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Determinants of Total Factor Productivity: A Literature Review

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Abstract

Based on micro, sectoral and macro studies, this review identifies several determinants that have an impact on TFP growth. Of these, education, health, infrastructure, imports, institutions, openness, competition, financial development, geographical predicaments and absorptive capacity (including capital intensity) appear to be the most important. Whereas most past papers reviewed only establish statistical associations and provide no causal direction, any policy discussion can only be indicative rather than directive. Nonetheless, these determinants suggest areas for policymaking. Examples include investment in human capital to enhance the absorptive capacity, which in turn, facilitates technology transfer, or trade reforms to increase access to foreign capital and intermediate goods.

Keywords: Total factor productivity; factor accumulation; knowledge creation; technology transfer and adoption; absorptive capacity

1. Introduction

Growth of total factor productivity (TFP) provides society with an opportunity to increase the welfare of people. It is, therefore, worthwhile to ask, what determinants should policy focus on to enhance the performance of TFP?[1] This paper attempts to review the determinants of productivity growth. It will also investigate to what extent the (robust) determinants found in empirical work have implications for policy, albeit always keeping in mind Jones' advice. Although the main focus is on change in TFP, it is sometimes impossible to refrain from discussing change in average labour productivity or productivity levels. One reason for this is that there are simply more studies based on change in labour productivity than on change in TFP. A second reason is that it does not always make sense to distinguish between the two. In particular, in the simplest framework, change in labour productivity depends on change in both TFP and capital deepening. However, the effect of change in TFP and capital deepening are difficult to discuss separately due to their interdependence.

From the outset, it is assumed that capital intensity is one of the main determinants of TFP and that policies that encourage investment also have a positive impact on TFP growth. Both a medium- and long-term view of determinants are provided. Long-term determinants can be viewed as so-called deep determinants in growth literature, in other words, integration (mainly trade), institutions and geography. The rest of the determinants, which serve the medium-term view, can be referred to as proximate, again following growth the literature. It should be noted that although this paper is mainly concerned with policies for the medium-term, they cannot be entirely disconnected from the long-term perspective. For example, medium term policies to increase capital formation or improve resource allocation – both factors that positively influence TFP – will only work in an environment with good institutions. Alternatively, take the example of geography. Policies to encourage foreign direct investment (FDI) inflows will not

[1] To state that policy affects productivity growth could be asking for too much. Although there are endogenous growth models with such implications, Jones (2004), for example, warns against them because of their tendency to require knife-edge solutions.

succeed unless unfavourable geographic conditions are dealt with beforehand, simply because foreign firms do not favour areas with a high disease burden.

Like all other literature reviews, this one too has some major limitations. First, it only covers research as of 1990 onwards, with a particular focus on developing countries. This means that major works by Solow, Jorgenson, Griliches, Denison and so on, are not directly touched upon, although well known to those familiar with productivity issues. Furthermore, thanks to improved datasets, econometric methods and some important theoretical advances, much of the recent work constitutes more of a refinement of the old literature with little new information.[2]

Secondly, because the empirical literature on productivity is vast and the number of journals (and hence possible outlets for empirical work) is constantly growing, it is impossible to cover everything that has been produced over the past 15 years. This could result in serious omissions.

Thirdly, all determinants considered here are grouped under four headings: Creation, transmission and absorption of knowledge; Factor supply and efficient allocation; Institutions, integration and invariants; and Competition, social dimension and environment. As can be expected, it is impossible to clearly demarcate between the variable groups. For example, whereas international trade may be important for technology transfer, it might also have other more direct positive effects on productivity growth. Therefore, trade is discussed twice in this review.

Fourthly, this review is mainly concerned with the supply side of the economy because producers make decisions on, for example, technology adoption. However, it is clear that demand-side pressures may very well trigger such decisions. Cornwall and Cornwall (2002) present both a model and empirical evidence, which suggest that strong aggregate

[2] For example, Arrow (1962) on endogenous growth theory, Abramowitz (1986) on technology transfer, Nelson and Phelps (1966) on absorptive capacity, Schultz (1961) on human capital, and Chenery and Syrquin (1988) on structural change, to name a few.

demand stimulates investment and technological change and leads to technology adoption on a broad front. Hence, when trying to identify TFP growth determinants it may be advisable to think in terms of both supply and demand.

Finally, this review is largely concerned with macroeconomic cross-country studies and, to a lesser extent, with sectoral and micro studies, the latter simply because of the scarcity of such studies. However, insofar as it has been possible to find sectoral and micro studies, and to the extent they bring additional information to the discussion, those results are also reported here.

This review starts by considering the creation, transmission and absorption of knowledge. A definition of knowledge[3] is provided followed by a discussion of variables related to its creation (for example, domestic and foreign, research and development (R&D) and some common channels for transfer of knowledge (for example, trade). The section closes with a review of some of the requirements for the effective adoption of technology. The next group of determinants concerns factor supply and efficient allocation. The focus here is on human capital (for example, schooling, health and training) and physical infrastructure (for example, roads and electricity) rather than physical capital (for example, machinery and equipment), as the latter is always included in the production function. Efficient allocation of resources is dealt with under two headings, namely, structural change (for example, allocation of resources to the most productive sectors) and the financial system (for example, a good financial system is able to allocate savings to investments with the highest returns, and high-quality investments imply a higher probability for TFP growth).

Thereafter, the focus is on the so-called "deep" determinants, by which are meant institutions, integration and invariants (geography). Among institutions, a distinction is made between political (for example, autocracy versus democracy) and economic institutions (for example, property rights), whereas in the case of integration the focus is on trade (FDI is covered under "knowledge transmission"). The section on geography

[3] In the discussion, the terms technology, knowledge and ideas are used interchangeably but are broadly interpreted the same way, unless otherwise stated.

concentrates on the location of countries and, in particular, the effects of being located in the tropics. Most of the discussion on deep determinants is concerned with overall economic development – as reflected in per capita income levels, although some studies also address TFP.

The final group is concerned with the role of competition, the social dimension and the environment for productivity growth. For example, a long-held view argues that competition is the main determinant of productivity growth. Another view is that environmental regulation deters productivity growth. The review closes with a summary of the findings and a discussion of the policy conclusions that may draw from those findings.

2. Creation, transmission and absorption of knowledge

Knowledge has a direct effect on TFP. It is believed that a good starting point for a discussion of the role of knowledge is to think of production as requiring two main components, inputs X (for example, labour and capital) and knowledge A, where the latter concerns how to best organize production (for example, what combination of labour and capital that produces the greatest output holding the costs constant). In principle, the more one has of A and X, the more can be produced – hence output growth is driven by the accumulation of inputs (change in X) and knowledge (change in A). Clearly, A also indicates the level of technology and should be seen as technological knowledge.[4] In the neoclassical growth tradition, change in technology can be referred to as TFP growth or technological progress. As will be seen later, the intimate relationship between knowledge creation and TFP growth breaks down when theory is confronted with reality.

Continuing in the neoclassical tradition, in the transition from one equilibrium to another, growth may stem from both change in A and X. However, at some (marginal) point it no longer pays off to increase X and, in the long run, output growth depends entirely on knowledge creation or technological progress. Much of the growth debate concerns whether factor accumulation or TFP growth is the most important factor behind output growth.[5]

In neoclassical growth models (for example, Solow, 1957), technological progress is seen as manna from heaven and determined outside the model (in other words, it is exogenous). Modern growth theory (for example, Romer, 1986, 1990) purports to explain technological progress and therefore expands the "old" model by adding an explanation on how knowledge is created (hence A is endogenous). In fact, thanks to endogenous knowledge creation, modern growth models allow for perpetual growth.[6,7] Innovation is crucial for technological progress and is complemented by specialization, in the sense that the latter enhances the former by improving the total sum of knowledge. Ideas combine to create new ideas and this process is self-generating and self-feeding in a dynamic way.

Why are knowledge and TFP in reality not the same? Measured TFP shows how much output was actually produced from a given amount of input. On the assumption that economic agents are rational, one may expect this to also be a reflection of knowledge, with the latter always encompassing TFP outcomes to the extent that it always exceeds TFP (that is, if this were possible to measure). However, the link between TFP and knowledge is considerably weakened by factors such as institutional quality, degree of openness and flexibility of the economy, to name a few. Furthermore, as this review emphasizes, not all knowledge is necessarily useful to all countries and poor countries

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[4] In the literature, a term sometimes used for technological knowledge is disembodied knowledge, in other words, knowledge not embodied in goods and machinery.

[5] For instance, Romer (1993) and Prescott (1998) argue for differences in technology, whereas the view that technology can flow freely across countries has led some researchers to model cross-country income differences as driven purely by factor differences rather than by differences in technology (for example, Mankiw, Romer and Weil, 1992).

[6] Many of the endogenous growth models could in fact be understood as enhanced neoclassical growth models.

[7] Note that there is an ongoing debate as to what extent knowledge spillovers can actually increase long-term per capita growth (as suggested by Romer, 1990). For example, Jones (1995) shows that, while the number of R&D scientists and engineers has increased sharply in the U.S. over the post-war period, TFP growth has remained more or less constant. The consequence is that Romer exaggerates the extent of knowledge spillovers. From a policy viewpoint, it would be important to know if and to what extent it would pay off to subsidise R&D activities.

can be expected to have knowledge that goes beyond the current level of production. In addition, knowledge produced at the world technology frontier is not likely to be readily usable, thus necessitating modifications. Knowledge is viewed here as one of several determinants of TFP, but is perhaps the most important.

Empirically, one often sees work trying to explain knowledge creation, but equally common are studies that explain TFP by knowledge. Because knowledge cannot be measured, in the former case, it is proxied by, for example, R&D and patent data, and more recently by information and communication technologies (ICT)[8], whereas in the latter case, R&D and patents (again representing knowledge) are included as determinants of TFP. Therefore, both types of studies are viewed here as representing the effect of knowledge creation on TFP growth.

Change in the stock of knowledge is the result of various domestic investments, for example, in R&D (public and private) and education, although the size of population (or rather, the number of persons involved in knowledge production) also matters. Knowledge could also be imported through several channels. For instance, goods embody technological know-how. Therefore, importing relatively advanced goods can potentially increase the stock of knowledge. Another channel can be FDI, which theoretically brings knowledge into a country. R&D activities in foreign countries, and thus contact with such countries, have been shown to spur growth domestically. Generally, one would expect more open economies to be better positioned to acquire knowledge from abroad, although knowledge transfer may be inhibited by lack of absorptive capacity. For example, a better-educated and healthier population is in a better position to learn and absorb knowledge. Human capital and R&D are important means of increasing a country's absorptive capacity. Other tools may include ICT and the overall institutional setting.

Industrialised countries are on, or are just below, the World Technology Frontier (see Isaksson, 2006) and in order to enhance TFP growth their primary focus is on innovation.

[8] Both ICT production and the use of it appear to promote growth. See, for example, Jorgenson and Stiroh (2000) for the case of the U.S.

However, the key task of developing countries is to tap existing technological knowledge so that they can catch up with the leaders. Hence, one can say that while the U.S. innovates, Tanzania absorbs. Advanced technologies can seldom be readily applied in poor countries and, therefore, require major modifications in order to be effective or even useful. As will be seen, in the case of developing countries, what is happening on the domestic scene, in terms of local R&D and education, may be more important than innovation at the frontier and the transfer of that knowledge.

2.1 Innovation and creation of knowledge

An effective innovation system is important for TFP growth. What is meant by an innovation system? Chen and Dahlman (2004) define it as "a network of institutions (for example universities, public and private research centres as well as policy think tanks), rules and procedures that influence the way by which a country acquires, creates, disseminates and uses knowledge." The chief role of an innovation system is to foster R&D that, in turn, leads to new products, processes and knowledge.

R&D is often said to have two faces: the first is innovation, while the second is to facilitate the understanding and imitation of others' discoveries. The latter is related to absorptive capacity and provides for efficient technology transfer. R&D is likely to take place at firm or industry level, but will ultimately promote overall economic development through enhanced productivity. R&D has two sources, domestic (as already described), or it can be generated from international spillovers. Literature seems to suggest that both channels are important for TFP growth.

Empirically, one would therefore expect a positive statistical correlation between investment in R&D (or its stock) and TFP. However, statistical results may be affected by incomplete measures of knowledge and its proxies, which could lead to problems, such as weak correlations, and even to questioning *what* has actually been estimated. A final point before turning to empirical results: since R&D activities are costly, they mainly occur in OECD countries. Hence, most studies discussed here, therefore, only cover such countries.

The most "direct" study on knowledge creation is that of Abdih and Joutz (2005), which exploits time series data of the U.S. to directly estimate the parameters of the knowledge production function. Those estimates are then used to assess the extent of knowledge spillovers. The authors find a positive long-run relationship between TFP and the stock of knowledge (proxied by patents). Moreover, their results suggest the presence of strong inter-temporal knowledge spillovers, which is consistent with Romer's (1990) model. However, the long-run impact on TFP growth from these spillovers turns out to be small. The conclusions drawn are that the application and incorporation of knowledge into productivity is complex, and the diffusion process is slow.

Guellec and van Pottelsberghe de la Potterie (2001) also mainly investigated the long-run relationship between R&D and TFP growth at the aggregate level of the economy for 16 OECD countries between 1980 and 1998. Three sources of R&D were considered, namely, domestic business research, public research (for example, by universities) and business research undertaken by other countries. The first and third sources lead to new goods and services, higher output quality and new production processes, while the second one generates and increases basic and scientific knowledge. The results show that all three sources of R&D are important for TFP growth, with foreign-sourced R&D having the largest effect. The second largest effect comes from domestic business research, with public research in third place. The social returns on business R&D outweigh private returns. In addition, the impact of business R&D increases over time. Interestingly, it appears that public and business R&D interact, which leads to the conclusion that it is "important for governments to provide the right framework for encouraging solid relationships between public and private research, so that knowledge flows more easily between the two sectors". Another policy conclusion is the importance of maintaining openness to foreign technology and ensure that firms have the absorptive capacity to best exploit it.

Ulku (2004), in general, agrees with the results of the former study, which suggests that innovation (as proxied by patent applications) is important for GDP per capita as well as TFP. There are, however, some qualifications in that only large OECD countries are able to increase their level of innovation through R&D investment; smaller OECD countries learn from that group to promote their own innovation. Another important result is that innovation only leads to short-term increases in the growth rate of output, which contrasts with the results reported above. Hence, according to this study there is no such thing as perpetual growth (in other words, it is inconsistent with Romer, 1990, while consistent with Jones, 1995).

Furman and Hayes (2004) address the issue of national innovative productivity among follower countries. The paper commences with some interesting salient features. First, the gap between the *most* actively innovative and other innovative countries has narrowed. Secondly, the set of countries that generates new-to-the-world innovations has increased in size, that is, more countries than before generate such innovations. An attempt is made to explain why some countries have managed to become innovators in a "new-to-the-world" sense, while others have failed. They base their analysis on the endogenous growth theory, the literature on national industrial competitive advantage (Porter, 1990) and national innovation systems (Nelson, 1993). They estimate an "ideas" production function for economically significant technological innovations, and assume that three resources for innovation stand out as being very important: a common innovation infrastructure, the environment for innovation in its industrial clusters, and links between the two.

Their study covers 23 OECD countries (1978-1999), categorized according to whether they are leaders or followers (to different degrees) in terms of innovation. Economically (in a commercial sense) significant innovations, as proxied by international patent applications two years ahead, is the output variable. The three explanatory variables mentioned above are proxied by variables, such as GDP per capita, openness, intellectual property rights, expenditures on secondary and tertiary education (clustered under the heading "Quality of the common innovation infrastructure"); percentage of R&D funded by private industry (“Quality of the cluster-specific innovation environment”); and percentage of R&D performed by universities (“Quality of linkages”).

The empirical results indicate that a national innovative capacity is a strong predictor of economically significant innovations. Furthermore, follower countries are becoming increasingly productive in their innovative output. Behind these results is a commitment (for example, innovation-enhancing policies and infrastructure) to become an innovator and to increase investment in factors important for doing so (for example, in human and physical capital). However, geographic origin and national systems of innovation also seem to matter, and different institutional configurations appear to be consistent with catch-up in innovative productivity and output.

Chen and Dahlman (2004) published another study that shows the importance of knowledge creation for TFP growth. Their value added is that they control for some important factors omitted in some of the studies discussed above. Domestic innovation is measured in terms of the number of patents, utility patents, published scientific and technical journal articles, and the amount of royalty payments and receipts. Approximately 80-90 countries (including developing countries) are covered between 1960 and 2000. Their basic results show that the coefficients for patent and journal publication are always statistically significant, while that for royalties is only occasionally relevant. They also experiment with various versions of human capital and find that schooling, along with schooling squared (reflecting diminishing returns to schooling), work best in terms of statistical significance. In addition, the ICT infrastructure appears important for explaining long-term economic growth. Interesting things occur when economic and institutional regime variables (for example, trade openness and institutions) are added. These variables are shown to play a big role in explaining growth, but render several knowledge variables, such as human capital and ICT, statistically insignificant. It could therefore be interpreted that knowledge creation is a function of openness and institutions.

So far, studies based on aggregate data only have been reviewed. The work of Cameron, Proudman and Redding (1999) is an example of an industry-level study. In the case of the

U.K., they find that R&D activity raises the rate of innovation, and thereby positively influences industrial productivity growth. Another industry example is Griffith, Redding and Van Reenen (2000). In the case of 13 manufacturing industries in 12 OECD countries between 1970 and 1992, they ask whether R&D has a direct effect on a country's rate of TFP growth through innovation, and whether R&D's effect on TFP growth depends on a country's level of TFP relative to the technology frontier. The potential for R&D to have an effect on TFP growth through technology transfer is thought to increase with the distance from the frontier. A positive and statistically significant effect of R&D on both rates of innovation and technology transfer was detected. Moreover, the effects are quantitatively important in the sense that the social returns to investment in R&D are significant. They also find that educational attainment is important for TFP growth through both innovation and technology transfer. Trade with a country on the world technology frontier, however, only showed a slightly positive effect on TFP growth through the speed of technology transfer, while leaving rates of innovation unaffected.

In the field of R&D, micro studies are most common. Wang and Tsai (2003) studied a sample of 136 large Taiwanese firms for the period 1994-2000 and found that R&D investment was a significant determinant of TFP growth. The estimated output elasticity with respect to R&D is 0.18, in other words, a 10 per cent increase in R&D investment is associated with approximately 2 per cent TFP growth, an effect greater than previously obtained in the literature. Dividing the sample into high-tech and other firms, it turns out that the elasticity for the former group increases to 0.3, while that of the latter is statistically insignificant. On the question whether relatively large firms are more likely to invest in R&D, support for such a hypothesis could not be found.

Other examples of micro studies finding a positive correlation between R&D investment and TFP growth include Lichtenberg and Siegel (1991) on 2,000 U.S. firms, Hall and Mairesse (1995) on 197 French firms between 1980 and 1987, and Dilling-Hansen et al. (1999) on 226 Danish manufacturing firms in 1993 and 1995.

Ahn (2001) argues that, in reality, it is not innovation input (in other words, R&D investment) per se that counts for productivity, but the actual use of innovation output (in other words, use of advanced technology). This obviously makes a lot sense, but empirical studies nevertheless tend to use input data because this is often the only information available. Geroski (1991) is an example of a study, which shows that innovations have a far greater impact on innovation users' productivity growth than on that of innovation producers'. Another example is the Baldwin and Diverty (1995) study based on the 1989 Survey of Manufacturing Technology in Canada, which shows that plant size and plant growth are closely associated with technology use. Added to this, McGuckin, Streitwieser and Doms (1998), in the case of the U.S., found that plants using relatively advanced technologies exhibited higher productivity, even after controlling for factors such as plant size and age, and capital intensity. Crépon, Duguet and Mairesse (1998), studying some 4,000 French manufacturing firms between 1986 and 1990 also found a positive correlation between higher productivity and new and advanced technologies.

However, Bartelsmann, van Leeuwen and Nieuwenhuijsen (1996) reported, in the case of the Netherlands, a contradictory result, in terms of the importance of new technology for productivity growth. The important factor behind labour productivity growth was instead shown to be capital deepening. Comin (2002) seriously questions the impact of R&D on TFP growth. In the case of the U.S., the world's leading country in R&D, he calibrates a model to assess the importance of R&D for TFP growth. He finds that less than 3-5 tenths of one percentage point of TFP growth can be attributed to R&D, a result very much contrary to the view that R&D is the main source of long-term growth. The author concludes that finding the driving force of TFP growth must be placed at the top of the research agenda. Support for Comin's result can be found, for example, in Jones and Williams (1998). Utilizing panel data analysis, they show that, taking account of fixed effects, results in R&D almost entirely lose its impact on TFP growth.

2.2 Technology transfer[9]

As has been alluded to in the previous section, knowledge is created by a small number of leader countries in technological terms. Because most countries do not produce state-of-the-art technology themselves, it must be acquired from elsewhere. There are several ways knowledge can cross national borders. For instance, technology is often embodied in goods. Thus, imports of a relatively high knowledge content can be exploited. Trade, in general, increases international contacts and can be a source of learning. FDI in the form of a plant in a foreign country can also entail technology transfers. Trade and FDI, as carriers of knowledge, should probably be seen as having indirect effects on TFP, as the better they work, the stronger their impact, albeit with no intrinsic direct effect on their own.[10] So, what is the empirical evidence for these two channels?

2.2.1 FDI[11]

Traditionally, FDI is viewed as being a key channel for the transfer of advanced technology and superior organizational forms from industrialised to developing countries. Furthermore, FDI is believed to generate positive externalities in the form of knowledge spillovers to the domestic economy through, for instance, linkages with local suppliers and clients (s- called backward and forward linkages), learning from nearby foreign firms and employee training programmes. However, negative externalities are also possible as barriers to accessing technology and competition may be raised. In the literature, the view adopted is often that positive externalities outweigh the negative ones and, for this reason, FDI is generally seen as a welcome addition to the domestic economy. In many cases, FDI is also encouraged (by governments and often also by international organizations) by offering grace periods for taxation purposes and different business support schemes. However, if the outflow of profits is too high, FDI could constitute a cost rather than a

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[9] Here, evidence of what may be termed global technology transfer is discussed, as opposed to local (within country) transfer. The latter form of transfer tends to be stronger.

[10] Direct effects would require human contact. The paper of Andersen and Dalgaard (2006) is probably one the first to discuss the distinction between transfer of embodied and disembodied technical knowledge. On the other hand, the use of consultants in the making of the East Asian Miracle is a well-known “real-world” example of direct knowledge transfer.

benefit. In addition, FDI may replace domestic production instead of increasing competition.

Notwithstanding the persuasive theoretical arguments, the question as to whether FDI spurs productivity growth is ultimately an empirical one. Although it can be studied at different levels of aggregation, micro level is by far the most common and is therefore concentrated on and examples of different approaches to such studies are provided. Because data quality and quantity in industrialised countries tend to exceed that of developing ones, the studies considered here are a mix of those focusing on both OECD and developing countries.

Keller and Yeaple (2003), studying plants in the U.S. (1987-1996), find a strong link between FDI and growth. Approximately 14 per cent of productivity growth over this period can be attributed to FDI spillovers. Furthermore, FDI spillovers seem to be stronger in high-tech compared to other sectors. The main reason for this unusually strong result, according to the authors, is a superior measure of foreign multinational activity. They therefore argue that their results can be generalized for other countries as well.

Another study that finds a positive effect of FDI is that of Griffith, Redding and Simpson (2003), who investigate both the dynamics of productivity growth in manufacturing establishments in the U.K. from 1980 to 1992 and the role of foreign multinationals. The authors focus on two mechanisms through which inward FDI can affect either the level or growth rate of domestic productivity. The first is the introduction of new technologies (in this case by foreign firms to the U.K.). The second is that a foreign presence may increase competition in the domestic market, as well as broaden the market by opening up to foreign markets. They find that foreign firms do indeed play a role in the convergence process, as do other high-productivity domestic firms. An increased foreign presence

[11] Because of the difficulty in disentangling the role FDI plays for technology transfer from the effects of FDI over and above transfer effects - although the latter belongs to integration (see below) - the combined impact of FDI on TFP growth will be discussed here.

within an industry is correlated with productivity growth in domestically-owned establishments through increased speed of technology transfer. The latter is consistent with foreign presence stimulating competition and increasing incentives for technology adoption. Another example of a U.K. study that reveals positive results is that of Haskel, Pereira and Slaughter (2002). In this case, however, the economic return is dwarfed by subsidies paid to attract FDI in the first place. Granér and Isaksson (2002) find that both mixed and pure foreign ownership is positively correlated with productivity growth. In addition, Keller (2004) reports on case studies showing large positive FDI spillovers.

Despite these examples of studies establishing a positive link between TFP growth and FDI, results on the FDI-growth link generally tend to be ambiguous. An oft-cited paper is that of Aitken and Harrison (1999), which shows a negative effect from FDI on productivity among Venezuelan plants. They attribute this to the fact that foreign-owned firms recruit most of the skilled workers and hence deprive domestic plants of their services. Hanson (2001) reports on three case studies and the message is that spillovers are non-existent or limited. In a survey of FDI articles, Görg and Greenaway (2002) reach a similar conclusion.

It appears that FDI has a positive impact on TFP growth in industrialised countries, while such positive results are harder to observe in developing countries. It may of course be that, in the latter case, recipients are too weak in terms of their absorptive capacity. Another possible explanation could lie in differences in the quality of data.

2.2.2 Trade

Mayer (2001) combines two strands of literature that relate to productivity growth. The first argues that trade is a carrier of knowledge and focuses on imports as a way of introducing foreign (relatively advanced) technology into domestic production, which in turn has a positive effect on TFP. In particular, certain kinds of imports, namely, machinery and equipment relating to foreign R&D, are expected to generate more technology transfer than others. This conjecture is also shown to hold empirically.

The second strand focuses on human capital and its role as a facilitator of both technology adoption from abroad and the creation of appropriate domestic technology. Note that human capital is not seen here as a separate input in the production function. The contribution of Mayer (2001), apart from combining the two literatures, is to refine the Coe et al. (1997) measure of technology transfer and combine it with human capital. The resulting interaction is then included as a measure of TFP changes in a cross-country growth regression.

Other examples of this literature supporting the view that trade enhances technology transfer include Coe and Helpman (1995) on 22 OECD countries, Coe et al. (1997) on a sample of both highly industrialised countries and developing countries (77 countries in total), Connolly (1997) on a cross-section of up to 32 countries, and Keller (1998).

Isaksson (2001) uses data on 73 countries between 1960 and 1994 and argues that trade can be viewed as a significant carrier of knowledge or technology, but that unless the recipient countries have the necessary level of human capital, this knowledge will bypass potential recipients (more about this in the next section on absorptive capacity). Harrison (1996) in work covering up to 51 countries between 1960 and 1987 also tries to relate several indicators of trade openness to human capital but, in this case, such interaction seldom proved statistically significant. Miller and Upadhyay (2000), covering 83 countries over the period 1960 and 1989, are more successful on the interaction of exports and human capital. Cameron, Proudman and Redding (1999) on the industrial productivity level in the U.K., also find support for trade as a means of technology transfer.

Hasan (2002) studies Indian manufacturing firms between 1976/1977 and 1986/1987. He investigates how productivity was affected by various embodied and disembodied technology inputs. In terms of the former, he generally establishes a significantly positive effect of imported new capital goods on both productivity and new domestic capital goods (the real effect of the two is about the same). By contrast, investment in disembodied capital affects productivity positively only if it is of foreign origin; in-house

R&D is never statistically significant. An additional result is that domestic and imported inputs are complements, which means that restrictions on capital imports will have a dampening effect on domestic capital acquisition, which in turn will decrease productivity growth. These results are particularly true for industries with considerable technical investment opportunities (for example, the chemical industry).

As in the case of FDI, it can be concluded that the trade channel is important for technology transfer, but that the degree of its significance depends on the absorptive capacity of the recipient.

2.3 Technology adoption and absorptive capacity

By absorptive capacity is meant a wide range of capacities, from the most basic skills in reading, writing and mathematics to scientific and other advanced capabilities. Empirical indicators usually only include R&D and human capital, the latter in a very broad sense so that it includes health and experience in addition to education. Viewing these indicators in terms of absorptive capacity, it is suggested that the effect on TFP is direct (human capital accumulation obviously also has indirect effects on TFP by raising income, although these are not considered here).

When thinking of knowledge in terms of ideas that are codifiable one might believe that much of it can be found in books and manuals. Unfortunately, this is seldom the case, as much of it tends to be tacit. In other words, such knowledge can be acquired only via consultants, visits to plants, etc. “Old” growth theory tends to assume that technology transfer was more or less free of cost. Although technology is a public good it can only be acquired at some positive cost. This seems to be also true in the long term. In fact, technology developed elsewhere could be very expensive because, in order to acquire relatively advanced knowledge, the borrower must develop an innovative capacity (Acha, Marsili and Nelson, 2004).

A good starting point for a review of this literature is the Nelson and Phelps (1966) model, which shows that the rate at which technological laggards achieve technological improvements in leader countries depends positively on their level of educational attainment, and proportionally on the technology gap between the leader and themselves. Only if new technology is introduced, will human capital have an impact on the output level. Similarly, only if technological progress is sustained, will skill accumulation continue. Hence, according to this view, human capital does not enter into the production process.

Benhabib and Spiegel (1994) extend this model by adding an endogenous growth component showing that the level of human capital influences a country's capacity to develop its own technological innovations, which in turn is a determinant of TFP growth. The gap is measured as the ratio between the income per capita of two countries interacted with human capital (education) in the lagging country over the period considered. Diffusion of technology from abroad can be expressed so that it directly relates to technology transfer, which, for example, can lead up to a Coe et al. (1997) specification for TFP. In this case, TFP is a function of R&D stock in the importing country's trading partner, the ratio to GDP of machinery and equipment imports from countries with significant domestic R&D expenditure in GDP, human capital and a country-specific parameter. Their results show that technology spills over from leaders to followers, and the rate at which this occurs depends on levels of education.

Mayer (2001) introduces an interaction between human capital and imports of machinery and equipment, covering 53 developing countries over the period 1970-1990. Technology diffusion is measured as the average of machinery imports over GDP during the sample period. The measure is based on the idea that a persistent increase in the stock of ideas requires a continuous stream of technology inflows. The results are clear: the interaction term has a significant coefficient. Therefore, human capital is used for technology adoption and is not a separate factor in the production function. Imports of machinery alone do not seem to affect growth, which could be an indication of their being too low. Isaksson (2001) independently obtains a similar result. General-purpose machinery has a stronger impact on growth, however. Several obstacles to technology diffusion/adoption are identified. These include low levels of education, various trade barriers (natural and artificial), and high cost of investing in new technology.

Benhabib and Spiegel (2002) further refine their own established model (Benhabib and Spiegel, 1994) by allowing for different functional forms for the technology diffusion process. One of the forms leads to balanced growth, with followers growing at the same pace as the leader. The second form, however, allows for divergence in TFP growth rates between the leader and followers, in particular, if human capital is too low. Studying 84 countries between 1960 and 1995, they established a positive role for human capital as an engine of innovation, as well as a facilitator of TFP catch-up. The predictive capacity of the model seems very good because 22 of 27 countries that were forecast to fall behind did in fact do so.

Using a database called the Historical Cross-Country Technology Adoption Dataset, which covers the adoption of many technologies over the past 215 years for 23 of the world's leading industrial economies, Comin and Hobijn (2004) try to understand what factors generate the observed cross-country differences in technology. The first observation is that of trickle-down diffusion, which is very robust across technologies. The affluent technological leaders innovate and are also the first to adopt new technologies. After this initial adoption, the laggards start adopting the new technologies and partly catch up with the leaders.

What determines the speed of trickle down? The main positive determinants turn out to be income per capita, human capital and trade openness and, on the negative side, governments that are neither military nor hold a public position. Another deterrent of technology adoption is a legislation that is "too" effective. The "losing" side of technology adoption may be influential and have a vested interest in delaying and even stopping the adoption of a new technology. Using its influence, it may convince legislators to enact a law against such adoption and, the more effective the legislation is, the slower the adoption of new technology. Finally, levels of the preceding technology and production of electricity have a positive effect on the degree of adoption of the current technology. It turns out that the importance of the above-mentioned determinants shifts across technologies, as well as over time. For instance, human capital, trade openness and effectiveness of the legislature were more important during the post-war period than before. By contrast, the nature of the political regime and the type of executive mattered more during the pre-1945 period.

Coleman II (2004) notes two limitations to Comin and Hobijn (2004). First, the finding that countries with low human capital levels are slow to adopt new technologies suggests that the speed of adoption is an efficient response to insufficient resources. For example, Caselli and Coleman (2002) show that, in a quantitative sense, human capital cannot be viewed as a very significant factor to explain the adoption of different technologies. Secondly, it is not clear if the new technologies are the most efficient ones. Could it not be that rapid adopters of new technologies inefficiently embraced these technologies too early? A final comment is that the database does not include any poor countries. Explanations for the slow rate of technology adoption, therefore, could be biased towards an efficiency-based explanation.

In addition to human capital, R&D investments may also be required to understand new technologies. This is supported by Griffith, Redding and Van Reenen (2000) who, using industry data of 12 OECD countries (1974-1990), establish a positive effect of R&D expenditures on TFP growth. The same authors (2004) also find that R&D and human capital affect the rate of convergence of TFP growth. Kneller and Stevens (2002), using data on nine manufacturing industries in 12 OECD countries (1973-1992), test whether differences in human capital and R&D explain differences in technical efficiency across industries. Although both variables are statistically significant, only human capital shows some serious economic impact. Kneller (2005) corroborates this result.

Acemoglu and Zilibotti (1999) argue that, even if all countries have access to the same technologies, there will still be large productivity differences among them. They focus on a certain aspect of technology transfer, namely, technology imported from North to

South, and acknowledge but exclude South-South trade. Although technology of the North may be superior to that of the South, conditions in the latter may make technology from the North inappropriate. As an example, they take skill scarcity, where the North has an abundance of skilled labour and therefore develop skill-biased technologies,[12] which are of limited use in the South.

Even in the absence of technology adoption barriers, their theoretical model shows how a mismatch in skill-difference induced technology may lead to productivity differences. Because the South, with its unskilled workers, cannot appropriately make use of the superior technology, they end up with a lower productivity level. Another important result is that the South and North are predicted to have comparable productivity levels in unskilled and highly skilled areas of production. However, in the medium term, skilled production in the South will lag behind in terms of productivity. In sectors where the North uses skilled workers and the South unskilled, there will also be large productivity differences. In addition, international trade is shown to reduce productivity differences because the South specializes in sectors where technology is appropriate for unskilled workers. Despite this reduction, labour productivity per worker diverges because the price of unskilled goods in the North decreases and discourages investment in unskilled technologies, which are most beneficial to the South. The consequence is that trade increases the relative productivity and wages of skilled workers, leading to a widening output gap between North and South. A result is that intellectual property rights emerge as an important determinant of technological development.

Before closing this section, reference is made to a theoretical paper by Basu and Weil (1998), which argues that technology is 'appropriate' only for countries with similar capital-labour ratios (capital intensities). This, in short, means that U.S. technology will not be appropriate for Lesotho, for example. If innovation takes place at high capital-labour ratios, such technology spillovers will not benefit countries with low capital-labour ratios and thus cause them to fall behind. Empirical evidence for such an effect

[12] Obviously, skill-biased technologies may also stem from other North-South differences, such as geography, climate or culture.

was provided in Isaksson (2006), but it also shown, for example, in Timmer and Los (2005).

2.4 Summary of "Creation, transmission and absorption of knowledge"

At the macro level, it seems that knowledge is important to overall economic growth and that it works through various facets of TFP growth. Some results suggest a long-term relation between TFP and R&D. There was also some evidence that the number of innovative countries has increased over time. Industry-level data appears to support macro results, whereas some conflicting results were obtained at micro level, although it is not widely accepted that R&D is important. For example, it was suggested that exploitation of innovation is more crucial than the input into its creation. This could be interpreted to be in line with an institutional view, which suggests that countries with strong institutions achieve a higher output from investment in R&D. Other reasons for adopting a cautionary view on the positive effects of R&D include the facts that the effect was shown to be small and that its measurement seems flawed.

Two channels for technology transfer were discussed, FDI and international trade. For the former it seems that inward investment has positive effects for industrialised countries, which is not necessarily the case for developing countries. This result may, again, suggest that institutional quality and absorptive capacity matter, but could also imply that the nature of FDI could differ, depending on the target country, or simply be more extractive in developing countries. The trade channel seems more promising for technology transfer, but there are strong indications that the efficiency of transfer depends on the absorptive capacity of the recipient country. This capacity is mainly dependent on human capital and capital intensity.

3. Factor supply and efficient allocation

In this section, a very selective view is adopted in the sense that the focus is on human capital (education and health) and infrastructure among the production factors (for example, the role of capital intensity is taken for granted). Both production factors work indirectly through output growth, as well as directly (for example, a better-educated workforce is more productive). Later, the role of sector allocation (structural change) in achieving higher TFP growth is discussed. This has a direct effect on TFP by, for example, replacing unproductive with firms that are productive.[13] Finally, attention is turned to the efficiency of the financial system in allocating savings to investment and creating incentives (both indirectly affect TFP through capital accumulation).

3.1 Education and training

A population that is well educated and well trained helps a society to increase its ability acquire as well as use relevant knowledge. Human capital, for example, in the form of level of education, has an important effect on TFP because of its role as a determinant of an economy's capacity to carry out technological innovation (Romer, 1990) and, for developing countries in particular, to adopt (and adapt and implement) foreign technology. One may want to distinguish between basic education and higher education.[14] The former is important for learning-capacity and utilizing information, while the latter is necessary for technological innovation.

In a literature review, Isaksson (2002) concludes that empirical results linking human capital and economic growth vary, in particular, with respect to statistical significance (significant or not), magnitude (small or large) and sign (positive or negative) of the estimated parameter. The tendency seems to be that the statistical relationship between growth and human capital weakens and the parameter sign switches over time, an effect that is mainly attributed to the advancement of statistical methods. Another conclusion is that, to the extent human capital is significant, marginal returns to human capital are high for countries where it is scarce, although the issue of causality remains unresolved. Another plausible explanation as to why education fails to show its importance is provided by Jones (1996) who contends that it is not the percentage change in educational

[13] Structural change is, in fact, more a source than a determinant.

[14] Perhaps a more important distinction is that between the quantity and quality of education, where the latter has been shown to have a stronger effect on economic growth (see, for example, Hanuschek and Kimko, 2000). Unfortunately, studies relating human-capital quality to TFP growth have not been found.

attainment that counts - the way education normally enters the regression - but rather the change in levels. This is in line with the original work of Mincer (1974).[15]

Human capital in the form of employee training is shown by Bartel (1992) to significantly increase productivity of companies in the U.S. However, it is lagged training investments rather than current training initiatives that positively affect productivity. The importance of training for productivity is corroborated, for example, by Barret and O'Connell (1999) in work covering 642 Irish firms (1993 and 1995). In addition to the significance of training, Black and Lynch (1996) demonstrate the importance of educational quality for productivity in both manufacturing and non-manufacturing sectors, based on information in a database comprising data on some 1,600 manufacturing and 1,300 non-manufacturing plants in the U.S.

Human capital also complements technology, as shown by Baldwin, Diverty and Sabourin (1995) using Canadian data. The point here is that, since skills are needed for adopting technology, firms are encouraged to train their staff. Those firms that are most likely to offer training tend to be innovative, engage in R&D activities, are established, foreign owned, and show strong growth. Hence, the relation between training and productivity is not only strong, but also somewhat complex, particularly in terms of causation. Hall and Kramarz (1998), examining 12 countries (10 OECD), drew the following conclusions: innovative firms tend to shift the composition of their labour force towards higher skills and increase overall employment; higher skills lead to higher wages; the correlation between advanced technology use and productivity is strong; and evidence of advanced technology adoption causing productivity growth is hard to find.

On the negative side, Miller and Upadhyay (2000; 2002) do not find evidence in support of human capital (education). When they add an interaction term between trade and human capital, mainly to account for threshold effects, human capital exerts a negative effect on TFP growth. They then investigate whether the effect of human capital differs

[15] In other words, an increase in educational attainment from five to six years should not be expressed in terms of a 20-per cent, but rather as a one-year, increase.

across levels of economic development. At low-income levels, human capital is negatively associated with TFP growth, while for middle- and high-income countries the effect is positive. This cautions against treating all countries across economic development in the same way, in particular, in terms of policy prescriptions.

3.2 Health

Health influences TFP growth directly through household income and wealth, and indirectly through labour productivity, savings and investments and demography, by reducing various forms of capital and technology adoption. Healthy workers are more productive, all else being equal. With lower mortality rates, the incentive to save increases and leads to higher TFP growth. However, as foreign investors are not attracted to environments where workers are exposed to a relatively high disease burden, some countries are deprived of potentially productivity-enhancing FDI. In addition, school attendance rates are higher if children are healthier and have a better cognitive ability. Furthermore, a longer life span is likely to increase the attractiveness of human capital investment.

Developing countries carry a heavier disease burden than do, for example, OECD countries. Lvovsky (2001) uses the disability-adjusted life years (DALYs) lost per million people, as a health indicator in a study on the burden of disease in developing countries, and finds that the number of years lost in developing countries is about twice that of developed countries.

Some of the links mentioned above are further developed. Take health and labour productivity, for example: if a disease, such as AIDS, affects the labour force proportionately across different levels of skill (there is evidence that this is indeed the case), this has a devastating effect on labour productivity (and most likely on overall productivity) in developing countries with low levels of human capital (in other words, most developing countries). Take AIDS and savings, for example: although the net effect on savings rates may be ambiguous (there is increased use of savings when income decreases, but households tend to save more because future income flows are uncertain), there is a significant risk that AIDS reduces national savings rates, which means that investment and hence capital accumulation decrease. Under such circumstances, the scope for productivity growth is undermined and economic regression may ensue.

Another example is health and schooling. As children are taken out of the educational system in order to replace the income earner of the family, the general level of human capital decreases. In the end, skilled labour, much sought by industry, will not be available when needed. Without the necessary production inputs, existing firms may have to consider closing down, or at least downsizing, and de-industrialisation may result. Moreover, foreign firms are said to hire three qualified persons for every skill-based position and this is obviously a serious drain on the pool of skilled people available to local industry. Finally, considering health and public investment: as a greater part of the government budget goes to health-related expenditures, less is available for the necessary upgrading and maintenance of, for instance, the infrastructure and the educational system. Hence, the private sector will receive less government assistance for productivity-enhancing activities and support schemes.

Cole and Neumayer (2003) investigate the impact of poor health on TFP ("key mechanism") based on 52 developed and developing countries over the (maximum) time period – from 1965 to 1996. They argue that, although other researchers have studied the effect of poor health on output growth, this effect is probably inaccurately measured because it is only indirect – it runs through its effects on the efficiency of labour and physical and human capital. The authors' contribution is to study the direct impact of poor health on cross-country aggregate productivity levels. Three health indicators are considered: the proportion of undernourished within a country (which mainly affects the workforce), the incidence of malaria and other waterborne diseases (which reduces labour productivity and human capital), and life expectancy. As expected, the general result is that poor health has a negative effect on TFP.[16]

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[16] The result appears consistent also across types of countries, including developed and developing. However, the parameter is largest (in absolute value) for African countries.

In cross-country studies, McCarthy, Wolf and Wu (2000) and Gallup and Sachs (2000) find that malaria reduces economic growth. The greatest effect on growth from malaria is established in the latter study, which shows that countries with widespread malaria in 1965 saw growth rates reduced by 1.3 per cent, while the former study suggests that the impact exceeds 0.25 per cent per year for about 25 per cent of the sample. Arcand (2001) focuses on malnutrition ("efficiency cost of hunger") in sub-Saharan Africa and also concludes that it has a negative effect on economic growth. The impact is quantitatively important and the elimination of undernourishment in sub-Saharan Africa would significantly raise the rate of economic growth.

According to the work of Bloom and Sachs (1998) for the period 1965 to 1990, health and demographic variables explain over 50 per cent of the differences in growth rates between Africa and the rest of the world. Covering 70 countries (1965-1990) Bloom, Canning and Malaney (1999) also find that low burdens, in terms of health and dependency, explain a large proportion of East Asia's success.

Another health indicator is life expectancy. Bloom, Canning and Malaney (1999), Gallup, Sachs and Mellinger (1999), and Bloom, Canning and Sevilla (2004) investigate the relationship between life expectancy at birth and economic growth. Taking the latter study as an example,[17] the authors include life expectancy in an aggregate production function in an attempt to establish whether health influences labour productivity and TFP. Using panel data covering the period 1960 to 1990 for 104 countries, they find that increased life expectancy has a positive effect on growth. A one-year improvement in the population's life expectancy contributes to an output increase of 4 per cent. In addition, their estimates based on aggregated data corroborate those using micro data. This established a direct health effect on growth, although there are also indirect effects to be considered. Among them, for example, is the extent to which health influences life cycle savings that, the authors speculate, may also have an effect on capital accumulation.

[17] In addition, the authors review a selection of papers that include health as a determinant of economic growth, as well as the magnitude of the effect on growth.

It might seem obvious that poor health has a negative effect on capacity to work in terms of both energy level and working hours. Tompa (2002) argues for three additional channels: first, individuals with a longer life expectancy may choose to invest more in education because they will enjoy greater returns on such investment. Secondly, they may also save more, which increases capital accumulation. Thirdly, improved health may reduce fertility and increase labour participation.

Knowles and Owen (1995) amend the Mankiw, Romer and Weil (1992) model with health "capital", as proxied by life expectancy (log of 80 years of age minus life expectancy). The interpretation of health is then the shortfall of average life expectancy at birth from 80 years. The authors admit the measure is crude because it excludes health quality beyond survival and is not adjusted for age distribution of the population. It turns out that health is a highly significant determinant in all specifications, except in the case of OECD countries. The results of Bosworth and Collins (2003) concur with those of Knowles and Owen.

3.3 Infrastructure

Investment in public capital, in particular, physical infrastructure, accounts for a large proportion of budgets of many countries.[18] The role of infrastructure is to expand the productive capacity by increasing resources and enhancing the productivity of private capital. However, although an increase in public capital formation normally leads to an increase in overall capital formation, it may also displace private capital formation through crowding out effects. Interestingly, the influence of public capital on TFP growth appears to be independent of its effect on factor accumulation. This section first reviews studies on the correlation between the stock of infrastructure and productivity. Thereafter, the extent of financing and management of public investment is dealt with. Finally, the issue of causality is considered, since for this determinant some empirical evidence to this end was detected.

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[18] See, for example, Munnell (1992), who provides a breakdown of the public capital stock in the U.S.

It is hardly surprising that physical infrastructure (for example, roads, water and sewage systems, electricity supply) improvements are correlated with productivity. Causality running from infrastructure to productivity can easily be envisaged. Yet, comparatively little attention has been paid to quantifying to effect of infrastructure on productivity. An oft-cited study on infrastructure and productivity is by Aschauer (1989) who finds a very large return to public investment in the U.S. One may conjecture that returns to such investment are significantly higher in places where infrastructure is poor. The author even goes as far as to argue that the productivity slowdown in the 1970s was related to a declining rate of public capital investment. Munnell (1992) argues that, on balance, public investment has a positive effect on private investment, output and employment growth. Recent studies tend to add aspects to the relationship between productivity and infrastructure. These studies usually start by revealing the positive correlation and then argue that its strength depends on, for example, management and financing of infrastructure.

From the investor's viewpoint, public capital substitutes for private capital and crowds out private investment. A study by Aschauer and Lachler (1998), based on 46 developing countries between 1970 and 1990, finds a positive effect of infrastructure if financed by lower current government spending, as opposed to a higher level of public debt. Dessus and Herrera (2000), covering 28 developing countries for the period 1981-1991, show that public capital accumulation is associated with an increase in long-term GDP growth. For example, the marginal productivity of public and private capital is of approximately the same magnitude. However, they argue that excessive public investment could be harmful to growth.

For a group of low- and middle-income countries (1970-1990), Hulten (1996) focuses more on the effectiveness of infrastructure. It turns out that the effect of inefficient infrastructure on real GDP growth is more than seven times greater than the impact of the percentage increase in the rate of public investment. In addition, those countries that use infrastructure inefficiently pay a growth penalty in the form of a much smaller benefit from new infrastructure investment. For example, Hulten compares four East Asian countries (with average annual growth of 3.26 per cent) with 17 African countries (with average annual growth of –0.2 per cent) and finds that 25 per cent of the growth difference is due to inefficient use of infrastructure. However, he acknowledges that this result may partly proxy for TFP differences. In any case, the policy implication is that aid to infrastructure projects may have limited effects, if aimed only at increasing the stock of infrastructure (in fact, some results even point to perverse effects). Based on the same data as Aschauer and Lachler (1998), Aschauer (2000) reports similar results with respect to infrastructure management but adds that the method of financing used is also crucial.

On the issue of causality, Fernald (1999) is able to show that in the case of the U.S., using industry data from 1953 to 1989, road network growth (his approximation for public investment because the road stock is the largest component in public capital) causes productivity growth and not the other way around. It is, however, worth noting that the first new road network can have an extremely positive effect on productivity, whereas the marginal benefit of a second network would be small or even nil. Easterly and Rebelo (1993) investigated some 100 countries between 1970 and 1988 and tended to agree somewhat with Aschauer (1989) that public spending on infrastructure has supernormal returns. There is also some evidence that causality indeed runs from infrastructure to growth.

The conclusion derived is that infrastructure is not only very important for productivity growth but even triggers it. However, it is important to closely monitor its management and financing.

3.4. Structural change and resource reallocation

Chanda and Dalgaard (2003) attempt to show that aggregate TFP is greatly influenced by the structure of the economy and here institutions are important for how the structure develops. Their main contention is that the correlation between institutions and TFP arises because the former determines the agricultural/non-agricultural composition of the economy. In economies where institutions are weak less funds are available for investment and, hence, capital accumulation. This in turn affects the output composition, since capital-intensive non-agricultural activities could offer higher wages and thereby attract labour from agriculture.

Here human capital enters the scene. As long as human capital increases the marginal product of labour in the non-agricultural more than in the agricultural sector, labour will be diverted from the latter sector. Furthermore, as long as the relative productivity in agriculture is lower than that of the non-agricultural sector, aggregate output per worker will increase. To the extent that human capital extends to health capital, assuming the latter is influenced by geography, TFP will be determined by geography independent of institutions.

Chanda and Dalgaard's article ends with some empirical findings largely supporting their theoretical predictions. It is established that institutions and, to some extent, geography explain the output structure, which in turn explains differences in TFP across economies. In addition, institutional quality loses its statistical significance when output structure is included in the model. Furthermore, the role of institutions reduces to ensure efficient allocation of resources across sectors, which suggests that policy instruments can compensate for weak underlying institutions.

Fagerberg (2000) produced another paper that investigates the relationship between the economic structure of a country and its productivity growth. He notes that one may expect countries specializing in high-tech production to experience high productivity growth, while countries specializing in low-tech products will lag behind. If prices fully adjust to reflect differences in productivity growth (that is, in a globalised world), this may not be such a big problem in terms of welfare. However, if producers of high-tech products, for some reason, manage to keep most of the rewards from faster technological progress, for example, by controlling prices low-tech producers, they will face severe problems.

Fagerberg acknowledges that a flexible production structure (in other words, the ability to undertake structural change) is an important element in productivity growth because it allows an economy to quickly redistribute its resources to take optimal advantage of changing patterns of technological progress, and that structural change provides an important impetus to growth. While in early studies the primary focus was on the shift from agriculture to manufacturing, Fagerberg chooses to focus on the relationship between specialization, structural change and productivity growth within the manufacturing sector.[19]

The sample consists of 39 market economies at different levels of development for the period 1973-1990, based on three-digit data from UNIDO Industrial Statistics Database. The particular focus was on labour productivity. Overall productivity growth for the sample was 2.3 per cent per year, however with substantial differences across industries. The fastest growing industry was by far electrical engineering, while the slowest growing was footwear. Republic of Korea had the highest annual labour productivity growth, closely followed by Taiwan (Province of China) and the Philippines, while the two slowest countries were Chile and Ecuador.

Using shift-share analysis, Fagerberg tries to account for structural change.[20] The results show that the main part of aggregate productivity growth is attributable to productivity growth *within* individual industries, while reallocation of resources from low to high productivity activities appears much less important. He concludes that structural change has an important influence – although different to heretofore, the main difference being concerned over the role played by new technologies in generating structural change. While expansion of an industry previously tended to imply an increase in employment, this no longer seems to be the case. Instead, industries with low to average productivity levels increased their share in total employment. Finally, the author draws attention to the

[19] See, however, Bloom, Canning and Malaney (1999), who explain that part of income growth in East Asia resulted from old-fashioned structural change, in other words, transformation from agriculture to manufacturing.

fact that countries capable of taking part in structural change associated with the electronics revolution also experienced higher aggregate productivity growth because the sector was very productive and there were major spillover effects to other industries.[21]

Peneder (2003) estimates the impact of industrial structure on aggregate income and growth for some 28 OECD countries over the period 1985-1998. Three interesting results emerge: first, structural change generates both positive and negative contributions to aggregate productivity growth. Productivity growth varies greatly across industries and implies that diversity at industry level is a fact of economic development. In net terms, however, the impact of structural change tends to be weak. Secondly, structural change is not uniform but shows up in clusters. Thirdly, structural change in favour of specific clusters/industries could still be conducive to economic growth. Regression analysis suggests that both technology-driven and high-skill industries have a positive impact on the level and growth of per capita income.

Foster, Haltiwanger and Krizan (2000) survey the establishment and firm-level literature in order to learn more about the role of resource reallocation for aggregate productivity growth. Across individual producers, there is large-scale, ongoing reallocation of outputs and inputs, the pace of which varies over time and across sectors. Furthermore, this reallocation seems to occur rather *within* than between sectors. Entry and exit play an important role in the process of reallocation, with new firms appearing to have higher productivity than those leaving the market. In addition, productivity levels and growth rates differ greatly across establishments within the same sector, and these differences are persistent. Literature attempting to explain these patterns is reviewed and shown to reach many different results and conclusions, which make generalizations very difficult. In the second step, the authors investigate sources of these differences.

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[20] Shift-share analysis is a descriptive technique that decomposes the change of an aggregate into a structural component (showing changes in the composition of the aggregate) and changes within the individual units that make up the aggregate.

[21] See Carree (2003) for a comment related to Fagerberg's last point. In particular, Carree shows that the role of electronics is much less significant than suggested by Fagerberg.

There is a high degree of within-sector heterogeneity. This may be associated with factors such as uncertainty (for example, concerning existing production techniques), differences in managerial ability across plants (for example, in terms of how to best organize production); capital vintage (for example, adoption of new technology may only be possible for new plants, or new technology is embodied in new capital); location (for example, different energy and labour costs) and imperfect and slow diffusion of knowledge.

A standard analysis is to decompose the time series change of an aggregate productivity index into components that show an intra-sector component and other effects reflecting the reallocation of the shares across establishments (including the role of entry and exit). It turns to be a near impossible task for the authors to come up with generalizations because idiosyncrasies seem to play a dominant role. Their survey shows the within-plant contribution to range from 23 to 100 per cent. It also seems clear that the impact of net entry is disproportionate because new plants displace relatively unproductive operations leaving the market. Another conclusion reached is that it is necessary to track the dynamics of microeconomic productivity growth in order to understand the dynamics of its aggregate growth.

The effect of reallocation on productivity in the case of Colombia is examined in Eslava et al. (2004). The argument put forward is that the economy’s efficiency in allocating outputs and inputs across firms is behind productivity growth and, in an economy with frictions (for example, market structure distortions, which show up in the data as very high productivity persistence), relatively productive firms find it hard to replace relatively unproductive ones. However, trade, financial and labour reforms are found to relieve countries of market rigidities. Colombia has undertaken a far-reaching reform programme and the objective of Eslava et al. is to study the effects of reforms on reallocation flexibility and productivity growth (among several other areas).

The authors make use of a very long panel-dataset on plants (with over 10 employees) over the period 1982-1998. They start by estimating KLEM[22] plant-level production functions to generate plant-level TFP. One important finding is that TFP is higher and its dispersion greater after the reforms. Efficient plants facing higher demand for their products/services manage to gain market shares. TFP is increasingly important for the allocation of activity, while the role of demand for activity allocation diminishes following reforms, in other words, causality appears to run in both directions. At the same time, rising aggregate productivity is largely accounted for by improved allocation of activity across plants. Those plants leaving the market seem less productive and face lower demand, while those entering tend to have relatively high levels of productivity. However, they face lower demand than existing plants. One important conclusion of the paper is that, in terms of productivity dynamics, old technology dominates learning effects.

One idea that emerges from the paper is that moves of the production-possibility frontier may be a function of past reallocations, in other words, to move the frontier a certain "level" of high-productivity firms is necessary in an industry/country. If this is true, then reforms facilitating improved reallocation are *very* important for developing countries.

3.5 Financial system

Technological change, which is part of TFP growth, can be embodied or disembodied. While the latter term means that it comes as "manna from heaven", embodied technological change means that the capital stock has been upgraded in terms of quality; recent vintages of capital are simply more productive than older ones. Every firm is aware of this and therefore constantly tries to upgrade its stock of machinery, albeit at a cost.

This raises the issue of financing capital accumulation. In economies where the financial system is well developed, investment opportunities can readily be seized, resources are

[22] In other words, production functions including capital, labour, energy and materials.

more likely to be allocated optimally and specialization is promoted. However, in developing countries with less sophisticated financial systems, this may not necessarily be the case. Firms may have to rely on retained earnings for investment or forego the opportunity. Intuitively, this has repercussions for productivity growth in developing countries.

Furthermore, financial constraints may prevent poor countries from taking full advantage of technology transfer. With tacit and circumstantially specific knowledge, countries have to invest resources in order to master foreign technologies and adapt them to the local environment. Financial repression, often exemplified by negative or artificially low real interest rates, thwarts incentives to save. They also distort the efficient allocation of savings into investment. Again, the negative effect on TFP growth is clear. It is definitely important to learn more about the association between financial development and productivity growth.

Fisman and Love (2004) study the relationship between industrial growth (covering 37 developed and developing industries in 42 countries between 1980 and 1990) and financial development. They start from the expectation that the role of financial development is to help firms or industries to take advantage of growth opportunities in a timely manner by allocating resources to the most productive use. The authors expect that growth rates across industries in different countries move together and this parallel movement should be predicted by financial development, assuming that it does indeed help firms to take advantage of growth opportunities.

First, they focus on global shocks that affect a given industry equally across all countries, thereafter they hypothesize that financial development leads to more correlated patterns of growth rates for countries with similar growth opportunities. Both hypotheses find support in their data and the overall conclusion drawn is that financial development spurs economic growth. Rajan and Zingales (1998) obtain a similar finding, albeit within a more restrictive framework.

Another example showing the importance of financial development is found in Aghion, Howitt and Mayer-Foulkes (2005), who study 71 countries between 1960 and 1995. They find that financial development is a threshold variable, which determines whether a country will converge or not. Financial development affects convergence mainly through TFP growth rather than capital accumulation.

Roubini and Sala-i-Martin (1991) estimate growth equations, including measures of financial repression/development (for example, dummy for real interest rate taking a value of 1 when it is positive, 2 when it is between zero and -5 per cent and 3 when it is below -5 per cent). The authors cover 53 countries and the regression is of a cross-section type. Financial repression is highly significant and has a negative impact with growth-depressing effects. Thereafter, they add a composite index of various market distortions, including financial, which enters with a negative parameter in the regression. An interesting result is that moderate financial repression may not be very harmful to growth, while a strong degree of financial repression most certainly is.

3.6 Summary of "Factor supply and efficient allocation"

In the earlier section addressing the role of human capital did not include the production process, in the sense that what occurred in the production function was not considered. Entering the production function via education produces mixed and somewhat puzzling results. For relatively rich countries, human capital is important, while its effect is negative for relatively poor ones. Human capital, in the form of training, seems to be important but is even more important in the form of health, which, in all studies, shows up with a strong positive effect (in other words, productivity is positively related to better health). Industrialised countries are, however, an exception here. One explanation for why education does not have a positive impact on growth in developing countries could be that the poor level of health prevents efficient learning. This points to the importance of accounting for quality as well as the level of education, but perhaps also to policy priorities: health before education.

Public capital, in particular, in the form of infrastructure, has an important effect on TFP growth. There is even some evidence of causality running from infrastructure to growth. Research has also addressed how public investment is financed and it seems that an allocation of public expenditure is preferred to an increase in public debt. Crowding out private capital formation does not seem to be of great concern. Instead, management of public capital is proven to be very important, again suggesting that institutions are very crucial. In the case of developing countries, it can therefore be concluded that policies aiming at investment in infrastructure should be of high priority, but that attention should be devoted to its management.

While it was not possible to establish strong empirical effects of structural change on TFP growth, there are certainly indications in that direction. Yet, decomposition exercises show that a greater part of productivity growth comes from within-industry and within-plant effects. However, results of one study suggest that market frictions hinder the economy's ability to allocate output and inputs efficiently across firms, indicating that there is clearly room for distortion-reducing policies. In terms of reallocation, net entry seems to be important, with entrants being more productive than those leaving the market.

Finally, although based only on a few studies, there is strong evidence that financial development is good and financial repression is bad for resource allocation, capital accumulation and incentives in an economy. Financial development is also shown to influence the speed of convergence through its effect on TFP growth. Financial sector reform, therefore, merits high priority on the policy agenda.

4. Institutions, integration and invariants[23]

In the growth literature, a distinction is often made between deep and proximate determinants. What is meant by deep and proximate is that there is a deeper force behind some of the common determinants used in the empirical literature. By identifying those

[23] This section is best seen as a discussion on the long-term determinants of productivity.

deep determinants policy makers are better able to improve their approaches to policy making by, for example, better understanding the conditions under which some policies are more likely to work (and conversely). Economists, however, disagree over the exact determinants. In the ongoing discussion, three determinants figure prominently in the literature, namely, trade (integration), institutions and geography (invariants), although sometimes trade is combined with other policies (and then becomes the policy hypothesis).

Whereas trade in the service of technology transfer was seen to have an indirect effect on TFP, here both an indirect and a direct view may be more appropriately taken. For example, insofar as there are learning effects from export activities they should readily affect TFP, while imports of foreign capital add to investments and have indirect effects by increasing capital formation. However, technology embodied in relatively advanced capital imports directly affects TFP. Geography has both direct and indirect effects: indirect, for example, through its effects on trade patterns, and direct since it determines soil quality. Finally, institutions (in a broad sense) directly affect capital accumulation (and hence indirectly TFP), as well as incentives to acquire foreign technology (and hence directly TFP).

The literature takes a long-term view in that it primarily tends to focus on economic development in the form of GDP per capita. Empirically the variable sought to explain this is growth in GDP per capita and not necessarily TFP. The presentation of each of the hypotheses below also includes an attempted explanation of how they relate to TFP.

First *integration.* The discussion as to whether trade has important growth effects also has a significant bearing on overall productivity. In principle, any link between GDP growth and trade put forward can also be applicable for productivity and trade. Work on trade and productivity covers many aspects of the relation including the following: how and to what extent is technology being diffused from industrialised countries to LDCs (as discussed above); what is the scope for learning-by-exporting; are certain types (imports versus exports) of trade more beneficial for productivity enhancement than others; do certain traded goods have more useful technology content than others. Such work is also devoted to the more obvious study of the relationship between trade and productivity in the first place, how strong it is and whether it differs, for instance, across regions or over time.

One obvious complication in this empirical literature is that of reverse causation (trade is obviously endogenous). For example, the theory of comparative advantage relies on relative productivity and suggests reverse causation (in other words, a country specializes in and exports goods that it is relatively productive in). However, specialization allows for exploitation of productivity opportunities. Most likely, causation runs in both directions but as will emerge, the empirical link between trade and TFP is far less solid than one might assume. Studies focusing on trade may also need to take account of country size, as small countries are more likely to be poor.

One effect of trade liberalisation is that it may lead to increased competition, which could lead firms to reduce X-inefficiency and force them to use inputs more efficiently.[24] Better access to imported intermediate inputs of higher quality and/or broader variety, exploitation of economies of scale and product specialization, increased export opportunities (which also relax foreign exchange constraints and allow for capital goods imports), more exposure to previously unattainable better technologies and those embodied in imported final goods are other reasons behind enhanced productivity resulting from more open trade regimes. At sectoral level, trade liberalisation can trigger increased turnover dynamics (that is, entry and exit), which might alter the composition of firms so that average productivity increases, in other words, low-productivity firms tend to exit leaving more room for those with relatively higher productivity.

Focusing on the *policy hypothesis*, the general view is that economic policies and institutions reflect current knowledge and political forces. When knowledge of the best

[24] Increased foreign competition may cut both ways. For example, foreign competition may lead producers to expand or cease operation. Specifically, demand shifts that accompany trade liberalisation, market flexibility (entry and exit) and the nature of competition may all affect the net effect of liberalisation on TFP (Tybout, 1992).

institutions for economic development changes, such institutions and economic policies will also evolve rapidly. According to the policy hypothesis, which is a broader concept than just trade-related policies, history does not affect a country's current situation because it can easily be reversed. Environmental circumstances are equally unimportant for understanding current economic development. However, sound macroeconomic policies and openness to capital flows and trade foster long-term economic success. For example, proponents of the integration view (for example, Frankel and Romer, 1999) argue that geography (invariants) influences economic development via government policy (in particular that of trade). Therefore, countries far away from markets (geography) experience slow growth because they are less likely to reap the benefits of trade.

Maddison (1999; 1997) is a strong believer in the virtues of increased integration as a way of exchanging ideas and allowing more rapid catch-up, but argues against believing that one set of policy measures is applicable to all countries. In fact, he contends that successive waves of growth have very little to do with changing policy decisions, plans, innovative ideas, or ideological changes. Instead, he argues, it is historical accidents or system shocks that have affected previous growth momentums and destroyed old institutional and geopolitical forces. Moreover, they have forced the development of new policies appropriate for the changed situation. In other words, events have triggered new policies and views about the efficiency of policy instruments. If Maddison is right, the policy hypothesis (including trade) should be shifted from the category of deeper to that of proximate determinants. Bosworth and Collins (2003) and Easterly and Levine (2002) have studied the policy hypothesis closely, but failed to find support for its positive effect on economic development once integration, geography and institutions are accounted for. Therefore, this hypothesis, viewed in a broad sense, is seen to concentrate on the trade (integration) aspects.[25]

The next deep determinant is *institutions*, which constitute the second alleged deep determinant. The literature highlights three main institutional issues, namely, enforcement of property rights (encourages investment), constraints on the actions of elitist, political and other groups with power (reduce risks of expropriation of incomes and others' investments), and equal opportunity for broad segments of society (enhanced investment in human capital and participation in productive activities). Whereas the state must be strong enough to protect property rights, its role must be limited in the sense of following the rule of law. Exceptions to the latter abound. These issues are normally captured in the terms, rule of law and property rights.

Institutions are clearly endogenous to economic development. For example, it could be that the environment (including geography) shapes institutions and that the impact of geography on economic development is channelled through institutions without having an independent effect. For instance, political and legal institutions to protect the rights of a few landholders may develop in environments where crops are most effectively produced on a larger scale, such as plantations (for example, Easterly and Levine, 2002). According to proponents of institutions, technology is endogenous to those institutions most likely to facilitate the adoption of superior production techniques. Furthermore, better institutions create more incentives for savings and investment, leading to higher TFP.

Institutions are also important for enhancing the process of learning and innovation, and hence TFP growth. Sachs (1999) argues that, because this process is so complex, markets alone should not be left to govern it. Although markets provide incentives for innovation, they do not cater for the optimal provision of knowledge (because it is a public good its provision is below the social optimum). This suggests a role for the state. In any case, a mix of market and state appears to be a characteristic of every innovative society, where the state is responsible for patent laws, subsidies, education, and so on.

Of the three deep determinants, *geography* is the most exogenous and perhaps the most exogenous an empirically-oriented economist can desire. Geography refers to the natural

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[25] Interestingly, the very influential article by Hall and Jones (1999) seems to assume that government policy and institutions are perfect substitutes.

climate, biology, geology, disease burden and, in particular, differences between the tropics and temperate zones. For example, it is very difficult to apply temperate-zone technological advances in a tropical setting. Geography affects the efficiency of resource allocation, partly by raising transportation costs. The poorest countries tend to be located near or on the equator, in very hot regions with torrential rains, in places where tropical diseases abound, and they often have no coastline. Being landlocked limits a country's ability to access large economic markets, which in turn is an obstacle to exploiting economies of scale and increasing productive efficiency. In addition, transport costs are high and technology diffusion to such regions is poor.

The environment shapes economic development directly by having an influence on inputs in the production function as well as on the function itself. Without doubt, diseases (for example, malaria) that affect both the level and quality of labour will have profound effects on overall productivity. Healthier workers are more productive and are less likely to be absent from work. According to Landes (1998), the sheer heat and humidity of the tropics inhibit working at full capacity. The relative fragility and low quality of land, high prevalence of crop pests and parasites and an inadequate and unstable water supply yield poor crops. Furthermore, production technologies used in temperate zones are less appropriate in hot climates. Diamond (1997) goes all the way to argue that germs and crops have actually affected the technological development of societies in these regions.

4.1 Integration (trade)

One common approach for estimating the effect of trade on productivity is cross-country regression. Using this method, Alcalá and Ciccone (2004) follow Frankel and Romer (1999) and Irwin and Tervio (2002) to investigate the relationship between trade and labour productivity. While Frankel and Romer established a positive effect of trade on labour productivity, Irwin and Tervio found that this effect disappears once a country's distance from the equator is taken into account. Alcalá and Ciccone, however, claim that the problems of finding a robust correlation between trade and productivity relate to the measurement of trade. The common trade indicator, total trade (imports plus exports) as a share of GDP, suffers from the inability to account for changes in relative prices between non-tradables and tradables. Therefore, a useful measure of trade had to be developed to ensure that relative price changes do not affect the relationship.

To this end, the authors developed two alternative measures: first, real openness, which is defined as total trade in US dollars relative to GDP in US dollars adjusted for purchasing-power-parity (PPP), and secondly, tradable GDP openness, defined as total trade as a share of tradable goods production by sector (as opposed to the entire GDP). Both measures eliminate the effect of cross-country differences in the relative price of non-tradable goods.[26]

Using these two measures, they find a strong positive and statistically significant effect of trade on productivity and causation running from trade to productivity. Their results are robust to various alternative specifications, including controlling for geography and institutional quality, the latter strongly emphasized by Rodrik, Subramanian and Trebbi (2002).[27]

Hall and Jones (1999) obtain the same result, using data adjusted to take into account institutions. Edwards (1992) uses nine alternative measures of trade orientation and concludes that more open economies tend to grow faster than countries with trade distortions.[28] The Bosworth, Collins and Chen (1995) study on 88 countries (1960-1992) reports a positive effect from outward orientation on TFP growth. However, this result does not seem to hold when seven East Asian countries are analysed separately by Collins and Bosworth (1996). More generally, Bosworth and Collins (2003), in respect of 84 countries (1960-2000), show how trade is rendered insignificant in the presence of institutional quality. This concurs with the sceptical views of Rodrik and Rodriguez (2000) on the virtues of trade for growth.

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[26] However, see Rodrik, Subramanian and Trebbi's (2002) very critical comment of real openness.
[27] The Rodrik et al. paper criticized the 2001 version of the Alcalá and Ciccone paper arguing that institutions are more important than trade and that the choice of instruments drives the results. While the first critique seems a moot point, the 2004 version of the paper more seriously addresses econometric issues (such as instrumentation) and finds even stronger results than the 2001 paper.

The main issue to deal with is that of endogeneity, in other words, that growth also affects trade. This problem has usually been tackled using instruments closely correlated with trade but not growth (for example, Frankel and Romer, 1999). However, instruments with such characteristics are nearly impossible to come by. Dollar and Kraay (2002) show the contrary and argue that the effects of trade and institutions on economic development cannot be disentangled. Their regressions are, however, not very informative when dealing with the endogeneity of trade and institutions (see Pritchett's (2002) comments on their paper). Moreover, they argue that one should distinguish between trade volumes, which are related to geography and trade policy, if one is interested in the effect of trade policies on growth. In their growth regressions, they find a strong positive trade effect, while the effect from institutions, although positive, is much weaker. Unfortunately, in their work geography was not controlled for.

As an alternative, Lee, Ricci and Rigobon (2004) employ the Identification through Heteroscedasticity (IH) methodology, which seems a useful way of dealing with endogeneity. Employing the standard statistical method yields no correlation between labour productivity and trade. With the IH method, the trade share is significant, but unfortunately, this result is not very robust. Furthermore, the model does not include institutions, which constitute a variable that often "kicks out" openness indicators.

Miller and Upadhyay (2002), covering 83 countries between 1960 and 1989, find that trade, measured as exports in GDP, is positively associated with TFP growth. They also show that human capital is a threshold variable, as evidenced when their study goes on to investigate how the correlation changes with economic development. For high levels of per capita income, trade has a positive significant impact, although its effects are *negative* for low per capita incomes; this seems to run counter to intuition. However, the interaction term between human capital and trade is positive at low income but otherwise negative. This means that for low-income countries a certain level of human capital is necessary to enjoy the benefits of trade, as established also by Isaksson (2001).

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[28] But note Pritchett's (1996) very critical comment on this article.

Instead of total trade, components of trade (for example, imports and exports, or types of imports) can be studied. Keller and Yeaple (2003), in their search for technology spillovers in the U.S., establish a positive, though tenuous, link between imports and productivity growth. It is possible that international R&D spillovers are driven by imports (Coe and Helpman, 1995) and that machinery rather than total imports should be considered (Xu and Wang, 1999; Mayer, 2001). All these studies support their respective contentions. This result also seems to hold at industry level (see, for example, Keller (2002)) working on data for the G7 countries, with the exception of Kraay, Isoalaga and Tybout (2001), who – covering three developing countries – find no import-related effects on productivity growth.

Macro studies mask a heterogeneity bias. For example, trade liberalisation might benefit large firms only, while the removal of protective measures could be harmful for smaller enterprises. Researchers tend to turn to micro data to uncover possible heterogeneity. For instance, Fernandes (2003) studies the impact of trade policy on productivity of Colombian manufacturing plants between 1977 and 1991. Her main findings include: trade liberalisation has a strong positive impact in economic terms on plant productivity; industry productivity gains are due to within-plant gains (as opposed to the departure of low-productivity plants) and trade liberalisation gains are higher for relatively large plants and in industries with a lower degree of domestic competition (higher concentration). Results along the same lines were obtained by Casacuberta, Fachola and Gandelman (2003) for a sample of Uruguayan manufacturing plants over the period 1982-1995. Another interesting result in the study is that unions are shown to reduce the positive effect of trade liberalisation on productivity.

Schor (2004) studied some 4,500 Brazilian manufacturing firms from 1986 to 1998 to learn more about firm response to trade liberalisation. She seeks to establish whether increased availability of foreign inputs (intermediate and capital goods), probably as a result of trade liberalisation, influences productivity. Instead of studying the observed volume of imported inputs, she directly investigates capital and intermediate goods markets. The second question addressed in her research is whether firms with different characteristics respond in the same manner to trade reform.

She starts by measuring TFP for 27 industries and concludes that the correlation between nominal tariffs and productivity is indeed negative, and that trade liberalisation leads to an increased supply *and* lower prices of foreign inputs. This leads to enhanced embodied technology and, as a result, productivity increase. Predictably, there is considerable heterogeneity among firms.

When trying to explain this heterogeneity, the initial argument of trade reform and increased productivity and the increased and cheaper supply of foreign inputs no longer holds true at a general level. It turns out that a reduction of tariffs increases productivity of relatively unproductive firms, while the (marginal) effect is surprisingly negative for firms that are more productive. One explanation for this may be reduced market share, in particular, if some inputs are fixed in the short run. In order to stay in operation low-productivity firms have to improve, although this rule does not necessarily apply to those with higher levels of productivity – at least not in the short run. Finally, the effect of tariff reduction on inputs is, however, positive for both categories of firms.

Results on the exports-TFP link are mixed, but tend to work against the hypothesis that trade promotes TFP. One area increasingly being explored is that of learning effects and self-selection, where some researchers argue that a positive exports-productivity association implies learning effects from exporting, while others maintain that firms have to be productive to enter export markets. Such learning may stem from receiving technical assistance from overseas buyers or from effects of increased competition. There is indeed anecdotal evidence of learning from exporting, but most results from regression analysis pointing in that direction have been shown to represent reverse causality. There is, however, a self-selection bias in that because of sunk costs associated with entry to export markets, forcing firms to be productive prior to entry. Causality therefore runs from productivity to exporting.

The perhaps best-known paper on self-selection is Clerides, Lach and Tybout (CLT, 1998), which covers manufacturing plants in Colombia (virtually all plants with at least 10 employees, 1981-1991), Mexico (2,800 larger plants, 1986-1990) and Morocco (most firms with at least 10 employees, 1984-1991) during the 1980s. They find support for self-selection but not for learning effect. In a study of the Chilean manufacturing sector, Granér (2002) establishes no significant differences between plants either in technical efficiency or in scale efficiency in terms of export history. However, relatively efficient non-exporting firms are more likely than inefficient ones to enter the export market, that is, exporting firms are already relatively efficient before they become exporters. Yet, another study with a similar result is Granér and Isaksson (2002) on manufacturing plants in Kenya. Aw, Chung and Roberts (1998), however, find that both self-selection and learning explain the higher productivity among exporting plants in Taiwanese manufacturing, while none of the hypotheses explain the disparity in productivity between exporters and non-exporters in the manufacturing sector of Republic of Korea. Bigsten et al (2002) found similar support for both hypotheses for four countries in sub-Saharan Africa.

At this point, it is worthwhile investigating more closely the findings of Bigsten et al. (2002). First, they argue that if learning effects exist, they should be found at least where scope for such effects is the largest, in other words, in sub-Saharan Africa. Using a three-year panel covering plants in Cameroon, Ghana, Kenya and Zimbabwe, they estimate three (referred to as CLT, Benchmark and Non-Parametric Maximum Likelihood (NPML), respectively) versions of the CLT-model.

The benchmark model supports learning and self-selection, as well as fixed costs of exports entry. The CLT model rejects learning and only supports self-selection at the 10-per cent level of statistical significance, while also supporting fixed costs. The NPML-model brings back learning to the picture, but maintains weak support for self-selection. Again, the fixed-cost hypothesis is strongly supported. It is somewhat ironic that it is the CLT model that fails to deliver support for self-selection although the reason seems to be statistical. The results obtained here obviously do not mean that the results of CLT (1998) can be rejected, as they are based on a completely different sample. Nevertheless, it casts some doubt on the nearly one-sided acceptance by many researchers that the positive correlation between exporting and productivity must be due to self-selection.

Blalock and Gertler (2004), covering over 20,000 Indonesian factories, show that they increased their productivity on entering the export market. The effect is somewhere between 2 and 5 per cent depending on the estimation methods and they interpret this as evidence of learning effects. A plausible explanation may be that poorer countries, such as Indonesia, have more to gain from exporting than, for example, middle- or high-income countries. Due to data availability, most studies have been undertaken on the latter group of countries. Two other studies that find evidence of learning effects are Granér and Isaksson (2006) and Van Biesebroeck (2003), where investigations focus on relatively poor countries.

Keller (2004) suggests that there is a need to learn more about export destination in relation to productivity research. This is exactly what Granér and Isaksson (2006) and Mengistae and Pattillo (2004) do. The former paper examines Kenyan manufacturing data for a three-year period, while the latter pools data from Ethiopia, Ghana and Kenya (the Kenyan data is more or less the same for both papers). Although questions posed by the two papers are similar, the methodologies are quite different. Granér and Isaksson ask whether export orientation yields new insights into the export and productivity question. Mengistae and Pattillo, however, are more interested in the size of productivity (level and growth) premiums of exporting, although they make conjectures as to whether this can be related to learning or self-selection, and whether lack of competitiveness is the reason for higher productivity of exporters.

Investigating the link between firm efficiency and exports in Kenyan manufacturing, the results of Granér and Isaksson (2006) show that exporters are more efficient than non-exporters, and relatively efficient firms self-select into exporting. An important new finding is that only for export markets outside Africa, firms must be efficient prior to entry; for those exporting within Africa this requirement does not seem to be binding.

Furthermore, the probability to export to other African countries increases if production is intense in physical and human capital, while for export activities outside Africa firm size is more important. Contrary to many other studies, it is also found evidence that export participation yields learning-effects. When testing the hypothesis that the main source of learning-effects is trade with developed countries (South-North), as opposed to trade with other developing countries (South-South), yet another new finding is that learning-effects only obtain in South-South trade. They conclude that controlling for the destination of exports importantly improves the understanding of the relationship between firm efficiency and exports.

Mengistae and Pattillo (2004) start by investigating the TFP premium gained from exporting. Thereafter, the number of exporters is split: those that directly export to purchasers and those that supply the international market through domestic intermediaries – indirect exporters. Direct exporters are then split further – those exporting to other African countries and those exporting outside Africa. One contribution is that they control for other channels of learning, for example, FDI, imports of physical inputs and international technical assistance arrangements.

Their first result is that exporters gain an average (across the three countries) productivity premium of 17 per cent. However, the premium is only statistically significant for direct exporters (some 22 per cent). Exporting outside Africa yields a premium of 42 per cent, compared with the 20 per cent for direct exporting within Africa. Thereafter they move to a productivity growth specification, controlling for productivity convergence (in other words, the initial productivity level is included in the control measures), which is always significant. The growth premium for exporting is 10 per cent and for direct exporting 20 per cent, although the export destination does not seem to matter in this case. They conclude that, since learning predicts higher productivity for both direct exporters and those exporting outside Africa – while the relative strength of self-selection could go either way – the results support the idea of learning effects from exporting, in particular for direct exporters.

4.2 Institutions

The term institutions originally referred to political entities, but today most economists seem to accept it as meaning economic rather than political ones. North (1990) argues that it is ultimately a friendly environment and policies that lead to economic prosperity. Institutions can therefore be defined as the rules and organs that drive the production climate (Ulubasoglu and Doucouliagos, 2004). In any case, it is useful to distinguish between political and economic institutions, where the former, for example, refer to democracy versus autocracy, while the latter are more concerned with rule of law and secure property rights. However, a relevant question to be asked is whether there are certain political institutions that secure, for example, property rights better than others. Nevertheless, an effort is made here to maintain this distinction throughout this section.

Przeworski and Limongi (1993) provide an apt discussion on political regimes and economic growth, which is drawn upon. One argument raised in their article is that the idea that democracy protects property rights is recent, as well as rather far-fetched. According to North and Weingast (1989), it is not enough for a government to establish a sound set of rights; it must also be committed to them. One argument that supports democracies in this context is that an autocrat cannot be forced to commit himself (for example, Olson, 1991), but this does not automatically mean that democracy works better in this respect. Threats to property rights could originate from the state and private sector likewise (for example, organized workers can threaten capitalist property).

Under capitalism, resources are allocated according to market forces. However, there is a second actor involved in this allocation, namely, the state, which allocates resources it does not own. The state allocates rights differently to market forces. Hence, the resource allocation preferred by individuals as citizens does necessarily coincide with the market solution, in which they, of course, participate. The role of democracy is to equalize the right to influence the resource allocation and therefore it increases the divergence between the two resource-allocation mechanisms. One could say that, in a democracy, citizens without property have power over those with property.

Insofar as democracy leads to a shift towards immediate consumption instead of investment, it may actually retard growth. Some have even argued that dictatorships may be preferable because of their ability to force savings (and hence investment and growth). However, are dictatorships really more future-oriented than democracies? Another argument for dictatorships is that they can withstand pressures from interest groups such as firms or unions. Therefore, it could be argued that a dictatorship (or state autonomy) is in a better position to pursue development policies.

One strand of the literature shows that dictatorships tend to be predatory, arguing for democratic institutions. Several models assume that governments assist the private sector by supplying inputs (not efficiently provided by the market) and by providing a regulatory framework (for example, law and order). Efficiency therefore requires interplay between the state and the market. Three groups can be discerned: democracy where citizens decide on government size and its resources (in the sense that state representatives cannot appropriate the resources); autocracy, where the state decides on both issues; and bureaucracy, which decides on government size only and leaves decisions on resources to the citizens.

Assuming that citizens are well informed when electing parties, and parties compete for votes, rent is eliminated through this competition and winners behave perfectly in their role as public agents. Democracy maximizes utility. At the other extreme, autocracy maximizes the difference between output and the cost of producing it. In autocracy, the result is the same as between high output and large government size and small output and small government size; utility is lower than that obtained in a democracy. A bureaucracy, finally, ends up in between these two extremes, with the size of government dictating which extreme it lies closest to. While the choice of regime, from an efficiency point of view based on the above, seems obvious (in other words, democracy), any deviation from the underlying assumptions of citizen behaviour under democracy may alter the results. But, are citizens really well informed? Is information really perfect? Is there perfect competition between parties?

What does empirical evidence reveal? Can dictatorships prove themselves better at savings mobilization, or would democracies do a better job on resource allocation? One interesting pattern emerging from the 18 studies examined in Przeworski and Limongi (1993) is that studies before 1988 tended to favour dictatorships; thereafter none of the nine reports agrees with this conclusion. The authors argue that ideology looms large here. Due to severe statistical problems, such as attrition, endogeneity and selection bias, coupled with inconclusive results, the authors refrain from drawing any conclusions on which policy regime is better for growth. However, one very interesting conclusion drawn is that the valid competition may not be that between democracy and authoritarianism per se. Instead, they propose "state autonomy" as an option, if it can be achieved under both types of regimes (see also Rodrik, 1992). The autonomous state must, however, be effective in what it does, while being insulated from what it does not want to do. Unfortunately, the institution that allows for both is an elusive concept.

Attention is now turned to studies that focus more on economic institutions. Ulubasoglu and Doucouliagos (2004) argue that empirical models tend to focus on the effect of institutions on productivity (the direct effect) but overlook their effects on factor accumulation. The reason for this is that those models often are based on the augmented Solow model. Ignoring the indirect effect has resulted in inconclusive results as to whether democracy is good for growth. Their results show that higher levels of democracy have a positive and statistically significant effect on TFP and human capital, although its effect on capital accumulation and labour force growth is negative. The same result is obtained when democracy is replaced with political freedom. Economic freedom renders labour force growth and initial income statistically insignificant in the growth equation but has a positive effect on both TFP and labour force growth. When both freedom variables (economic and political) are included in the system they basically repeat the result: both institutional variables have a positive effect on TFP, political freedom is negative for capital accumulation and labour force growth and positive for human capital accumulation, while economic freedom is positive for all input accumulation. Finally, both institutional variables are important for growth.

Hall and Jones (1996, 1999) first quantify large productivity differences across 127 countries and thereafter endeavour to explain those differences. They strongly believe that the primary fundamental determinant of a country's long-run economic performance (as measured by output per worker) is its social infrastructure. Their interpretation of the concept is that institutions and government policies provide incentives so that individuals and firms behave in a manner that leads to a convergence of social and private returns.

They note that in a society free of diversion (that is, rent-seeking, theft and corruption) productive units are rewarded by the full amount of their production. If there is diversion, it works as a tax on output. With effective social control of diversion, there is no need to invest resources to prevent it. Social control is possibly correlated with the concept of social capital in that at least part of social capital includes trust and reciprocity. A proxy for this broad concept is certainly needed and social infrastructure – measured as an average of an index of government anti-diversion policies (GADP) and an index capturing trade openness – represents such a proxy.[29]

It is clear that the authors' sole determinant of output per worker is actually not as isolated as one may think because trade is allowed to creep in. Therefore, it can be argued that their paper includes two deep determinants – institutions and trade (but excludes geography). An important test for robustness is that of separating GADP from trade openness and it emerges that both variables show statistical significance.

Concerned with measurement error for social infrastructure, they purge their initial findings to arrive at the following quantitative result: differences in social infrastructure can account for a 25.2-fold difference in output per worker across countries. Finally, differences in social infrastructure cause large differences in capital accumulation, educational attainment and productivity, resulting in huge income disparities across countries.

[29] The first index is created from data assembled by a firm that specializes in providing risk assessments for international investors – Political Risk Services – while the second is the one used in Sachs and Warner (1995a).

Acemoglu, Johnson and Robinson (2001; 2002) argue that the correlation between economic prosperity and institutions could reflect omitted variables or reverse causality. Therefore, they argue for the need of a source of exogenous variation in institutions – a natural experiment where institutions change for reasons not related to omitted variables. Their choice turns out to be European colonization (measured by potential settler mortality from diseases such as malaria and yellow fever) in the fifteenth century because colonialists changed the institutions in conquered or administered countries. If institutions are an important determinant of growth, then those countries where good institutions were introduced or developed ought to be richer than those in which colonialists introduced or maintained extractive institutions to plunder or exploit resources.

Based on regressions on 64 former colonies, the authors find a strong correlation between settler mortality and institutional quality and, therefore, conclude that the former works well as an instrument for institutions. The authors also find a remarkable reversal of fortunes in economic prosperity, where formerly rich civilizations – such as the Aztecs and Incas in the Americas – became poorer and are today clearly surpassed by those in, for example, Australia and North America. Furthermore, because the formerly rich civilizations are located in hot regions, while the currently rich, but formerly poor ones, are located mainly in temperate zones, geography cannot be the main reason for reversal in fortune. They maintain that this phenomenon is widespread and the former European colonies that are relatively rich today were poor prior to colonization. What happened in terms of reversal is exactly what the institutions hypothesis predicts.

Albouy (2004) and Olsson (2004) contest the validity of these results, the former disagreeing with settler mortality as a measure, as that leads to a weak instruments problem, while the second study argues that it is incorrect to group together the colonies from three different continents (Latin America, Africa and “the rest” (Asia, Australia, New Zealand and North America)). In particular, Olsson (2004) argues that, when the Spanish and Portuguese colonized Latin America, there were no good institutions in Europe (hence, that policy option simply did not exist, independent of the environment), whereas during the scramble for Africa good ones already existed, implying that good institutions could have been instituted in Africa. In addition, medicines for tropical diseases had been developed and settler mortality could be reduced significantly. Because of this, the disease environment might not have had an important impact on colonial policy in Africa. Unfortunately, the data on settler mortality used by Acemoglu, Johnson and Robinson (2001) relate to the period 1817-1848, which is well before the colonization of Africa.

Repeating the econometric exercise in Acemoglu, Johnson and Robinson (2001), this time on the three sub-samples listed above, Olsson (2004) finds that - for Africa and Latin America (78 per cent of the total sample) - the link between the disease environment and institutional quality is weak or rejected and hence settler mortality turns out to be an inappropriate instrument for institutions. For the remaining 22 per cent, the third group, settler mortality works well as an instrument. The conclusion drawn, based on logics as well as regression analysis, is a warning against drawing too strong conclusions in the cases of Africa and Latin America based on the general theory in Acemoglu, Johnson and Robinson (2001).

For 1995 cross-country samples covering between 80 and 140 countries, Rodrik, Subramanian and Trebbi (2002) investigate the respective roles of geography, institutions and integration in income levels. They show that the quality of institutions supersedes everything else, but that causality is complex. Their regression results show that once institutions are controlled for, trade does not have a direct effect on income levels. Geography, on the other hand, maintains (at best) a weak direct link with income levels. Institutions have a positive effect on trade. While the reverse link is also true, the latter indicate that trade might have an indirect effect on income levels through institutions. Geography also positively affects institutions. More importantly, for the purpose of this review, institutions are shown to positively affect both factor accumulation and TFP growth, whereas trade and geography both enter with negatively signed coefficients. Finally, the difference in institutional quality has a very significant effect on income levels, as evidenced by the following example. If Bolivia could acquire institutions of

Korean quality, its income per capita would be close to $18,000 instead of its current level of $2,700.

It is not entirely obvious where the Easterly and Levine (2002) paper should be placed, since its purpose is to test three hypotheses, namely, how important the hypotheses for geography, institutions, and policy are for economic development. Because the conclusion favours institutions (a conclusion considered debatable) their paper is placed in the current context, but it could just as well have been placed in the next sub-section. Their sample consists of 72 former colonies. The dependent variable is the logarithm of real per capita GDP in 1995, which can be explained by variables supporting the geography hypothesis (settler mortality, latitude, crops/minerals and landlocked location), the institutions hypothesis (institution index featured in several other articles) and the policy hypothesis (inflation, real exchange rate overvaluation and trade openness).

They find that institutions explain economic development. In addition, geography (mainly settler mortality and natural resources such as germs and crops) explains the aggregate institutions index with a large economic impact. However, it emerges that geography only explains economic development through institutions. What about macroeconomic policies? Policy indicators fail to serve any additional explanatory purpose. Hence, according to the authors, results support the institutions hypothesis, but not the geography and policy hypotheses. This conclusion is somewhat puzzling in that geography actually explains institutions, which could make geography a so-called prime mover. This does not deny the importance of good institutions, but to ignore the importance of geography if it affects the development of institutions in countries seems rather ‘dangerous’. It is felt that the deep determinant in that case appears to be geography!

If one were willing to conclude that institutions are important, it would be worth finding out why some societies, which have bad institutions, do not change for something better. This is the question asked by Acemoglu (2003). One reason for the persistence of poor institutions is that they affect both the size of the economy and how income is distributed.

This means that changing institutions involve losers and winners, the former in control of the bad institutions. Hence, they (the losers) cannot be credibly compensated for the loss of power. Secondly, the Europeans did not set up institutions for the benefit of society as a whole, but only if they derive benefits from doing so. At the time of independence, indigenous rulers inherited the institutions and with them the power and claim to economic rents. Institutions can, however, change, albeit at a slower pace. Botswana is a good example of a country where such a change has benefited society as a whole.

Engerman and Sokoloff (1997) and Sokoloff and Engerman (2000) study the effects of land endowments on growth, showing how the social dimension may work through institutions (the social dimension is covered later in this review). In Latin America, land was good for commodities (for example, silver and sugar cane) featuring economies of scale and/or the use of slave and indigenous labour, leading to power concentration among the plantation and mining elite. The elite subsequently created institutions that would preserve their power, in particular, with respect to distribution of income and rents. By contrast, in North America, land suggested commodities (for example, maize and wheat) grown on family farms, which led to the growth of a large middle class with a wide distribution of power. This resulted in institutions that were more open and egalitarian.

With regard to the questions raised by Acemoglu (2003), Glaeser et al. (2004) challenge whether the evidence of institutions dominating everything else is that strong. The issue is whether appropriate (political) institutions are necessary to start serious factor accumulation, or whether institutions are caused by such accumulation via growth. If the latter theory holds, then one could envisage pro-market dictators securing property rights as a matter of policy choice. The question therefore is not whether institutions matter – because they definitely do – but rather which comes first? The authors start by revisiting some of the common measures of institutions and find them to be poor proxies. They show that conventional measures of institutions are unrelated to constitutional constraints on governments and draw the conclusion that these measures can hardly be viewed as being deep. Ultimately, the authors conclude that human capital is the prime mover of both growth and institutions. Human capital[30] determines the institutional opportunities of a society and, the more a country has of it, the greater these opportunities. It also increases the institutional and productive capacities of a society, and better institutions result in economic development. From a policy point of view, the authors suggest policies favouring human and physical capital accumulation over, for example, democracy.

4.3 Geography

Easterly and Levine (2002) argue that the geography mechanism works entirely through institutions and that, once institutions have been controlled for, geography, in itself, exerts no influence on growth. Acemoglu, Johnson and Robinson (2001) argue along the same lines. However, Bosworth and Collins (2003) attribute a significant effect to location in the tropics (along with institutional quality), a result that is corroborated by Sachs and Warner (1997) and Gallup, Sachs and Mellinger (1999). Diamond (1997) maintains that geography is a key determinant of cross-country differences in technology. Taking a long-term view, Warner (2002) suggests that mountainous terrains, distance to rivers or coastlines and land area in the extreme tropics have a negative impact on income levels. Geography, according to the author, works through institutions, but also has an independent effect through climate and distance. Sachs (2003), while controlling for institutional quality, responds to Rodrik, Subramanian and Trebbi (2002) by showing that malaria transmission, which is strongly affected by ecological conditions, directly affects per capita income.

Sachs and Warner (1995b) examine another aspect of geography, namely, that of resource abundance. They start by noting that a negative correlation exists between economic growth and resource abundance. Several reasons have been put forward to explain this, one of which is social, and argues that easily obtained wealth leads to laziness. Another explanation is found in the realm of political economy and contends that rent-seeking is more prevalent in resource-rich economies. A third oft-studied reason

[30] To be fair, drawing on Djankov et al. (2003), the authors talk about human *and* social capital determining institutional opportunities.

is purely economic and is the well-known phenomenon of Dutch Disease, where production is focused on natural resources instead of manufacturing leading to a concentration of production factors in the non-tradables sector. Their work is valuable because it is probably the first to empirically estimate the aforementioned correlation across several countries. Their main finding is that economies with a high ratio of natural resource exports to GDP in 1971 indeed tended to exhibit low growth rates between 1971 and 1989 (the sample period). Furthermore, they also find indications that Dutch Disease might be the channel through which negative correlation operates, thus lending support to the notion that a key division, important for endogenous growth effects, is tradable manufacturing versus natural resource sectors.

Bloom and Sachs (1998) show that the proportion of land area in the tropics accounts for 16 per cent of the differences in growth rates between Africa and the rest of the world. Bloom, Canning and Malaney (1999) also find a significantly negative effect on countries located in the tropics. Sachs and Warner (1997) and Gallup, Sachs and Mellinger (1999) find that landlockedness has a negative effect on growth.

In a very interesting study Gallup and Sachs (1998) also investigate the role of geography, in terms of being landlocked (countries with coast matters for trade and TFP, and cities along coastlines tend to be growth engines in an economy), and include factors such as distance from core economies, prevalence of infectious disease and climate (notably tropical, mainly through its effect on agricultural productivity). Their data cover up to 150 countries for 1995 in the case of income levels, and the period 1965 to 1990 for growth equations. They control for variables related to economic and political institutions, and find that both policy (openness, quality of public institutions) and geography are significant explanatory variables for income levels.[31] In the case of economic growth, education, the investment rate and openness are important positive variables, while malaria has a strong detrimental effect. In addition, a higher coastal population is associated with faster growth, while a higher interior population is only

[31] Unlike the findings of, for example, Easterly and Levine (2002), it appears that institutions are seen as a policy variable in this case.

weakly correlated with slower growth. This finding is interpreted as economies of agglomeration playing a role in coastal regions. The conclusion is once again that both geography and policy matter. However, while location in the tropics is negative for growth and coastal populations positive, distance from core markets does not seem to play a very significant role.

In regional terms, they find that, in Africa, tropical location, malaria, a low coastal population density and a low proportion of the population near the coast imply particular obstacles. For South Asia, the main hindrances are a high and dense inland population together with a large proportion of tropical land area. In Latin America, these factors pose only small to moderate problems. Health and geography factors are estimated to reduce growth by two percentage points per year, a greater impact than openness, institutions and investment. The corresponding figure is -0.8 in South Asia and negligible in Latin America. Finally, geography seems to affect policy choices by changing the trade offs facing governments. For instance, the effect of openness on growth depends on geography, where the mechanism could be that a coastal economy may face a high output elasticity response with respect to trade taxes (unlike an inland economy).

4.4. Summary of "Institutions, integration and invariants"

Starting with macro-based studies, total trade in general, reveals positive and significant results. However, this literature has been highly criticized, in particular, for not correctly addressing endogeneity problems and for omitting institutions and geography from the analyses. Adjustments for endogeneity and the inclusion of institutions and geography have a tendency to render trade statistically insignificant. One component of trade, namely, imports, was shown to be strongly associated with productivity.

It emerged from the micro literature that data contain a great deal of heterogeneity. For example, there was evidence that trade liberalisation has a greater impact on large plants and in industries where competition is low. Furthermore, relatively unproductive firms benefit largely from trade liberalisation because they have either to improve or exit. Relatively productive firms suffer less from such increased pressure because they have a buffer. Trade liberalisation was also shown to positively affect access to foreign capital (that is, technology) and to lower cost of it. It can be concluded that the import effect shows up in the micro data as well. On the export side, it seems that learning effects are very meagre or non-existent, and there is even evidence suggesting that causality runs from productivity to exporting.

The conclusion is that trade openness (as a policy) is important and that, in terms of outcome, imports are crucial for TFP. Based on the empirical evidence reviewed here, export promotion for the sake of learning should receive less priority, but it should be noted that exports are important for financing imports. Policies to promote a better handling of knowledge embodied in foreign capital should receive more attention. Also, acknowledging that trade policies have an uneven effect on firm performance should result in more fine-tuned policies.

A differentiation between political and economic institutions was made. For the former, the results are very inconclusive and ideology may have affected research. However, there were some indications that democracy/economic freedom promoted TFP but have a negative effect on capital accumulation, with a positive net effect on overall growth. In the case of economic institutions, there is overwhelming evidence favouring the notion that institutional quality has a strong positive effect on productivity (both level and growth). In empirical work focused on long-term development, institutional quality tends to "kick out" trade, while geography remains.[32]

A follow-up question arises as to why some countries retain poor institutions. The answer probably lies in the fact that some powerful groups benefit from the situation and therefore have no interest in policies that would alter it. An interesting result was that institutions might evolve from human capital, thereby calling into question the depth of institutions. In terms of policy for TFP growth, it seems clear that policies promoting

[32] There are even cases where trade is shown to exert a negative effect on income once institutional quality has been controlled for. This can hardly be viewed as a credible result (why should trade have a negative effect?) and points to the need to improve econometric modelling.

good institutional quality must be given priority. In addition, a focus on human capital might help to achieve this goal. Democracy appears to be of relatively lesser importance.

"Poor" geography clearly affects possibilities to enjoy the fruits of technology transfer and this obviously influences TFP growth. Some evidence suggests that geography might work entirely through its effect on institutions, although there are also indications of direct effects. Policies to deal with unfavourable geographic conditions are difficult to develop, in particular, for the medium term. One way of offsetting the negative effects of being landlocked could be to conclude (possibly regional) agreements with coastal countries. Another possibility for the short to medium term could be to accept the predicament of, for example, being located in the tropics and then attempt to properly address its consequences. Natural resource abundance, on the other hand, could be handled by limiting the expansion of the non-tradables sector, for example, through taxation. As in the case of Norway, oil income could simply be saved for the future. Generally, however, geography ought to be viewed as an issue that can only be addressed in the long-term.

The overall conclusion for the three deep determinants is that institutions and geography indeed exert strong first-order effects on TFP growth, although there are some uncertainties about their effects on trade, in terms of depth.[33] Perhaps trade is best seen as being part of the policy hypothesis – although this weakens its case for trade even further. Unfavourable geography is hard to influence through policy measures, whereas institutions can change. In particular, the latter seems to hold true in the case of good human capital. Trade, on the other hand, is more amenable to policy and can quickly change, but again, its effect on TFP is unclear.

[33] To clarify, imports are important but may not be a deep determinant.

5. Competition, social dimension and environment

5.1 Competition

Barone (2004) surveys the theoretical and empirical economic effects of privatisation and regulation of natural monopolies. He starts by looking at the performance (for example, productivity) of state-owned and private enterprises. The more or less accepted view seems to be that the former are inefficient compared with the latter, which begs the question why is this the case? He considers the role of competition versus ownership structure, as well as the objectives of governments. In addition, he studies the various forms and process of privatisation.

One argument for privatisation is that of increased competition, which is believed to be one of the strongest instruments to reduce management slack.[34] Some researchers think that the relative inefficiency of state-owned enterprises is due to political pressures, which cause relative inefficiency to persist. Another view holds that the problem lies in the (lack of) separation of control and ownership. The "political pressures view" finds empirical backing and suggests that privatisation (or increased competition) will be effective only if governments are ready to forego the temptation to use state-owned enterprises for political goals.

Empirical evidence also suggests that state-owned enterprises seldom try to maximize profits and therefore have greater incentives and ability to adopt anti-competitive behaviour. Theoretical and empirical evidence also maintain that the ownership-structure of state-owned enterprises, even with benevolent governments, cannot replicate the incentive structure of the private sector and hence cannot be as efficient as private enterprises.

If one accepts the view that privatisation is good for productivity, the next questions are: does it matters how, and how fast, privatisation occur? Theory underlines the importance

[34] Note that this was an argument developed with private firms in mind and may therefore not hold for state-owned enterprises.

of gradual privatisation. In the case of a natural monopoly, a privatised enterprise cannot be expected to behave like a private enterprise. Instead, effective regulation should be imposed in order to limit allocative and productive inefficiencies. It is also argued that it is better to have a private monopolist rather than a public one, since the former is at least efficient and leads to lower prices and larger output.

Underdevelopment of capital markets, weakness of bankruptcy procedures and an ineffective court system are obstacles to successful privatisation. The type of government (for example, benevolent versus self-interested) also affects the actual sale of state-owned enterprises, where certain types may want to maximize revenue and therefore distort the privatisation process. Under pricing of state-owned enterprises for supporters or in exchange for favours, is another important distortion to consider.

In the case of natural monopolies, competition is neither possible nor desirable because it leads to duplication of fixed costs. One question is whether it is better to have a regulated private company, or a state-owned enterprise providing the goods. It turns out that the answer is linked to whether contracts are complete or incomplete. In theoretical models with complete contracts, public and private ownership leads to the same outcome, while in the real world of incomplete contracts no such convergence occurs. In many developing countries, the regulatory capacity of governments is weak and public ownership might be preferable.

As for empirical evidence, there is some limited support for the notion that privatisation has significantly improved the performance of state-owned enterprises. The main features are increases or improvements in capital investment, profitability, productivity, output and decreasing leverage. While these tend to be long-term features, it is likely that there will be a short- to medium-term negative effect on the distribution of assets and income.

One empirical example of the effect of regulation and the institutional environment on productivity is the work of Scarpetta, Hemmings, Tressel and Woo (2002). They note that, across OECD countries, growth paths have become increasingly disparate in the past decade. Two main reasons for this are suggested: differences in productivity patterns of certain high-tech industries and differences in the adoption of information and communications technology (ICT). The interesting question is why OECD countries, which presumably have access to common technologies and strong trade and investment links, differ in terms of their ability to innovate and adopt new technologies.

Based on micro data from the late 1980s to the mid-1990s across 10 OECD countries, they find that stringent regulatory settings in the product market negatively affect TFP. High hiring and firing costs (unless offset by lower wages or internal training) also have a negative effect on TFP. In addition, the negative effects on TFP are worse for firms in countries far from the technological leader, in other words, strict regulation is an obstacle to technology adoption. Strict regulation is also a hindrance to innovation, possibly because it reduces competitive pressures, technology spillovers and the entry of new high-tech firms. Furthermore, market access of small and medium-sized enterprises is negatively affected by product market regulations and labour market legislation.

Based on an investment climate survey (firm data) conducted by the World Bank (2003) in five transition economies – the Kyrgyz Republic, Moldova, Poland, Tajikistan and Uzbekistan – Bastos and Nasir (2004) conclude that productivity differences across countries can be explained largely by differences in the investment climate – policy, institutional and regulatory environment – in which businesses operate. Returns to investment are higher and the cost of doing business is lower where property rights are secure, governments provide efficient services and the infrastructure is well developed. Competition seems to be the most important factor behind productivity performance, followed in second place by infrastructure, while rent predation occupies third place.

According to Nickel (1996), based on U.K. data, competition has positive effects on productivity. Based on 143,000 establishments in the U.K., Disney, Haskel and Heden (2000) supported Nickel’s results. Lewis (2004) brings together results from sectoral research on the economies of 13 developed and developing countries. Some conclusions may appear surprising. For instance, he suggests that official development assistance spent on education in poor countries may not be so effective. The bottom line of his reasoning is that competitive forces drive productivity growth, and the way to a more competitive market is to put consumers' interests first.

5.2 Social dimension

By social dimension is primarily meant income distribution and wealth in an economy, but also to some extent social policy interventions that indirectly affect TFP growth through health and education. Some may want to add social capital to this group of determinants but it was not included, partly because there is no credible empirical evidence of it having any effect on TFP growth, and it is still a fuzzy concept. Harris (2002) adds political stability to the list of social determinants of productivity, some aspects of which have already been discussed in the section on institutions.

The effect of social policy on TFP growth is difficult to assess because it works through other factors, such as factor accumulation, incentives to invest, save and work, or through induced effects, fiscal effects or similar variables (Harris, 2002). Unfortunately, the number of empirical studies on social policy and growth is very limited and they tend to cover industrialised countries only. Because of similarities between industrialised countries, it may be difficult to obtain clear answers on the importance of social policy for TFP growth. As mentioned earlier, public capital formation appears to positively affect TFP growth, although this variable does not really work as a measure for social policy.

The relationship between productivity and welfare is probably bi-directional, especially when welfare is measured in a broad sense to include incomes of households, economic security for workers, poverty and social exclusion, extent of inequality in life prospects, strength of social cohesion and sustainability of environmental heritage. Furthermore, the relationship may vary over time. Social and cultural factors may influence the desire and capacity to invest in human capital and overall development of children. In the end, this has an impact on productivity growth (Branting, Share and St-Hilaire, 2002).

Another area to be studied is the effect of social diversity on productivity. Human beings tend to associate mainly with people similar to themselves. This being the case, social divergence might generate barriers to communication among groups, which work as an obstacle to technology and knowledge diffusion and subsequently lead to lower productivity. The costs of exchanging ideas and innovations increase with the number of distinct social groups. For instance, ethnic diversity may generate high levels of rent-seeking among competing ethnic groups. Ethno-linguistic and religious diversity may give rise to conflict, political instability and weak institutional frameworks. Economic inequality may work the same way on growth. However, it has also been argued that social diversity may be positive for growth. If so, it is important to decrease the costs of communication to realize such benefits.

Grafton, Knowles and Owen (2001) covering 31 developing countries regress the Hall and Jones (1999) TFP estimates on a set of variables that are supposed to proxy for social divergence: religious homogeneity (for example, measured as the probability that two randomly selected individuals in a country share the same religious belief), educational distance (for example, educational inequality), a Gini-coefficient for personal expenditures and ethno-linguistic fractionalisation (measures the probability that two randomly selected individuals in a country belong to different ethno-linguistic groups). The study finds that higher levels of social divergence are associated with lower levels of TFP. Furthermore, the effects are quantitatively important. For example, the mean TFP levels of those countries in the lowest quartile in terms of social divergence were, on average, more than double those in the highest quartile.

Grafton, Knowles and Owen (2002) extend the analysis to between 52 and 100 developing countries depending on data availability of variables related to social divergence. In addition to using the TFP level from Hall and Jones (1999), they obtain data on labour productivity from Penn World Tables version 5.6, included another indicator of social divergence (a land-ownership Gini-coefficient), but excluded the Gini-coefficient for personal expenditures. Simple scatter plots between the four social-divergence indicators and TFP suggest the expected association in three of the cases while land ownership does not appear to be associated with TFP levels. The same exercise for labour productivity repeats the results of TFP but, in this case, land ownership is also shown to be associated with labour productivity. Although the results are consistent with the discussion, other explanations are possible. For example, high ethnic diversity could be associated with lower levels of trust (social capital), which in turn would be correlated with lower growth rates.

Grafton, Kompas and Owen (2004) developed a dynamic model of social networks to test the effects of social barriers to communication on cross-country differences in productivity (and factor accumulation). The model emphasizes three features. First, cooperation and group interactions facilitate the use of large amounts of specialized knowledge (for example, Lucas, 1988). Secondly, the creation and transfer of tacit knowledge depends largely on communication links within and across social networks – despite knowledge being non-rival. Thirdly, similarity between individuals makes communication easier.

The model assumes that output increases with physical and human capital, the amount of effort devoted to production and the number of communication links between social networks, where the latter are part of effective labour and stimulates productivity-enhancing ideas and transmission of tacit knowledge. Social barriers (for example, linguistic differences) to communication and interchange increase the cost of productivity-enhancing communication.

Two policy propositions result from the model. First, lowering the costs of forming links across social networks increases the network-augmented rate of return, which in turn induces capital accumulation and raises the steady-state levels of consumption and capital. Two regressions on human capital and capital per worker, respectively, test this proposition. Secondly, policies to reduce social barriers to communication raise TFP. This proposition is tested by regressing the Hall and Jones (1999) measure of TFP on the basis of variables, such as mass communication, population density, trade openness and level of social infrastructure - all of which are thought to mitigate the effects of social barriers to communication (linguistic, ethnic and religious fractionalisation). While concentrating on the TFP regression, it can be confirmed that social barriers to communication negatively affect capital accumulation.

In the TFP regression, for the second proposition above to hold, the authors expect at least some of the fractionalisation variables to be negative and statistically significant. Adjustment is made for Hall and Jones' (1999) social infrastructure indicator. Regression analysis for between 82 and 110 countries yields that language is a robust explanatory variable with an economically significant impact, a result that holds for both rich and poor countries, as well as different measures of TFP and estimation with instrumental variables. These results may not only explain cross-country differences in TFP, but suggest they may persist over time. Some evidence is also put forward that improvements in mass communication may ease the negative effects of social barriers.

Theoretically, social policy affects income inequality, which in turn has a negative influence on productivity growth. Persson and Tabellini (1994), covering both developing and industrialised countries, found support for the idea that higher inequality negatively affects growth significantly, although Forbes (2000) obtained contradictory results. On land distribution, Alesina and Rodrik (1994) reported that higher land inequality likewise negatively affects growth.

For the time period 1970-1988 (21 OECD countries), Arjona et al. (2001, 2002) find that active social spending stimulates growth, while passive spending has a detrimental effect. However, when active spending is allowed to also include health expenditures, the parameter is rendered insignificant. Nonetheless, the importance of health is best reflected in samples consisting of both poor and rich countries, a result which is not very surprising. In summary, it seems that social expenditures promoting adjustment and labour market participation increase labour productivity growth, whereas other kinds of social expenditures may have negative or negligible effects – a conclusion which concurs with that of Watson (2002).

Can the age structure of a country be used to predict future productivity?[35] Alternatively, is age structure irrelevant for productivity growth? First, a distinction has to be made between population growth and age structure. More specifically, in successive periods population growth will be concentrated in different age cohorts (for example, young or middle-aged adults) and, as the population grows the age structure changes. A typical pattern evolves in the course of economic development: in the first phase, mortality, in particular that of children and infants, decreases and the population grows because fertility is maintained. Hence, the number of children increases.

In the second phase, the young cohort expands, followed by an increase in the middle-aged population that marks the beginning of the third phase. Once the mortality decline starts, this process takes some four to five decades until the final phase is reached when the increased cohort reaches retirement as the population gets older. In general, fertility rates are low at this point. One further interesting fact is that rich countries tend to have old, and poor countries young, populations. It may be worth noting that countries significantly differ in terms of historical traditions, climate and geography, yet have experienced similar demographic transitions, which is something of a challenge to explain.

How can productivity be linked to demographic transition? Literature on growth has considered age structure before, and most, if not all, of the arguments on how it affects growth also apply in the context of productivity. One important factor seems to be the size of dependent groups, where size is inversely related to growth (for example, through reduced labour supply and lower savings). On the other hand, the larger the working age group (for example, through increased labour supply, higher savings, higher tax revenue), the faster the growth.

It seems reasonable to assume that the larger the middle-aged population, the more efforts go into productivity-enhancing activities. Nevertheless, one direct effect on productivity comes from the sheer number of people working over a longer period of time (in particular, women that enter the labour market earlier and are away for shorter intervals because of children) that contribute to "creative thinking". One could refer to this as a "large-country" effect, in the sense that a large country - in absolute numbers – always has more people involved in productive work (for example, Jones, 2004).[36] Longevity also has a positive effect on growth by reducing the need to have children for pension purposes (in the case of developing countries) and by influencing the amount of time devoted to human-capital accumulation.

Corroborating the arguments above, covering 70 countries (1965-1990), Kögel (2005) shows that countries with a higher youth dependency ratio will indeed have lower aggregate savings, which leads to fewer funding opportunities for R&D and imitation of ideas. Accordingly, TFP growth will also be lower.

Scarth (2002, 2003) addresses the issue of aging and productivity, and the concern that aging will reduce future productivity and hence welfare. He argues that three adjustment mechanisms speak against such a scenario. First, relative factor prices will change so that the price of capital will decrease relative to that of labour (since the volume of the latter declines). As interest rates fall and wages increase, capital will largely be substituted for labour, at least in a closed-economy setting. Secondly, if the population fears that welfare will deteriorate due to an aging population, it is likely that savings will increase, which means that debt can be repaid. The ensuing lower interest costs leave room for higher domestic consumption. However, greater savings may also induce faster capital accumulation, which contributes to growth. Thirdly, as labour becomes relatively scarce, returns to investment in human capital increase and higher levels of such investment may be expected, thus benefiting growth.

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[35] The discussion draws on Malmberg and Lindh (2004).

[36] In this context, a link to asset distribution and institutions can be made. Take Latin America, for example, where skewed distributions and preservation of privileges of a small elite group is likely to reduce the number of people involved in innovative activities.

5.3 Environment

Traditionally, the depletion of natural resources (for example, overuse of clean water) and the degradation of the environment (for example, air pollution) have not been accounted for in the TFP framework. There are at least two reasons for integrating environmental concerns into productivity measurement. First, an attempt to use productivity measures to address the question of welfare. Secondly, the environment can be seen as a production factor. As such ignoring it, leads to an overestimation of productivity. On the output side, however, abatement efforts unaccounted for will underestimate productivity. Work on the integration of this issue is ongoing, for instance, in the form of accounting for the production of undesirable outputs.[37]

Continuing along this line of thinking, albeit with a slightly different twist, early literature on regulation and productivity growth suggested a negative correlation between the two variables, in other words, regulation reduces productivity growth. However, insofar as environmentally damaging effects trigger environmental policies, such as taxes or regulation, the result might actually be an underestimation rather than an overestimation of (long-term) productivity. The reason is that an environmental tax may improve both the efficiency of resource use (technical efficiency) and technological change in the longer run. Furthermore, in many developed countries economic instruments have spurred the development of a sector focused on environmental technology.

All of this suggests that it is important to account for environmental issues in production, both for welfare purposes, to appropriately measure productivity growth, and to better understand the effects of regulation. A number of papers on regulation and TFP growth are reviewed below. How environmental concerns affect the measurement of productivity is beyond the scope of this review, but – because it is such a dynamic area – it is dealt with briefly in the summary of this section.

[37] See, for example, Ball, Färe, Grosskopf and Nehring (2001).

Gray and Shadbegian (2003) analyse the effect of environmental regulation on productivity in the pulp and paper industry in the U.S., a heavily air- and water-polluting industry, between 1979 and 1990. Their review of previous work in general shows that regulation reduces productivity, although not significantly. However, in the case of the aforementioned industry, regulation led to much greater reductions in productivity. Their conclusion is that regulatory burdens differ across industries, something that must be taken into account by policy-makers, and also that the economic impact of regulation tends to be understated.[38]

Their own analysis is taken further by looking at differences in the impact across different plants, vintages and production technologies. They find a significant negative relationship between pollution abatement costs and productivity levels, but mainly for mills that incorporate a pulping process. Vintages do not matter, though older plants are slightly less sensitive to abatement costs. Finally, allowing for differences in plant technology is shown to matter when measuring the reduction in productivity, as it increases by 8 per cent when technology is included in the model.

Berman and Bui (2001) start from the allegation that environmental regulation reduces productivity. Abatement costs are often used to measure the economic costs of regulation. However, if costs, such as time spent by managers in dealing with regulatory matters, are overlooked, the true net economic cost will be underestimated. On the other hand, if regulation induces plants to install cleaner and more efficient technologies, productivity could increase and abatement costs would overestimate the net economic costs of

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[38] It may be noted that the paradox of firms' (over-) compliance with environmental regulation is growing in importance. Why a paradox? The argument starts with Becker's (1968) notion that a profit-maximizing firm will comply with an environmental regulation only as long as the compliance cost is less than the expected penalty for violation. Yet, empirical research tends to show that firms comply with environmental regulations to a larger extent than would be expected from theory. Nyborg and Telle (2004), however, show in the case of Norway, that when scrutinizing the data this paradox breaks down. Firms indeed behave according to Becker's predictions, a fact which only becomes obvious on more detailed study of the data.

regulation. In other words, gross and net costs of regulation may differ substantially and the correct way to measure net costs is to study change in productivity.

The authors review the empirical literature and find that there is lack of consensus when it comes to the effects of regulation on productivity (compared with Gray and Shadbegian's more decisive conclusions from their literature review). They attribute this lack partly to a heterogeneity bias (for example, relatively dirty plants forced to address pollution problems are those least productive, which gives the impression that regulations reduce productivity. At the same time, relatively productive plants may choose to abate because they find it easy, thus creating a positive relationship between regulation and productivity). The lack of consensus is also partly due to problems with measurement error.

Using firm data, the paper studies the effects of regulations on productivity in the petroleum refining industry, in the South Coast Air Quality Management District in the U.S. They start by estimating the effects of regulations on pollution abatement costs. A second approach is to estimate the effects of regulation on TFP, while allowing for the possibility that pollution abatement expenditures inaccurately reflect economic costs of regulation.

They find strong evidence that regulations have induced large investments in abatement capital, while the effect on TFP has only been transitory. Compared with other oil districts in the U.S., in the period when the most stringent regulation came into effect, productivity actually increased, while it fell elsewhere in the country. Another finding is that abatement costs overstate the economic cost of regulation because they fail to account for productivity increase following regulation.

Turning to a different environmental aspect, natural capital, Olewiler (2002) in the case of Canada, finds that changes in the stock of non-renewable capital did not lead to a sustained decrease in productivity (labour and TFP). It thus appears that technological change (whether induced by environmental regulation or stock depletion) outweighs any negative effects. However, due to poor resource management practices productivity in renewable resource industries has been declining. She highlights the importance of understanding threshold effects and that, once such a threshold is crossed, damage may be irreversible. Decreasing productivity may be a warning that production and consumption are heading towards a path of non-sustainability. Furthermore, it can also signal that technological change is lagging behind depletion, that there are no substitutes available, and/or market failure is not properly addressed by regulatory or other measures.

5.4 Summary of "Competition, social dimension and environment"

Privatisation in general appears to be a good policy because it induces competition, but it should probably be a slow and carefully monitored process. One exception to privatisation is that of natural monopolies, where state ownership may be preferable or the monopoly should, at least, be correctly regulated. Obstacles to successful privatisation, for example, include weak bankruptcy procedures. An ineffective court system and policies may be geared to cover such areas. In the case of developing countries, a case can be made for public ownership if governments have poor regulatory capacity. Empirically there is some evidence in favour of privatisation. For example, former state-owned enterprises tend to improve their performance following privatisation. Empirical results also suggest that stringent product regulation decreases productivity. One conclusion drawn is that competition is very important for TFP growth.

Literature on the social dimension and TFP is very limited and inconclusive. Some results however suggest that social diversity is associated with lower productivity. With respect to income inequality and productivity, it is very difficult to draw any conclusions.[39] Land inequality, on the other hand, seems to be negatively correlated with labour productivity and perhaps with TFP as well. From the even more limited literature on age structure, one finds that high youth dependency ratios negatively correlate with TFP growth. Because of the small base from which a conclusion can be drawn, policy areas can only very tentatively be proposed. One policy objective could be to reduce communication costs between social groupings. It is also possible that land distribution policies could have an effect on TFP growth, though that would probably be in the longer term.

Early literature on productivity and environmental regulation maintained that it had a negative impact on TFP, but more recent work appears to suggest otherwise. There are some indications that environment regulation could lead to a faster rate of technological change. The main additional problem to be dealt with here is inadequate productivity measurement, where conventional measurement is biased towards showing negative effects. This occurs because, for example, reductions of emissions are not included on the output side; hence, output and productivity are understated. One body of the literature, for example, Repetto et al. (1996) and Gollop and Swinand (2000) suggests that reductions of undesirable outputs be measured as negative inputs (or as positive output), but the problem with their methodology is the need for price information. Perhaps more promising is the second body of the literature, in which Färe and Grosskopf figure prominently,[40] and propose productivity measures that do not require price information.[41] In general, the "adjusted" measures produce larger productivity measures than conventional ones. This is indeed a very exciting and dynamic area for research. However, at this stage it might be unwise to propose policies for TFP growth, although there may obviously be other reasons for environmental policies.

6. Conclusions

This review has identified several determinants that have an impact on, or are at least associated with, TFP growth. Of these, human capital (education and health),

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[39] See, however, the main conclusion of the latest Human Development Report (UNDP, 2005) in which inequality (in a broader sense than just that pertaining to income) is viewed as a decisively strong barrier to development.

[40] See, for example, Färe, Grosskopf and Pasurka, Jr (2001) and Chung, Färe and Grosskopf (1997).

[41] This is not entirely true because measures of allocative and overall economic efficiency always require price information. This group of researchers, however, is also developing methods for shadow price computation. See, for example, Färe, Grosskopf and Pasurka, Jr. (2003) and Färe, Grosskopf, Noh and Weber (2005).

infrastructure, imports (but not trade in general) institutions, openness, competition, financial development, geography and capital intensity/deepening occupied prominent positions, some directly and others indirectly affecting TFP growth. The view is that empirical evidence linking structural change, social dimension and environment to TFP growth is yet too inconclusive for policy implications. Innovation and R&D are shown to be important for TFP growth in industrialised countries, but there is little evidence of their importance for developing countries. Having identified these determinants, the next step is to discuss what sort of policies that can be devised to increase TFP growth in developing countries.

In general, policies aimed at capital accumulation can never be wrong because the more capital workers have, the more they produce. Furthermore, capital was also shown to matter for absorptive capacity in the sense that more advanced technology spillovers could be enjoyed only at a high enough level of capital intensity. However, it is not only the quantity of capital that matters, because more recent vintages of capital tend to be more productive. Hence, policy should also aim at improving the quality of capital. To this end, important policies for developing countries include financial sector reform to increase savings, better allocate them to investment and maintain healthy incentives. Trade reforms are also vital for increasing access to foreign capital. Capital accumulation will not occur unless good institutions are in place – good governance should also clearly be a policy choice. Infrastructural improvements are also important, provided that governments sensibly finance their capital formation and establish good management systems. Management is, of course, related to institutions and good institutions are more likely to provide good management.

Another important form of capital is human capital, which includes education, training and health. It is not only important for increasing labour productivity, although evidence in this area tends to be tenuous, it is also a significant determinant for whether technology transfer from abroad will impact on TFP growth (in other words, absorptive capacity). This argument is valid both in respect to education and health. In addition, unhealthy students tend to attain a lower level of education. There was also indication that human capital may be behind institutional quality and, if so, given the latter's significance for development, investment in human capital becomes even more central. Public spending on education and health appears to be an obvious policy choice. In Africa and South Asia, investment in "health capital" can be expected to be particularly productive. As a by-product to directly increase productivity, such a policy is subsequently likely to increase the returns to education as well, thus further spurring TFP growth. Additionally, longer life expectancy makes it more meaningful to invest in education. Interestingly, a healthy and educated population attracts FDI, although the positive spillovers of such investment remain unclear.

In terms of policies for knowledge creation, it might be advisable to work backwards in the following sense. First, the absorptive capacity must be strengthened, implying that investment in human capital, and perhaps R&D, is necessary before technology transfer can be fully exploited. Secondly, openness to foreign technology is vital and here, in particular, trade liberalisation seems an important tool for increasing such transfer. Finally, knowledge creation occurs at the world technology frontier and where high levels of capital intensity exist. Developing countries are behind in both respects and focus on innovation can, therefore, be questioned compared to other policy priorities. Therefore, it is doubtful whether (for developing countries) investment in R&D can be expected to yield significant results in terms of productivity growth (other than for absorptive capacity purposes).

Policies to stimulate competition are also vital in order to increase TFP growth. One such policy is privatisation, although it must be implemented with care. Policies to facilitate market entry for new firms, possibly at the expense of relatively unproductive ones, will increase TFP growth and stimulate competition. Trade liberalisation is likely to increase competition from abroad, but one concern is that it may cut both ways.

Because institutions have been shown to have profound effects on most TFP determinants, policies to create new and strengthen existing institutions may be necessary. It is chiefly protection of property rights and rule of law that are of concern to economists; the type of political institution in place seems to be of lesser importance. One must be aware that – for various reasons – it might not be easy to change existing institutions. Even slower to change are geographic conditions, which pose fundamental problems that cannot immediately be dealt with. Policies here are better directed at the consequences of such tribulations as, for example, health concerns, high transportation costs, access to coasts and poor soil quality, to name a few. Regional integration could, for example, be a way to offset problems associated with being landlocked. Environmental policy instruments could be used to protect the relatively vulnerable environment caused by unfavourable geographic conditions, while investment in infrastructure could play a role in lowering transportation costs. Finally, concerning trade and productivity, imports are of prime importance, while exporting may be seen more as a means to acquire foreign exchange to fund imports. Imports that embody technological knowledge can be used directly in the production process (after suitable modifications to domestic production conditions). Furthermore, acknowledging that trade policies have an uneven effect on firms should result in more fine-tuned policies.

Before concluding this review, it would be pertinent to issue some warnings. Policy conclusions normally require that, for example, institutions *cause* productivity growth (technically speaking, strong exogeneity is required). However, most studies covered here have only managed to identify associations, not causal directions. This means that one must exercise caution before accepting the policy interpretations presented here. It has, however, been argued that some variables, such as those associated with geography, are indeed exogenous. This means that a statistical association most likely has causality running from geography to TFP growth, which in turn implies that policies directed at combating the negative impact of geography on TFP growth could credibly be accepted. In cases where no causal direction has been identified or the determinant of interest is not exogenous, the policy discussion should be seen as indicative rather than directive.

References

Abdih, Y. and F. Joutz (2005), "Relating the Knowledge Production Function to Total Factor Productivity: An Endogenous Growth Puzzle", *IMF Working Paper No. WP/05/74*, Washington, DC: International Monetary Fund.

Abramowitz, M. (1986), "Catching Up, Forging Ahead, and Falling Behind", *Journal of Economic History*, Vol. 46, pp. 385-406.

Acha, Marsili and Nelson (2004), "What do we know about innovation? Editorial. *Research Policy*, Vol. 33, pp. 1253-1258.

Acemoglu, D. (2003), "Root Causes: A Historical Approach to Assessing the Role of Institutions in Economic Development", *Finance and Development*, June, pp. 27-30.

Acemoglu, D., Johnson, S. and J.A. Robinson (2001), "Colonial Origins of Comparative Development: An Empirical Investigation", *American Economic Review*, Vol. 91, pp. 1369-1401.

Acemoglu, D., Johnson, S. and J.A. Robinson (2002), "Reversal of Fortune: Geography and Institutions in the Making of the Modern World Income Distribution", *Quarterly Journal of Economics*, Vol. CXVII, pp. 1231-94.

Acemoglu, D. and F. Zilibotti (1999), "Productivity Differences", *NBER Working Paper No. 6879*, Cambridge, MA: NBER.

Aghion, P., P. Howitt, and D. Mayer-Foulkes (2005), "The Effect of Financial Development on Convergence: Theory and Evidence", *Quarterly Journal of Economics*, Vol. 120(1), pp. 173-222.

Ahn, S. (2001), "Firm Dynamics and Productivity Growth: A Review of Micro Evidence from OECD Countries", *Economics Department Working Papers No. 297*, Paris: OECD.

Aitken, B. and A. Harrison (1999), "Do domestic firms benefit from foreign direct investment? Evidence from Venezuela", *American Economic Review*, vol. 89, pp. 605-18.

Albouy, D. (2004), "The Colonial Origins of Comparative Development: A Reinvestigation of the Data", *mimeo*, Berkeley: University of Berkeley, California.

Alcalá, F. and A. Ciccone (2001), "Trade and Productivity", *CEPR Discussion Paper 3095*, London: CEPR.

Alcalá, F. and A. Ciccone (2004), "Trade and Productivity", *Quarterly Journal of Economics*, Vol. 119, pp. 613-46.

Alesina, A. and D. Rodrik (1994), "Distribution Politics and Economic Growth", *Quarterly Journal of Economics*, Vol. 109, pp. 465-90.

Andersen, T.B. and C-J. Dalgaard (2006), "Cross-Border Flows of People, Technology Diffusion and Aggregate Productivity", *Working Paper*, University of Copenhagen.

Arcand, J.L. (2001), *Undernourishment and Economic Growth: The Efficiency Cost of Hunger*, Rome: Food and Agriculture Organization.

Arjona, R., M. Ladaique, and M. Pearson (2001), "Growth, Inequality and Social Protection", *Labour Market and Social Policy Occasional Paper No. 51*, Paris: OECD.

Arjona, R., M. Ladaique, and M. Pearson (2003), "Growth, Inequality and Social Protection", *Canadian Public Policy*, Vol. 28, pp. S119-139.

Arrow, K.J. (1962), "The Economic Implications of Learning By Doing", *Review of Economic Studies*, Vol. 29, pp.155–73.

Aschauer, D.A. (1989), "Is Public Expenditure Productive?", *Journal of Monetary Economics*, Vol. 23, pp. 177-200.

Aschauer, D.A. (2000), "Public Capital and Economic Growth: Issues of Quantity, Finance, and Efficiency", *Economic Development and Cultural Change*, Vol. 48(2), pp. 391-406.

Aschauer, D.A. and Lachler, U. (1998), "Public Investment and Economic Growth in Mexico", *Policy Research Working Paper No. 1964*, Washington, DC: The World Bank.

Aw, B.Y., S. Chung, and M. Roberts (1998), "Productivity and the Decision to Export: Micro Evidence from Taiwan and South Korea", *NBER Working Paper No. 6558*, Cambridge, MA: NBER.

Baldwin, J.R. and B. Diverty (1995), "Advanced Technology Use in Canadian Manufacturing Establishments", *Statistics Canada Research Paper Series No. 85*, Ottawa: Statistics Canada.

Baldwin, J.R., Diverty, B. and D. Sabourin (1995), "Technology Use and Industrial Transformation: Empirical Perspective", *Statistics Canada Working Paper No. 75*, Micro-Economics Analysis Division, Ottawa: Statistics Canada.

Ball, V.E., R. Färe, S. Grosskopf, and R. Nehring (2001). "Productivity of the U.S Agricultural Sector: The Case of Undesirable Outputs," in C. Hulten, E. Dean, and M. Harper (Eds.), *New Developments in Productivity Analysis*, Studies in Income and Wealth, Vol. 63, ed., pp. 541-586. Chicago: University of Chicago Press.

Barone, A. (2004), "Privatization and Regulation: Efficiency and Equity Issues in Developing Countries", *mimeo*, European University Institute, Florence, Italy.

Barrett, A. and P.J. O'Connell (1999), "Does Training Generally Work? The Returns to In-Company Training", *IZA Working Paper No. 51*, Bonn: IZA.

Bartel, A. (1992), "Training, Wage Growth and Job Performance: Evidence from a Company Database", *NBER Working Paper No. 4027*, Cambridge, MA: NBER.

Bartelsmann, E.J., van Leeuwen, G. and H.R. Nieuwenhuijsen (1996), "Advanced Manufacturing Technology and Firm Performance in the Netherlands", *Netherlands Official Statistics*, Vol. 11, pp. 40-51.

Bastos, F. and J. Nasir (2004), "Productivity and the Investment Climate: What Matters Most", *Policy Research Paper*, No. 3335, Washington, DC: World Bank.

Basu, S. and D.N. Weil (1998), "Appropriate Technology and Growth", *Quarterly Journal of Economics*, Vol. 113, pp. 1025-54.

Becker, G. (1968), "Crime and Punishment: An Economic Approach", *Journal of Political Economy*, Vol. 76, pp. 169-217.

Benhabib, J. and M.M. Spiegel (1994), "The Role of Human Capital in Economic Development: Evidence from Aggregate Cross-Country Data", *Journal of Monetary Economics*, Vol. 34(2), pp. 143-174.

Benhabib, J. and M.M. Spiegel (2002), "Human Capital and Technology Diffusion", forthcoming in P. Aghion and S. Durlauf (Eds.), *Handbook of Economic Growth*, 4, Amsterdam: North Holland.

Berman, E. and L.T.M. Bui (2001), "Environmental Regulation and Productivity: Evidence from Oil Refineries", *Review of Economics and Statistics*, Vol. 83, pp. 498-510.

Bigsten, A., P. Collier, S. Dercon, M. Fafchamps, B. Gauthier, J.W. Gunning, A. Oduro, R. Oostendorp, C. Pattillo, M. Söderbom, F. Teal, and A. Zeufack (2002), "Do African Manufacturing Firms Learn From Exporting?", *CSAE Working Paper*, WPS/2002-09, Oxford: Centre for the Study of African Economies, Department of Economics, Oxford University.

Black, S.E. and L.M. Lynch (1995), "Beyond the Incidence of Training: Evidence from a National Employers Survey", *NBER Working Paper No. 5231*, Cambridge, MA: NBER.

Blalock, G. and P.J. Gertler (2004), "Learning From Exporting Revisited in a Less Developed Country", *Journal of Development Economics*, Vol. 75, pp. 397-416.

Bloom, D.E. and J.D. Sachs (1998), "Geography, Demography, and Economic Growth in Africa", *Brookings Papers on Economic Activity*, Vol. 1998(2), pp. 207-95.

Bloom, D.E., Canning, D. and P.N. Malaney (1999), "Demographic Change and Economic Growth in Asia", *CID Working Paper No. 15*, Center for International Development at Harvard University.

Bloom, D.E., Canning, D. and J. Sevilla (2004), "The Effect of Health on Economic Growth: A Production Function Approach", *World Development*, Vol. 32, pp. 1-13.

Bose, N., M.E. Haque and D.R. Osborn (2003), "Public Expenditure and Economic Growth: A Disaggregated Analysis for Developing Countries", *mimeo*, University of Manchester.

Bosworth, B.P., Collins, S.M. and Y-C. Chen (1995), "Accounting for Differences in Economic Growth", *Conference Paper for Structural Adjustment Policies in the 1990s: Experience and Prospects*, Institute of Developing Economies, Tokyo, Japan.

Bosworth, B.P. and S.M. Collins (2003), "The Empirics of Growth: An Update", *mimeo*, Washington, DC: Brookings Institution.

Branting, K., Sharpe, A. and F. St-Hilaire (2002), "Towards a Social Understanding of Productivity: An Introduction and Overview", in A. Sharp, K. Branting and F. St-Hilaire (Eds.), *The Review of Economic Performance and Social Progress*, Ottawa: Centre for the Study of Living Standards and Montreal: Institute for Research on Public Policy, McGill-Queen's University Press, posted at www.csls.ca, pp. 1-27.

Cameron, G., J. Proudman and S. Redding (1999), “Technology Transfer, R&D, Trade and Productivity Growth”, *working paper*, London: London School of Economics.

Carree, M.A. (2003), “Technological Progress, Structural Change and Productivity Growth: A Comment”, *Structural Change and Economic Dynamics*, Vol. 14, pp. 109-15.

Casacuberta, C., Fachola, G. and N. Gandelman (2003), “The Impact of Trade Liberalization on Employment, Capital and Productivity Dynamics: Evidence from the Uruguayan Manufacturing Sector”, *mimeo*, Montevideo: DE, FCS, Universidad de la República.

Caselli, F. and W.J. Coleman II (2002), “The World Technology Frontier”, *Working Paper*.

Chanda, A. and C-J. Dalgaard (2003), “Dual Economies and International Total Factor Productivity Differences”, *Economic Policy Research Unit Working Paper*, University of Copenhagen.

Chen, D.H.C. and C.J. Dahlman (2004), “Knowledge and Development: A Cross-Section Approach”, *Policy Research Working Paper, No. 3366*, Washington, DC: World Bank.

Chenery, H. and M.C. Syrquin (1988), “Patterns of Structural Change”, in H.B Chenery and T.N. Srinivasan (Eds.), *Handbook of Development Economics*, Amsterdam: North-Holland, pp. 203-73.

Chung, Y.H., R. Färe and S. Grosskopf (1997), “Productivity and Undesirable Outputs: A Directional Distance Function Approach”, *Journal of Environmental Environment*, Vol. 51, pp. 229-40.

Clerides, S., Lach, S. and J. Tybout (1998), “Is learning by exporting important? Micro-dynamic evidence from Colombia, Mexico and Morocco”, *Quarterly Journal of Economics*, Vol. 113, pp. 903-48.

Coe, D.T: and E. Helpman (1995), “International R&D Spillovers”, *Economic European Review*, Vol. 39, pp. 859-87.

Coe, D.T., Helpman, E. and A.W. Hoffmaister (1997), “North-South R&D Spillovers”, *Economic Journal*, Vol. 107, pp. 134-49.

Cole, M.A. and E. Neumayer (2003), “the Impact of Poor Health on Total Factor Productivity: An Empirical Investigation”, *mimeo*, Birmingham: University of Birmingham.

Coleman II, W.J. (2004), “Comment on: “Cross-Country Technology Adoption: Making the Theories Face the Facts””, *Journal of Monetary Economics*, Vol. 51, pp. 85-87.

Collins, S.M. and B.P. Bosworth (1996), “Economic Growth in East Asia: Accumulation Versus Assimilation”, *mimeo*, Washington, DC: Brookings Institution.

Comin, D. (2002), “R&D? A Small Contribution to Productivity Growth”, *Economic Research Reports #2002-01*, New York: C.V. Starr Center for Applied Economics, New York University.

Comin, D. and B. Hobijn (2004), “Cross-Country Technology Adoption: Making the Theories Face the Facts”, *Journal of Monetary Economics*, Vol. 51, pp. 39-83.

Connolly, M.P. (1997), “Technology, Trade and Growth: Some Empirical Findings”, *Research Paper #9727*, New York: Federal Reserve Bank of New York.

Cornwall, J. and W. Cornwall (2002), “A Demand and Supply Analysis of Productivity Growth”, *Structural Change and Economic Dynamics*, Vol. 13, pp. 203-29.

Crépon, B.E., Duguet, E. and J. Mairesse (1998), “Research, Innovation, and Productivity: An Econometric Analysis at the Firm Level”, *NBER Working Paper No. 6696*, Cambridge, MA: NBER.

Dessus, S. and R. Herrera (2000), “Public Capital and Growth Revisited: A Panel Data Assessment, *Economic Development and Cultural Change*, Vol. 48(2), pp. 407-18.

Diamond, J. (1997), *Guns, Germs and Steel*, New York: Norton.

Dilling-Hansen, M., T. Eriksson, E.S. Madsen and V. Smith (1999), “Productivity, Competition, Financial Pressure and Corporate Governance--Some Empirical Evidence”, in S. Biffignandi (ed.), *Micro- and Macrodata of Firms: Statistical Analysis and International Comparison, Contributions to Statistics*. Heidelberg: Physica, pp. 279-96.

Disney, R., Haskel, J. and Y. Heden (2000), “Restructuring and Productivity Growth in U.K. Manufacturing”, *CEPR Discussion Paper No. 2463*, London: CEPR.

Djankov, S., R. La Porta, F. Lopez-de-Silanes and A. Schleifer (2003), ”The New Comparative Economics”, *Journal of Comparative Economics*, Vol. 31(4), pp. 569-619.

Dollar, D. and A. Kraay (2002), “Institutions, Trade, and Growth”, *Journal of Monetary Economics*, Vol. 50, pp. 133-62.

Easterly, W. and S. Rebelo (1993), “Fiscal Policy and Economic Growth: An Empirical Investigation”, *NBER Working Paper No. 4499*, Cambridge, MA: NBER.

Easterly, W. and R. Levine (2001), “It’s Not Factor Accumulation: Stylized Facts and Growth Models”, *World Bank Economic Review*, Vol. 15(2), pp. 177-219.

Easterly, W. and R. Levine (2002), “Tropics, Germs, and Crops: How Endowments Influence Economic Development”, *Journal of Monetary Economics*, Vol. 50, pp. 3-39.

Edwards, S. (1992), “Trade Orientation, Distortions and Growth in Developing Countries”, *Journal of Development Economics*, Vol. 39, pp. 31-57.

Engerman, S. and K. Sokoloff (1997), “Factor Endowments, Institutions, and Differential Paths of Growth Among New World Economies”, in S.H. Haber (Ed.), *How Latin America Fell Behind*, Stanford, CA: Stanford University Press.

Eslava, M., Haltiwanger, J., Kugler, A., and M. Kugler (2004), ”The Effects of Structural Reforms on Productivity and Profitability Enhancing Reallocation: Evidence from Colombia”, *Journal of Development Economics*, Vol. 75, pp. 333-71.

Fagerberg, J. (2000), “Technological Progress, Structural Change and Productivity Growth: a comparative study”, *Journal of Development Economics*, Vol. 11, pp. 393-411.

Fernald, J. G. (1999), “Roads to Prosperity? Assessing the Link Between Public Capital and Productivity”, *American Economic Review*, Vol. 89, pp. 619-38.

Fernandes, A.M. (2003), “Trade Policy, Trade Volumes and Plant-Level Productivity in Colombian Manufacturing Industries”, *World Bank Policy Research Working Paper 3064*, Washington, DC: World Bank.

Fisman, R. and I. Love (2004), “Financial Development and the Composition of Industrial Growth”, *NBER Working Paper No. 9583*, Cambridge, MA: NBER.

Forbes, K. (2000), “A Re-assessment of the Relationship Between Inequality and Growth”, *American Economic Review*, Vol. 90, pp. 869-87.

Foster, L., J. Haltiwanger and C.J. Krizan (2000), ”Aggregate Productivity Growth: Lessons from Microeconomic Evidence”, *mimeo*, University of Maryland.

Frankel and Romer (1999), “Does Trade Cause Growth?”, *American Economic Review*, Vol. 89, pp. 379-99.

Furman, J.L. and R. Hayes (2004), “Catching Up or Standing Still? National Innovative Productivity Among “Follower” Countries, 1978-1999”, *Research Policy*, Vol. 33, pp. 1329-54.

Färe, R., S. Grosskopf and C.A. Pasurka, Jr. (2001), “Accounting for Air Pollution Emissions in Measures of State Manufacturing Productivity Growth”, *Journal of Regional Science*, Vol. 41, pp. 381-409.

Färe, R., S. Grosskopf and C.A. Pasurka, Jr. (2003), “Estimating Pollution Abatement Costs: A Comparison of ‘Stated’ and ‘Revealed’ Approaches”, *mimeo*, Washington, DC: U.S. Environmental Protection Agency.

Färe, R., S. Grosskopf, D-W. Noh and W. Weber (2005), “Characteristics of a Polluting Technology: Theory and Practice”, *Journal of Econometrics*, Vol. 126, pp. 469-92.

Gallup, J.L., J.D. Sachs, and A.D. Mellinger (1998), “Geography and Economic Development”, in *Annual Bank Conference on Development Economics*, Washington, DC: World Bank, pp. 127-78.

Gallup, J.L, Sachs, J. and A. Mellinger (1999), “Geography and Economic Development”, *Working Paper no. 1*, Cambridge, MA: Center for International Development at Harvard University.

Gallup, J.L and J. Sachs (2000), “The Economic Burden of Malaria”, *Working Paper no. 52*, Cambridge, MA: Center for International Development at Harvard University.

Geroski, P.A. (1991), *Market Dynamics and Entry*, Oxford: Basil Blackwell.

Glaeser, E.L., R. La Porta, F. Lopez-de-Silanes and A. Schleifer (2004), ”Do Institutions Cause Growth?”, *Journal of Economic Growth*, Vol. 9, pp. 271-301.

Gollop, F. and G. Swinand (2000), “Total Resource Productivity: Accounting for Changing Environmental Quality”, in E. Dean, M. Harper and C.R. Hulten (Eds.), *New Developments in Productivity Analysis*, Chicago: University of Chicago Press.

Grafton, Knowles and Owen (2001), “Social Divergence and Economic Performance”, *Working Paper 0103E*, Ottawa: University of Ottawa.

Grafton, Q.R., Knowles, S. and D.P. Owen (2002), “Social Divergence and Productivity: Making a Connection”, in A. Sharp, K. Branting and F. St-Hilaire (Eds.), *The Review of Economic Performance and Social Progress*, Ottawa: Centre for the Study of Living Standards and Montreal: Institute for Research on Public Policy, McGill-Queen’s University Press, posted at www.csls.ca, pp. 203-24.

Grafton, R.Q., Kompas, T. and P.D. Owen (2004), ”Productivity, Factor Accumulation and Social Networks: Theory and Evidence”, *Economics Discussion Papers*, No. 0304, Dunedin: University of Otago.

Granér, M. (2002), ”Export-led Efficiency or Efficiency-led Exports: Evidence from the Chilean Manufacturing Sector”, Essay II in *Essays on Trade and Productivity: Case Studies of Manufacturing in Chile and Kenya*, Ekonomiska Studier utgivna av Nationalekonomiska institutionen vid Göteborgs universitet no. 115, doctoral dissertation at Department of Economics, Göteborg University.

Granér, M. and A. Isaksson (2002), “Export Performance”, in A. Bigsten and P. Kimuyu (Eds.), *Structure and Performance of Manufacturing in Kenya*, London: Palgrave.

Granér, M. and A. Isaksson (2006), “Firm Efficiency and the Destination of Exports: Evidence From Kenyan Plant-Level Data”, *mimeo*, Vienna: UNIDO.

Gray, W.B. and R.J. Shadbegian (2003), “Plant vintage, technology, and environmental regulation”, *Journal of Environmental Economics and Management*, Vol. 46, pp. 384-402.

Griffith, R., Redding, S. and J. Van Reenen (2000), “Mapping the Two Faces of R&D: Productivity Growth in a Panel of OECD Industries”, *CEPR Discussion Paper no. 2457*, London: CEPR.

Griffith, R., Redding, S. and H. Simpson (2003), “Productivity Convergence and Foreign Ownership at the Establishment Level”, *Discussion Paper No. 572*, London: Centre for Economic Performance.

Griffith, R., S. Redding and J. Van Reenen (2004), “Mapping the Two Faces of R&D: Productivity Growth in a Panel of OECD Countries”, *Review of Economics and Statistics*, Vol. 86, pp. 883-95.

Guellec, D. and B. van Pottelsberghe de la Potterie (2001), “R&D and Productivity Growth: Panel Data Analysis of 16 OECD Countries”, *OECD Economic Studies No. 33*, pp. 103-26.

Görg, H. and D. Greenaway (2002), “Much Ado About Nothing? Do Domestic Firms Really Benefit from Foreign Direct Investment?”, *CEPR Discussion Paper 3485*, London: CEPR.

Hall, R.E. and C.I. Jones (1996), “The Productivity of Nations”, *NBER Working Paper No. 5812*, Cambridge, MA: NBER.

Hall, R.E. and C.I. Jones (1999), “Why Do Some Countries Produce So Much More Output Per Worker Than Others?”, *Quarterly Journal of Economics*, Vol. 114(1), pp. 83-116.

Hall, B. and F. Kramarz (1998), “Introduction: Effects of Technology and Innovation on Firm Performance, Employment, and Wages”, *Economics of Innovation and New Technology*, Vol. 5, pp. 99-107.

Hall, B. and J. Mairesse (1995), “Exploring the Relationship Between R%D and Productivity in French Manufacturing Firms”, *Journal of Econometrics*, Vol. 65, pp. 263-93.

Hamoudi, A.A. and J.D. Sachs (1999), “Economic Consequences of Health Status: A Review of the Evidence”, *CID Working Paper No. 30*, Center for International Development at Harvard University.

Hanson, G. (2001), “Should Countries Promote Foreign Direct Investment?”, *G-24 Discussion Paper 9*, UNCTAD, Geneva: UNCTAD.

Hanuschek, E.A. and D.D. Kimko (2000), “Schooling, Labour Force Quality, and the Growth of Nations”, *American Economic Review*, Vol. 90, pp. 1184-1208.

Harris, R. (2002), “Social Policy, Inequality and Productivity: What Are the Linkages?”, *The Review of Economic Performance and Social Progress*, Vol. 2, pp. 279-306.

Harrison, A. (1996), “Openness and Growth: A Time Series, Cross-Country Analysis for Developing Countries”, *Journal of Development Economics*, Vol. 48, pp. 419-447.

Hasan, R. (2002), “The Impact of Imported and Domestic Technologies on the Productivity of Firms: Panel Data Evidence from Indian Manufacturing Firms”, *Journal of Development Economics*, Vol. 69, pp. 23-49.

Haskel, J.E., S.C. Pereira and M.J. Slaughter (2002), "Does Inward Foreign Direct Investment Boost the Productivity of Domestic Firms", *NBER Working Paper No. 8724*, Cambridge, MA: NBER.

Hulten, C.R. (1996), "Infrastructure Capital and Economic Growth: How Well You Use It May Be More Important Than How Much You Have", *NBER Working Paper No. 5847*, Cambridge, MA: NBER.

Irwin and Tervio (2002), "Does Trade Raise Income? Evidence from the Twentieth Century", *Journal of International Economics*, Vol. 58, pp. 1-18.

Isaksson, A. (2001), "The Importance of Human Capital for the Trade-Growth Link", *UNIDO Working Paper No. 2,* Vienna: UNIDO.

Isaksson, A. (2002), "Human Capital and Economic Growth: A Survey of the Empirical Literature from 1990 to the Present", *mimeo*, Vienna: UNIDO.

Isaksson, A. (2005), "Determinants of Total Factor Productivity: An Assessment of Recent Evidence", *mimeo*, Vienna: UNIDO.

Isaksson, A. (2006), "Total Factor Productivity, Technological Change and Change in Technical Efficiency: A Global Picture", *mimeo*, Vienna: UNIDO.

Jones, C.I. (1995), "R&D-Based Models of Economic Growth", *Journal of Political Economy*, Vol. 103(4), pp. 759-84.

Jones, C.I. (1996), "Human Capital, Ideas, and Economic Growth", *mimeo*, Stanford: Stanford University.

Jones, C.I. (2004), "Growth and Ideas", forthcoming in P. Aghion and S. Durlauf (Eds.), *Handbook of Economic Growth*, 4, Amsterdam: North Holland.

Jones, C. and J. Williams (1998), "Measuring the Social Return to R&D", *Quarterly Journal of Economics*, Vol. 113, pp. 1119-38.

Jorgenson, D.W. and K.J. Stiroh (2000), "Raising the Speed Limit: U.S. Economic Growth in the Information Age", *Brookings Papers on Economic Activity No. 1*, pp. 125-211.

Keller, W. (1998), "Are International R&D Spillovers Trade-Related? Analyzing Spillover Among Randomly Matched Trade Partners", *European Economic Review*, Vol. 42, pp. 1469-91.

Keller, W. (2002), "Knowledge Spillovers at the World's Technology Frontier", *mimeo*, University of Texas.

Keller, W. (2004), "International Technology Diffusion", *Journal of Economic Literature*, Vol. XLII (3), pp. 752-82.

Keller, W. and S.R. Yeaple (2003), "Multinational Enterprises, International Trade, and Productivity Growth: Firm-Level Evidence from the United States", *NBER Working Paper No. 9504*, Cambridge, MA: NBER.

Kneller, R. (2005), "Frontier Technology, Absorptive Capacity and Distance", *Oxford Bulletin of Economics and Statistics*, Vol. 67(1), pp. 1-23.

Kneller, R. and P.A. Stevens (2002), "Absorptive Capacity and Frontier Technology", *mimeo*, National Institute of Economic and Social Research, London.

Knowles, S. and P.D. Owen (1995), "Health Capital and Cross-Country Variation in Income Per Capita in the Mankiw-Romer-Weil Model", *Economics Letters*, Vol. 48, pp. 99-106.

Kraay, A., Isoalaga, I. and J. Tybout (2001), "Product quality, productive efficiency, and international technology diffusion: Evidence from plant-level panel data", paper presented at the NBER institute, July.

Kögel, T. (2005), "Youth Dependency and Total Factor Productivity", *Journal of Development Economics*, Vol. 76, pp. 147-73.

Landes, D. (1998), *The Wealth and Poverty of Nations*, New York, NY: W.W. Norton.

Lee, H.Y., Ricci, L.A. and R. Rigobon (2004), "Once again, is Openness Good for Growth?", *Journal of Development Economics*, Vol. 75, pp. 451-72.

Lewis, W.W. (2004), *The Power of Productivity*, Chicago: The University of Chicago Press.

Lichtenberg, F.R. and D. Siegel (1991), "The Impact of R&D Investment on Productivity: New Evidence Using Linked R&D-LRD Data", *Economic Inquiry*, Vol. XXIX, pp. 203-28.

Lucas, R.E. (1988), "On the Mechanics of Economic Development", *Journal of Monetary Economics*, Vol. 22, pp. 3-42.

Lvovsky, K. (2001), "Health and Environment", *World Bank Environment Strategy Paper No. 1*, Washington, DC: World Bank.

Maddison, A. (1997), “Causal Influences on Productivity Performance 1820-1992: A Global Perspective”, *Journal of Productivity Analysis*, Vol. 8, pp. 325-60.

Maddison, A. (1999), “Perspective on Global Economic Progress and Human Development – Economic Progress: The Last Half Century in Historical Perspective”, *Annual Symposium 1999*, Academy of the Social Sciences.

Malmberg, B. and T. Lindh (2004), “Forecasting Global Growth by Age Structure Projections”, *Working Paper*, No. 204:5, Stockholm: Institute for Futures Studies.

Mankiw, N.G., D. Romer, and D.N. Weil (1992), “A Contribution to the Empirics of Economic Growth”, *Quarterly Journal of Economics*, Vol. 107, pp. 407-37.

Mayer, J. (2001), “Technology Diffusion, Human Capital and Economic Growth in Developing Countries”, *Discussion Papers*, No. 154, Geneva: United Nations Conference on Trade and Development.

McCarthy, F.D., Wolf, H. and Y. Wu (2000), “The Growth Costs of Malaria”, *NBER Working Paper No. 7541*, Cambridge, MA: NBER.

McGuckin, R.H., Streitwieser, M. and M. Doms (1998), “Advanced Technology Usage and Productivity Growth”, *Economic of Innovation and New Technology*, Vol. 7, pp. 1-26.

Mengistae, T. and C. Pattillo (2004), “Export Orientation and Productivity in Sub-Saharan Africa”, *IMF Staff Papers*, Vol. 51, pp. 327-53.

Mincer, J. (1974), *Schooling, Experience, and Earnings*, New York: Columbia University Press.

Miller, S.M. and M.P. Upadhyay (2000), “The Effects of Openness, Trade Orientation, and Human Capital on Total Factor Productivity”, *Journal of Development Economics*, Vol. 63, pp. 399-423.

Miller, S.M. and M.P. Upadhyay (2002), “Total Factor Productivity, Human Capital, and Outward Orientation: Differences by Stage of Development and Geographic Regions”, *mimeo*, University of Nevada, Las Vegas.

Munnell, A.H. (1992), “Policy Watch: Infrastructure Investment and Economic Growth”, *Journal of Economic Perspectives*, Vol. 6, pp. 189-98.

Nelson, R.R. (1993), *National Innovation Systems: A Comparative Analysis*, New York, NY: Oxford University Press.

Nelson, R. and E. Phelps (1966), "Investment in Humans, Technological Diffusion, and Economic Growth", *American Economic Review*, Vol. 56, pp. 69-75.

Nickel, S.J. (1996), "Competition and Corporate Performance", *Journal of Political Economy*, Vol. 104, pp. 724-46.

North, D.C. (1990), *Institutions, Institutional Change and Economic Performance*, New York: Cambridge University Press.

North, D.C. and B.R. Weingast (1989), "Constitutions and Commitment: the Evolution of Institutions Governing Public Choice in Seventeenth-Century England", *Journal of Economic History*, Vol. 49, pp. 803-32.

Nyborg, K. and K. Telle (2004), "A Dissolving Paradox: Firms' Compliance to Environmental Regulation", *Memorandum No. 02/2004*, Department of Economics, University of Oslo.

Olewiler, N. (2002), "Natural Capital, Sustainability and Productivity: An Exploration of the Linkages in A. Sharpe, K. Branting and F. St-Hilaire (Eds.), *The Review of Economic Performance and Social Progress*, Ottawa: Centre for the Study of Living Standards and Montreal: Institute for Research on Public Policy, McGill-Queen's University Press, posted at www.csls.ca, pp. 203-24.

Olson, M. Jr. (1991), "Autocracy, Democracy and Prosperity", in R.J. Zeckhauser (ed.), *Strategy and Choice*, pp 131-57. Cambridge, MA: MIT Press.

Olsson, O. (2004), "Unbundling Ex-Colonies: A Comment on Acemoglu, Johnson and Robinson, 2001, *Working Papers in Economics*, No. 146, Göteborg: Department of Economics, Göteborg University.

Peneder, M. (2003), "Industrial Structure and Aggregate Growth", *Structural Change and Economic Dynamics*, Vol. 14, pp. 427-48.

Persson, T. and G. Tabellini (1994), "Is Inequality Harmful for Growth?", *American Economic Review*, Vol. 84, pp. 600-21.

Porter, M.E. (1990), *The Competitive Advantage of Nations*, New York, NY: The Free Press.

Prescott, E.C. (1998), "Needed: A Theory of Total Factor Productivity", *International Economic Review*, Vol. 39, pp. 525-51.

Pritchett, L. (2002), “Comment on: Institutions, Trade, and Growth”, *Journal of Monetary Economics*, Vol. 50, pp. 163-65.

Pritchett, L. (1996), “Measuring Outward Orientation: Can it be Done?”, *Journal of Development Economics*, Vol. 49, pp. 307-35.

Przeworski, A. and F. Limongi (1993), “Political Regimes and Economic Growth”, *Journal of Economic Perspectives*, Vol. 7, pp. 51-69.

Rajan, R. and L. Zingales (1998), “Financial Dependence and Growth”, *American Economic Growth*, Vol. 88, pp. 559-86.

Repetto, R., D. Rothman, P. Faeth and D. Austin (1996), *Has Environmental Protection Really Reduced Productivity Growth?: We Need Unbiased Measures*, Washington, DC: World Resources Institute.

Rodrik, D. (1992), “Political Economy and Development Policy”, *European Economic Review*, Vol. 36, pp. 329-36.

Rodrik and Rodriguez (1999), “Trade Policy and Economic Growth: A sceptic's guide to the cross-national evidence”, *NBER Working Paper No. 7081*, Cambridge, MA: NBER.

Rodrik, D., A. Subramanian and F. Trebbi (2002), “Institutions Rule: The Primary of Institutions Over Geography and Integration in Economic Development”, *NBER Working Paper No. 9305*, Cambridge, MA: NBER.

Romer, P. (1986), “Increasing Returns and Long Run Growth”, *Journal of Political Economy*, Vol. 94, pp. 1002-37.

Romer, P. (1990), “Endogenous Technological Change”, *Journal of Political Economy*, Vol. 96, pp. S71-S102.

Romer, P. (1993), “Idea Gaps and Object Gaps in Economic Development”, *Journal of Monetary Economics*, Vol. 32, pp. 543-73.

Roubini, N. and X. Sala-i-Martin (1991), “Financial Repression and Economic Growth”, *Journal of Development Economics*, Vol. 39, pp. 5-30.

Sachs, J.D. (1999), “Why Economies Grow”, in B. Swedenborg and H.T. Söderström (Eds.), *Creating an Environment for Growth*, Stockholm: SNS.

Sachs, J.D. (2003), “Institutions Don’t Rule: Direct Effects of Geography on Per Capita Income”, *NBER Working Paper No. 9490*, Cambridge, MA: NBER.

Sachs, J.D. and A. Warner (1995a), "Economic Reform and the Process of Global Integration", *Brookings Papers on Economic Activity*, Vol. 1, pp. 1-95.

Sachs, J.D. and A.M. Warner (1995b), "Natural Resource Abundance and Economic Growth", *Development Discussion Paper No. 517a*, Cambridge, MA: Harvard University.

Scarpetta, S., P. Hemmings, T. Tressel and J. Woo (2002), "The Role of Policy and Institutions for Productivity and Firm Dynamics: Evidence from Micro and Industry Data", *OECD Working Paper No. 329*, Paris: OECD.

Scarth (2002), "Social Divergence and Productivity: Making a Connection", in A. Sharpe, K. Branting and F. St-Hilaire (Eds.), *The Review of Economic Performance and Social Progress*, Ottawa: Centre for the Study of Living Standards and Montreal: Institute for Research on Public Policy, McGill-Queen's University Press, posted at www.csls.ca, pp. 203-24.

Scarth, W. (2003), "Population Aging, Productivity, and Growth in Living Standards", *SEDAP Research Paper No. 90*, Hamilton: McMaster University.

Schor, A. (2004), "Heterogeneous Productivity Response to Tariff Reduction. Evidence from Brazilian Manufacturing Firms", *Journal of Development Economics*, Vol. 75, pp. 373-96.

Schultz, T.W. (1961), "Investments in human capital", *American Economic Review*, Vol. 51, pp. 1-17.

Sokoloff, K.L. and S.L. Engerman (2000), "Institutions, Factor Endowments, and Paths of Development in the New World", *Journal of Economic Perspectives*, Vol. 14, pp. 217-32.

Solow, R. (1957), "Technical Change and the Aggregate Production Function", Review of Economics and Statistics, Vol. 39, pp. 313-20.

Timmer, M.P. and B. Los (2005), "Localized Innovation and Productivity Growth in Asia: An Intertemporal DEA Approach", *Journal of Productivity Analysis*, Vol. 23(1), pp. 47-64.

Tompa (2002), "Social Divergence and Productivity: Making a Connection", in A. Sharp, K. Branting and F. St-Hilaire (Eds.), *The Review of Economic Performance and Social Progress*, Ottawa: Centre for the Study of Living Standards and Montreal:

Institute for Research on Public Policy, McGill-Queen's University Press, posted at www.csls.ca, pp. 203-24.

Tybout, J.R. (1992), "Linking Trade and Productivity: New Research Directions", *World Bank Economic Review*, Vol. 6, pp. 189-211.

Ulku, H. (2004), "R&D, Innovation, and Economic Growth: An Empirical Analysis", *IMF Working Paper, WP/04/185*, Washington, DC: International Monetary Fund.

Ulubasoglu, M.A. and C. Doucouliagos (2004), Institutions and Economic Growth: A Systems Approach", *mimeo*, Melbourne: School of Accounting, Economics and Finance, Deakin University.

UNDP (2005), *Human Development Report 2005 – International Cooperation at a Crossroads: Aid, Trade and Security in an Unequal World*, Oxford: Oxford University Press.

Van Biesebroeck, J. (2003), "Exporting Raises Productivity in Sub-Saharan African Manufacturing", *NBER Working Paper Series, No. 10020*, Cambridge, MA: NBER.

Wang, J-C. and K-H. Tsai (2003), "Productivity Growth and R&D Expenditure in Taiwan's Manufacturing Firms", *NBER Working Paper 9724*, Cambridge, MA: NBER.

Watson, W. (2002), "Social Policy and Productivity: Anybody Here See Any Levers?", *The Review of Economic Performance and Social Progress*, Vol. 2, pp. 307-21.

Xu, B. and J. Wang, (1999), "Capital Goods Trade and R&D Spillovers in the OECD", *Canadian Journal of Economics*, Vol. 32, pp. 1258-74.