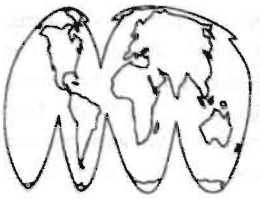
Uneven growth between interdependent economies : an evolutionary view on technology gaps, trade and growth

PART FOUR

Summary and Conclusions



CHAPTER 10. A Concluding Summary

The main aim of this thesis was to examine the nature of the relation between economic growth and technological change in an international context. The analysis centred around three major themes. The first theme is the identification of the issues to be explained (*stylized facts*) and the choice of the methodological framework in which to analyze them. Part One was mainly devoted to these topics. The second theme is the influence of knowledge spillovers on international growth patterns. This was developed in theoretical and empirical detail in Part Two. The third theme is the relation between trade, competitiveness and the international division of growth. Part Three was devoted to setting up a model which gives a stylized overview of this relation, and exploring its consequences by means of simulation techniques and empirical analysis.

The concluding summary in this chapter will also focus on these three issues. Each of them will be discussed in a separate section. In addition, the last section will try to make some links between the current thesis and some other fields in the economics of technological change and (international) growth, thus outlining some possibilities for further research.

10.1. The Merits of a Dynamic Evolutionary Approach

The approach chosen in Chapter 3 and later developed in Chapters 5 and 7 can be characterized as *dynamic* and *evolutionary*. The main points that lend the presented models their specific character, are the idea of diversity (in behavioural patterns) as the driving force of the economic system, the idea of out-of-equilibrium behaviour of the agents and the system, and the notion of learning (in a Lamarckian sense) as the most important way of feedback between performance and behaviour. Looking back at the models presented and the tests undertaken, what can be identified as the specific advantages of this dynamic evolutionary perspective?

To answer this question is more difficult than it seems. The reason for this is that unlike some other areas of science (especially the *natural sciences*), the application of experimental or empirical methods cannot give a definite answer to the question which of the two alternative theoretical perspectives is better. However, a number of preliminary conclusions can be drawn on the basis of the above.

In the case of knowledge spillovers, considered in Part Two, the dynamic approach chosen obviously has big advantages. Spillovers constitute *additions* to the

knowledge stock of a country (firm), and as such they require a dynamic perspective almost by definition, as in early approaches to the subject (Nelson 1968, Gomulka 1971). Apart from the methodological argument for a dynamic model of knowledge spillovers, the specific way of modelling used in Part Two (placing differences in learning capacity at the centre) proved to be very useful from a theoretical and empirical point of view. This will be discussed in more detail below.

The advantages of the dynamic evolutionary framework are even more prominent in the model presented in Chapter 7. As shown in Chapters 2 and 3, the mainstream growth theories in the literature start by specifying the relations between the variables in the model by means of *static* equations. The more recent new neoclassical growth models with endogenous technological change model the growth rate of knowledge by relating it to R&D investments. However, in both cases, the outcome of the model is that an equilibrium growth rate is achieved in the long run, the so-called situation of balanced growth. This view of the world stresses that the economic system will at some point in time settle in a situation with a fixed growth rate differential between different economies. Changes in this equilibrium growth rate (differential) can be induced by changes in the parameters or exogenous variables, but not by the endogenous behaviour of the agents in the model.

In some cases, the equilibrium growth rate is not fixed, but has a more complicated regular pattern, as for example a growth cycle (Aghion and Howitt 1990). However, this does not change the basic characteristic of the model. Even in the case of a growth cycle, the regular pattern that the model generates cannot be changed without changes in parameters and / or exogenous variables.

The model developed in Chapter 7 is strongly opposed to this view of the world as a system in which *regularity* is the most important characteristic of growth. The dynamic evolutionary character of the model generates growth patterns which are far from regular, and in which the growth path of output, and fluctuations in employment, prices and productivity growth are quite unpredictable in the medium or longer run. The basic assumption that underlies this difference is the evolutionary idea that *diversity* is the driving force of the economic system, rather than a homogeneous behavioural pattern that is assumed in most mainstream growth theories.

The regularity of the growth path has also been raised in the debate on long waves (see for example Maddison 1982), a field in which the evolutionary approach to economics is fairly prominent (Schumpeter 1939, Clark *et al.* 1982). Some approaches (especially the early ones) to the subject of long waves have started from the assumption that the *long wave* is in fact a *long cycle*. This usage of the term *cycle* points to the inherent regularity in the growth path which connects up- and downturns in the same way over and over again. Thus, although most of the contributions to the long-wave debate can be characterized as 'outside mainstream economic analysis', these particular interpretations conform quite well to a mainstream idea about the character of growth.

Several authors have objected to this perspective on long waves (for example Clark *et al.* 1982 and Maddison 1982). They argue that there is no inherent mechanism which connects up- and downturns in a regular way, but that the explanation for observed wave-like patterns is more diffuse. Maddison argues that one should rather speak of different *phases* in long-term growth. In light of the model proposed here, the dynamic evolutionary way of modelling stresses this particular interpretation of growth. But even if the basic ideas underlying many of the assumptions of the model are due to Schumpeter (see Chapter 3), who is also considered the founder of the *innovation*-driven long-wave theory, the model has not shown any signs of a long-wave pattern. It would be interesting to see under what assumptions a model like the one in Chapter 7 could generate a growth pattern which resembles Maddison's phases in long-term growth. Such a model could contribute to the specific (methodological) long wave debate about the distinction between *long cycles* and *waves*.

One might be inclined to consider the conclusion of the irregularity of growth paths as not being a particularly interesting one, since the economic history of the (most recent) past contains lots of examples of this phenomenon. However, it is paradoxical to see that, for example, the major break in the growth path that occurred in the 1970s has led to a 'panicky reaction' among economists. The mainstream theories developed until then were all aimed at explaining balanced growth, and the fact that reality did not conform to this idea was shocking to most people in the field. An example of this is the debate on the so-called productivity slowdown, which centers around the question why the (supposed) potential of technological progress has not yet materialized in higher productivity growth (for an overview of this debate, see for example Link 1987). The evolutionary idea of a complex relation between technological change and growth in which different countries react differently to different circumstances might be more fruitful in this debate than the mainstream 'linear' view of the production function (see for example Freeman 1986).

On the other hand, the extremely unequal growth between the developed and undeveloped world, did not seem to shock the mainstream economics profession until recently. Theories dealing with the falling behind of the third world otherwise than by pointing to exogenous factors have received little attention. The new neoclassical growth models might provide a promising new line of research in this field, although the first preliminary ways of 'translating' the new models into empirical relevant models for the poorest countries are perhaps a little disappointing (Romer 1989).

One of the reasons why the evolutionary view on growth put forward above did not receive much attention, is the lack of formal methods in the evolutionary tradition until recently (see Chapter 3). The current analysis has tried to add to the growing stream of work that is filling this gap. Although the models developed above are not really *on par* yet with the level of sophistication in methods and detail of much of the mainstream theory in the same field, the developments in the area of nonlinear mathematics seem to be promising in this respect (see for example Lorenz 1989). The nature of nonlinear dynamic models seems to make them highly suitable for application in the field of evolutionary theory (Silverberg

1988), but also poses all sorts of problems with regard to testability and the nature of the conclusions drawn from them.

10.2. Knowledge Spillovers: Catching Up or Falling Behind?

Much in line with the way in which the notion of balanced growth has been taken for granted, the idea of automatic knowledge spillovers from rich to poor countries has gained ground in the catching-up debate. The idea that the advance of technological knowledge benefits everyone in the world eventually, seems to be implicit in this notion of automatic international diffusion of innovation. Starting from a situation which is described by inequality in innovation capacity, international knowledge spillovers are believed to *radiate* the beneficial effects of technological progress all over the world.

The analysis in Part Two has shown the inaccuracy of the view of knowledge spillovers as an unconditional blessing for the world as a whole. In line with arguments found in many fields of the economic literature, the model developed here argues that spillovers do not take place automatically, but require a certain *assimilating* capacity from the side of the receiving party. Moreover, it was assumed that the larger the technological distance between leader and follower, the less effective technology spillovers will be, an idea which is supposed to capture the effect of cumulativeness of technological change. The model was aimed at explaining two stylized facts of world long-run growth patterns formulated in Chapter 4. The first of these is that for a limited set of (OECD) countries, the initial levels of labour productivity are inversely related to the rate of technological progress. This stylized fact is the basis for the optimistic views on knowledge spillovers referred to above. The second stylized fact to be explained is that the inverse relation between initial labour productivity and the rate of technological progress, or the rate of growth of income, is not valid for the part of the world lagging furthest behind the technological or welfare frontier.

Using a functional, nonlinear specification of knowledge spillovers that is based upon some of the insights in parts of the economic literature on technological change, it was shown that for countries lagging too far behind the technological frontier, the effects of knowledge spillovers are much too small in order to be able to provide them with a catching-up perspective. For growing gaps, the *actual* knowledge spillovers tend to zero. The model predicts that countries which are relatively close to the technological frontier and have a relatively high intrinsic capability to assimilate knowledge spillovers are likely to catch up. Countries lagging far behind and / or having a low intrinsic capability to assimilate spillovers will fall (even further) behind. The empirical analysis in Chapter 6 proved the functional specification of the model to be most valuable as compared to other specifications in the literature and special cases of the equation proposed.

The different possibilities for growth patterns predicted by the model link up quite closely to the ideas of growth that were described in the above section. Instead of a regular growth pattern, the model predicts that (sudden) shocks and trend reversals in the growth path might arise if the intrinsic capability to assimilate knowledge spillovers changes over time. In a mathematical way, the model shows,

even given its very simple nature, some of the possibilities of nonlinear dynamics referred to above, and generates a *bifurcation* pattern.

Since most of the factors influencing the intrinsic capability to assimilate knowledge spillovers - such as education and infrastructure, two variables which are used in the empirical test of the model - are more or less public goods, there is a possibility for governments to influence growth performance by means of an active policy in this field. As the analysis of the estimation results in Chapter 6 shows, this holds particularly true for the poorest, mostly African, countries, which are in a position in which the intrinsic knowledge assimilating capability is low to the extent that they cannot catch up, irrespective of the value of the initial gap. However, the brief discussion of policy alternatives in Chapter 6 has mentioned the problem that most of the governments of the countries involved do not have the money to pursue such a policy, or lack the political will to spend the money in this way.

10.3. International Trade, Growth and Competitiveness

Part Three of this thesis was aimed at explaining the first three stylized facts of international growth in Chapter 4. The first of these says that growth rates differ between countries, although the differences are smaller between groups of relatively homogeneous countries. The second and third stylized facts suggest a structural explanation for the question why growth rates differ. The second stylized fact stresses the differences between sectoral rates of technological change and the third stylized fact points to differences in the production (and consumption) structure between countries.

In an attempt to explain these phenomena, the three chapters in Part Three of the thesis have highlighted the role of technology (and wages) in the process of international competition for growth. The model that was presented in Chapter 7 has challenged the traditional view that free trade benefits every party involved. Although the static Ricardian logic of comparative advantages is undisputed, and actually comes out of the model in terms of emerging specialization patterns, the model has shown that some countries benefit more from trade than others. It was in this chapter that the evolutionary logic proposed was expanded fully into a model, stressing the importance of variety in the specification of the selection environment using the replicator equation, and using the idea of Lamarckian feedbacks between performance and (learning) behaviour in the specification of equations for the wage rate, productivity growth, the exchange rate and income elasticities of consumer demand.

A normative argument about whether or not a country is better off with free trade has not been given, because this proves to be impossible in the setting of the simple model used. The model showed that free trade induces specialization patterns, which are highly path-dependent due to feedback effects in the form of learning. It is hard to judge whether or not a country would have been better off if it had been on a different specialization path due to (initially) closing its economy.

What the model *did* show is that growth rate differentials arise between heterogeneous economies that trade with each other. These differences in growth paths are partly due to demand side effects like income elasticities, and partly due to supply side effects like differential rates of technological change between sectors and countries. Thus, once again the conclusion is that technological change is not something that equally benefits everyone in the world.

The model stresses the interaction between trade and growth, and argues that the possibilities to grow faster than other countries are materialized by an increasing market share in world markets. This is why the model describes the *competitive struggle for growth*. The factor that determines trade performance, and hence growth, is competitiveness. In the theoretical model and in the empirical analysis, competitiveness has been divided into technological competitiveness and wage rate competitiveness.

In a framework where increasing market shares are the vehicle for growth, expansion of the economy beyond the capacity limits is a real threat for some (highly competitive) countries. Therefore, the models contains a negative feedback effect from performance to competitiveness. This feedback mainly works through the labour market, and takes the form of a modified Phillips curve. There is also a technological effect in the form of decreasing marginal returns to learning. Because of the multi-sector context of the model, there is a structural part to growth. Growth rate differentials can arise because of varying income elasticities. Also, specialization patterns are induced by technological advantages (comparative or absolute), the domestic consumption structure, and competitive pressure.

The resulting growth pattern in an open economy that is modelled in this way is best described as *dynamic*. With the exception of some special cases, in which countries and / or sectors are alike or very symmetric, each country will generally generate a growth rate different from that in the rest of the world. This result links up closely to the empirical finding in Chapter 4 that homogeneous groups of countries have shown more similar growth patterns than heterogeneous groups of countries. Moreover, due to the complex (Lamarckian) links between the different variables in the system, the growth rate differential itself is subject to sudden and unexpected shocks.

The empirical analysis of the model highlights the importance of the assumption of variety in the current framework. Regressions undertaken in Chapter 8, testing the specific way of modelling the impact of variety on trade performance, in general support the evolutionary way of modelling, although the evidence is not altogether conclusive.

With regard to the use of patents as indicators of innovation, the regressions in Chapter 8 showed that in the context of explaining the static, structural relation between trade and technology (in manufacturing) that is often found in other work (Dosi *et al.* 1990), significant and positive relations can be obtained. This result was also reached in previous work on the subject. However, using the same data in the dynamic context proposed in the model in Chapter 7, where the motion of market shares is explained by the level of competitiveness, patent variables behave in a

much more unexpected way. Many of the estimated coefficients have a negative sign, as opposed to positive signs in the structural, static approach. As a preliminary explanation for this phenomenon, the specific role of patents as indicators of the (international) appropriation of technology was alluded to. Due to imitation and the presence of multinationals, patents might not be a very good indicator of innovative power in an international dynamic context. For example, patents are generally assigned to the country where the research lab of the applicant is located, but the application of the knowledge embodied in the patent might well take place in another country. In the current framework, this tendency might lead to a negative correlation between patents and growth of export market shares. This puts forward the interesting issue of the role of multinational corporations and low-wage countries in the process of international appropriation of knowledge. However, the exact nature of this relation is beyond the scope of this thesis, and requires more research.

Whereas the regressions in Chapter 8 show the merits of the approach with regard to trade alone, empirical analysis in Chapter 9 has shown the usefulness of the general approach of linking trade to growth in the dynamic evolutionary way proposed. Using the estimated values of the evolutionary elasticities from Chapter 8, the value of competitiveness (defined as the expected percentage point additions to the growth rate differential of a country in manufacturing) are calculated. Regressions using these data show that there is a highly significant relation between competitiveness and structural differences between countries on the one hand, and aggregate (manufacturing as well as total GDP) growth rate differentials on the other. Other variables which could not be taken into account in the framework of Chapter 8, such as fixed capital accumulation and the degree of specialization of the economy, are shown to have a significant influence as well. Despite the significance of these variables, the explanatory power of the regressions is generally low. This deficiency was attributed partly to the lack of good indicators for various aspects of competitiveness.

One specific issue in the estimates was the role of openness in the relation between trade and growth. In order to test for this, a number of nonlinear regressions were set up. Together with the linear regressions, these showed the limits of the approach followed in Part Three with regard to countries that have relatively closed economies, especially the large ones like the USA and Japan. The more open a country, the higher the influence of competitiveness on growth. Thus, the model in Chapter 7 needs to be enhanced with regard to the domestic side of the economy in order to give a more complete description of growth for countries that are not so open.

An additional case study approach in Chapter 9 showed the importance of variety for explaining growth paths of the Asian NICs. The good performance of these countries, which had already been observed in Chapter 4, can be explained by several factors among which low wages, specialization and (recently) technological dynamism are at the centre. However, the analysis also showed that even in this limited sample of Asian 'tigers', there is not one single recipe for growth. Each of the countries has its own specific way in which high growth rates were achieved.

10.4. The Connection to Other Fields of Research on International Growth and Technology: Possibilities for Further Research

The issue of international growth and technological change has been approached in this thesis from a macroeconomic perspective. Although the models proposed here are not very similar to the ones the current macroeconomic literature focuses on (see for example Blanchard and Fischer 1989), the basic equations underlying them can be found in other (older) parts of the macroeconomic literature. While the above discussion shows that a number of interesting points emerge from this approach, it would also have been possible to treat the main themes from a different perspective.

Two of these alternative frameworks which are quite close to the main methodological, evolutionary ideas underlying this thesis, and therefore come to mind directly, are the fields of *national systems of innovation* (Freeman 1986, Lundvall 1992, Nelson 1992 and the four contributions in Part V of Dosi *et al.* 1988), and the (mostly nonformal) part of the field of *industrial economics* that focuses on firm level dynamics of international production (Cantwell 1990), including such issues as the behaviour of multinational corporations (Cantwell 1989) and interfirm cooperation (in R&D) (Hagedoorn and Schakenraad 1992). A much more elaborate discussion of the possibilities of both fields is in Soete (1991).

The importance of the effects of multinational corporations has already been outlined when discussing the paradoxical results of the regressions in Chapter 8. But it is not only the presence of multinationals that makes industrial organization relevant. Basically, the dynamics that have been described in Parts Two and Three take place at the firm level. Competition takes place between firms rather than nations. And although it is justifiable to treat all firms in a country as a group, as was done in the above, performing the analysis at the firm level most certainly will add to the understanding of the dynamics of international trade and growth.

Recently, a lot of work on interfirm technology agreements has been done (for example Hagedoorn and Schakenraad 1992). Most of this work can be seen as concentrating on the question as to what determines technological strengths and weaknesses of firms, and how this affects their willingness to share inputs and costs in the innovation process with other firms. As such, 'traditional' issues such as diversification, vertical integration, protection of technologies, market structure, etc. are relevant to this field of research. Thinking about the application of this line of research leads to the question as to what is the relation between all these industrial organization topics and the topic of the current thesis. To what extent does the specific Japanese corporate structure influence the trade and growth performance of this country? What is the role of market structure upon innovativeness in an international context? What role does technology transfer between national units of multinational firms play? To what extent can small and open economies rely on the presence of multinational firms for their technological strength? Will international technological cooperation between firms facilitate knowledge spillovers, and under what circumstances will cooperation take place? All these questions are highly relevant to the central topic of this thesis, and might be answered by looking in more detail at the field of industrial organization.

Of course, a great deal of work in the field of industrial organization falls under the heading of mainstream theory, and is thus subject to the critique that much of the current thesis has centred around. The narrow optimization perspective taken by much of the work in this field does not easily conform to the evolutionary view proposed here. Nevertheless, there are a number of interesting lines of research in the branch of industrial organization, among which those mentioned by Cantwell and Hagedoorn and Schakenraad, which seem to be more close to the evolutionary view, are perhaps the most prominent. It would be a useful exercise to see to what extent an integration between this work and the current macroeconomic approach could take place, much along the same lines along which new growth theory has combined Solow's model and the more traditional work from the field of industrial organization.

A second useful road for integration might be the recent work on *national systems of innovation*. The central idea in this field of research is that countries differ with regard to the general nature of institutions (government policy, educational systems, legal framework, managers attitude towards risk, etc.) influencing technological change. It is argued that each country has a specific system, which may or may not place it in an advantageous position at some point in time. One of the ideas in this field which is very close to the current topic, is the link between differences in national systems and performance (for example Freeman 1986). As such, this line of research provides an important way of analyzing one of the central themes of this thesis: national differences in technological capability. In much of the above analysis, these differences, despite their crucial importance for the line of the argument, have remained largely unexplained. They were either assumed to depend on policy variables (Part Two), or modelled in a very stylized way (Part Three). Therefore, the theory about national systems of innovations provides a useful way of further specifying one crucial issue in the current approach.

However, if one wants to integrate these two lines of research, one has to deal with the differences in methodological approaches. The current perspective has been one of formal methods, using models and statistical analysis. However, the most fruitful way to analyze national systems of innovation is by means of a descriptive, case study-like approach. The reason for this is obvious: Factors like institutional frameworks, (qualitative) government policy and legal issues are not easy to quantify in a model, and even harder to measure and put into a statistical analysis. Therefore, if one tried to apply a narrow formal framework to the issue of national systems, this would probably result in a loss of the most important benefits of the approach.

On the other hand, it is also clear that the current way in which national systems are analyzed could benefit from the increased use of formal methods. Due to the descriptive nature of much of the work, the evidence is fragmented, and open to doubts with regard to the generality of the results. Therefore, the conclusion that a compromise between both methodological frameworks would be most fruitful seems obvious. In any case, the collection of new, internationally comparable data on institutions and policy variables seems to be a promising way of integrating these two lines of research.