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# Managerial Capital and Business R&D as Enablers of Productivity Convergence

**Dan Andrews,**

**Ben Westmore**

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## ABSTRACT/RESUMÉ


### Managerial capital and business R&D as enablers of productivity convergence

This paper explores the role of managerial capital and business research and development (R&D) in fostering multifactor productivity (MFP) convergence in a panel of 42 countries. The OECD long-term growth model is augmented to show that, in addition to trade openness, an economy's speed of convergence to its long-run steady state level of MFP is an increasing function of the quality of its managerial capital and the size of its domestic R&D sector. The economic importance of these two enabling factors are examined in the context of a scenario, whereby MFP growth at the technological frontier is ½ percentage point higher (than in the baseline projection) per annum until 2060. This exercise shows that some countries benefit significantly more from higher frontier growth than could be expected based on their trade openness alone. In turn, evidence on the policy determinants of managerial capital and business R&D is reviewed, which highlights the importance of structural reforms and carefully-designed innovation policies.



*JEL classification codes:* L20, O11, O30, O43, O47.

*Keywords:* long run growth, productivity, conditional convergence, R&D, management.


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### Capital managérial et R-D des entreprises, moteurs de la convergence de la productivité

Ce document analyse le rôle que jouent le capital managérial et les activités de recherche et de développement (R-D) menées par les entreprises pour renforcer la convergence de la productivité multifactorielle (PMF) dans un groupe de 42 pays. Le modèle de croissance à long terme de l'OCDE est élargi pour montrer que, outre l'ouverture aux échanges, la vitesse de convergence d'une économie vers son niveau de stabilité de la PMF à long terme est une fonction croissante de la qualité de son capital managérial et de la taille de son secteur national de la R-D. L'importance économique de ces deux facteurs déterminants est examinée dans le contexte d'un scénario dans lequel la croissance de la PMF à la frontière technologique est supérieure de ½ point de pourcentage (à celle retenue dans la projection de référence) par an jusqu'en 2060. Cet exercice montre que certains pays qui ont atteint la frontière bénéficient d'une croissance beaucoup plus forte que ce à quoi on pourrait s'attendre en se basant uniquement sur leur ouverture aux échanges. Cette étude examine ensuite les éléments de l'action publique qui déterminent le capital managérial et la R-D des entreprises, révélant l'importance des réformes structurelles et de politiques soigneusement conçues en faveur de l'innovation.



*Codes de classification JEL :* L20, O11, O30, O43, O47.

*Mots-clés :* croissance à long terme, productivité, convergence conditionnelle, R-D, management.

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# MANAGERIAL CAPITAL AND BUSINESS R&D AS ENABLERS OF PRODUCTIVITY CONVERGENCE

By

By Dan Andrews and Ben Westmore[1]

## 1. Introduction

1. Wide and persistent differences in the level of multi factor productivity (MFP) account for the bulk of income per capita gaps across countries (Figure 1, Panel A; Easterly and Levine, 2001).[2] Similarly, those countries that have succeeded in converging towards high income countries over recent years have often done so on the back of a convergence in MFP (Figure 1, Panel B). A key vehicle for this process is the diffusion of knowledge from the global technological frontier, which can potentially occur rapidly, given the tendency for new knowledge to be non-rival and only partially excludable. But the process of productivity convergence is not to be taken for granted and history suggests that a lot can go wrong along the way (Pritchett, 1997). In this context, understanding the factors that shape cross-country differences in technological adoption represents a potentially fruitful area for research, particularly since economic growth over the next 50 years will increasingly depend upon improvements in MFP (Braconier et al., 2014).

2. Against this background, this paper explores how two key knowledge-based capital (KBC) assets – managerial capital and business research and development (R&D) – facilitate technological adoption and productivity convergence. While these factors have been shown to directly impact productivity performance in frontier economies (Bloom et al., 2014; Hall et al., 2010; Westmore, 2013), managerial capital and R&D are also important enabling factors, with respect to technological adoption. For example, implementing and realising the full productivity benefit from new technologies generally entails significant organisational restructuring, which requires considerable managerial skill. At the same time, a domestic R&D sector is necessary to benefit from technological advances at the frontier, since some aspects of new technologies are tacit and difficult to codify and thus require practical investigation before they can be properly incorporated into production processes (Griffith et al., 2004).

3. It is in this context that cross-country differences in the degree of managerial talent and size of the domestic R&D sectors – which turn out to be significant – take on heightened importance. To highlight this point, we augment the OECD long-term growth model developed by Johansson et al. (2012) and show that, in addition to trade openness, an economy's speed of convergence to its long-run (country-specific) steady state level of MFP is an increasing function of the quality of its managerial capital and the size of its

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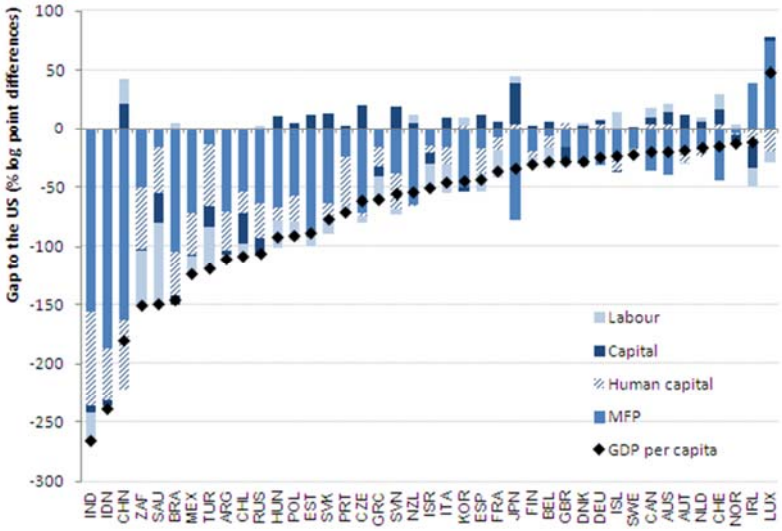
1 Corresponding authors are: Dan Andrews (Dan.Andrews@oecd.org) and Ben Westmore (Ben.Westmore@oecd.org) from the OECD Economics Department. The authors would like to thank Henrik Braconier, Giuseppe Nicoletti and Jean-Luc Schneider for their valuable comments, and Catherine Chapuis, Sarah Michelson and Inés Gómez Palacio for excellent statistical and editorial support. The views expressed in the paper are those of the authors and do not reflect those of the OECD and its member countries.

2 MFP growth relates a change in output to changes in several types of inputs. MFP is often measured residually, as that change in output that cannot be accounted for by the change in combined inputs. It should be highlighted that the concept of MFP used here is referred to as labour efficiency in the Economic Outlook Long-term Database. The two concepts are closely related but not identical. Specifically, log(MFP)=log(labour efficiency)*(labour share) with the labour share held constant at (2/3) in the long-term model.

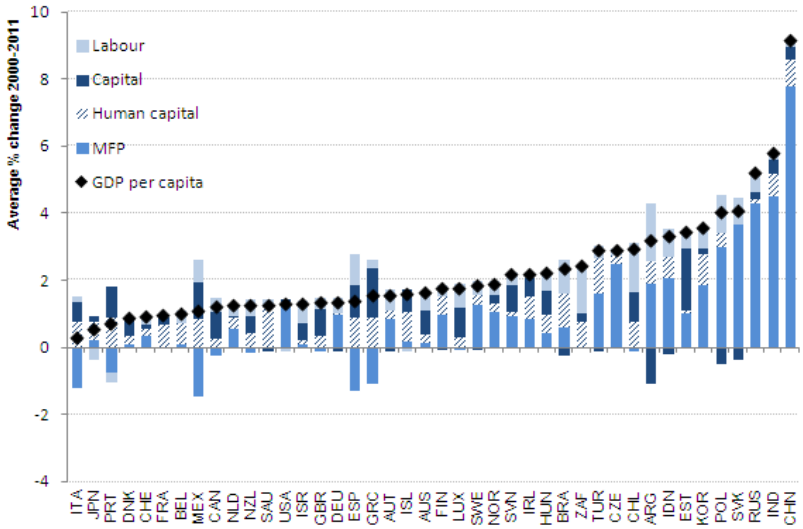
domestic R&D sector. Regarding economic magnitudes, the speed of catch-up is estimated to be about three times faster in countries with high managerial quality and business R&D relative to the average country in the sample. Using the augmented long-term growth model, we then sketch a future growth scenario whereby MFP growth at the technological frontier is assumed to be ½ percentage point higher than in the baseline projections. While this increases the country-specific target level of MFP, the speed at which economies converge to their new steady state varies between the baseline model (where convergence depends on openness) and the augmented model, where there is also a role for the two enabling factors of interest. In short, accounting for managerial quality and business R&D leads to a significant re-ordering in the distribution of gains from higher frontier growth, with countries such as Japan, Sweden and Germany benefiting significantly more than could be expected based on their trade openness alone. In contrast, these effects are much smaller in many Southern and Eastern European countries where the resources devoted to investment in KBC tend to be much smaller (see Andrews and Criscuolo, 2013).

**Figure 1. Multi-factor productivity drives cross-country differences in GDP per capita**

A: Contribution of production factors to GDP per capita (relative to the United States in 2011)




B: Contribution to growth (2000-2011)




*Source:* Johansson et al., (2012).

4. The paper proceeds as follows. The next section reviews evidence on the technological adoption literature, with a particular focus on the contribution to productivity growth of two enabling factors: managerial quality and domestic business R&D. Section 3 uses the empirical framework underpinning the OECD long-term growth model to explore the extent to which differences in managerial capital and R&D shape the ability of economies to absorb frontier technologies, while Section 4 highlights the economic significance of these effects in the context of a future growth scenario. Section 5 discusses policy implications and Section 6 offers some concluding thoughts.

## 2. Technology diffusion, enabling factors and productivity growth

5. International knowledge transfer is an integral part of the model underlying the OECD long-term growth projections (see Johansson *et al.,* 2012), as growth at the technological frontier is one of the key drivers of each country's estimated long-run MFP level. New innovations developed in frontier countries diffuse through the world, with the ability to benefit productivity in multiple regions at once. In principle, this process can occur rapidly, given that the property rights of new knowledge are difficult to enforce, insofar as owners cannot preclude others from partly enjoying the benefits. Moreover, many knowledge-based assets are non-rival in their use as the fixed cost incurred in developing new ideas – typically through R&D – does not get re-incurred as the ideas are combined with other inputs in the production process (Andrews and Alain de Serres, 2012). This gives rise to increasing returns to scale – the important property that makes ideas and knowledge an engine of growth (Jones, 2005). Thus, even in the presence of constraints on physical capital, improvements in the stock of knowledge based assets can underpin firm level MFP growth (Aghion and Howitt, 1997).

6. Diffusion of knowledge is thought to be one of the primary ways in which developing economies "catch-up" with those at the frontier (Rodrik, 2011). All else equal, countries further behind the frontier are likely to benefit more from new frontier technologies, as the marginal productivity benefit of implementing technological innovations will rise the less sophisticated is the technology embedded in existing capital. Nonetheless, technological diffusion is not just about imitation. The process is far more complex, encompassing a non-linear course of learning and development whereby the access of follower countries to foreign technologies is an important element in forging a unique development path.[3]

7. Of course, countries will not necessarily converge at the same pace, with economic history providing numerous instances where some countries (i.e. the Asian tigers) have bridged the gap at a much faster rate than others (i.e. many African or Latin American countries), despite starting from a comparable economic position. These patterns partly reflect cross-country differences in the adoption of new technologies, particularly with respect to the extensive margin of adoption (Comin and Mestieri Ferrer, 2013). Notably, Comin and Hobjin (2010) show that the lag between the time it takes for new technologies to be introduced in developed and developing countries has diminished over the past 200 years[4] (i.e. the intensive margin of technology adoption), while cross-country differences in the penetration of technologies – i.e. the extensive margin of adoption – have become increasingly significant over time (Comin and Mestieri Ferrer, 2013).

3 Indeed, Juma and Clark (2002) note that in the case of Japan, technological imitation involved recycling and refining traditional ideas while gathering and exploring new ideas from abroad that would assist in generating innovations for a domestic context.

4 For example, while nineteenth century technologies such as telegrams or railways often took many decades to initially arrive in some countries, more recent technologies (e.g. cell phones and the internet) have arrived on average within a few decades (in some cases less than one) after their invention.

8. Thus, the process of technological adoption and productivity convergence is not a *fait accompli* and a lot can go wrong along the way. While the factors behind cross-country differences in the ability to absorb and implement frontier technologies are manifold, policies and institutional settings of non-frontier regions are likely to be important. For example, institutional settings that create an environment in which lobbying by producers of incumbent technologies is common can slow technological adoption (Comin and Hobjin, 2009). We now review evidence on three possible enabling factors that are heavily influenced by government policies and institutions: openness, managerial quality and R&D.

### *2.1 Openness*

9. A key enabling factor for countries to gain exposure to frontier technologies is the intensity with which they trade. While the magnitude of the effect is likely to depend on the types of products and sectors involved, cross-country empirical evidence suggests that a country's speed of convergence to a long-run MFP level rises with trade openness (see Johansson et al., 2012). These impacts of trade openness are realised through a number of channels. First, trade and foreign direct investment are associated with increased flows of knowledge from global customers and suppliers (Crespi et al, 2008; Duguet and MacGarvie, 2005) and from the activities of multinational firms. Second, trade openness increases the effective market size, which in turn magnifies the expected profits arising from the successful adoption of foreign technologies (Schmookler, 1966; Acemoglu and Lin, 2004). Finally, openness leads to tougher product market competition, which in turn promotes productivity-enhancing reallocation via the expansion of the most productive firms into foreign markets and exit of low productivity firms that cannot compete in the global market (Melitz, 2003; Melitz and Ottaviano, 2008; Melitz and Trefler, 2012).

### *2.2 Managerial capital*

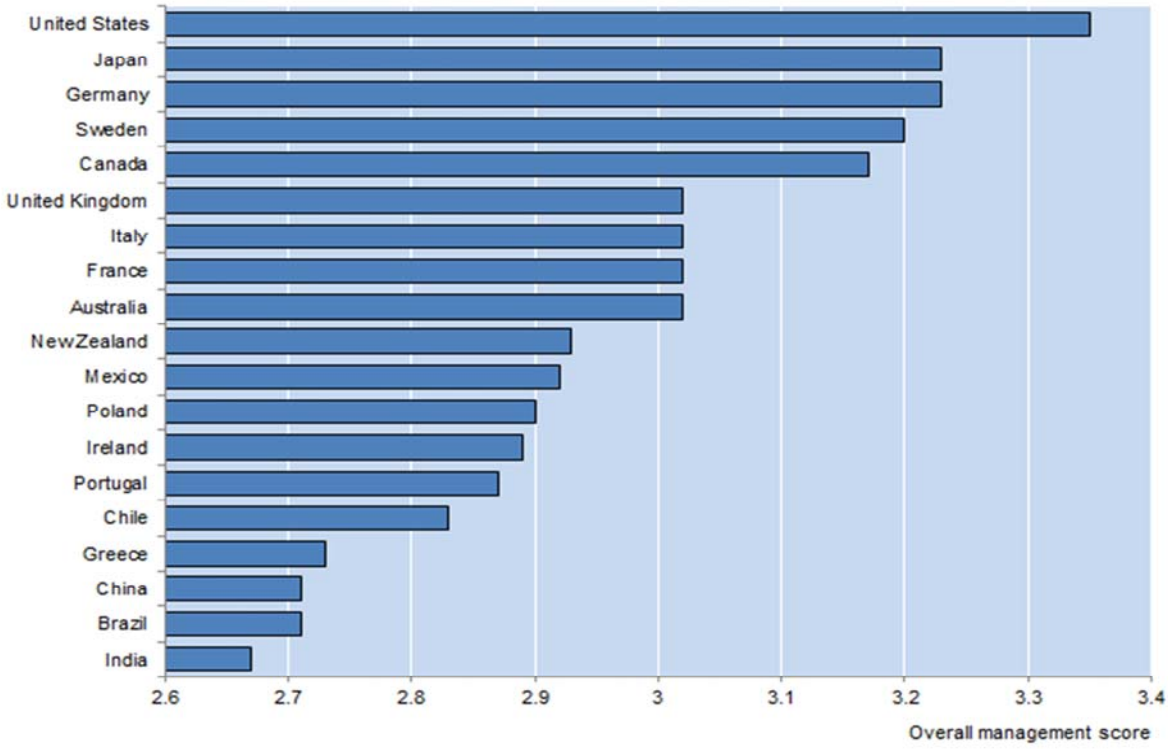
10. Regarding managerial capital, a prominent productivity researcher once noted: "no potential driving factor of productivity has seen a higher ratio of speculation to empirical study" (Syverson, 2011). The wheel has begun to turn, however, with the release of the World Management Survey (WMS), which measures core managerial practices in the areas of monitoring, targets and incentives (see notes in Figure 2). Indeed, a body of evidence documenting a robust positive relationship between managerial quality and productivity has emerged (Bloom and Van Reenen, 2010), with evidence from randomised control trials suggesting that the impact of managerial practices on productivity is likely to be causal (Bloom et al., 2013a).[5]

11. Given that cross-country differences in management scores are significant (Figure 2), management may account for a substantial portion of observed differences in MFP. For example, Bloom et al. (2013b) estimate that managerial quality accounts for (on average) one-quarter of MFP gaps between the United States and other countries – a figure which rises to around one-half when Italy and Portugal are compared to the United States.[6] The same is true with respect to within-country MFP differences, with managerial quality estimated to account for around one-third of the spread between firms at the 90$^{th}$ and 10$^{th}$ percentile of the MFP distributions in the United States and the United Kingdom.

5 A key advantage of randomised control trials is that they are robust to potential biases arising from the possibility that more productive firms can employ superior management consultants.

6 By contrast, for Sweden and Japan, management is estimated to account for one-tenth of the MFP gap with the United States.

**Figure 2. Managerial quality differs across countries**




Unweighted average management quality score across firms in the manufacturing sector; selected countries

Notes: The overall management score is an average of responses to 18 survey questions that are designed to reveal the extent to which firms: *i)* monitor what goes on inside the firm and use this information for continuous improvement *ii)* set targets and track outcomes; and iii) effectively utilise incentive structures (e.g. promote and rewarding employees based on performance). The sample is based on medium-sized firms, ranging from 50 to 10 000 employees.

*Source:* Bloom et al. (2012a).

12. A key channel through which managerial capital raises productivity is by facilitating the absorption and implementation of new ideas. There are a number of examples from economic history which suggest that better managed firms may be more adept at reorganizing operations to maximise the returns to frontier technologies. For example, while electrification of US factories began in the 1890s, productivity growth in those factories did not start to increase significantly until some 30 years later. This extended transition phase reflected that while the first wave of managers replaced steam engines with electric motors, it fell to the next generation of managers to invent new work practices and redesign factories in order to fully exploit electricity's flexibility (Brynjolfsson and McAfee, 2011).

13. More recent evidence emphasises complementarities between management and new ICT capital, which are particularly significant given that cross-country differences in aggregate growth in OECD countries depend to a large extent on the performance of key ICT-intensive sectors (van Ark et al., 2008). For example, in order to extract the maximum benefit from ICT, firms typically need to adopt ICT as part of a "system" of mutually reinforcing organisational changes (Brynjolfsson et al., 1997), which will be easier to accommodate in firms with better organisational capital. Indeed, Bloom et al., (2012b) attributed

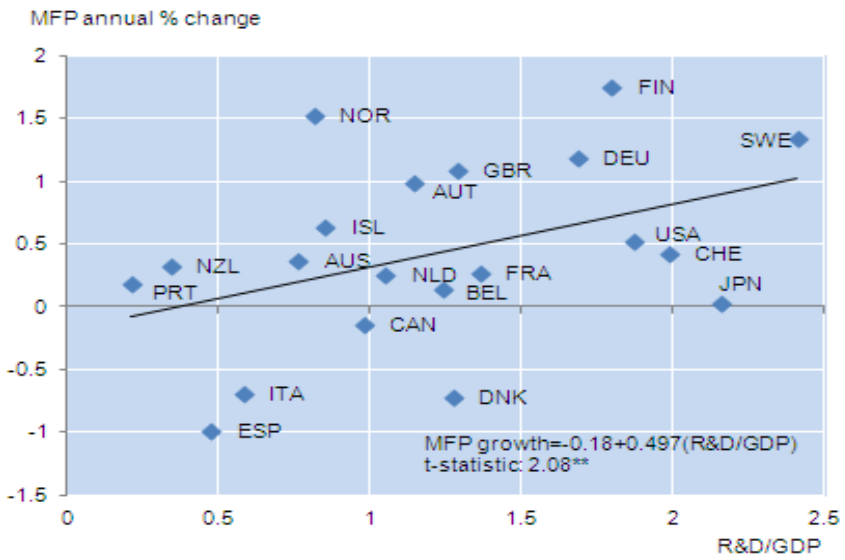
at least one-half of the United States-"Europe"[7] difference in labour productivity growth between 1995 and 2004 to superior management practices, which significantly raised the productivity of ICT capital in the United States. Furthermore, firm-level evidence from a broader sample of OECD countries shows that in sectors that use ICT particularly intensively, increases in organisational capital intensity are associated with swifter firm MFP growth than in other sectors (see Andrews and Criscuolo, 2013). Despite the important links between management, technological adoption and productivity, there is very little direct empirical evidence on the role of managerial capital in facilitating productivity convergence, thus providing a key motivation for the empirical analysis in the next section.

### *2.3 Research and Development*

14. There are persistent differences in the intensity of business R&D across countries, which are closely linked to productivity performance (Figure 3; see Griffith et al., 2004; Hall et al., 2010; Westmore, 2013).[8] Regarding its impact on productivity, there are two faces of R&D (Griffith et al., 2004). First, R&D has a direct effect on productivity growth by stimulating innovation. Second, a strong domestic R&D sector is important for countries' ability to benefit from new discoveries by facilitating the adoption of foreign technologies. Some aspects of new technologies are difficult to codify and require practical investigation before they can be properly incorporated into production processes. In this regard, researchers in a non-frontier country that can de-mystify "tacit" knowledge play a crucial role.

**Figure 3. MFP growth and Business R&D intensity**

Selected OECD economies, 1986 - 2008




*Source*: Reproduced from Andrews and Criscuolo (2013). Original sources are: OECD (2011), OECD Productivity Database and OECD calculations, based on Johansson et al., (2012). See Westmore (2013) for more details.

7 In Bloom et al.'s study, Europe includes the following seven countries: France, Germany, Italy, Poland, Portugal, Sweden, and the United Kingdom

8 The differences remain after controlling for differences in industrial structure, suggesting that such variation in the use of R&D cannot solely be explained by structural differences such as trade specialisation patterns. For example, in a sample of 26 OECD countries in 2008, the rank correlation between headline Business R&D (BERD) Intensity and BERD adjusted for differences in industrial structure is around 0.80 (see OECD 2011 for details).

## 3. Empirics

### *3.1 Structure of baseline model*

15. The empirical specification underlying the MFP convergence process draws on recent work by Bourlès et al. (2010), Bouis et al. (2013) and Johansson et al. (2012). It accounts for the effect of framework policies and international spillovers by explicitly allowing productivity to depend on product market regulation, whilst the speed of convergence towards the world frontier depends on trade openness. Specifically, denoting the log of aggregate MFP by $a$, its rate of growth by $\Delta a$, MFP growth at the frontier by $g$, trade openness by $O$ and the speed of MFP convergence towards the country-specific level $a*$ by $\rho^a$, for country $c$ at time $t$, MFP dynamics are governed by the following error correction model:

$$\Delta a_{c,t} = \rho^a_{c,t}(a^*_{c,t} - a_{c,t-1})$$

$$a^*_{c,t} = \partial_c + g_t + \beta PMR_{c,t}$$

$$\rho^a_{c,t} = f(O_{c,t})$$

where $g$ is the exogenous long-term growth rate common to all countries, which corresponds to the pace of the world technological frontier and is captured by time dummies, and $\partial_c$ is a country fixed effect. Product market regulation (PMR) – sourced from the OECD – measures the extent to which domestic policies favour competitive pressures and is assumed to affect the long-run level of MFP. The country specific speed of convergence $\rho^a$ towards this long-run level is assumed to be a function of trade openness, $O$, which is measured as (Exports+Imports)/GDP.[9] A key long run property of the model is that while the long-run level of MFP may differ across countries, the long-run growth rate of MFP will be the same across countries provided policies and other institutional settings are kept constant.

### *3.2 Data*

#### *3.2.1 Multifactor productivity*

16. Following Johansson et al. (2012), estimates for multi-factor productivity (A) are derived from GDP per capita (Y), the physical capital stock (K), human capital stock (h) and employment rate (L) as follows, with the capital share (α) set equal to one-third in all countries:

$$A_{c,t} = Y_{c,t} / \left(K_{c,t} / Y_{c,t}\right)^{\alpha/1-\alpha} h_{c,t} L_{c,t}$$

17. To the largest extent possible, OECD data are used. When these data are not available, external sources, such as IMF's World Economic Outlook (WEO), World Development Indicators (WDI) and national sources, are used. Some key features of the data are: i) GDP per capita is computed for each country as the ratio of GDP expressed in constant 2005 PPP USD to population; ii) Productive capital stocks are taken from the OECD productivity database or are built up from investment series (excluding housing investment) through the perpetual inventory method, assuming a 4% annual depreciation rate; iii) Human capital stocks are constructed by converting average number of years of schooling across the population aged 25-64 into a human capital stock based on an assumption regarding returns to education. For more details, see Johansson et al. (2012). Data are available for 42 countries (34 OECD countries plus: Argentina, Brazil, China, India, Indonesia, Russia, Saudi Arabia and South Africa) over the period 1998-2008.

9 Past work has shown that such a measure downwardly biases larger countries (Tang, 2011) and it may be better interpreted as a measure of trade dependency rather than trade openness.

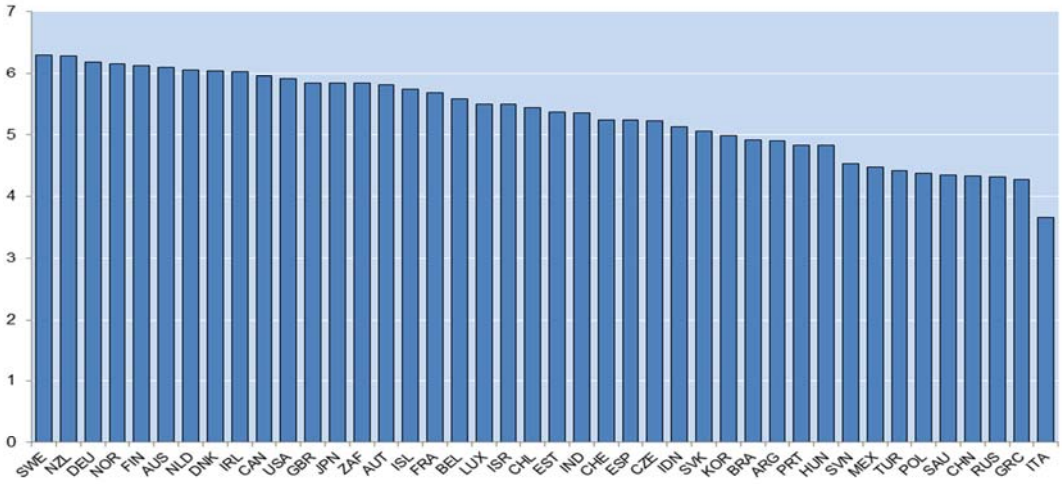
### *3.2.2 Managerial capital and R&D*

18. The two additional enabling factors, managerial quality and business R&D, are proxied by various sub-indices from the World Economic Forum Global Competitiveness Index (WEF GCI). Clearly, these indicators – which are based on surveys of business executives – are relatively crude compared to some other available measures that are outlined in Section 2.2. However, they carry the practical advantage of being available for all 42 countries that comprise the sample, and further analysis (outlined below) suggests that they are reasonable proxy variables.

19. Managerial quality is proxied by the reliance on professional management sub-index, which is derived from the answers of business leaders to the following survey question: "In your country, who holds senior management positions? (1=usually relatives or friends without regard to merit; 7=mostly professional managers chosen for merit and qualifications)". Figure 3 highlights that reliance on professional management varies significantly across countries. It is important to note that this indicator of managerial capital is narrower in scope than the Bloom and Van Reenen WMS indicator (see Section 2.2). Nevertheless, it is similar in spirit to the incentives pillar of the WMS indicator, which gauges the extent to which firms promote and reward employees on the basis of performance. Indeed, the rank correlation between the two overall indicators is quite reasonable at around 0.6 for the overlapping set of countries for which data are available. Indeed the countries which rank highly on the WMS measure in Figure 2 also record relatively high scores in Figure 4 (e.g. the United States, Germany and Sweden), while Greece, Portugal and China score relatively poorly according to both indicators.

**Figure 4. Reliance on Professional Management**

In your country, who holds senior management positions? (1=usually relatives or friends without regard to merit; 7=mostly professional managers chosen for merit and qualifications)



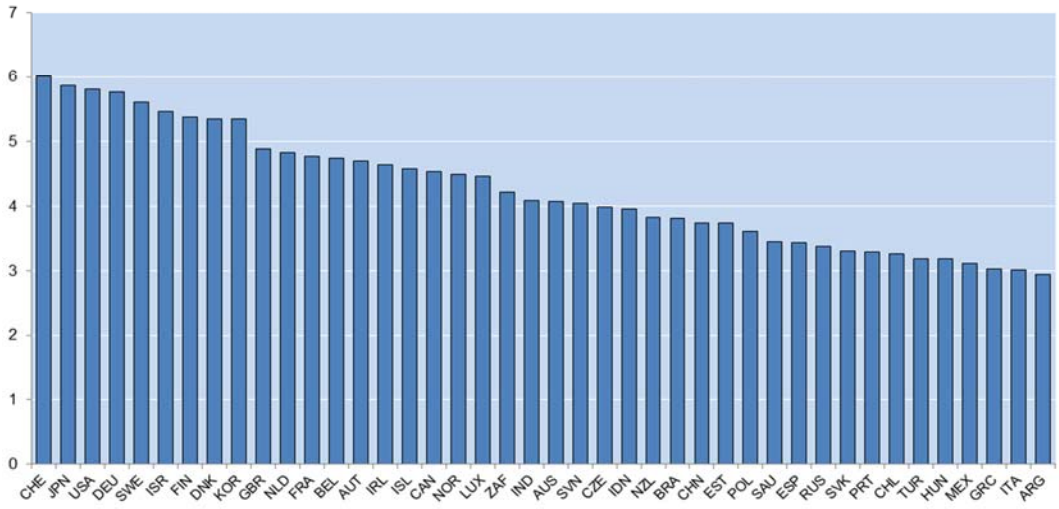

*Source:* World Economic Forum *Global Competitiveness Report 2013-2014*.

20. Ideally, we would use data on business enterprise R&D (BERD) expenditure from the OECD to measure the second enabling factor but this high quality data source is not available for all 42 countries in our analysis. Thus, as a second best approach, the indicator of business R&D is derived from the answers of business leaders to a survey question: "In your country, to what extent do companies spend on R&D? (1=do not spend; 7=spend heavily on R&D)". The results are shown in Figure 5. One alternative to using this indicator would be to combine data from the OECD Main Science and Technology Indicators (MSTI)

database and the UNESCO Institute for Statistics relating to business R&D. However, there are issues with data comparability for some countries in the sample (in particular, India). In any case, the correlation of the WEF indicator and an indicator of OECD countries' business R&D intensity is very high (Figure 6), suggesting that countries which perform well (poorly) according to the official R&D also perform well (poorly) in the WEF indicator.

**Figure 5. Spending on Research and Development**

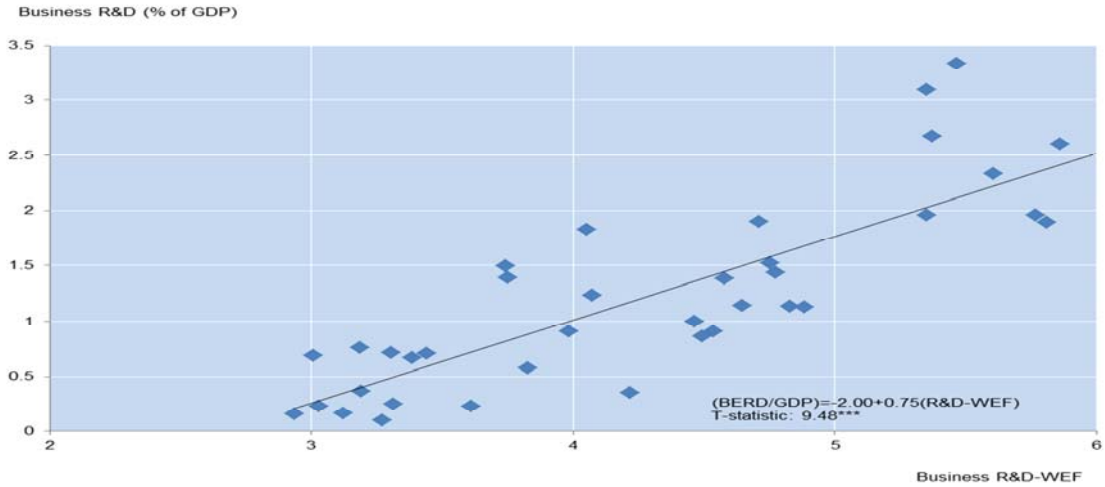
In your country, to what extent do companies spend on R&D? (1=do not spend; 7=spend heavily on R&D)




*Source:* World Economic Forum *Global Competitiveness Report 2013-2014.*

**Figure 6. The WEF indicator of Business R&D spending is highly correlated with the official OECD measure**

Business Enterprise R&D Intensity (per cent of GDP) and WEF Survey Measure of company spending on R&D (1=do not spend; 7=spend heavily on R&D)




*Source:* OECD Main Science and Technology Indicators Database and World Economic Forum *Global Competitiveness Report 2013-2014.*

### *3.3 Empirical results*

#### *3.3.1 Baseline results*

21. The baseline results from the MFP equation of the long term growth model are reproduced in the first column of Table 1. The speed of catch-up term ($\rho$) is positive and statistically significant indicating that MFP growth tends to be faster when a country's actual productivity is much lower than its (country-specific) target steady-state level. Moreover, the interaction term shows that the strength of this catch-up effect increases with the degree of trade openness. Finally, the coefficient on PMR is negative and significant, illustrating the tendency for pro-competitive reforms to product market regulations to be associated with higher MFP growth.

#### *3.3.2 Extensions to the long term model*

22. By way of introduction, the relevance of managerial capital and domestic R&D to the speed of catch-up can be illustrated by comparing the results from the baseline MFP specification from the long-term growth model with the results from an exercise where the MFP process is re-estimated only for the group of countries in the top half of the managerial capital and business R&D distributions. The results from this exercise suggest that countries with higher levels of managerial quality (row 1 of Column 2) and business R&D (row 1 of Column 3) exhibit a speed of catch up that is around three times higher than the cross-country average reported in Column 1 (row 1). These differences, which are also statistically significant, provide *prima facie* evidence for the notion that the underlying process of productivity convergence is different in countries that possess a more skilled managerial pool and engage more intensively in R&D.

**Table 1. The effect of enabling factors on the speed of MFP convergence**

| | Baseline | High Managerial Capital | High BusinessR&D |
|---|---|---|---|
| | (1) | (2) | (3) |
| Speed of catch-up | 0.065** | 0.180*** | 0.215*** |
| | 2.55 | 3.89 | 4.2 |
| Speed of catch-up*openness | 0.043* | 0.167*** | 0.201*** |
| | 1.76 | 3.16 | 3.49 |
| PMR | -0.434** | -0.107 | -0.053** |
| | 2.09 | 1.18 | 2.37 |
| Time fixed effects | Yes | Yes | Yes |
| Country fixed effects | Yes | Yes | Yes |
| Adjusted R^2 | 0.526 | 0.56 | 0.58 |
| Observations | 347 | 199 | 191 |

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

Note: t-statistics in parentheses. The regressions include country and time fixed effects and robust standard errors. The baseline is run on an unbalanced panel (over the 1998-2008 period) due to the limited availability of the PMR indicator for non-OECD countries. The fact that these countries tend to be below-median on the measures of managerial quality and business R&D leads to the sample size in columns (2) and (3) exceeding half the overall sample (i.e. column 1).

23. With a view to facilitate the scenario analysis in Section 4, these findings can be formally incorporated into the long-term growth model by re-specifying the speed of convergence process as the function:

$$\rho_{c,t}^{a} = f(O_{c,t} * X_c)$$

where *X* is the country specific indicator of either managerial quality or business R&D spending. We allow an economy's speed of convergence to its long-run steady state level of MFP to depend on the product of its openness and a given enabling factor (management or R&D). This reflects the idea that the speed of catch-up for countries with above (below) average trade openness will be enhanced (diminished) by higher (lower) levels of managerial quality or R&D. At the same time, this approach is required due to a lack of time variability in the enabling factors, which gives rise to multicollinearity problems when the speed of catch-up variable appears too many times in the regression.[10]

24. The results of the exercise are shown in Table 2. For ease of interpretation, the terms relating to the enabling factors are demeaned so that the coefficient on the speed of catch-up term indicates the impact of catch-up on productivity growth at average levels of; openness in column (1), *openness*management* in column (2) and *openness*R&D* in column (3). The interaction terms, *Speed of catch-up*(openness*managerial quality)* (Column 2) and *Speed of catch-up*(openness*R&D)* (Column 3), are estimated to be positive and statistically significant. Additional analysis suggests that these estimates are broadly robust to dropping one country at a time.[11] The results suggest that countries which combine greater openness with high managerial quality and greater openness with high business R&D tend to converge more quickly to their long-run MFP level than other countries.

10 The results are qualitatively robust to the inclusion of additional speed of catch up terms (e.g. Speed of catch-up*openness) but the Speed of catch-up*openness*R&D interaction become marginally insignificant. Importantly, the management triple interaction remains positive and becomes statistically significant at the 5% level.

11 These results are not shown for sake of brevity and are available from the authors on request.

**Table 2. Multifactor productivity growth**

| | (1) | (2) | (3) |
|---|---|---|---|
| Speed of catch-up | 0.065** | 0.075*** | 0.084*** |
| | 2.55 | 2.62 | 2.87 |
| Speed of catch-up*openness | 0.043* | | |
| | 1.76 | | |
| Speed of catch-up*(openness*Man.Qual.) | | 0.008* | |
| | | 1.82 | |
| Speed of catch-up*(openness*bus.R&D) | | | 0.012* |
| | | | 1.95 |
| PMR | -0.434** | -0.416** | -0.382** |
| | 2.09 | 2.15 | 2.26 |
| Time fixed effects | Yes | Yes | Yes |
| Country fixed effects | Yes | Yes | Yes |
| Adjusted R^2 | 0.526 | 0.527 | 0.529 |
| Observations | 347 | 347 | 347 |

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

Note: t-statistics in parentheses. The regressions include country and time fixed effects and robust standard errors. It should be noted that the sample mean of the *openness*Man.Qual.* and *openness*bus.R&D* terms exceeds that for *openness*. This scale effect leads to the magnitude of the estimated coefficients on the interaction terms in columns (2) and (3) being lower than that on the variable in column (1).

## 4. An alternative scenario for frontier growth

25. To further illustrate the economic significance of managerial quality and business R&D in technological adoption and productivity convergence, this section sketches a future growth scenario whereby MFP growth at the technological frontier is assumed to be ½ percentage point higher than in the baseline projections of the long term growth model where frontier growth was assumed to be 1.3% per year. Over the horizon to 2060, we make the simplifying assumption that the United States will continue to be the frontier country in developing new innovations, which we justify on the basis of the following observations: *i)* R&D intensity and patent applications, which suggests the United States is currently the world's most important innovator (Bottazzi and Peri, 2007); *ii)* that a large share of the recent ICT-related frontier technology have originated from the United States; and *iii)* cross-country MFP studies, which show that the United States overwhelmingly occupies the leader position (Bourles et al., 2013).[12]

26. Before proceeding, it is important to recognise the lack of consensus surrounding the future outlook for frontier growth. There is a pessimistic view associated with Gordon (2012), which holds that the recent productivity slowdown is a permanent phenomenon and that recent and future innovations (e.g. ICT) are insignificant compared to those that took place during the first half of the 20th century (e.g.

12 For example, in Bourles et al., (2013) dataset comprising 15 countries and 20 industries over the period 1984-2007, the United States occupied the leader position in almost 60% of cases. The next highest is Canada, which occupied the frontier position in 20% of industry-year cases.

electricity). By contrast, technological optimists (e.g. Brynjolfsson and McAfee, 2011) tend to argue that the underlying rate of technological progress has not slowed and that the IT revolution still has a long way to run and will continue to dramatically transform frontier economies. Against this background, it is important to emphasise that our choice of an upside scenario is largely for illustrative reasons and should not be interpreted as an endorsement of a particular view. That said, Table 3 highlights that the assumption for annual frontier growth rate of 1.3% over the period to 2060 currently embodied in the central scenario of the long term model is very cautious as it would have underestimated frontier growth in the recent US peak-to-peak growth cycles for which comparable data are available.

**Table 3. MFP growth in the United States**

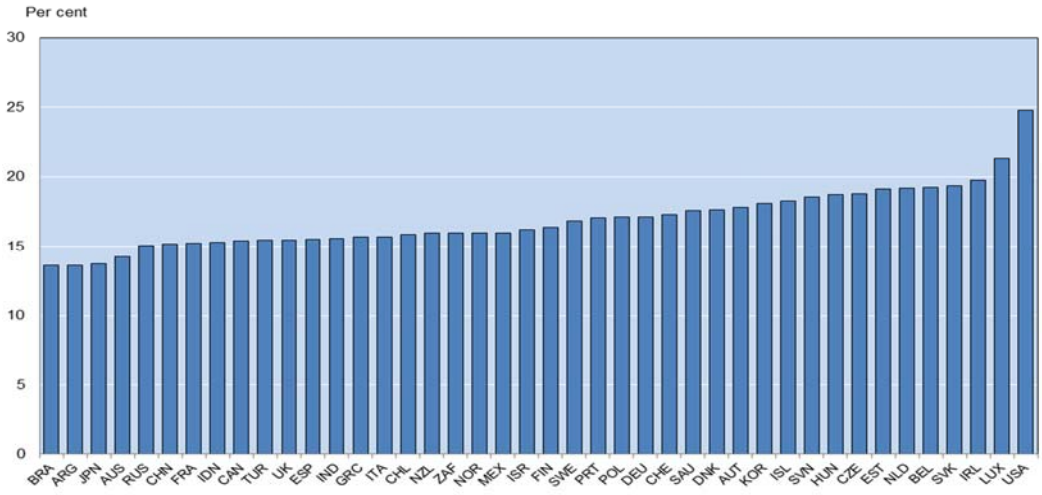
| Time period | Annual average % change |
|---|---|
| 1990-2001 | 1.90% |
| 2001-2007 | 1.70% |

*Source:* OECD Economic Outlook 93 long-term database

27. With this background in mind, an exercise is conducted within the framework of the baseline long-term growth model in which the technological frontier grows at a rate of 1.8% per year until the horizon of the model in 2060.[13] Various barriers (i.e. policy, geographic, cultural, etc.) to the transmission of new ideas imply that non-frontier countries may not be able to fully capture the benefits of higher frontier MFP growth. However, by 2060 there is a notable increase in GDP per capita in all countries relative to the baseline (Figure 7). The gains range from 13½% in Brazil to 25% in the United States, with the distribution reflecting relative levels of trade openness.

**Figure 7. GDP per capita at 2060**

% change compared to central scenario as a result of higher frontier growth

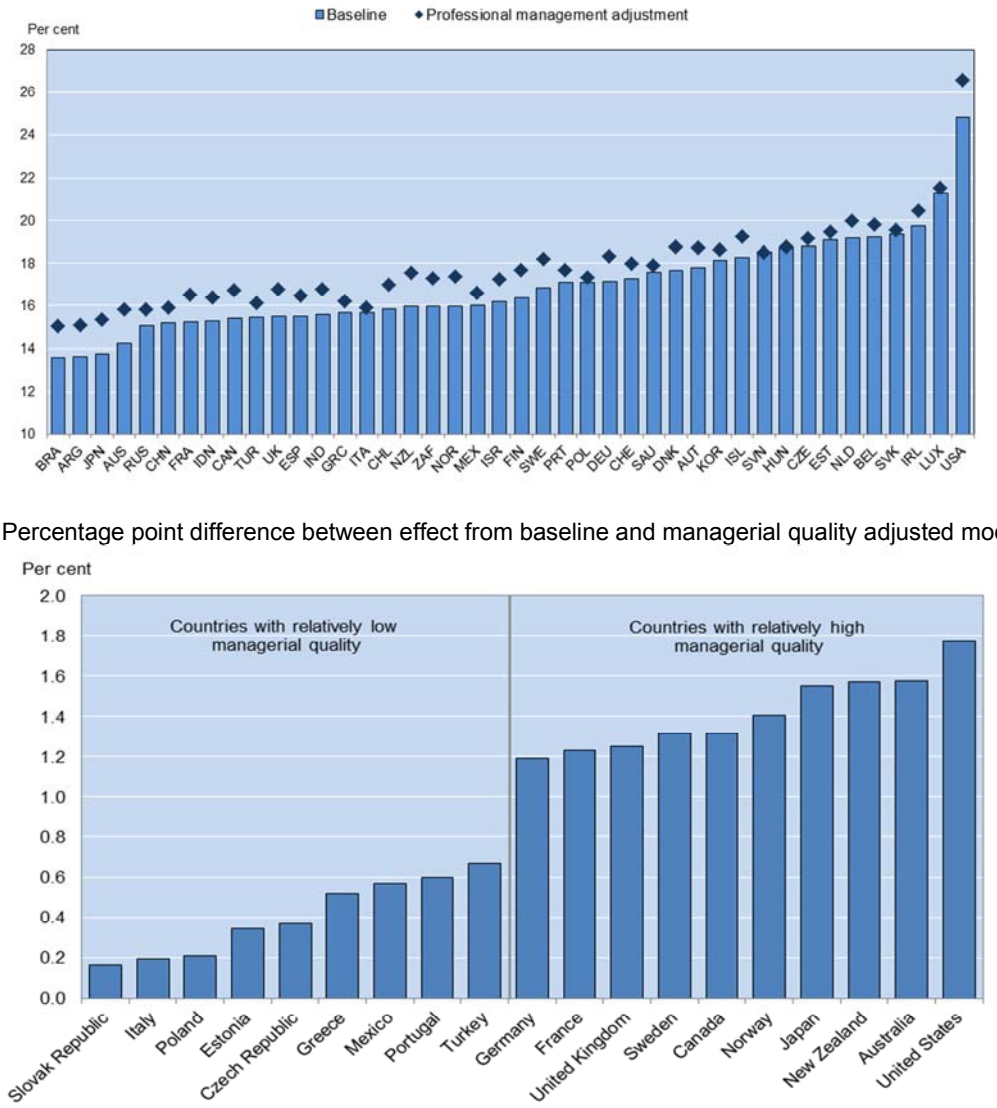



*Source:* Authors' calculations based on OECD Economic Outlook 93 Long-term Database

13 Given that we make the simplified assumption that the United States is the frontier country, the shock to US MFP growth is incorporated directly into the long-term growth model by an adjustment to the level of the country-specific fixed effect for the US.

28. When the long-run model is augmented to allow for the role of managerial quality (i.e. adopting the specification estimated in Column 1 of Table 2) in influencing the extent of technological absorption, there are some changes in the distribution of gains from the higher frontier growth scenario across countries (Figure 8). For example, while France, Canada and New Zealand all shift five places up the distribution, Mexico and Italy fall seven and nine places respectively. Moreover, the additional impact on the 2060 GDP per capita of the augmented specification (i.e. the difference between the bars and the markers in Figure 8A) is shown in Figure 8B for a selection of countries with relatively low and high levels of managerial quality. Interestingly, the countries that receive the largest proportional boost from the managerial capital adjustment (see right hand panel of Figure 5B) are also countries with below-average trade openness (e.g. Australia, Canada, Japan), implying that the baseline model underestimates the speed of convergence in these countries. In contrast, these effects are considerably smaller in many Southern and Eastern European countries where the quality of managerial capital is much lower (left hand panel of Figure 8B).

**Figure 8. GDP per capita at 2060 – Managerial quality adjustment**

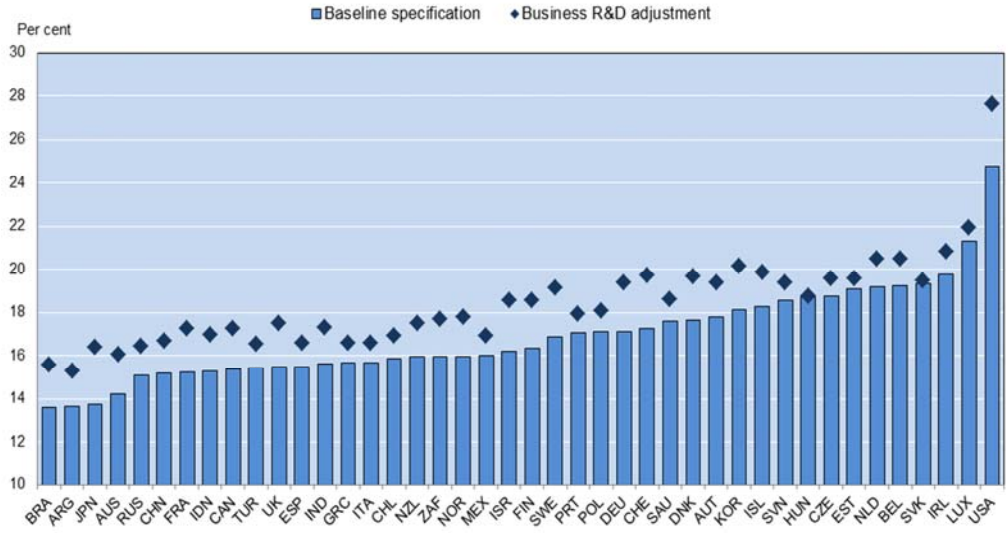



*Source:* OECD Economic Outlook 93 Long-term Database, WEF, authors calculations.

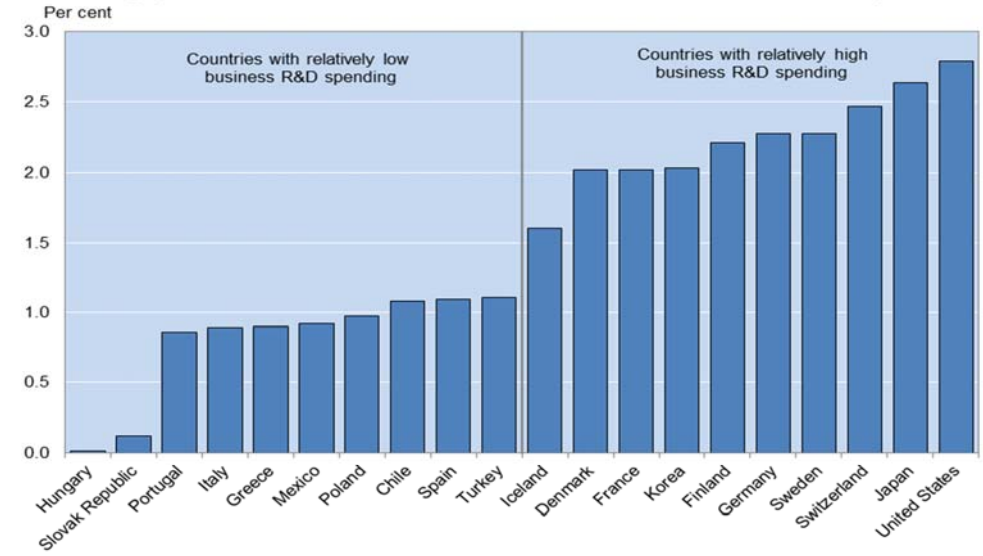
29. As when the model is adjusted to account for managerial quality, the specification that allows for the role of both trade openness and business R&D in influencing the speed of convergence (i.e. Column 2 of Table 2) leads to some re-ordering in the distribution of gains from higher frontier growth (Figure 9). While Switzerland and Korea shift up the distribution 8 and 6 places respectively, the Slovak Republic and Greece fall 8 and 7 positions. The additional impact on GDP per capita at 2060 of the augmented specification (i.e. the difference between the bars and the markers in Figure 9A) is shown in Figure 9B for a selection of countries with relatively low and high business R&D spending. Accounting for business R&D significantly increases the speed of catch up in some northern European countries, Japan and Korea, while the boost is again much smaller in Southern and Eastern Europe where the resources devoted to business R&D investment tends to be much smaller.

**Figure 9. GDP per capita at 2060 – R&D adjustment**

A. % change as a result of higher frontier growth




B. Percentage point difference between effect from baseline and business R&D adjusted model




*Source:* OECD Economic Outlook 93 Long-term Database, WEF, authors calculations.

## 5. Policy discussion

30. The empirical analysis highlights that in addition to trade openness, higher managerial quality and business R&D facilitate technology adoption and thereby increase the speed with which countries converge to their steady-state level of MFP. Clearly, in addition to static efficiency considerations, an important argument in favour of further reductions in barriers to international trade and investment the role of openness in fostering MFP convergence. Moreover, policies to raise human capital are likely to be central to raising both managerial quality and R&D stocks of an economy.[14] But since the fruits of human capital-related policy interventions take a long time to materialise, we focus on some more immediate strategies that governments might pursue to cultivate such enabling factors.

### *5.1 Improving managerial quality*

31. Public policy initiatives to improve managerial quality and raise the returns (with respect to aggregate productivity impacts) from a given level of management could focus on three main areas.

#### *5.1.1 Product market competition*

32. A key channel through which product market reforms raise productivity is via improved managerial performance, which enhances the ability of firms to undertake the internal reallocations required to implement new technologies and to sustain the innovation process. Pro-competition policies are likely to improve management performance by imposing greater market discipline, which forces poorly managed (and unproductive) firms out of the market (Schmitz, 2005; Bloom and Van Reenen, 2010). Similarly, the incentives to improve managerial practices are likely to be greater if competition "raises the stakes" either because: *i)* managers are more fearful of losing their jobs; and/or *ii)* efficiency improvements have a larger impact on shifting market shares. Consistent with this, the tail of poorly managed firms in countries where product market regulations are less stringent – particularly, the United States – is smaller than in other countries where product market regulations are, on average, more cumbersome (Andrews and Criscuolo, 2013).

33. The liberalisation of barriers to trade and international investment will also improve managerial capital to the extent that multinational enterprises are generally well managed, and tend to transplant these superior organisational practices in the countries in which their subsidiaries are based (Bloom et al., 2012b).

#### *5.1.2 Resource reallocation*

34. While improvements in the quality of management lead to high productivity within firms, from the perspective of the economy as a whole, these gains will be maximised when the most effective managers command a larger share of the economy's resources. With this in mind, Figure 10 decomposes the employment share-weighted management scores (expressed in standard deviations) into: i) average unweighted firm management scores (the same concept as in Figure 2); and ii) a reallocation effect that measures the covariance between management scores and employment shares (this term is positive when firms with higher management scores account for a larger share of employment).

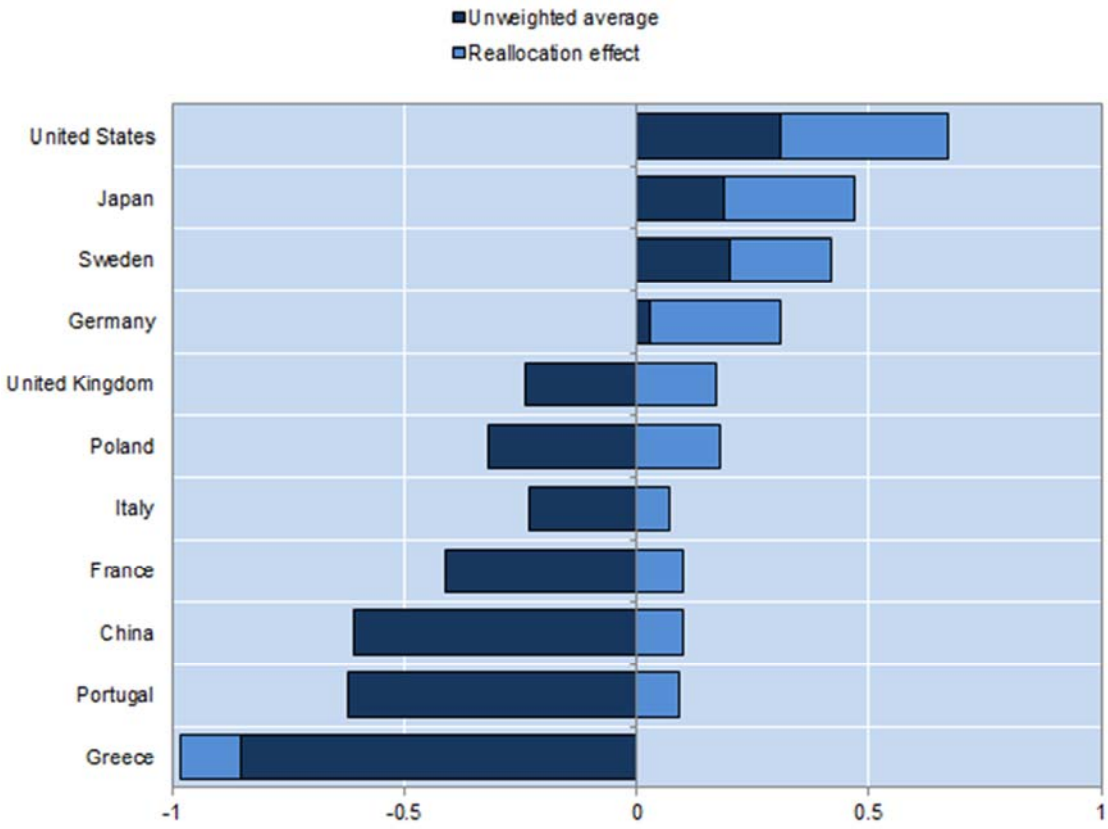
35. Some interesting cross-country differences emerge which suggest that some countries are more successful at channelling resources to better managers than others. For example, the United States not only has the highest unweighted management score but it also has the highest degree of effective reallocation.

14 The policy levers to boost the supply of skills in an economy are discussed at length in OECD (2012).

By contrast, not only is there a greater share of poorly managed firms in Southern European countries than in the United States (i.e. the unweighted term) but the contribution from reallocation effects tends to be much lower. This suggests that even firms with relatively decent managerial capital will struggle to grow and reach a large share of the economy in Southern European economies. In fact, the contribution from reallocation in Greece is negative, which suggests that firms with above average managerial quality supervise a workforce that is smaller than the average Greek firm.

**Figure 10. Decomposition of the Weighted Average of Management Scores**

Standardised management scores; domestically-owned firms only, 2006




Notes: Weighted average management scores (with standard deviation=1) are decomposed into an unweighted firm average (dark bar) and a reallocation effect (light bar). The chart shows that the weighted average management score in Greece is 1.65 (0.67+0.98) standard deviations lower than the United States. The calculation is based on a measure of firm size reported by the plant manager. For multi-national enterprises (MNEs), firm size may be ambiguous to the extent that the manager may report the global MNE size which is not necessarily closely related to the management. As a result, MNEs are excluded from the above calculations which leads to some minor discrepancies between the unweighted term reported above and in Figure 2.

*Source:* Bloom et al., (2013).

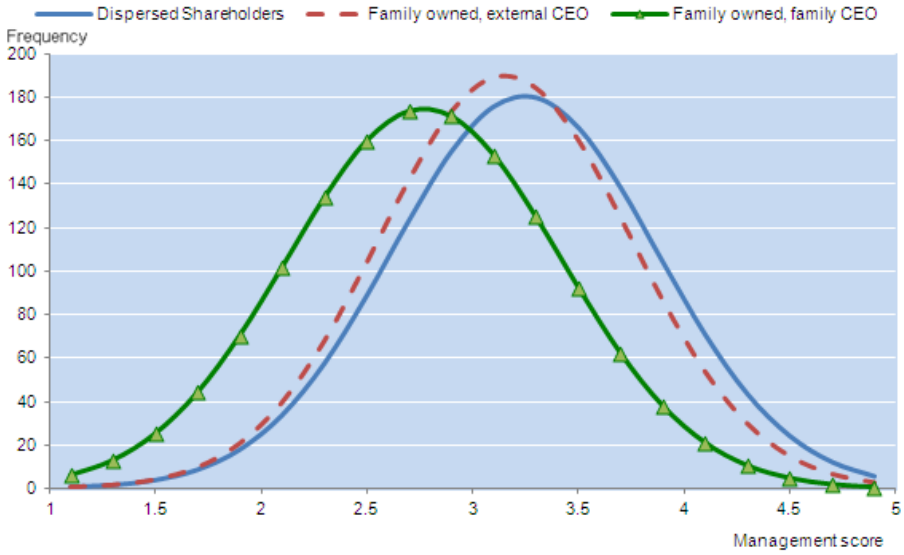
36. Emerging empirical evidence suggests that public policies are an important source of cross country differences in the efficiency of resource allocation (Bartelsman et al., 2013; Andrews and Cingano, 2014). For example, Andrews and Cingano (2014) construct estimates of static allocative efficiency at the industry level for a large sample of OECD countries that is conceptually identical to the reallocation term in Figure 10 but uses firm-level labour productivity instead of management scores. The policy analysis shows that more stringent regulations affecting product and labour markets and bankruptcy laws that excessively penalise business failure are associated with less efficient resource allocation. Thus, well-

designed framework policies are likely to be crucial to extract the full productivity benefit from a country's pool of managerial capital.

*5.1.3 Ownership structure and taxation*

37. Family-owned firms are typically less well-managed, especially those managed by the oldest son of founders (Bloom and van Reenen, 2007; Figure 11). Selecting the CEO from among the small group of potential family members reduces the available pool of managerial ability and the incentives of the children of firm owners to acquire human capital. At the same time, product market competition may be less effective at driving poorly managed family-owned firms out of business to the extent they are subsidised by their family owners through cheap capital (Bloom et al., 2014). From this perspective, inheritance tax exemptions with respect to family firms might lower managerial quality. Indeed, tentative evidence suggests that in countries where inheritance tax exemptions for family firms are generous – e.g. the United Kingdom, France and Germany – the share of family-managed firms tends to be higher than in the United States, which has no substantial family firm exemptions (Bloom and Van Reenen, 2007). Thus, a policy reform that eliminated – or at least significantly reduced the generosity of – inheritance tax exemptions for family firms in affected countries could reduce the incentive for badly managed firms to remain in family ownership and might boost aggregate productivity and intergenerational social mobility.

**Figure 11. Managerial quality and ownership structure**




*Source:* Authors calculations based on Bloom et al., (2012a).

## *5.2 Stimulating R&D*

*5.2.1 Innovation policies*

38. There is scope for policies that raise private incentives to invest in R&D, as the existence of knowledge spillovers that cannot be appropriated by the investing firm cause private underinvestment in R&D relative to socially desirable levels.

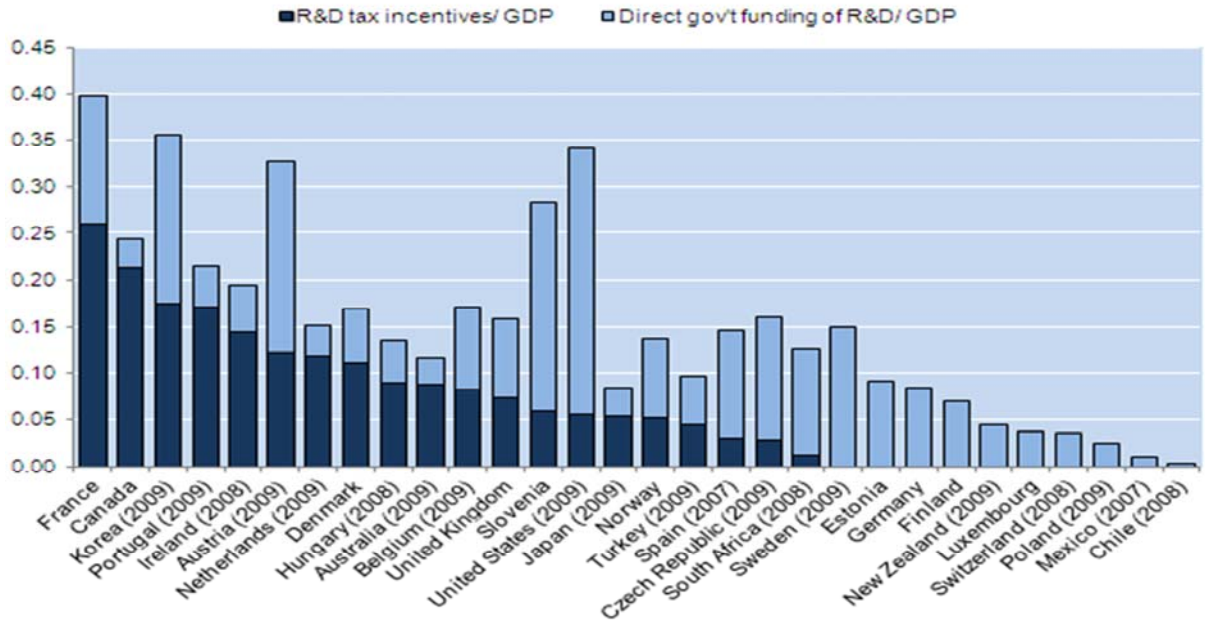
39. Intellectual property rights (IPR) provide firms with the incentive to invest in R&D, but maximum effects are obtained when they are coupled with pro-competition policies (Aghion and Griffith,

2005;Westmore, 2013). Even so, IPR may have unintended consequences that need to be acknowledged. In some emerging KBC sectors where the innovation process is typically fragmented (e.g. software), the patent system may unduly favour incumbents at the expense of young firms, thus undermining incentives to invest in KBC (Cockburn et al., 2009). Empirical evidence from the United States suggests that the cost of litigation exceeded the profit from patents in the late 1990s in industries outside pharmaceuticals and chemicals (Bessen and Meurer, 2008). Indeed, the increasing emergence of "patent aggregators" that accumulate software patents with the sole objective of extracting rents from innovators may challenge innovation activities. While the patent system remains effective at promoting innovation in sectors such as pharmaceuticals and chemicals, the rising importance of the digital economy raises an important policy dilemma for governments, which is yet to be resolved in academic and policy circles.

40. Aside from setting appropriate intellectual property rights, there is scope for public finance policies that subsidise innovation-related KBC. The most frequent policies are tax incentives and direct support (i.e. loans, grants) for R&D (Figure 12), with reliance on the former increasing dramatically over recent decades in many economies.

**Figure 12. Direct government funding of business R&D (BERD) and tax incentives for R&D**

Budget impact as a percentage of GDP; 2010 or latest year available




Notes: Countries ranked from highest to lowest R&D tax incentives/GDP. R&D tax incentives do not cover sub-national incentives. Direct government funding includes grants and public procurement of R&D and excludes repayable loans. Figures are not shown for Greece, Israel, Italy, the Slovak Republic, China and the Russian Federation, which provide R&D tax incentives, but cost estimates are not available. For the United States, direct government funding of R&D includes defence spending on R&D by the government in the form of procurement contracts or the subcontracting by government agencies of non-classified projects to private firms. That is, it includes only R&D spending not directly performed by national or publicly funded institutions (e.g. military laboratories etc.). If a project is conducted by the private firm in direct collaboration with the government, publicly funded institutions or universities, only the part that is done by the private firm and paid to them would be included.

*Source:* OECD, Main Science and Technology Indicators (MSTI) Database, June 2012; OECD R&D tax incentive questionnaires of January 2010 and July 2011; OECD (2011) and national sources.

41. While both policies can be effective, their design features are crucial in order to minimise the cost to the taxpayer and unintended consequences:

- It is important that R&D tax incentives are refundable or contain carry-over provisions so as to avoid overly favouring less dynamic incumbents at the expense of dynamic young firms. Many young innovative firms are typically in a loss position in the early years of an R&D project and thus will not benefit from the program unless it contains provisions for immediate cash refunds for R&D expenditure or allows such firms to carry associated losses forward to deduct against future tax burdens (see Andrews and Criscuolo, 2013 for how the design of R&D tax incentive schemes varies across countries).

- Recent improvements in the design of schemes that provide direct government support to R&D may explain why, in contrast with earlier empirical research, there is now clearer evidence of a positive impact on private R&D (Westmore, 2013). For example, the structure of public support has become more focused on subsidies for commercial R&D activities and with matching grants (for private sector investments) being a more common feature of government funding programmes.

### *5.2.2 Framework policies*

42. In general, well-functioning product, labour and (early stage) venture capital markets and bankruptcy laws that do not overly penalise failure are associated with greater investment in knowledge-based assets (see Andrews and Criscuolo, 2013). These benefits are partly realised through stronger competitive pressures and more efficient reallocation, which make it easier for successful firms to implement and commercialise new ideas and, by lowering the costs of failure, encourage firms to experiment with uncertain growth opportunities.

43. More specifically, a modest reduction in PMR in the energy, transport and communications sectors – corresponding to the difference in regulation between Australia and Austria in 2008 – could result in a 5% increase in the stock of business enterprise R&D in the long run (Westmore, 2013).[15] At the same time, the positive impact of knowledge spillovers from abroad on domestic patenting activity is significantly higher in countries where barriers to entry for new firms are relatively low (Westmore, 2013), suggesting that reforms to PMR can also raise the incentives for firms to incorporate foreign technologies (Parente and Prescott, 2000; Holmes et al., 2008). Along similar lines, more debtor-friendly bankruptcy codes are associated with more rapid technological diffusion, which may be through the positive influence of such policies on the market share of KBC-intensive firms (Westmore, 2013).

44. There is also scope for policy complementarities between innovation policies and framework policies that affect the firm exit margin, such as bankruptcy laws and employment protection legislation. It is increasingly being recognised that the growth potential of innovative firms is inversely related to the amount of resources that are absorbed by other less productive firms. For example, Acemoglu et al., (2013) show that policy intervention such as R&D tax subsidies are only truly effective when policy-makers can encourage the exit of "low-type" incumbent firms, in order to free-up R&D resources (i.e. skilled labour) for innovative "high-type" incumbents and entrants. This reflects the idea that low-type firms – despite their lack of innovation – still employ skilled labour to cover the fixed costs of operation, such as management and back-office operations. One implication is that a R&D subsidy will be fully capitalised into the high skilled wage rate – without a concomitant rise in innovation output – unless the effective supply of high skilled labour can rise to meet additional demand via the downsizing and/or exit of "low-type" firms.

15 This could be expected to raise annual MFP growth by around 0.1% but the effects would take some time to materialise given the relatively sluggish adjustment of R&D to shocks.

## 6. Conclusions

45. International knowledge diffusion is an integral part of the model underlying the OECD's long-term growth projections, with growth at the technological frontier being a key driver of each country's estimated long-run MFP level. While increasing global integration is expected to continue to facilitate knowledge transfer between countries, the diffusion of new technologies can occur with long and variable lags and the process of productivity convergence is far from a *fait accompli*.

46. Accordingly, we augment the OECD long-term growth model and show that an economy's speed of convergence to its long-run (country-specific) steady state level of MFP is an increasing function of two key enabling factors: managerial quality and business R&D expenditure. In the context of a scenario where MFP growth at the technological frontier is assumed to be ½ percentage point higher than in the baseline projections until 2060, we document how patterns of convergence to the new steady state vary between: *i)* the baseline model, where convergence depends on openness; and *ii)* the augmented model, where there is also a role for the two enabling factors of interest. In short, accounting for managerial quality and business R&D leads to a significant re-ordering in the distribution of gains from higher frontier growth, with countries such as Japan, Sweden and Germany benefiting significantly more than could be expected based on their trade openness alone. In contrast, these effects are much smaller in many Southern and Eastern countries where the resources devoted to investment in KBC tend to be much smaller.

47. From a policy perspective, existing evidence suggests that framework conditions that foster competition are positively related to both the quality of managerial capital and the size of the domestic research sector. For example, policies that improve the efficiency of resource reallocation mechanisms can encourage KBC investment and magnify the gains to aggregate-productivity from a given improvement in managerial quality by ensuring that the most effective managers are responsible for a larger share of the economy's resources. Such policies include those that enhance the functioning of product and labour markets, and bankruptcy laws that do not overly penalise failure. The literature also warns against the potential adverse effects on managerial capital of tax policies that subsidise family firms. Focusing on business R&D, tax incentives and direct support measures are found to boost R&D investment. However, design features are crucial in order to minimise the fiscal cost and unintended consequences of these policies, while it is likely that efficacy of such innovation policies will be enhanced by well-designed framework policies. Finally, well-defined intellectual property rights (IPR) can provide firms with the incentive to innovate, especially in the chemicals and pharmaceutical sectors. However, such IPR regimes need to be coupled with pro-competition policies to ensure maximum effect while rising litigation costs are undermining the effectiveness of the patent system in promoting innovation in the software sector.

48. More speculatively, if countries are more active in building managerial capital and investing in the domestic research base over the period to 2060, there may be associated pressures that require consideration by policymakers. Both a boost in managerial quality and business R&D spending imply an increase in demand for high skilled workers. In those regions already facing skill-biased technological change, this may lead to further tightening in the market for skilled labour and serve to widen within-country income disparities (Braconier et al. 2014). In this context, in order to ensure that the gains from productivity growth are broadly shared, better-targeted tax and benefit systems and structural adjustment policies (e.g. job retraining) to cope with skill biased technological change will become increasingly important.

## REFERENCES


Acemoglu, D. and J. Lin (2004), "Market Size in Innovation: Theory and Evidence from the Pharmaceutical Industry", *Quarterly Journal of Economics*, 119(3), pp. 1049–1090.

Acemoglu, D., U. Akcigit, N. Bloom and W. Kerr (2013), "Innovation, reallocation and growth" *NBER Working PaperSseries,* No. 18993.

Aghion, P. and R. Griffith (2005), *Competition and Growth*, The MIT Press, Cambridge, MA.

Aghion, P. and P. Howitt (1997), "Endogenous Growth Theory", *The MIT Press*.

Andrews, D. and F. Cingano (2014), "Public Policy and Resource Allocation: Evidence from Firms in OECD Countries", *Economic Policy*, No. 29(78), April 2014, pp. 253-296.

Andrews, D. and C. Criscuolo (2013), "Knowledge-based capital, innovation and resource allocation", *OECD Economics Department Working Paper*, No. 1046, OECD, Paris.

Andrews, D. and A. de Serres (2012), "Intangible Assets, Resource Allocation and Growth", *OECD Economics Department Working Papers,* No. 989, OECD, Paris.

Bartelsman, E., J. Haltiwanger, and S. Scarpetta (2013), "Cross Country Differences in Productivity: The Role of Allocation and Selection", *American Economic Review*, No. 103(1), pp. 305-334

Bessen, J. and M.J. Meurer (2008), "Patent Failure: How Judges, Bureaucrats and Lawyers Put Innovators at Risk", *Princeton University Press*.

Bloom, N. and J. Van Reenen (2007), "Measuring and Explaining Management Practices Across Firms and Countries", *Quarterly Journal of Economics*, 122(4), pp.1351-1408.

Bloom, N. and J. Van Reenen (2010), "Why Do Management Practices Differ across Firms and Countries?", *Journal of Economic Perspectives,* No.24(1), pp. 203–224.

Bloom, N., C. Genakos, R. Sadun and J. Van Reenen (2012a), "Management Practices Across Firms and Countries", *NBER Working Paper*, No 17850.

Bloom, N., R. Sadun and J. Van Reenen (2012b), "Americans Do IT Better: US Multinationals and the Productivity Miracle", *American Economic Review*, No. 102(1), pp. 167–201.

Bloom, N., B. Eifert, A. Mahajan, D. McKenzie and J. Roberts. (2013a), "Does Management Matter: Evidence from India", *Quarterly Journal of Economics*, Vol. 128(1), pp. 1-51.

Bloom, N., R. Sadun, and J. Van Reenen (2013b) "Management as a Technology", LSE mimeo http://cep.lse.ac.uk/textonly/_new/staff/vanreenen/pdf/mat_2013dec1.pdf

Bloom, N., R. Lemos, R. Sadun, D. Scur, John Van Reenen (2014), "The New Empirical Economics of Management", *NBER Working Paper*, No. 20102.

Bottazzi, L., and G. Peri (2007), "The International Dynamics of R&D and Innovation in the Long Run and in the Short Run", *Economic Journal*, No. 117(518), pp. 486-511.

Bouis, R., R. Duval and F. Murtin (2011), "The Policy and Institutional Drivers of Economic Growth Across OECD and Non-OECD Economies: New Evidence from Growth Regressions", *OECD Economics Department Working Papers*, No. 843, OECD, Paris.

Bourlès, R., G. Cette, J. Lopez, J. Mairesse and G. Nicoletti (2013), "Do Product Market Regulations In Upstream Sectors Curb Productivity Growth? Panel Data Evidence For OECD Countries," *Review of Economics and Statistics,* No. 95(5), pp. 1750-1768

Braconier, H., Nicoletti, G. and B. Westmore (2014)," Policy Challenges for the Next 50 Years", *OECD Economics Department Policy Papers*, No 9, OECD Publishing, Paris.

Brynjolfsson, E., A. Renshaw and V. Marshall Alstyne (1997), "The Matrix of Change: A Tool for Business Process Reengineering", *Sloan Management Review*, pp. 37-54.

Brynjolfsson, E., and A. McAfee (2011), "Race Against The Machine: How the Digital Revolution is Accelerating Innovation, Driving Productivity, and Irreversibly Transforming Employment and the Economy", Digital Frontier Press.

Cockburn, I.M., M.J. MacGarvie and E. Muller (2009), "Patent Thickets, Licensing and Innovative Performance", *ZEW Discussion Paper*, No. 08-101.

Comin, D., and B. Hobijn (2009), "Lobbies and Technology Diffusion", *Review of Economics and Statistics* 91(2), pp. 229–244.

Comin, D., and B. Hobijn, (2010), "An Exploration of Technology Diffusion," *American Economic Review*, Vol. 100(5), pp. 2031-59.

Comin, D., and M Mestieri Ferrer (2013), "If Technology Has Arrived Everywhere, Why Has Income Diverged?" *NBER Working Paper Series*, No. 19010.

Crespi, G., C. Criscuolo and J. Haskel, (2008), "Productivity, Exporting, and the Learning-by-Exporting Hypothesis: Direct Evidence from UK Firms", *Canadian Journal of Economics*, No. 41(2), pp. 619-638.

David, P.A. and G. Wright (2005), "General Purpose Technologies and Productivity Surges: Historical Reflections on the Future of the ICT Revolution", *Economic History.*

Duguet, E. and M. MacGarvie (2005), "How Well do Patent Citations Measure Flows of Technology? Evidence from French Innovation Surveys", *Economics of Innovation and New Technology*, No. 14(5), pp. 375-393.

Easterly, W. and R. Levine (2001), "It's Not Factor Accumulation: Stylized Facts and Growth Models", *World Bank Economic Review*, No. 15(2), pp. 221-224.

Griffith, R., S. Redding and J. Van Reenen (2004), "Mapping the Two Faces of R&D: Productivity Growth in a Panel of OECD Industries", *The Review of Economics and Statistics*, No. 86(4), pp. 883-895.

Gordon, R.J. (2012), "Is U.S. Economic Growth Over? Faltering Innovation Confronts the Six Headwinds", NBER Working Paper No. 18315.

Hall, B., J. Mairesse and P. Mohnen (2010), "Measuring the Returns to R&D", in *Elsevier Handbook of the Economics of Innovation*, B.H. Hall and N. Rosenberg (eds.), Burlington Academic Press.

Holmes, T.J., D.K. Levine and J.A. Schmitz Jr. (2008), "Monopoly and the Incentive to Innovate When Adoption Involves Switchover Disruptions", *NBER Working Paper*, No.13864.

Johansson, Å., Y. Guillemette, F. Murtin, D. Turner, G. Nicoletti, C. de la Maisonneuve, P. Bagnoli, G. Bousquet and F. Spinelli (2012), "Long-term growth scenarios", *OECD Economics Department Working Paper*, No. 1000, OECD, Paris.

Jones, C.I. (2005), "Growth and Ideas", *Chapter 16 in Handbook of Economic Growth*, Vol. B, Edited by P. Aghion and S. Durlauf. Elsevier B.V. Dan Diego.

Juma, C. and N. Clark (2002), "Technological Catch-Up: Opportunities and Challenges for Developing Countries", SUPRA Occasional Paper, Research Centre for the Social Sciences, University of Edinburgh.

Melitz, M. (2003), "The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity", *Econometrica*, No. 71, pp. 1695-1725.

Melitz, M. and G. Ottaviano (2008), "Market Size, Trade, and Productivity", *Review of Economic Studies*, No. 75: pp. 295-316

Melitz, M. and D. Trefler (2012), "Gains from Trade When Firms Matter", *Journal of Economic Perspectives* 26(2), pp. 91-118.

OECD (2011), *OECD Science, Technology and Industry Scoreboard 2011*, OECD, Paris.

OECD (2012), *Better Skills, Better Jobs, Better Lives: A Strategic Approach to Skills Policies*, OECD Paris.

Parente, S.L. and E.C. Prescott (2000), "Barriers to Riches", *MIT Press: Cambridge*, MA.

Pritchett, L. (1997), “Divergence, big time”, *Journal of Economic Perspectives*, No. 11(3), pp. 3-17.

Rodrik, D. (2011), “The Future of Convergence”, *HKS Faculty Research Working Paper Series*, RWP11-033, John F. Kennedy School of Government, Harvard University.

Schmitz, J.A., Jr. (2005), “What Determines Productivity? Lessons from the Dramatic Recovery of the U.S. and Canadian Iron Ore Industries following Their Early 1980s Crisis”, *Journal of Political Economy*, No. 113(3), pp. 582-625.

Schmookler, J. (1966), "Invention and Economic Growth", *Harvard University Press*, Cambridge, MA.

Syverson, C. (2011), “What Determines Productivity?” *Journal of Economic Literature* 49(2), pp. 326–365

Tang, K.K. (2011), “Correcting the Size Bias in Trade Openness and Globalization Measures”, *Global Economy Journal,* Vol. 11, Issue 3.

van Ark, B., M. O’Mahony and M.P. Timmer (2008), “The Productivity Gap between Europe and the United States: Trends and Causes”, *Journal of Economic Perspectives,* 22(1): pp. 25–44.

Westmore, B. (2013), “Innovation and Growth: Considerations for Public Policy”, *Review of Economics and Institutions*, Vol. 4, No.3, pp. 50, December.

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