

University of Groningen

Why growth rate differences persist

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Document Version

Publisher's PDF, also known as Version of record

Publication date:

2006

[Link to publication in University of Groningen/UMCG research database](#)

Citation for published version (APA):

Rensman, M. (2006). *Why growth rate differences persist: International technology diffusion in the long run*. [Thesis fully internal (DIV), University of Groningen]. s.n.

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Chapter 6

Conclusions

6.1 Summary

The current thesis aimed to provide new empirical evidence on how international technology diffusion affect labour productivity growth differences between countries. It contributed to the current literature by putting this evidence in a historical perspective. The second contribution of the thesis was the use of an eclectic approach, which combined the insights on growth and diffusion from the economic-historical literature on technology diffusion and economic performance, growth accounting methods and endogenous growth theory. This clarified the working of the mechanism of technology diffusion in the catching up and convergence process in the long run.

First I developed a conceptual framework on changes of technology systems and innovation systems in the very long run. I applied this framework on long run time series of the US and the UK from 1840 to 1990, and used the insights from the economic-historical literature to interpret the developments from the perspective of technology diffusion and growth between these two countries. This analysis suggests that transfer of institutions for human capital and research might have been more important for long run comparative economic performance than the actual technology transfer itself. Moreover, the transfer of the innovation-related institutions takes more time to diffuse than direct technology transfer.

Subsequently I constructed an endogenous macro-economic growth model in order to estimate the impact of technology diffusion on growth. In the model, R&D effort helps a follower country to reduce its technol-

ogy gap with a leader country. In contrast to the previous historical analysis, the international differences in technology systems and innovation systems are now taken as given. The model was estimated for the market sector as a whole and the manufacturing sector separately in France, Germany and the UK in the period 1956-1996, with the US as the presumed leader. The results suggest that technology accounts for a large part of productivity growth, which varies across countries and sectors. Even more interesting is the impact of R&D efforts on technology diffusion. The estimations show that given the technology gap in the previous year, R&D effort increases the technology level. But without R&D effort, the distance of the countries to the US frontier will increase. Countries appear to differ in the need for R&D to exploit the catch up potential. Without a change in the international differences in technology systems and innovation systems, the long run distance to the technology frontier will continue to differ across follower countries, and technology growth differences with the US may persist.

Finally, I applied an endogenous industry level growth model with two channels for technology diffusion. The first diffusion channel transfers industry specific technology from a leader industry abroad into the follower industry. The second channel transfers general purpose technology from the domestic technology pool into the industry. The model is estimated with data for six manufacturing industries in France, Germany and the UK in the period 1973-1993, with the US as a benchmark. The estimation results suggest that the model is able to discriminate across industries in the impact of these two diffusion channels. For some industries, such as the electronic equipment industry, the absorption of industry purpose technology from the leading industry abroad seems to be of importance. Investment in R&D has a positive impact on their speed of absorption. Without R&D, they would fall further behind the foreign leader industry. The absorption of the industry purpose technologies likely requires some absorption and adaptation of accompanying institutions, though this is more difficult and takes more time. For other industries, such as chemicals, R&D investment has a positive impact on the speed of absorption of general purpose technology from the domestic technology pool. Without R&D, they fall behind the domestic technology frontier. The absorption of general purpose technologies requires a properly working national innovation system in order to transfer the technologies to the industry under consideration.

What are the implications of the research outcomes in this thesis for

the interpretation of trends in economic growth and technology diffusion between countries today? Currently, there seems to be hardly any technology gap between the US and Western European economies. The European countries have largely caught up in terms of technology, and new ideas diffuse relatively fast today. But there still does exist a productivity gap, with the US at a higher level than European economies (Conference Board and Groningen Growth and Development Centre, 2006). The difference is explained by a difference in sectoral structure, but also by within-industry differences in productivity levels. For instance, the US are producing relatively more in high tech manufacturing branches, while many Western European economies have relatively more activity in low and medium tech manufacturing branches. But even within industries, top US firms are often more productive than top European firms.

At a more fundamental level, the productivity gap might be explained by a difference in innovation-related institutions. The research in this thesis shows that diffusion of innovation-related institutions is probably more important than technology diffusion as such, and that these institutions take more time to diffuse. One might argue that European economies still fail to absorb and adapt institutions from the US. Policy makers in the European Union today often argue that certain US institutions are more effective than European institutions. Often mentioned examples are a relatively positive attitude to entrepreneurship, a short time-to-market for inventions, certain forms of science-industry interaction in research, and the rewarding of excellence in education or research. Adoption and adaptation of these US institutions are supposed to lead to a more efficient and effective innovation system in Europe.

But the current situation is more complex than in the nineteenth century, because Western economies have tighter relations due to ongoing internationalisation and specialisation. Also, the links between science, technology and economy are relatively close, leading to increasingly complex technology and knowledge development. This shows up in the innovation systems of the Western economies. Countries do not perform systematically better or worse than other countries in education, research and science (Antenbrink et al., 2005). They show relative weaknesses and strengths, such as in science-industry interaction (Rensman, 2004; Canton et al. 2005).

The European economies may absorb and adapt US institutions, but should also continue to invest in R&D and human capital accumulation.

This mobilizes the current institutions in their economies, thereby enhancing technology absorption. As the US also continues to invest in innovation, a lack of R&D and human capital accumulation in the European economies would put them back. Furthermore, the absorption and diffusion of general purpose technologies is likely to depend on an effective and efficient national innovation system. Also, absorption of industry purpose technologies by industries are likely to be fostered by diffusion of innovation-related institutions.

6.2 Future research

The empirical research in this thesis revealed a range of issues which may be subject of future research. I distinguish three potential issues: data problems, model specification and estimation, and the concept of absorptive capacity.

Data As growth accounting studies have shown, the need to improve the quality of economic data should not be underestimated. Our understanding of the process of economic growth and technology progress and diffusion, and the testing of economic growth models depends on such data. Particularly when very long time series, panel data and sectoral level data are utilised, poor quality of the data can lead to confusing or even wrong insights. With long time series, a small error at one point of time may have large consequences for distant points of time in the series. Furthermore, international comparisons benefit from international standardisation methods. Panel data offer the possibility of international comparison, but often the time period is relatively short. Furthermore, testing with sectoral or industry level data suffer from relatively large outliers. Finally, in the process of testing the economic models, the construction of proxies for the variables is the next step in the use of data. Proxies might not always perfectly match the variables, but without data, testing is impossible. The quality of these data might be improved with considerable effort to improve data construction and collection by economic researchers and organisations like the OECD.

Modelling As is mentioned in Chapters 4 and 5, model specification and testing has its own problems. Nevertheless, modelling has a value added in that it forces more explicit formulation about assumptions and causal relationships, and it can be tested. One of the problems in testing

a growth model is that subtleties which occur in the joint diffusion of technology and institutions are not easy to grasp by the model. The research outcomes, however, point to the importance of institutions. The recent developments in endogenous growth theory (see Section 2.4.3) seem to be on the right way. In future research, the specification of the growth models such as applied in this thesis might be improved. For instance, the currently used aggregate production function might not apply to the industry level. Second, the estimation methods (WLTSLS, WLS, or GMM estimation for dynamic panel data, Hicks or Harrod neutral technological progress) might be scrutinized more into detail to unveil underlying estimation problems. Finally, the possibility of a SUR estimation of the productivity growth equation and technology growth equation together can also be analysed. The proxies might also be changed, such as the technology and R&D variables. Technology might be measured by other data than patents; or the R&D variable might be constructed as an R&D stock, or in growth rates. It should be noted that even if the model is well-specified and even if advanced econometric estimation methods are used, testing might still be pointless if poor data are used.

Absorptive capacity More intrinsically, the concept of absorptive capacity deserves further research. It is an appealing concept which also brings the empirical and theoretical growth literature together. Currently, economic growth research is focussing more and more on this concept (see also Chapter 2). Broadly speaking, the concept does not only involve the idea that R&D increases absorptive capacity, but also that institutions are key to the creation of absorptive capacity. That is, it is probably a too narrow view to only consider R&D investments as such. As the Anglo-American long run comparative performance shows, human capital, in conjunction with research institutions, determine absorptive capacity. In this respect, it is not only the level of human capital but also the type and organisation of human capital that deserves attention in economic research. For instance, historically the US apparently were able to absorb and master various general purpose technologies (steam and water power, railways, electricity, and by now, ICT) because they had general secondary and higher education institutions which were accessible for the mass. General education offered the flexibility needed to absorb these technologies from the technology leader, the UK, and to develop them further after adaptation to local circumstances in the US.

