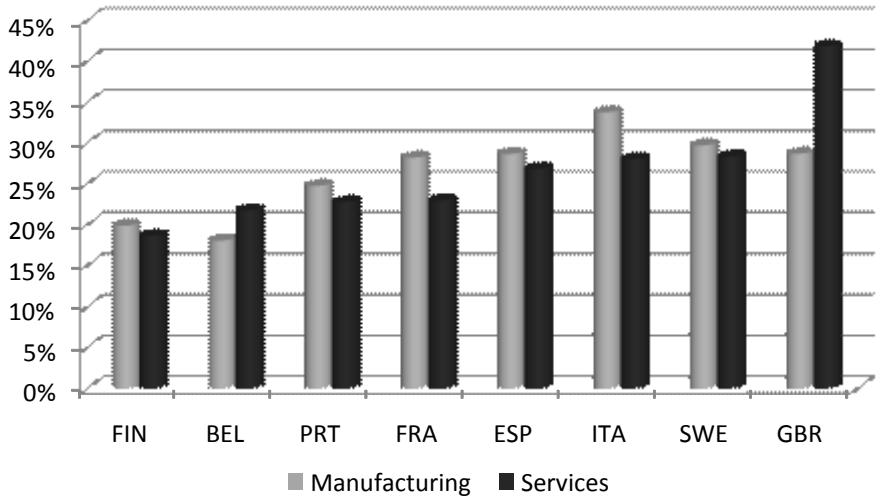
where P_t is sectoral productivity, P_{it} is firm-level productivity, θ_{it} is the share of activity for the firm, N_t is the number of businesses in the sector and a 'bar' over a variable represents the unweighted industry average of the firm-level measure. The simple interpretation of this decomposition is that aggregate productivity can be decomposed into two terms involving the unweighted average of firm-level multifactor productivity plus a cross term that reflects the cross-sectional efficiency of the allocation of activity. The cross term captures *allocative efficiency* since it reflects the extent to which firms with greater efficiency have a greater market share (θ).

65. This simple decomposition is very easy to implement and essentially involves simply measuring the un-weighted average productivity *versus* the weighted average productivity. Measurement problems make comparisons of the levels of either of these measures across sectors or countries very problematic, but focusing on the relative contribution of allocative efficiency to the observed aggregate productivity level only involves comparing productivity levels of firms in the same industry and countries where most measurement problems are controlled for. As discussed below, there are several possible approaches to measuring MFP at the firm level. Since no cross-country or cross-sector comparability issues arise in the Olley-Pakes decomposition, we take the standard approach of estimating, for each sector and country, a production function in logarithmic form and take the residual, *i.e.* the part of output that is not explained by factor inputs, as a measure of MFP.

66. Figure 14 presents the estimated indicator of efficiency (OP=WP/(AP+WP)) in the allocation of resources in a sample of EU countries for which we have consistent firm-level data from the Amadeus database over the early 2000s. It focuses on manufacturing and services separately and for each of the two broad sectors a weighted average of 2-digit industry level OP cross terms was used. The OP decomposition suggests that in all countries allocative efficiency accounts for a significant fraction of the overall observed MFP levels: between 20-40% of the observed productivity levels can be ascribed to the actual allocation of resources with respect to a situation in which resources were allocated randomly across firms in each sector. However, there are also interesting differences across the two broad sectors – manufacturing and business services – and across countries. In particular, cross-country differences in allocative efficiency in manufacturing are smaller than those observed in business services, where regulatory reforms have been more hesitant in a number of continental EU countries and where foreign competition is less acute. The United Kingdom, arguably a country that, as discussed above, has introduced already in the 1980s market-

friendly regulations in most service industries, stands with the highest degree of allocative efficiency in services, almost 15 log points above that of the second highest country in the service sector.[54]

Figure 14. Contribution of resource allocation to sectoral MFP levels (early 2000s)
***Based on Olley-Pakes productivity decomposition*[1]**



1. The data reported in the figure represent the share of total MFP level that is due to an efficient allocation of resources. The degree of efficiency in resource allocation is measured by the cross-term of the Olley and Pakes decomposition (see main text), which is defined as the log difference between the weighted (P_t) and un-weighted averages (AP_t) of firm-level productivity.
Source: Authors' calculations based on Amadeus data base

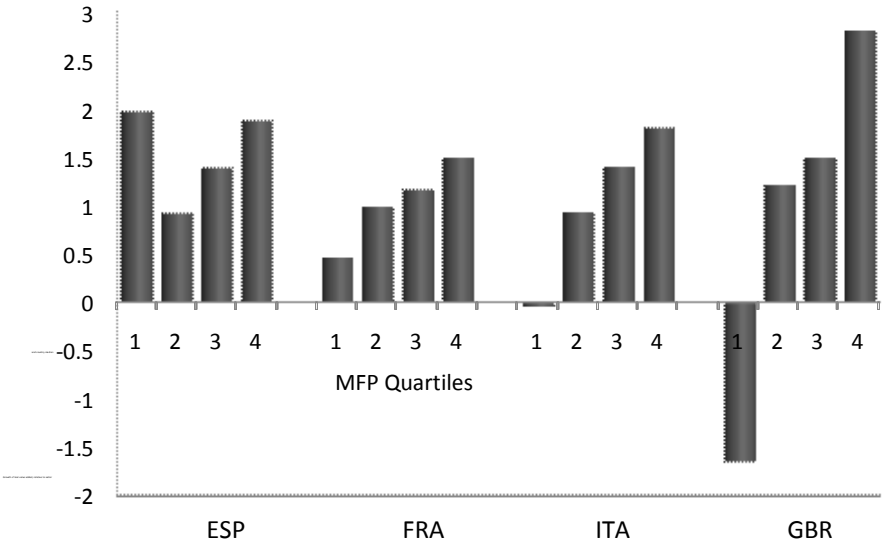
67. As a further step in our analysis of allocative efficiency, Figure 15 plots firm growth by firms belonging to the four quartiles of the productivity distribution. The quartiles divide firms according to their MFP (relative to the median of the sector and country for which the production function was estimated, on average over 1998-2004). Thus, the top quartile represents the 25% most productive firms in each industry. Firm growth is measured in terms of real value-added, also averaged over 1998-2004, and normalised by the country/sector average (which is set equal to 1 in the figure).[55] In theory, an efficient allocation of resources should promote the expansion of most productive firms; in other words, firms with relatively high productivity levels should be gaining market shares, while those at the bottom of the distribution should be contracting and eventually exiting. Of course, this is a partial analysis that does not consider dynamic processes, *i.e.* some of the low productivity firms may be new ventures that are involved in a learning-by-doing process and catching up to the efficiency of more mature businesses, while some of the high productive businesses may have less scope for further expansion. Bearing these caveats in mind, the figure suggests that in all but one country (Spain), more productive firms indeed experience a higher growth than their lower productivity counterparts. However, the difference in the growth of low and high

54. A similar analysis is presented in Bartelsman *et al.* (2004) with reference to labour productivity in manufacturing in the 1990s in a sample of OECD countries that also includes the United States. Interestingly, the United States stands in this analysis as the country with a much higher degree of allocative efficiency as compared with the other OECD countries. In these data (drawn from census and enterprise surveys) the degree of allocative efficiency in the United Kingdom is fairly low. However, the data refers to the manufacturing and to the 1990s, while in the evidence of a high allocative efficiency reported in this paper the focus is on the early 2000 and to the business service sector.

55. In other words, a value of 3 for the highest quartile in the United Kingdom means that these firms grew on average three times faster than their peers in the same sector/country cell. To minimize endogeneity problems, the growth in firm value-added is calculated one year later than the productivity quartiles.

productivity firms varies significantly across countries. While in Spain there is no clear relationship between productivity levels and expansion, in France the most productive 25% have an average growth that is twice as high as the 25% least productive firms, while in Italy it is three times as high and in the United Kingdom it is five times as high. This confirms our finding based on the cross-sectional OP productivity decomposition, namely that some countries are better at channelling resources towards high productivity firms, thereby encouraging them to grow rapidly and strongly contributing to the overall productivity performance.

Figure 15. Do better firms grow faster?[1]
(Value-added growth by quartiles of the MFP distribution of firms)



1. The figure presents the average real value-added growth of the four quartiles of the MFP (relative to the median of the sector and country for which it was estimated) distribution of firms in each country. Firm level real value-added growth are normalised by country/sector average to improve comparability.
Source: Authors' calculations based on Amadeus data base.

68. Two questions emerge at this point: Why have some countries been better than others at reallocating resources towards fast growing firms, especially in industries having a high potential for exploiting new general-purpose technologies? What are the mechanisms through which inappropriate regulations affect reallocation across sectors and firms? Before providing a formal econometric analysis of the links between firm-level productivity performance and regulations in the next section, a first step towards answering these questions is to simply correlate our OP indicator of allocative efficiency across countries, sectors and time with the OECD indicators of the knock-on effects of non-manufacturing regulation on all sectors of the economy (Table 1). We use a fixed-effect specification in which, in addition to our regulatory impact indicator, we include a full set of time-varying country-specific and sector-specific effects.[56] The results for the overall business sector suggest a negative effect of anti-competitive regulations on the efficiency of the allocation of resources. However, breaking down the sample into manufacturing and services suggests that the negative effect of regulation originates from services. This is not surprising, since cross-country differences in the regulatory environment, and regulatory reforms over the past decade mostly concerned the service sector. Interestingly, if we split the industry sample between ICT using and non-ICT using sectors we find that anti-competitive regulations affect more strongly the ICT sectors. In other words, in those sectors where there was more heterogeneity in firm performance because of greater experimentation and learning by doing around this new general purpose technology,

56. The sample includes a set of OECD countries for which the Amadeus database has a good coverage of firms: Austria, Belgium, Finland, France, Germany, Italy, Portugal, Spain, Sweden, United Kingdom; the period is 1998-2004.

regulations that restricted competition and entry of new firms have had a strong negative effect on the ability of the market to quickly channel resources towards those firms with the highest realised performance. This echoes nicely previous results obtained by Conway *et al.* (2006) on industry-level data, illustrating one channel through which restrictive regulations in ICT-using sectors may have curbed the ability of some countries to fully benefit from the diffusion of ICT over the past decade.

Table 1. Product market regulation and allocative efficiency

Dependent Variable: Olley/Pakes indicator of allocative efficiency	Business Sector	Manufacturing only	Services only	ICT using sectors	Non-ICT using sectors
Regulation Impact Indicator	-0.36 **	0.34	-0.28 *	-0.67 ***	-0.41 *
	(0.15)	(0.64)	(0.15)	(0.16)	(0.24)
Country-year FE	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes
N	849	629	220	242	607
R2	0.20	0.20	0.36	0.36	0.18

Standard Errors in parentheses. *, **, *** indicate statistical significance at the 10, 5 and 1 percent levels, respectively.
Agriculture, forestry, fishing, mining are excluded, as are public administration, education and health sectors.

III.4 Firm-level evidence on regulation and MFP growth

69. The discussion so far has indicated that aggregate productivity growth is largely driven by some high growth ICT sectors and, within them, by the presence of a group of highly performing firms (the "gazelles"). While there is empirical evidence on the links between industry-level productivity growth and ICT investment and regulations, the evidence on how regulations influence the emergence and expansion of these high performing gazelles is very scant. In the previous section we have shown that inappropriate regulations, not only affect the dispersion in productivity across firms, but are also likely to hinder the allocation of resources towards the most productive ones. Here we move one step forward and look at the drivers of firm-level productivity.

70. We adopt the same neo-Schumpeterian growth framework discussed in previous sections and used in the industry-level empirical work surveyed above. This model allows for two distinguishing features: *i)* persistent heterogeneity in firm level performance, even in narrowly-defined industries; and *ii)* the possibility of firms to catch up with the technological frontier through adoption of leading technologies. In particular, we consider a catch-up specification of firm-level productivity whereby, within each industry, the production possibility set is influenced by technological and organisational transfer from the technology-frontier firms to other firms.[57] In this context, firm-level multi-factor productivity for a given country *c,* industry *s* at time *t* (MFP_{icst}) can be modelled as an auto-regressive distributed lag *ADL(1,1)* process in which the level of MFP is co-integrated with the level of MFP of the frontier firm *F*. Formally,

$$\ln A_{icst} = \alpha_0 \ln A_{icst-1} + \alpha_1 \ln A_{Fcst} + \alpha_2 \ln A_{Fcst-1} + \alpha_3 regimpact_{cst-1} + \gamma_s + \gamma_{ct} + \varepsilon_{icst} \quad (2)$$

57. Aghion *et al.* (2005) use a similar approach to study the effect of foreign entry on innovation incentives and productivity growth of UK incumbent firms.

where A_{icst} is the MFP level of a non-frontier firm *i*, A_{Fcst} is the MFP level at the technological frontier *F*, *regimpact* is the lagged indicator of the impact of non-manufacturing regulations in each sector/country/period, and γ_s , γ_{ct} are sector and country-year fixed effects, respectively; ε_{icst} is a random error term. The ADL(1,1) process in equation (2) has the following Error Correction Model (ECM) representation:[58]

$$\Delta \ln A_{icst} = \alpha_1 \Delta \ln A_{Fcst} - (1-\alpha_0)\ln\left(\frac{A_{ics,t-1}}{A_{Fcs,t-1}}\right) + \alpha_3 regimpact_{cst-1} + \gamma_s + \gamma_{ct} + \varepsilon_{icst} \qquad (3)$$

71. Equation (3) is the baseline specification of the policy-augmented MFP equation. The ECM representation has many attractive statistical properties and a straightforward interpretation.[59] Productivity growth of firm *i* is expected to increase with productivity growth of the frontier firm *F* and with firm *i*'s distance from the frontier firm *F*. Notice that, even though the ECM representation is estimated with MFP growth as the dependent variable, the underlying ADL(1,1) model is in productivity levels and not in growth rates. The model implies equilibrium firm heterogeneity in MFP levels because *i)* the innovation potential of the frontier firm is higher than innovation potential of the non-frontier firms and *ii)* convergence to the frontier takes time. Standard errors are clustered by country and sector to allow the error term to be correlated across establishments and time within sectors in the same country (Moulton, 1991, Bertrand *et al.* 2004).

72. As mentioned above, MFP measurement is not an easy task, due to comparability problems across different countries and sectors, and should be consistent with the purposes of the analysis. The standard approach of measuring MFP as the residual from a regression of (log) output on (log) inputs hinges on the accurate estimation of the production function, which is usually performed at the sector level for a given country. In a cross-country setting, however, it would be a strong assumption to restrict the coefficients of the production function to be equal across all countries. At the same time, however, if one estimates country and industry-specific production functions, the resulting productivity estimates are not comparable across countries, which makes it impossible to compare a firm's performance to an "international" technological frontier. A second approach is to use a superlative index number approach (see Caves *et al.* 1982a,b). The index approach allows comparisons of MFP in levels across countries, but it is based on a number of potentially restrictive assumptions, including constant returns to scale and perfect competition on factor markets.

73. For the present sample of European countries with intensive ties in trade and investment, it is likely that catch-up to best practice across borders plays a significant role for explaining MFP growth. Given that a model with an international productivity leader requires a MFP measure that is comparable across countries, the MFP index approach was chosen as the preferred MFP measure for the regression analysis, although we also check that this choice does not matter for our results (see below). MFP at the technological frontier is measured as the average MFP of the 5% most productive firms in sector *s* in year *t* in our sample of countries.

74. Following Griffith *et al.* (2006), the superlative index measures of MFP growth and MFP level in firm *i* at time *t* are calculated as a function of value-added Y and the two input factors labour and capital, denominated x^z (with z=1,2):

58. Under the assumption of long-run homogeneity (1-□0=□1+□2).

59. See Hendry (1996) for the statistical properties of the ECM model.

$$\Delta MFP_{it} = \Delta \ln Y_{it} - \sum_{z=1}^{2} \tilde{\alpha}_{it}^{z} \Delta \ln x_{it}^{z}, \quad (4)$$

$$MFP_{it} = \ln\left(Y_{it} / \overline{Y}_{j}\right) - \sum_{z=1}^{2} \sigma_{i}^{z} \ln\left(x_{it}^{z} / \overline{x}_{j}^{z}\right),$$

where $\tilde{\alpha}^{z}_{it}$ is a two-period average of the factor compensation shares in value-added ($\tilde{\alpha}^{z}_{it}$= ½ α^{z}_{it}+ ½ α^{z}_{it-1}). In the levels equation, upper bars depict geometric means of all firms in the same industry over all countries and years, and $\sigma^{z}_{i} = \alpha^{z}_{i} + \overline{\alpha^{z}_{j}}$ is the average of the factor share in firm *i* and the geometric mean factor share in industry *j*. Constant returns to scale are assumed by imposing $\sum_z \tilde{\alpha}^{z}_{it}$ =1 and $\sum_z \sigma^{z}_{i}$=1.

75. It should be stressed at the outset that our analysis focuses on the productivity growth of incumbents across different industries and countries. There are, however, other drivers of productivity growth that cannot be explored with the Amadeus data. The most important one is reallocation of productive inputs and outputs via the entry and exit of firms. In Amadeus it is not possible to accurately distinguish entry into the market from entry into the sample and exit from the market from exit from the sample.[60] The importance of creative destruction in promoting productivity growth is empirically supported by Olley and Pakes (1996), Pavcnik (2002) and more recently by Aghion *et al.* (2007) who found that restrictive entry regulations curb entry of new firms in sectors naturally characterised by high firm turnover. While our estimates cannot directly account for firm turnover, they account for the indirect effect that entry may have on incumbents' productivity through entry regulations that affect the competitive pressure, especially in non-manufacturing sectors where our indicators of "regulation impact" measure mostly barriers to entry. The indicators are, however, unable to capture this effect in other sectors, where they measure mostly the burden (e.g. in terms of additional costs of adjustment) imposed on firms by regulations that bar entry in non-manufacturing industries.[61]

76. The first three columns in Table 2 present estimates of the baseline specification of the productivity equation focusing on the total business sector, ICT-using and non-ICT-using sectors respectively. In line with the theoretical framework and previous evidence at the sectoral level (Griffith *et al*. 2000; Nicoletti and Scarpetta, 2003 and Inklaar *et al.* 2007) and at the firm level (Griffith *et al*. 2006, for the United Kingdom), outward shifts in the technological frontier (*leader growth* in the table) influence productivity of follower firms. Furthermore, other things being equal, the larger the distance to the industry-specific technology frontier (*gap to the leader* in the table), the greater the scope for catching up and experiencing strong productivity growth on the transitional path to the frontier.[62] Confirming industry-level results, the regulatory impact variable has a statistically-significant negative effect on firm-level productivity, but only in the ICT-using industries. As discussed earlier, these are the industries where most of the product market reforms took place, with different intensities across European countries, and where there was greater scope for competition-enhancing reforms to strengthen new entry and rivalry among firms, promoting escape competition strategies by incumbents via the adoption of IC technology.

60 . Moreover, it is difficult to distinguish new firms from mergers.

61. To the extent that the costs of adjustment implied by the use of intermediate inputs produced by regulated industries are correlated with entry in using industries, it is possible therefore that the regulation impact indicators may capture the effect of the omitted entry variable in these industries. This is unlikely, however, since our results indicate that regulation has a significant impact only in ICT-using sectors, which are to a large extent non-manufacturing ones.

62. Similar results are obtained by a number of studies focusing on UK firm-level data and using foreign entry as the key competition-enhancing factor. See Aghion *et al.* (2004), Aghion et al. (2005) Griffith *et al.* (2002) and Haskel *et al.* (2002).

Table 2. Firm-level MFP and regulations (using superlative index MFP and global frontier)

Dependent Variable: MFP growth (Superlative Index)	Business Sector	ICT using sectors	Non-ICT using sectors	ICT-using: Catch-up	ICT-using: Distance from frontier
Leader Growth	0.08 ***	0.07 ***	0.10 ***	0.36 ***	0.63 ***
	(0.01)	(0.01)	(0.01)	(0.03)	(0.03)
Gap to the Leader	-0.15 ***	-0.15 ***	-0.16 ***	-0.09 ***	-0.26 ***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
PMR	-0.05	-0.07 **	0.04		
	(0.04)	(0.03)	(0.08)		
Catch-up firms: PMR				-0.06 **	
				(0.03)	
Non-catch-up firms: PMR				0.04	
				(0.04)	
Dummy for catch-up firms				0.27 ***	
				(0.02)	
Catch-up firms close to frontier: PMR					-0.04 ***
					(0.01)
Catch-up firms far from frontier: PMR					-0.03
					(0.02)
Dummy for close to frontier					0.18 ***
					(0.01)
Country-year FE	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes
N	204838	100032	104806	100032	88306
R2	0.09	0.10	0.10	0.41	0.38

MFP is measured as a superlative index, calculated as described in equation 5. Standard Errors are in parentheses. *, **, *** indicate statistical significance at the 10, 5 and 1 percent levels, respectively. Agriculture, forestry, fishing, mining are excluded, as are public administration, education and health sectors. Catch-up firms are defined as those firms in each country and industry with above median catch-up towards the frontier during the past year. Similarly, firms are labelled close to the frontier if their gap to the technological frontier is below the median of the respective country and industry in absolute value.

77. The last two columns of the table shed some light on which firms are potentially most affected by inappropriate regulations. In particular, in Column 4 we test whether these regulations have disproportionate effects on dynamic firms (*i.e.* those with the potential to rapidly catch up) and in Column 5 we test whether regulations have such effects on the high-productivity firms that, as discussed earlier, mostly drive aggregate performance.[63] In the first case, we interact the regulatory impact variable with dummies indicating firms that have approached the frontier faster than the median firm in the same country and industry over the last year; while in the second we focus on most productive firms and interact the regulatory variable with dummies indicating firms close or further behind the frontier than the median firms in the same country and industry. The empirical results clearly indicate that burdensome

63. Catch-up firms are defined as those that reduced the gap with the frontier during the past year. Firms close to the frontier are those with a productivity gap below the median in absolute value.

regulations – by curbing competitive pressures and limiting the scope for escape competition strategies – affect predominantly the best performing firms in each sector, both from a static (most productive firms) and a dynamic perspective (rapidly catching up firms). Interestingly, firms that are very distant from the frontier do not seem to be affected by regulation.

78. These results are consistent with those of Aghion *et al.* (2004; 2005): using firm-level data for the United Kingdom and foreign entry as the key competition-enhancing factor, they found that entry spurs escape entry strategies and innovation incentives mainly for technologically-advanced firms. But how do our results square with the industry-level results discussed in the previous section suggesting that market-unfriendly regulations affect in particular those industries further behind the world technology frontier? The two sets of results are not inconsistent: industry-level results includes entry and exit effects at the industry level, as well as reallocation among incumbents; while firm-level results, by construction only focus on individual firms' performance conditional on their survival. In particular, market-unfriendly regulations – by curbing entry and innovation incentives and permitting low productivity firms to survive – lower the industry-average productivity performance, and the effects are the largest the more the industry as a whole could benefit from adoption of leading technologies in world markets. Within each industry, however, and conditioning on the sample of surviving firms, regulations that curb competitive pressures and increase costs reduce only escape competition strategies and innovation incentives of the more advanced firms that have the greatest potential for adopting leading technologies available in the market.

Sensitivity analysis: productivity measures and other covariates

79. We test the robustness of our empirical results by considering alternative estimators of MFP and by further augmenting our MFP equation to include other policy covariates. The alternative firm-level MFP measures are based on a production function approach. In particular, we estimate the production function using both ordinary least squares (OLS) and the semi-parametric estimation technique of Levinsohn and Petrin (2003). The latter technique controls for an econometric problem that may arise if unobserved productivity shocks of firms influence their factor input choices, which could potentially create a bias in OLS estimations of the production function (see Annex 3 for more details). Since the production function is estimated separately for each sector and country, the resulting MFP estimates are not comparable across countries in levels. This, in turn, requires a different definition of the technological frontier: in particular, we define a country/industry-specific technological frontier for the construction of the variables *Leader growth* and *Gap to the leader* as the top 5% firms in each sector, country and year in this case. To the extent that the top performing firms in each country are operating very close to international best practice, possibly because a significant number of them belong to multinational enterprises in our data, this is an appropriate measure of the technological frontier.

80. Table 3 uses residual MFP measures from an OLS-estimation of the production function, while the MFP measures in Table 4 are the residuals of a production function estimated using the semi-parametric approach of Levinsohn and Petrin (1999). As can be seen from these tables, all our qualitative findings regarding the link between regulations and MFP carry through using these two measures.

Table 3. Regulations and firm-level MFP
(using OLS residuals and country-specific frontier)

Dependent Variable: MFP Growth (Residuals using OLS)	Business Sector	ICT using sectors	Non-ICT using sectors	ICT-using: Catch-up	ICT-using: Distance from frontier
Leader Growth	0.19 ***	0.16 ***	0.26 ***	0.50 ***	0.72 ***
	(0.03)	(0.02)	(0.03)	(0.05)	(0.04)
Gap to the Leader	-0.18 ***	-0.17 ***	-0.20 ***	-0.10 ***	-0.31 ***
	(0.02)	(0.03)	(0.02)	(0.02)	(0.05)
PMR	-0.04	-0.09 **	-0.07		
	(0.05)	(0.04)	(0.09)		
Catch-up firms: PMR				-0.14 ***	
				(0.04)	
Non-catch-up firms: PMR				-0.03	
				(0.06)	
Dummy for catch-up firms				0.26 ***	
				(0.02)	
Catch-up firms close to frontier: PMR					-0.02 **
					(0.01)
Catch-up firms far from frontier: PMR					0.00
					(0.02)
Dummy for close to frontier					0.15 ***
					(0.02)
Country-year FE	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes
N	202161	98734	103427	98734	87750
R2	0.12	0.12	0.14	0.45	0.43

Standard errors are in parentheses. *. **. *** indicate statistical significance at the 10.5 and 1% levels, respectively. Agriculture, forestry, fishing, mining are excluded, as are public administration, education and health sectors. Catch-up firms are defined as those that approached the frontier during the past year. Close to the frontier is defined as a productivity gap below the median in absolute value.

Table 4. Regulations and firm-level MFP
(using Levinsohn-Petrin residuals and country-specific frontier)

Dependent Variable: MFP Growth (Residuals using L/P)	Business Sector	ICT using sectors	Non-ICT using sectors	ICT-using: Catch-up	ICT-using: Distance from frontier
Leader Growth	0.12 ***	0.08 **	0.17 ***	0.41 ***	0.66 ***
	(0.03)	(0.04)	(0.04)	(0.08)	(0.06)
Gap to the Leader	-0.15 ***	-0.15 ***	-0.16 ***	-0.09 ***	-0.29 ***
	(0.01)	(0.02)	(0.01)	(0.02)	(0.05)
PMR	-0.03	-0.08 **	0.02		
	(0.05)	(0.03)	(0.07)		
Catch-up firms: PMR				-0.10 ***	
				(0.03)	
Non-catch-up firms: PMR				-0.02	
				(0.04)	
Dummy for catch-up firms				0.24 ***	
				(0.02)	
Catch-up firms close to frontier: PMR					-0.03 **
					(0.01)
Catch-up firms far from frontier: PMR					0.02
					(0.02)
Dummy for close to frontier					0.15 ***
					(0.02)
Country-year FE	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes
N	194000	94386	99965	94386	83398
R2	0.11	0.12	0.11	0.44	0.40

Standard Errors are in parentheses. *, **, *** indicate statistical significance at the 10, 5 and 1% levels, respectively. Agriculture, forestry, fishing, mining are excluded, as are public administration, education and health sectors. Catch-up firms are defined as those that approached the frontier during the past year. Close to the frontier is defined as a productivity gap below the median in absolute value.

81. Another step in assessing the robustness of our empirical results is to consider other policy and institutional factors that could influence firm-level productivity. In particular, product market regulations tend to be correlated with other regulations (*e.g.* labour market regulations) and with other institutional settings (*e.g.* financial market conditions) and their exclusion from the analysis may lead to an omitted variable bias. However, it should be stressed that our baseline MFP specifications presented in Table 2 always include country-specific year dummies that remove all country-wide changes in regulatory or institutional settings. This is likely to prevent most other policy changes from biasing our findings on PMR.

82. We consider two key sector-specific policy indicators in augmented specifications of the MFP equations. The first proxies for the degree of financial development. Given the difficulty of directly

measuring the efficiency of financial markets, we use two standard indicators of financial intermediation and the structure of financial systems (Levine, 2005): the ratio to GDP of bank credit to the private sector; and the share of stock market capitalisation in GDP. In the empirical analysis we consider the sum of these two indicators. These indicators capture broad patterns of financial development and do not distinguish between sectors of the economy. To consider the possibility that financial development influences productivity outcomes differently depending on the extent to which firms in different sectors rely on external finance, we use a difference-in-difference approach (see *e.g.* Rajan and Zingales, 1998). In particular, we interact the synthetic indicator of financial development with a sector-specific measure of dependence on external finance. This measure is constructed from the average ratio of debt to fixed assets across firms at the industry level (see Inklaar and Koetter, 2008, for a similar approach). In order to limit the possible endogeneity of this variable, we construct it only on the basis of firms from the United Kingdom, arguably the economy with the most developed financial market in our sample. Hence, the amount of external finance used by UK firms in different sectors is probably the best available proxy for the technologically-driven differences in exposure to external finance across sectors.[64] The testable hypothesis with respect to this interaction variable would be that firms in sectors with stronger reliance on external finance should benefit more than other firms from a high level of financial development. Given that financial development is likely to have a positive effect (if any) on MFP, because it may improve firms' options for making productivity-enhancing investments regardless of current cash-flow, the expected sign on this variable is positive.

83. Aside from financial development, we also control for differential effects of labour market regulation on MFP -by exploiting an indicator of employment protection legislation (EPL) created by the OECD (OECD, 2004). This indicator measures the stringency of regulations affecting the hiring and firing of workers. EPL tends to raise labour adjustment costs possibly discouraging firms to innovate and adopt new technologies, both of which may require adjusting the workforce to reorganize the production process. The effect of stringent EPL on MFP is likely to be stronger in industries that are characterised by inherently large job turnover rates because of more frequent fluctuations in demand or wider technological shocks. For this reason, we interact the EPL indicator with a measure of job flows at the industry level from the United States. [65]

84. Table 5 replicates our main regression for the business sector and the subset of ICT-using sectors including these two additional policy measures. It is noticeable that our findings with respect to product market regulation are not affected by the inclusion of these additional controls. Financial development appears to affect MFP positively, while we fail to find a statistically significant effect for employment protection legislation. This may be due to several reasons: It could be the case that the differential effect of EPL across sectors is actually weak, but that it does have an effect of similar order of magnitude on firms in all sectors. Such a uniform effect would be absorbed by the fixed effects for each country-year combination. Alternatively, our country sample could be such that there is not much variation in these policy variables across our sample of mostly continental European countries (with the United Kingdom being the only exception to this). By extending our sample to the United States, for example, there might be enough variation to estimate a statistically significant effect. While it would be beyond the scope of this

64. We have also tried a different sectoral measure of external dependence on finance, based on Compustat data for the United States. This is a similar measure as the one originally employed by Rajan and Zingales (1998), except that it uses more recent data. Using this measure instead of the one employed below, we find the same results for PMR but financial development is not statistically significant. It should be stressed, however, that the indicator used in Table 5 – the industry-level averages of the ratio of debt to fixed assets in the United Kingdom – drawing from the Amadeus database that also covers unlisted businesses is arguably more appropriate to characterise the average dependence of external finance than a measure based on Compustat for the United States that only considers larger listed businesses.

65. Job flows in the United States are used as a benchmark because of data availability at a fine level of disaggregation and because the United States is one of the least regulated labour markets in the OECD and its job flows are likely to characterise well the technology and market-driven need for labour reallocation of different industries.

paper to explore these questions, we nonetheless take comfort from the fact that the PMR measure remains statistically significant even once other policy dimensions are controlled for.

Table 5. Controlling for additional policy variables

Dependent Variable: MFP Growth (Superlative Index)	Business Sector	ICT using sectors
Leader Growth	0.08 ***	0.07 ***
	(0.01)	(0.01)
Gap to the Leader	-0.15 ***	-0.15 ***
	(0.01)	(0.01)
Financial Development	0.001 *	0.001 **
	(0.000)	(0.000)
Labour Market Regulation	0.000	-0.001
	(0.000)	(0.001)
PMR	-0.05	-0.08 **
	(0.04)	(0.04)
Country-year FE	Yes	Yes
Industry FE	Yes	Yes
N	204838	99792
R^2	0.09	0.10

MFP is measured as a superlative index, calculated as described in equation 5. Standard Errors are in parentheses. *, **, *** indicate statistical significance at the 10, 5 and 1 percent levels, respectively. Agriculture, forestry, fishing, mining are excluded, as are public administration, education and health sectors.

IV. Concluding remarks

85. In this paper, we review productivity growth patterns in the OECD countries over the past decades at the aggregate, sectoral and firm-level and shed some light on the role of product market reforms in shaping these patterns. Our analysis was mainly motivated by the apparent dichotomy between widening disparities in growth performance and a significant process of regulatory convergence across countries.

86. The first part of the paper summarises existing aggregate and industry-level evidence on the regulation-performance link. Several conclusions emerge from recent work in this area:

- First, differences in investment in new technologies – in particular the information and communication technology – and multi factor productivity (MFP) growth in both ICT-producing and, increasingly, ICT-using industries underpin the observed growth disparities across OECD countries. These factors contributed to boost growth in the United States, Australia, the United Kingdom and a number of smaller EU countries, while they held back growth in large continental EU countries and Japan.

- Second, despite efforts in almost all OECD countries to make non-manufacturing regulations more market friendly, the dispersion in regulatory regimes widened in the 1990s and only started to converge in the most recent years. In particular, despite the Single Market Programme, EC competition policies and the European Monetary Union, EU member countries have been characterised by disparate reform patterns in these sectors until the late 1990s, with continental countries remaining relatively regulated until recently. Anticompetitive non-manufacturing regulations are particularly burdensome for ICT-using sectors that are themselves regulated (*e.g.* business services), use intensively intermediate inputs from regulated non-manufacturing sectors (*e.g.* machinery and equipment) or both.

- Third, the pace and intensity of product market reforms in non-manufacturing sectors were crucial in shaping the growth process at the time when a new general-purpose technology fully emerged. Due to lack of competitive pressures or high adjustment costs, in European countries that delayed reforms ICT investment remained relatively low and the opportunities offered by the new technology were not fully exploited. At the industry level, there is evidence that inappropriate non-manufacturing regulations bit the most in ICT-using sectors, largely by curbing the potential for adopting and using efficiently globally available leading technologies, especially where sectoral productivity lags behind the technological frontier. Thus, further encouraging competition in non-manufacturing sectors seems to be a priority for raising the productivity potential of continental EU countries and, thereby, of the EU as a whole.

87. The paper then provides new original evidence on the mechanisms through which product market regulations have affected productivity performance at the firm-level in a subset of OECD countries for which such comparable data are available. Our main findings can be summarised as follows:

- Starting from the observation of a significant dispersion in productivity performance across industries and (within each industry) across firms, we find that ICT-intensive sectors tend to have a wider dispersion in productivity performance, with a fat right tail of rapidly growing firms (the "gazelles") that drives the overall sectoral performance.

- Market-friendly regulations tend to ease the reallocation of resources towards these highly dynamic firms. Indeed, not only does the productivity distribution of ICT-intensive sectors show a fatter right tail in the more market-friendly countries, but lighter regulations are also found to be associated with the expansion of the most productive businesses. Moreover, countries that have promoted competition in non-manufacturing have seen a significant increase in the dispersion of productivity in ICT-intensive sectors, largely because of the emergence of very high productivity firms at the top of the distribution.

- Taking a multivariate perspective - which accounts for a host of other factors that could potentially influence productivity performance over and above product market regulations - we find that in ICT-using sectors inappropriate regulations refrain productivity growth of best-

performing businesses, *i.e.* those that catch up and that are closest to the productivity frontier. In these sectors, firms with relatively better productivity levels and growth performance are the ones with the potential to further raising the domestic technological frontier, by adopting the leading technologies and innovating. Regulations that shelter them from competition, increase adjustment costs and allow low productivity firms to survive curb their incentives to exploit at best their potential. These empirical results are robust to a range of sensitivity checks.

88. All in all, our analysis, which focuses on the productivity of incumbent firms, is consistent with the view that delaying market-oriented reforms in a number of OECD countries, including the large continental European ones, has not only reduced the scope (if not the magnitude) of the creative destruction process (the entry and exit of firms and reallocation among incumbents), but also, by curbing market contestability, weakened the incumbents' incentives to shift to ICT in key sectors of the economy where such technologies would have otherwise allowed for strong efficiency gains.

89. Much work remains to be done to further explore the mechanisms through which regulations affect economic performance. Consistent with a growing body of comparative firm-level studies, the key message from our paper is that assessing these mechanisms requires going beyond aggregate data and explore how regulations affect the performance of individual sectors and, within each of them, the process of creative destruction and allocative efficiency. The good news is that harmonised industry-level as well as firm-level data are becoming available for a growing group of countries. At the same time, significant progress has been made in characterising the different aspects of product market regulations (*e.g.* barriers to entry, red tape and state control for each individual sector) while more work is still required to assess whether certain firms enjoy preferential treatments, either because of their size, age or geographical location.

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ANNEX 1

Product market indicators

The OECD indicators of non-manufacturing regulation (NMR)

90. Measuring cross-country differences and changes in the regulation of non-manufacturing sectors is important for at least two reasons. First, these sectors represent around two-thirds of economic activity and are the most dynamic part of the economy (in terms of productivity growth and employment) in many OECD countries. Second, non-manufacturing is the area in which most economic regulation is concentrated and where domestic regulations are most relevant for economic activity and the welfare of consumers. Because import penetration is much more limited than in manufacturing sectors, final and intermediate consumers of non-manufacturing products have little alternative than to purchase these products on the domestic market. Domestic regulations affect the quality, the variety and the price of such products in a number of ways.

91. Clearly, many of these regulations serve the public good, either by addressing market failures or by pursuing non-economic objectives. Accordingly, it is particularly important that the analysis of non-manufacturing regulations be driven by well-defined criteria. The overarching criterion on which this paper surveys and assesses regulations is their effect on competition where competition is viable. Therefore, each of the OECD sectoral indicators reflects regulations that curb efficiency-enhancing competition, whereas regulations in areas in which competition would not lead to efficient outcomes (*e.g.* natural monopolies) are not considered. This approach yields indicators that are well-focused and account for the different technological characteristics of sectors. At the same time, the indicators are silent on the quality of regulation according to criteria other than competition or the extent to which regulations achieve non-economic policy goals.

92. By and large, all the indicators are constructed in a similar way. They cover information in four main areas: state control, barriers to entry, involvement in business operations and, in some cases, market structure. The information summarised by the indicators is "objective", as opposed to survey-based, and consists of rules, regulations and market conditions. All of these regulatory data are vetted by member country officials and/or OECD experts. The indicators are calculated using a bottom-up approach in which the regulatory data are quantified using an appropriate scoring algorithm and then aggregated into summary indicators by sector of activity in each of the four areas or across them. While this approach involves a degree of discretion, notably in choosing scores and aggregation weights, it has the merit of transparency and makes it possible to trace each indicator value to the underlying detailed information about policies and market conditions.

93. The resulting indicators of non-manufacturing regulation cover energy (gas and electricity), transport (rail, road and air) and communication (post, fixed and cellular telecommunications) over the 1975-2003 period in 21 OECD countries, and retail distribution and professional services for 1998 and 2003 in 30 OECD countries. In addition, indicators of the "knock on" effects of anti-competitive regulation in these sectors (plus the finance sector) on sectors that use the outputs of these sectors as intermediate inputs are also calculated. To the best of our knowledge, these indicators provide the broadest coverage, of sectors and areas, and the longest time-series currently available for comparing product market regulation across countries. They are complementary to indicators of economy-wide anticompetitive regulation

already published by the OECD (Conway *et al.* 2005). All indicators are updated on a regular basis and their values as well as background documentation are publicly available at www.oecd.org/eco/pmr.

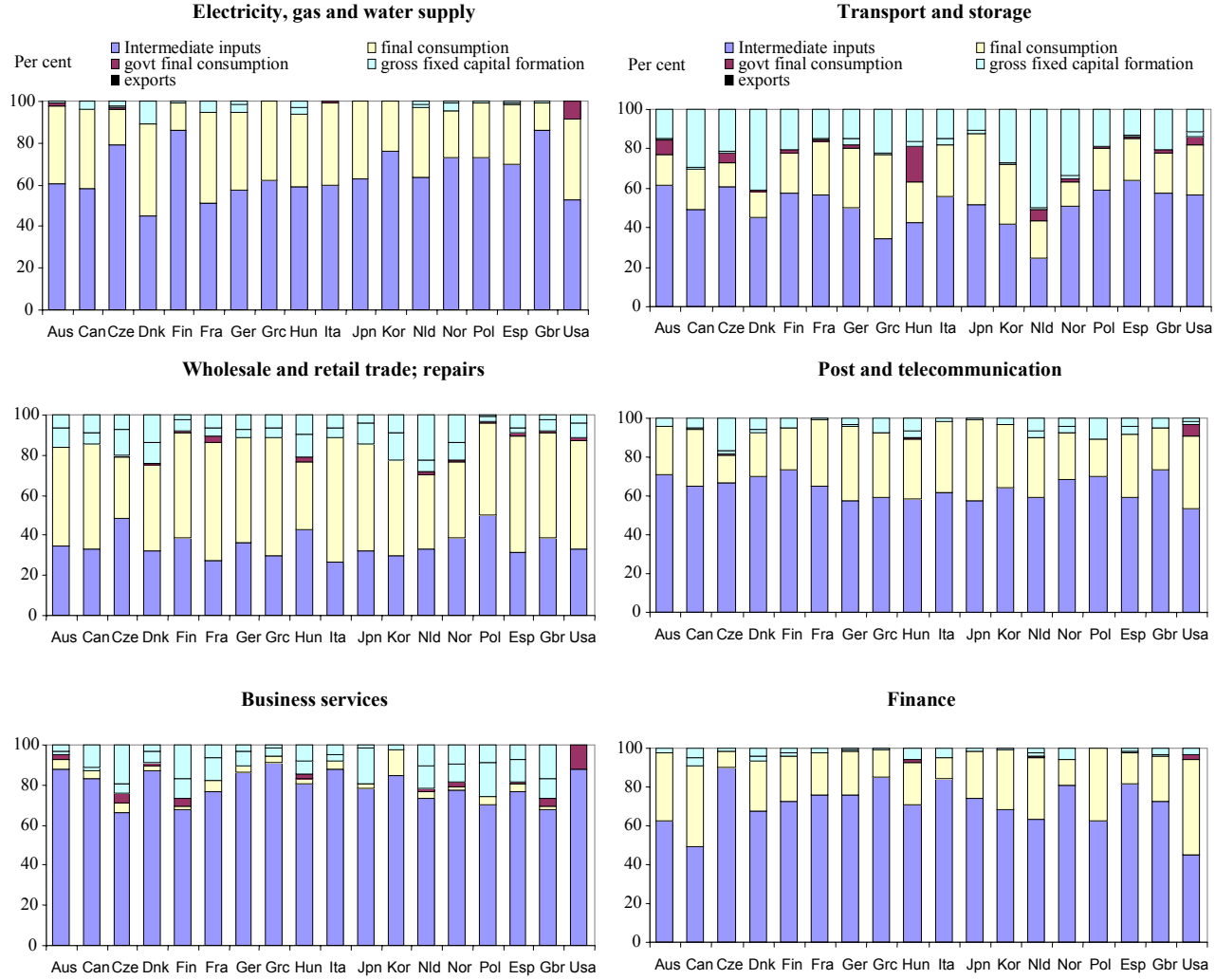
Measuring the 'knock-on' effects of anti-competitive non-manufacturing regulation: the regulatory impact indicators (RI)

94. The effect of product market regulations that restrict competition in non-manufacturing sectors is by no means confined to these sectors. It will also have a less visible impact on the cost structures faced by firms that use the output of non-manufacturing sectors as intermediate inputs in the production process.[66] For example, if product market regulation in the business services sector in a particular country is restrictive of competition then the prices charged by firms operating in this sector will tend to be higher and/or the quality of service lower than for firms operating in a competitive business services environment. In turn, this will affect the costs of entry for new firms that need to use these services, the extent to which existing firms outsource these services, the organisation of work within firms, the allocation of resources between firms and, ultimately, the scope for the associated productivity improvements.

95. These "knock-on" effects of non-manufacturing regulation are likely to have become particularly salient over recent years given the large and increasingly important role of the non-manufacturing sector as a supplier of intermediate inputs in OECD countries. For example, on average across countries for which (harmonised) input-output data exist, in the late 1990s almost 80% of the output of the business services sector was used as an intermediate input in the production processes of other sectors in the economy (Figure 1.1). Similarly, between 50 and 70 % of the output of the finance, electricity, and post and telecoms sectors is destined to be used as intermediate inputs to the production process. In addition, the importance of non-manufacturing sectors as a source of intermediate inputs has been growing rapidly over recent decades, along with the rest of the services sector. For example, Kongsrud and Wanner (2005) report that the service sector now accounts for roughly 70% of all jobs and value-added in the OECD area, which is more than 5 percentage points higher than in 1990.

66 . The 'knock-on' effects of regulation in the non-manufacturing sector will also propagate through the economy via a number of other channels such as the effect on the price of investment goods and "Baumol disease" effects that act through wages. In this context, focusing on the role of non-manufacturing sectors as suppliers of intermediate inputs provides only a lower bound to these propagation effects. It does, however, facilitate their empirical measurement.

Figure 1.1 Share of intermediate and final demand in gross business sector output: selected non-manufacturing sectors



Source: OECD harmonised input-output tables. The countries included in the graphs reflect data availability. For most countries the input-output tables are for a given year in the mid- to late-1990s.

96. In any given country the magnitude of these 'knock-on' effects of non-manufacturing regulation on the economy will be a reflection of two factors:

- the extent of anti-competitive regulation in non-manufacturing sectors, and
- the importance of these sectors as suppliers of intermediate inputs.

97. The first of these factors is captured by the OECD indicators of regulation in non-manufacturing sectors;[67] the second factor is measured using total input coefficients derived from (harmonised) input-

67 . As mentioned above, an indicator of anti-competitive regulation in the finance sector – described in detail in de Serres et al. (2006) – is also used as part of the analysis of anti-competitive regulation in non-manufacturing and the calculation of the RI indicators.

output tables, which provide a snapshot view of the purchases and sales of intermediate inputs between different sectors in a given year.[68]

98. Using total input-output coefficients, the sectoral regulation impact indicators (RI) are calculated as follows in each country:[69]

$$RI_{kt} = \sum_{j} NMR_{jt} \bullet w_{jk} \qquad 0 < w_{jk} < 1$$

where the variable NMR_{jt} is an indicator of anti-competitive regulation in non-manufacturing sector j at time t and the weight w_{jk} is the total input requirement of sector k for intermediate inputs from non-manufacturing sector j. The (harmonised) input-output data for OECD countries, and therefore the w_{jk}, exist at the 2-digit (ISIC rev3) level, implying that the NMR must also be calculated at this level of sectoral aggregation. Accordingly, the NMR indicators are mapped into the ISIC system as shown in Figure 1.2. If more than one of the NMR indicators map into a given 2-digit ISIC sector then NMR_{jt} is calculated as a simple average of the constituent indicators.

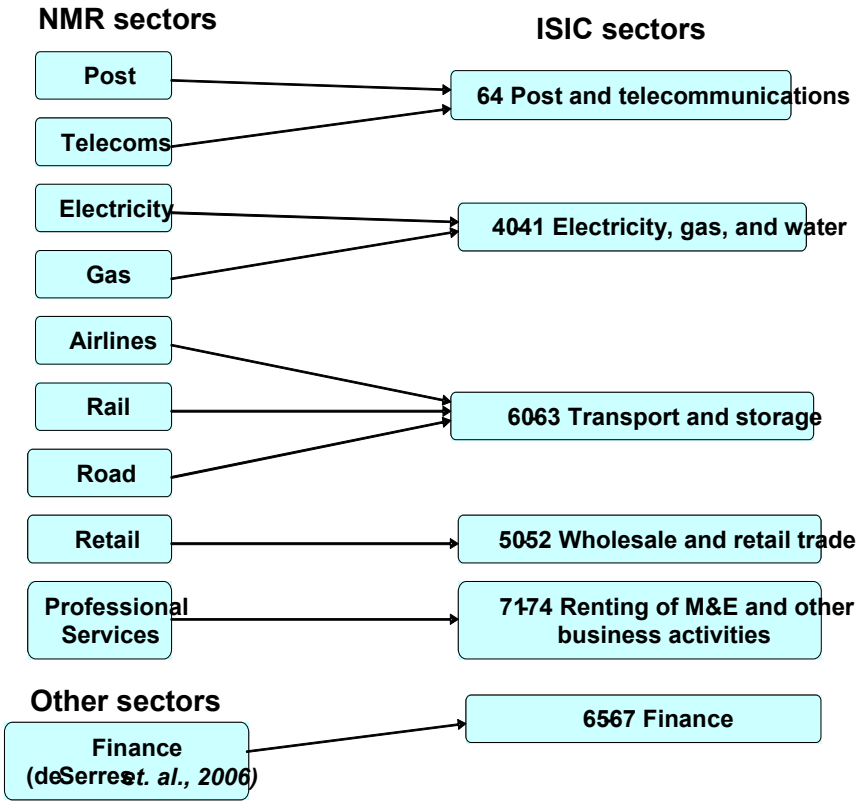
68 . Total input coefficients are calculated as follows. If Y is a vector of industry gross outputs, D a vector of demand for final goods, and A a matrix of technical coefficients – that is, the share of inputs from industry j used in producing one unit of output of industry k – then the basic relation between output and final demand can be expressed as:

D=(I-A)Y, or alternatively, Y=(I-A)-1D

In this equation (I-A)-1 is the Inverse Leontief Matrix of the input-output coefficients and describes how many units of an industry's output have to be produced at any stage of the value chain in order to produce one unit for final demand.

69 . This technique for calculating the regulation impact indicators is a variant of that used by Faini et al. (2006). Total input-output coefficients have also been used by Allegra et al. (2004) to derive the impact on export-oriented sectors of economic activities that are problematic from the point of view of antitrust law.

Figure 1.2 5. The correspondence between the indicators of non-manufacturing and ISIC sectors



99. For non-manufacturing sectors, where $k=j$ in the above formula, the total impact coefficient for the sector's own output (w_{jj}) is typically relatively large, implying a large weight on the own indicator of anticompetitive regulation (NMR_{jj}) in the RI indicator for that sector. As a result, the RI indicators for the non-manufacturing sectors where $k=j$ are measured in a consistent way as for the other sectors where $k \neq j$ but are highly correlated with the original NMR indicator for that sector.

100. The RI indicators are calculated in this way for 39 (ISIC rev3) sectors in 21 OECD countries over the period 1975 to 2003 and provide a large database on the sectoral impact of non-manufacturing regulation in OECD countries. It should be noted that, in the formula, NMR_{jt} is equal to either the ETCR indicators, for which complete time-series data are available, or the RBSR (plus finance) indicators for the other sectors, which have been estimated for only one or two years. Thus, due to data limitations, the variability of the RI indicators over time reflects mostly changes in the regulation of the energy, transport and communication sectors.

ANNEX 2

The classification of ICT-producing, ICT-using, and non-ICT intensive sectors

101. Empirical measures of ICT use by sector are available for several countries, based on capital flow matrices and capital stock estimates. Work using data for the United States implies that investment in ICT equipment is concentrated in service sectors. For example, according to some estimates 78% of total business investment in ICT in the United States is undertaken in the wholesale and retail trade, finance, insurance, and real estate sectors. Manufacturing, on the other hand is found to be responsible for only 17% of ICT investment. The classification of ISIC rev.3 sectors into ICT-producing (P), ICT-using (U), and non-ICT intensive (N) sectors used in this paper follows Inklaar, *et al.,* (2003) and is as follows:

ISIC code	*Industry*	*ICT classification*
15-16	Food Products, beverages and tobacco	N
17-19	Textiles, textiles products, leather & footwear	N
20	Wood except furniture	N
21-22	Pulp, Paper, paper products, printing & publishing	U
23-25	Chemical, rubber, plastics & fuel products	N
26	Other non-metallic mineral products	N
27-28	Basic metals and fabricated metal products	N
29	Machinery and equipment, n.e.c.	U
30-33	Electrical and optical equipment	P
34-35	Transport equipment	N
36-37	Furniture; recycling	U
40-41	Electricity, gas and water supply	N
45	Construction	N
50-52	Wholesale and retail trade; repairs	U
55	Hotels and restaurants	N
60-63	Transport and storage	N
64	Post and telecommunications	P
65-67	Financial intermediation	U
70	Real estate	N
71-74	Renting of M&EQ and other business activities	U

Legend: P=ICT-producing sector; U=ICT-using sector; N=non ICT sector

ANNEX 3

Firm-level data, productivity measures and additional robustness checks

The Amadeus database

102. In the firm-level analysis of productivity we use a sample of firms extracted from the commercial database Amadeus of the Bureau van Dijk. This database covers European OECD members and in our version it includes 1.5m firms.

The productivity estimates

103. For the productivity analysis we calculate three sets of multi factor productivities (MFPs), one using a superlative index approach as in Griffith *et al.* (2006), and the other two using a production function approach. In the latter case, we estimate the production function using both ordinary least squares (OLS) and the semi-parametric estimation technique of Levinsohn and Petrin (2003). The latter estimation technique controls for an econometric problem that may arise if unobserved productivity shocks of firms influence their factor input choices, which could potentially create a bias in OLS estimations of the production function.[70] In both cases we use a value-added specification, based on primary information for value-added, correcting for extraordinary profits. In those cases where primary information on value-added was not available we imputed value-added as the residual between operating revenue and material inputs. For capital stocks we use primary information on net capital stocks. For labour we use primary information on the total wage bill. Nominal values are deflated using price indices from the EUKLEMS or OECD STAN databases. We do not use estimated MFP values which either the coefficient on capital stocks or the wage bill is negative. Productivity observations for which the sum of the coefficients is smaller than 0.6 are also dropped.

Re-sampling procedure

104. As any firm-level data set, the raw Amadeus data contain missing values for some variables that are required for the productivity estimates. This implies that once MFP estimates are obtained, we are in fact left with a different sample from the original one. In order to ensure representativeness of our effective firm-level sample along the three dimensions country, sector and size groups, we resample the original Amadeus data set. In a first step, we obtained information about the true underlying population of firms above 20 employees along these three dimensions from the Eurostat *Structural Business Statistics* database for the year 2000. Then we set the total sample size to 100 000 firms (not observations) and divided this number into size-sector-country strata according to the true population. As a final step, random draws with replacement from each size-sector-country strata in the MFP sample were taken until the weight of each strata corresponded to its population weight.

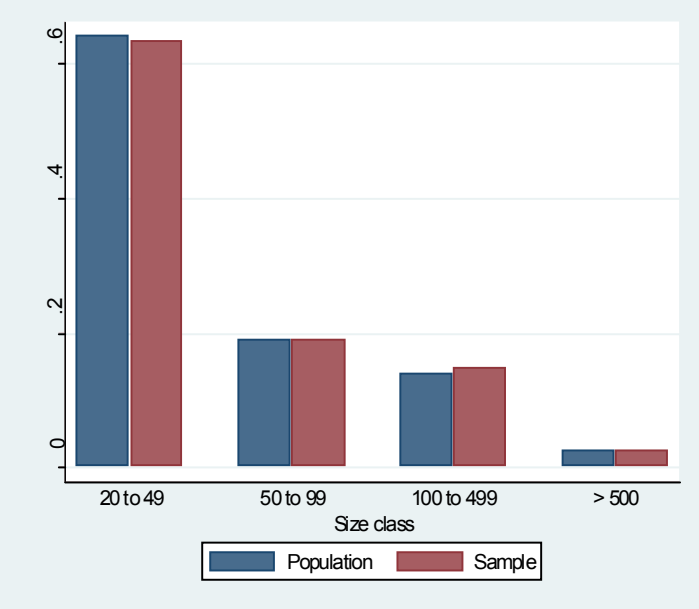
105. The results of this resampling procedure are shown in Figure A3.1, where Panel A compares the size distributions of our estimation sample with the true population, while Panel B does the same for the industry distribution. In both cases, our resampled firm-level data set comes very close to the true population.

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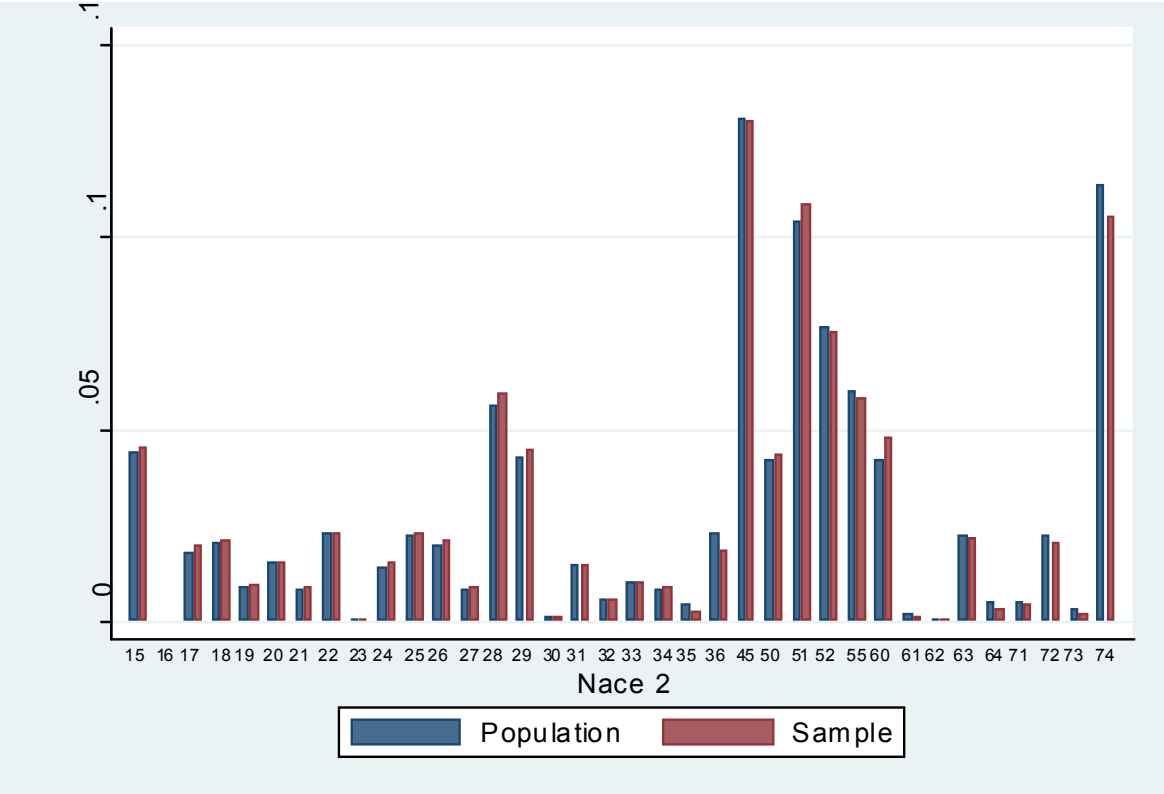
[70] Note that it is not possible to follow the methodology of Olley & Pakes (1996). The reason is that we do not have primary information on investment in Amadeus so that investment has to be calculated as the residual between current and lagged capital stock after correcting for depreciation. This clearly violates Olley & Pakes' (1996) orthogonality condition between lagged capital stock and investment.

Figure 3.1 Firm population vs. Estimation Sample after resampling

Panel A: Size distribution



Panel B: Industry distribution



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