Technology, Growth and Trade: Schumpeterian Perspectives

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TECHNOLOGY, GROWTH AND TRADE

Schumpeterian perspectives

by

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TECHNOLOGY, GROWTH AND TRADE SCHUMPETERIAN PERSPECTIVES

SUMMARY

This is an attempt to apply Schumpeterian theory to the study of "international economics". The first chapter gives a brief outline of the Schumpeterian perspective, considers how it may apply (and has been applied) to the study of international economics and presents some preliminary hypotheses, to be further developed and tested in later chapters. Chapter 2 uses the Schumpeterian model of innovation-diffusion as a framework for the study of "why growth rates differ" between countries, while chapter 3 extends the analysis to include international trade - or "competitiveness" - as well. The main finding of chapters 2-3 is that differences in the growth of national technological activities, whether measured through R&D or patent statistics, contribute significantly to differences in economic growth and export performance across countries. Chapter 4, which focuses on the relation between innovation-diffusion, structural changes in world trade and export performance, extends the analysis of the preceding chapters to the multi-sector frame-work. The results show that the structural changes in world trade in the Post-War period were most favourable for countries with a high level of national technological activity, an advanced export structure and a large domestic market. However, the rapid growth in world trade in this period did at the same time allow countries on a lower level of economic and technological development to catch up through imitation and exploitation of cost-advantages. The countries least favourably affected were small countries with a high level of income and costs, but a relatively low level of national technological activity. Chapter 5 considers the problems of small, developed countries in more detail, using the Nordic countries as illustrations, while chapter 6 uses the same empirical material to discuss the implications of innovation-diffusion for changes in specialization patterns/intra-industry trade. The final chapter (7) contains summary and conclusions.

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Statement

This thesis has not, whether in the same or a different form, been submitted to this or any other University for a degree.

Aalborg, 23.06.88

Jan Fagerberg

CHAPTER 1

SCHUMPETERIAN PERSPECTIVES ON GROWTH AND TRADE

1.1 INTRODUCTION

This study attempts to apply Schumpeterian theory to the study of growth and trade. Why? One important reason, to be discussed below, relates to the problems encountered by researchers brought up in the neoclassical tradition when confronted with Post-War empirical evidence on growth and trade. Another, to be set out following sections of this chapter, rests in the authors belief in the fruitfulness of Schumpeterian theory when coming to grasp with these problems.

From a historical point of view, the period from the end of the Second World War to the early seventies was characterized by exceptionally high and stable economic growth. At the same time there have been large differences across countries in the rates of growth. Countries like the United States and Great Britain, for example, have experienced much lower growth than most other countries, whereas for instance Japan has had a rate of growth far above the average. According to the neoclassical theory of growth, the growth of a country is a function of the growth of the factors of production and the growth of free knowledge (exogenously given). Hence, we should expect the differences in growth between countries to be explained by differences in the growth of the factors of production. But even the most thorough studies have not succeeded in explaining the differences in growth between countries in this way. This fact is sometimes referred to as "the growth paradox" (Andersen (1984)).

During the last decades, many countries have found themselves in a situation where balance of payments problems have put restrictions on the growth of domestic demand and employment. In many cases, unused capacity, rising unemployment and balance of payments problems have coexisted for a considerable period of time. These problems, which are generally referred to as "competitiveness problems", cannot be easily approached by a theory based on neoclassical equilibrium assumptions. Following these assumptions, prices and quantities will always adjust, and full capacity utilization, including labour, and balanced trade will always be ensured. Thus, to be theoretically consistent, students of competitiveness problems have always had to start by assuming a certain amount of "imperfection" or disequilibrium in the markets. The most popular story of this kind, accepted by many macro-economic modelers, predicts that if the level of unit labour costs in a country grows relative to other countries, this will cause the market shares of the country, domestically as well as abroad, to decline, with detrimental effects for the external balance, economic growth and employment. However, though widely accepted, these predictions are not necessarily supported by empirical findings. On the contrary, as Kaldor (1978) has pointed out, a reverse relation can be established for several countries and time spans, i.e. that increasing relative labour cost corresponds to increasing market shares and vice versa. This is often referred to as "the Kaldor paradox".

The strong growth in the Post-War period has been accompanied by an even stronger growth in international trade. At the same time, trade has to an increasing degree been of an "intra-industry" character (Grubel and Lloyd (1975)). That means that a country, instead of exporting on set of commodities and importing another, ends up by exporting and importing products that belong to the same commodity groups. As a consequence, the structures of production and trade among the industrialized countries have become increasingly similar, i.e. they have become less and less specialized. This clearly contradicts what should be expected from traditional neoclassical trade theory (the Heckscher-Ohlin theory). According to this theory, the very advantage of taking part in international trade is based upon the opportunity for each country to specialize in the production of commodities that make extensive use of factors of production with which the country concerned is relatively well equipped. Thus, following this theory, we should expect countries to be increasingly specialized through trade. We may label this "the specialization paradox".

The growth paradox, the Kaldor paradox and the specialization paradox are three examples of problems which, in spite of considerable research efforts, have not yet been solved through developments based on neoclassical theory. This, of course, is no proof that it cannot be done. Nevertheless, it may be taken as an indication that it may prove fruitful to search in other directions for a theory of growth and trade that is consistent with what we can observe empirically. Further indications of this can be found in the research that, building on assumptions other than those of neoclassical equilibrium theory, has tried to explain the phenomena referred to above. In fact, it can be shown[1] that this research, to a much larger extent than generally acknowledged, has found its theoretical basis in the works of Schumpeter. This, we shall argue, is no coincidence.

1.2 SCHUMPETER'S PERSPECTIVE

What basically distinguishes Schumpeter from the neoclassicals is the role he attributes to innovation. According to Schumpeter, innovation is the source of economic growth (and growth in capital and labour), not the other way around:

> "What we, unscientifically, call economic progress means essentially putting productive resources to uses hitherto untried in practice, and withdrawing them from the uses they have served so far. This is what we call "innovation" (Schumpeter(1928), p. 378)
> ".. the general expansion of the environment we observe -increase of population included-is the result of it .." (ibid, p. 377)

His concept of innovation is wide and covers both the introduction of a new product in a new context, the application of a new method of production or raw material, and the introduction of a new form of organization.[2] The capitalist

[1] See section 3 of this chapter.

[2] See, for instance, Schumpeter (1928), p. 377-8 and Schumpeter (1934), p. 66.

system differs, according to Schumpeter, from other social systems by the fact that technological progress (innovation) has been endogenized and become a condition for the reproduction of the system. Indeed, he points out, "the atmosphere of industrial revolutions - of "progress" - is the only one in which capitalism can survive" (Schumpeter (1939) p. 1033). It is this endogenous revolution of production and consumption patterns that Schumpeter labels "the process of creative destruction" (Schumpeter (1943) p. 83) - a label which since has been widely used (and misused).

Technological competition

The process that, according to Schumpeter, secures that "the process of creative destruction" goes on, is technological competition between the firms, which he describes vividly as follows:[3]

> "Economists are at long last emerging from the stage in which price competition was all they saw. As soon as quality competition and sales effort are admitted into the sacred precincts of theory, the price variable is ousted from its dominant position. However, it is still competition within a rigid pattern of invariant conditions, methods of production and forms of industrial organization in particular, that practically monopolizes attention. But in capitalist reality as distinguished from its textbook picture, it is not that kind of competition which counts, but the competition from the new commodity, the new technology, the new source of supply, the new type of organization (the largest-scale unit of control for instance) - competition which commands a decisive cost or quality advantage and which strikes not at the margins of the profits and the outputs of the existing firms, but at their foundations and their very lives" (ibid. p. 84).

[3] It should be noted that this model was outlined much earlier by Marx. However, Marx was mainly concerned with process innovation. Schumpeter extended the framework by taking into account both product and process innovation.

A firm that successfully carries through an innovation, may sell its product at a higher price or produce at a lower cost than its competitors, and obtains in this way higher rate of profits than the average. "It is the premium put upon successful innovation in capitalist society and is temporary by nature: it will vanish in the subsequent process of competition and adaptation" (Schumpeter (1939) p. 105). To remain more profitable than other firms, a firm will have to be continuously more innovative than the average.

Clustering

According to Schumpeter, innovations are not evenly distributed across industries or through time:

> "... on the contrary they tend to cluster, to come about in bunches, simply because first some, and then most, firms follow in the wake of successful innovation; second, that innovations are not at any time distributed over the whole economic system at random, but tend to concentrate in certain sectors and their surroundings" (ibid. p. 100 f).

Why? In Schumpeterian theory, an entrepreneur is not the same as a risk taker. On the contrary, he points out, "risk bearing is no part of the entrepreneurial function" (ibid. p. 104). An entrepreneur is essentially a person who is much more creative than the average. This is a talent for which Schumpeter assumes limited supply. In addition, since it is much easier to follow in the wake of an important innovation than to make one, he assumes that most entrepreneurs will prefer the former. This is what Schumpeter labels "swarming" and describes as follows:

> "Then other entrepreneurs follow, after them still others in increasing number, in the path of innovation, which becomes progressively smoothed for successors by accumulating experience and vanishing obstacles. We know the reasons why this is likely to happen in the same field or in- technologically, as well as economically - related fields: although in some respects a successful innovation will make other innovations easier to carry out in any field, it primarily facilitates them in the lines in which it may be directly copied as a whole or in part or for which it opens up new opportunities. Consequences begin to make themselves felt overall in the system in perfectly logical concatenation" (ibid. p. 131).

The logic, then, is the following: Important innovations depend on the supply of entrepreneurs and are relatively rare. However, when an important innovation has occurred, this will induce other (minor) innovations in the same and related industries or sectors. The original and the induced innovations create a cluster that for some time will be the source of strong economic activity.

Business cycles and long waves

The fact that innovations do not take place evenly over time, but gather in clusters, causes, according to Schumpeter, business cycles of varying lengths. Long waves, of fifty years or so, are the results of interactions between a large number of shorter cycles. He mentions three long waves: The first from the end of the eighteenth century until around 1840 (the industrial revolution), the second from then until around 1900, related to steam and steel, and a third from the turn of the century onwards related to electricity, chemical, large-scale industry and the internal combustion engine.

Figure 1. BUSINESS CYCLE

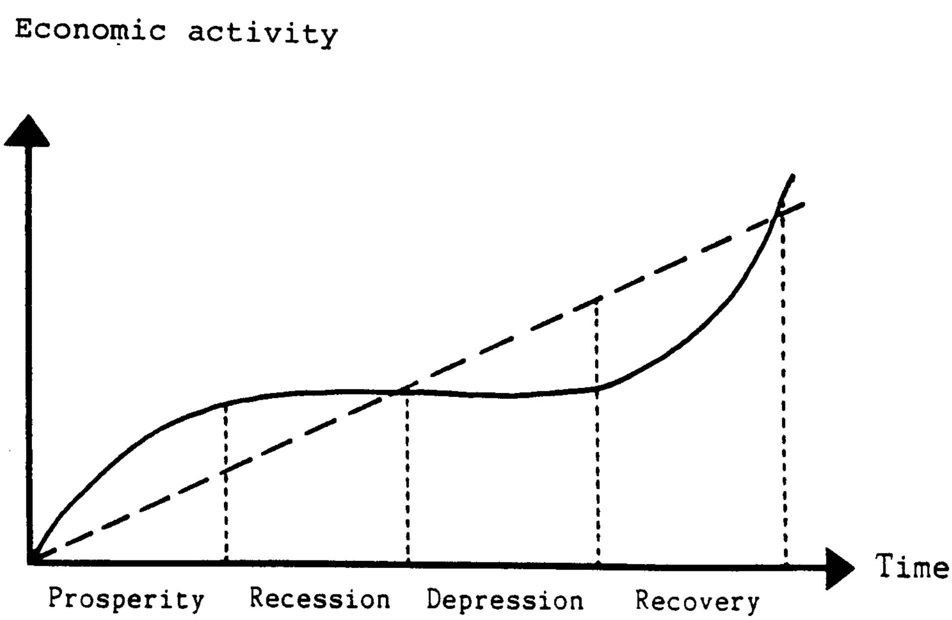


Figure 1 shows Schumpeter's division of a business cycle into phases. During the prosperity phase, the expansive effects of the cluster of innovation will spread through the economy and cause strong growth. This will partly take place through the induced demand for capital goods, and partly through increased demand for consumption goods, caused by an overall increase in employment and wages.[4] As the expansive effects work their way through the system, the economy proceeds to a new phase, recession:

> "We may note, again, that recession besides being a time of harvesting the result of preceding innovation, is also a time of harvesting its indirect effects. The new methods are being copied and improved, adaptation to them or to the impact of the new commodities consists in part in "induced inventions"; some industries expand into new investment opportunities created by the achievements of entrepreneurs, others respond by rationalization of their technological and commercial processes under pressure, much dead wood disappears" (Schumpeter (1939) p. 143).

In a sense, prosperity may be interpreted as a (positive) divergence from a steady state growth path.[5] Similarly, recession

[4] ".. for the new demand, first of the entrepreneur and then of those who extend operations (...) is, directly and indirectly, chiefly demand for labor". (Schumpeter (1934), p. 248)

[5] The use of the concept "steady state" is due to the author, not to Schumpeter, and is used for pedagogical purpose only. In Schumpeter's works, the concept of equilibrium plays the role of a "reference solution", i.e. a description of what would happen if no innovations occur. He explicitly denounced the use of the concept of a "moving equilibrium" because in his view "what really happens is destruction of equilibria in the received meaning of the term" (Schumpeter(1928), p. 369). It must be emphasized, therefore, that according to Schumpeterian logic, the economy will never settle down on a steady state growth path. On Schumpeter's use of the concept of equilibrium, see Schumpeter(1928).

may be interpreted as convergence towards a steady state. However, at the same time, new factors develop that cause a new (negative) divergence (depression). During the depression an extensive restructuring of production will take place, and sooner or later tendencies will occur that reverse the process and brings the economy on a path towards a steady state again (recovery, ibid. p. 149 ff). However, Schumpeter strongly emphasized that there is no guaranty for a quick and painless transition from depression to recovery, and that it is not at all certain that the most innovative firms are those which will survive the depression:

> "in particular it often liquidates and weeds out firms which do not command adequate financial support, however sound their business may be, and it leaves unliquidated concerns which do command such support, although they may never be able to pay their way" (ibid.).

Competitive versus trustified capitalism

It may be objected that Schumpeter's writings on business cycles, especially long waves, to some extent remind more of a description of history than of a theory of self-repeating cycles of specific lengths. In fact, Schumpeter himself strongly emphasized that these theories were tied to a historically given institutional setting:

> ".. it should be emphasized once more that our model and its working is, of course, strongly institutional in character. It presupposes the presence, not only of the general features of capitalist society, but also of several others which we, no doubt, hold to be actually verified, but which

> are not logically implied in the concepts either of economic action or of capitalism. Our argument rests on (abstractions from) historical facts which may turn out to belong to an epoch that is rapidly passing. In this sense the analysis presented has, in fact, itself been called historical" (ibid. p. 144).

The historical facts to which Schumpeter refers are the existence of capitalist institutions and attitudes and a system of relations between firms which he labels "competitive capitalism". By this Schumpeter means a system where the firms are led by entrepreneurs, and where the relationships between the firms are regulated through technological competition. As opposed to this he puts "trustified capitalism", where the innovation process has been institutionalized within large enterprises, and where neither technological competition between firms, nor the entrepreneurs, matter any longer. In the latter case, the tendency to mechanization of progress has been brought to the extreme, and "any technological improvement which is becoming "objectively possible" tends to be carried into effect" (Schumpeter (1939) p. 108 f). The innovation process, according to Schumpeter, should in this case be expected to be far more continuous, and the tendency to clustering as well as business cycles far weaker, than in competitive capitalism Schumpeter(1934), p. 230).

Schumpeter recognized that there was a clear tendency in the direction of "trustification", but emphasized that this development at the time of writing had not gone far enough as to require changes in theory. He also expressed belief that this would not happen for a long time to come (he suggests 50 - 100 years (Schumpeter (1943) p. 163)). The essential, according to Schumpeter, is not whether the firms on average become larger[6], but whether the system of technological competition between firms still works or not:

> "Even in the world of giant firms, new ones rise and others fall into the background. Innovation still emerge primarily with the "young" ones, and the "old" ones display as a rule symptoms of what is euphemistically called conservatism" (Schumpeter (1939) p. 97).

The emphasis on technological competition (innovation and diffusion) as the driving force of capitalist development is probably the most basic element in Schumpeter's economic thinking and constitutes in our view his main contribution to economic theory. His analysis on long waves, though incorporating important insights on the systemic character of the process of innovation and diffusion, are more descriptive in character and depend to a larger extent on specific historic circumstances. However, this does not imply that they are not useful. In recent years, there has been a revival of interest for his theory of long waves, and several researchers have attempted to develop

[6] Contrary to this, many interpretations of Schumpeter(see, for instance, Kamien and Schwartz (1982)) emphasize that Schumpeter believed large firms to be more innovative than small firms (and monopolistic firms more innovative than firms working in perfectly competitive markets). However, these interpretations make too much out of a few polemic remarks in his Capitalism, Socialism and Democracy (1943) on contemporary anti-trust policy in the US. As is apparent from above, if a distinction between firms with respect to innovative ability is to be made, Schumpeter was more concerned with the differences between new and old firms, than between large and small firms. Regarding the distinction between imperfect and perfect competition, Schumpeter's point is not that the former is more conducive to innovation than the latter, but that the latter represents an empty set (see the quotation on p. 5).

these parts of his theory further. We will return to this in the fourth section of this chapter.

1.3 THE INTERNATIONAL CONTEXT

Schumpeter himself did not, to our best knowledge, extend his analysis to include international trade, even if the level of analysis in Business-Cycles (1939) was the three largest capitalist countries of that time: the United States, Germany and Great Britain. However, when Leontief in 1953 established that the pattern of specialization in US foreign trade seemed to be the contrary of what the Hecksher-Ohlin theory predicted (the United States was shown to export labour-intensive products and import capital- intensive ones), a need for an explanation arose, and several researchers began to search in new directions. Many of these came to adopt Schumpeterian perspectives on the working of the economy, especially the idea of technological competition as the driving force of capitalist development.

The availability theory

One of the first attempts to use technological competition as a framework for analysis of international trade was made by Kravis (1956). In a paper inspired by Leontief's findings, Kravis presented the hypothesis that the US industry, because it was more knowledge intensive and innovative than the industries of other countries, would be a main producer of products from knowledge- (or skill-) intensive industries and firms. As a consequence, the United States would at any time produce a large number of new knowledge-intensive products that, because of lags in the transfer of production technology, would only be available in the United States. Thus, prospective buyers of these products in other countries would, for a period of time, be left with no other choice than to import these products from the US. Kravis held this to be a reasonable explanation of the finding that US exports seemed to be more labour intensive (or skilled-labour intensive) than US imports.

The technology-gap theory

This model, which was only quite roughly outlined in Kravis's paper, and without reference to Schumpeter, was later further developed by Posner (1961). Posner, who was clearly inspired by Schumpeter, introduced two new concepts to explain the diffusion process: demand lag and imitation lag. Demand lag is the time it takes from a product is introduced in the innovating country until it is demanded in the imitating country. Imitation lag is accordingly the time from the product is introduced in the innovating country until it is produced in the imitating country. The difference between the two lags - the net lag as Posner labels it - indicates the length of the period in which the innovating country will export the product to the imitating country without facing any competition from domestic producers there.

Even though a general tendency towards diffusion may be traced, this does not, however, imply that diffusion necessarily will take place. Posner discusses to some degree factors that contribute to a large net lag or block diffusion entirely. He mentions, among other things, the organization of the markets (the degree of monopoly) and technological barriers (static and dynamic economies of scale, especially the effect of continuous learning and induced innovation processes in the innovating country). He also considers the case where one country succeeds in being permanently more innovative, or "dynamic", than another. According to Posner, this may create a situation where the "dynamic" country continuously improves its terms of trade relative to the "less dynamic" country, with unfavourable consequences for the external balance and growth of the latter.

During the 1960's several sector studies based on technology-gap assumptions appeared, as, for instance, Freeman (1963, 1965 and 1968) and Hufbauer (1966). The method was to study the development of important innovations in one sector, and then examine how the diffusion process developed with regard to production and trade. These studies, concentrating mainly on the chemical and electronic industries, confirmed by and large the underlying hypotheses. However, the length of the lags varied considerably between products, industries and countries. Walker (1979) comments this as follows:

> "As is apparent from above, the technology-gap theory's main shortcoming was a rather naive view of the mechanisms behind the transfer of production from one country to another; imitation was overemphasized, capital mobility (and monopoly powers) underemphasized. As a consequence, the theory lacks precision in its predictions of the timing and direction (to which countries) of production transfers"

(Walker,1979,p.18.)

On a macro level, technology-gap assumptions were used by Gomulka (1971), Cornwall (1976, 1977) and others to explain differences in growth between countries ("the growth paradox"). The method was to regress growth, or productivity growth, on a proxy for the scope of imitation (based on GDP per capita) and other variables assumed to influence growth. Even though these models turned out to explain a large part of the actual differences in growth between countries, they were - as pointed out by Pavitt (1979-1980) - essentially convergence models. Differences in innovative performance across countries were excluded from the empirical analysis. As a consequence of this and other omissions, some of the differences in growth between countries continued to be unaccounted for (for example, the industrial growth of United Kingdom has been significantly below what Cornwall's model predicts).

The product-cycle theory

A related theory that seeks to give a more precise prediction of the process of innovation and diffusion was developed by Vernon (1966). Vernon's theory is based on three elements; a theory of technological competition (à la Schumpeter), a theory of the relation between the different stages of diffusion and the technological requirements (that most of all resembles Marx[7]),

[7] What Vernon and Marx have in common is that they both assume technological competition to lead to the introduction of capital-intensive techniques. In the case of Marx, this led to the formulation of the famous law of the falling rate of profit.

and Linder's (1961) theory on the importance of the domestic market for innovation and diffusion.

According to Vernon, new products are generally unstandardized and produced by skill-intensive production methods. In this early phase, prices will be high and growing, because production costs are high and demand generally grows faster than supply. However, in the course of time, products and technologies will gradually standardize, and this makes it easier for new suppliers to start production. But as new competitors arrive, price competition becomes gradually more important. Increasing standardization of products and processes, together with greater emphasis on price competition, increases the scope for introducing capital-intensive forms of production based on the exploitation of static economies of scale. Thus, in the late stages of the product-life cycle, production methods are likely to be capital intensive.

Like Kravis, Vernon assumes that new products originate in the United States. The reason for this, Vernon sees, in approval of Linder (1961), in the high income level and the advanced demand structure in the United States. This is assumed to give US producers incentives and possibilities to develop new, advanced products that initially are demanded in the US only, but subsequently will be demanded in other countries as well, depending on their levels of income. As the product matures and price competition hardens, costs of transportation and changes in the composition of demand in the markets make it profitable to start production in other countries as well. For very standardized products, where price competition is severe and the exploitation of static economies of scale through capital-intensive methods of production very important, a transfer of production to a low-cost country will be of interest. Thus, a story may be constructed where the United States exports (skilled) labour-intensive goods and imports mature, but capital-intensive goods, from less-developed, low-cost countries.

It is easy to see that Vernon's theory gives a possible solution to the so-called Leontief paradox. But to what extent is this perspective confirmed by empirical research? Wells (1972) reviews some of the research that has originated from Vernon's theory. According to Wells, the Linder part of the theory - that countries specialize in products where domestic demand is important, i.e. that a complementarity exists between the export structure, the level of income and the structure of consumption, has been confirmed by several studies. Also the hypothesis that, in late stages of the product cycle, the production of products will have a tendency to be transferred to low-cost countries (developing), has, according to Wells, proven to be fruitful-although the number of studies at the time of the review was fairly modest.

A more critical evaluation of the product cycle theory and the empirical evidence may be found in Walker (1979). His main objection is that the two most important hypotheses of the theory, that products will gradually standardize, and that production will be gradually more capital intensive and based on the exploitation of static economies of scale, have never been thoroughly tested. He discusses this in relation to three selected sectors: textile machinery, chemicals and consumer electronics. In the case of textile machinery, Walker found no tendency to either standardization of the products or a change towards more capital-intensive methods of production. Within chemicals there was a tendency toward standardization of the products, but continuous process innovation prevented a standardization of the production process and, in combination with an oligopolistic market structure, slowed down or blocked the transfer of production to other countries, especially the developing ones. For consumer electronics one could also trace a tendency to standardization of the products without a corresponding standardization of the process of production. Another characteristic feature of consumer electronics was that continuous process innovation contributed to the maintenance of the labour-intensive character of the production process. Walker, therefore, concludes that even in cases where the tendency toward standardization of products is quite manifest, technological competition through process innovations will prevent the type of standardization of production technology - and the associated relocation of production - that the product-cycle theory predicts.

Another shortcoming, pointed out by a.o. Vernon himself (Vernon, (1979), Caves(1982) and Mansfield(1982)), is that the theory does not take the increasing importance of multinationals with world-wide activities (MNE's) sufficiently into account. If the innovator is a MNE, this may according to these writers significantly shorten (or abolish altogether) the period where the innovating country exports the product in question, since the MNE is free to locate production in other countries than the innovating one. Thus, MNE's should to some extent be expected to speed up the process of diffusion and counteract the tendencies towards delayed or blocked diffusion emphasized by Walker. However, as pointed out by Vernon (1979), this is probably more relevant for large countries than for small countries.

However, in spite of these shortcomings, the product-cycle theory often remains a fruitful framework (or starting point) for applied work. Even if the concept of maturity is a difficult one, it is hard to deny that products (and often also industries) mature and that transfer of production takes place, though at different paces and to different degrees. Rosenberg(1982), for instance, points out that in a historical perspective

> ".. the transfer of industrial technology to less developed countries is inevitable. (..) the central questions are not whether industrial technologies will be transferred, but rather when it will happen, where it will happen, which technologies will be transferred, how they will be modified in the process, and how rapidly this process will occur." Rosenberg(1982, p.270)

Walker has, however, satisfactorily shown that the product-cycle theory is not valid as a <u>general</u> theory of diffusion or transfer of production (from high- to middle- and low-income countries).

Innovative efforts

The starting point for Kravis, Posner, Vernon and others was an attempt to explain the specialization pattern of US trade from a model where new products originate in the United States and subsequently, at a varying pace, diffuse to other countries. However, by the end of the sixties it was not longer evident that the United States was the technological leader in all areas. As a consequence, the perspective of world trade as a medium for "catch-up" processes (through imitation), with other countries converging to, but not surpassing, the United States as a technological leader, became partly obsolete. To analyse the development on the technological frontier, the framework had to be broadened to include both innovation and diffusion processes.

In the last part of the sixties, Vernon and his associates at Harvard started to model and test the US lead in new technologies and products as the result of innovative efforts. In a paper from 1967, they ranked American industry according to R&D intensity (expenditures on research and development as a share of gross production value), and showed that the United States had over-average market shares in R&D-intensive industries. They concluded, therefore, that "All roads lead to a link between export performance and R&D" (Gruber, Metha and Vernon (1967)). In a later paper (Gruber and Vernon (1970)) they examined the relation between export specialization and industry structure for a larger group of countries, where the export and the industry structures were classified in terms of "research intensive", "capital intensive" and "work intensive (unskilled)". However, the test, which used a classification of industries based on US data, gave significant results for a few countries only.

The method of using the research intensity of American industry as a basis for international comparisons has been criticized by several authors. The industries that are the most research-intensive in the United States, it is argued, need not be the most research-intensive in other countries as well. An alternative method would be to start from national research statistics and calculate the research intensity for different industries or products for each country. This was done by Walker (1979), who found a significant and positive relation between export growth/growth of the market share, and research effort/research intensity for aircraft, "chemicals, rubber and plastics", drugs, ferrous metals and instruments for the period 1963-1973. However, for electrical as well as mechanical machinery, no significant correlation between exports and research efforts was found, even not for the most research-intensive industries/parts. One possible explanation of the poor results for these industries may be that several of the factors that influence the process of innovation in these industries are not included in the term "research and development expenditures" (R&D).

On this background Soete has proposed to substitute R&D (a "technology-input measure") by patents (a "technology-output measure") as a measure of innovativeness. Because national patent statistics are of quite varying quality, Soete chose to use foreign patents in the United States as basis for the analysis (this provides comparable figures for all countries except the United States). In a series of studies, Soete and others (Soete (1978, 1981, 1987), Pavitt and Soete (1980), Dosi and Soete (1985)) tested the correlation between export performance on the one hand, and patent activity, supplemented by other variables assumed to affect exports, on the other, for a number of OECD countries. These studies demonstrated a significant and positive correlation between the ranking according to exports per capita and patent activity per capita for a large number of industries, including, for instance, the machinery sector (except consumer durables) and a large part of the chemical sector.

In summary, this section has shown the fruitfulness of applying a Schumpeterian perspective to the study of international trade. In particular, applications of his model of technological competition to Post-War experience have increased our understanding of specialization patterns[8] and diffusion processes (on a micro as well on a macro level). Still, it is fair to say that the contributions discussed so far have been rather limited both in scope an methods. In most cases, they have either used convergence assumptions, overemphasizing diffusion and underemphasizing innovation aspects, or limited themselves to static (cross-sectional) analysis of specialization patterns. Thus, the fundamental dynamic character of Schumpeterian thinking has not yet been adequately reflected in most applied research.

[8] On this, see also Hufbauer(1970).

1.4 NEO-SCHUMPETERIAN PERSPECTIVES ON LONG RUN ECONOMIC DEVELOPMENT

Schumpeterian-oriented research on growth and trade has so far concentrated on applications of the theory on technological competition to the relation between countries. As shown in the preceding section, this has been a fruitful trajectory to follow. But at the same time, important parts of Schumpeter's perspective have been left out, especially his emphasis on the relation between innovation-diffusion, structural changes and long-run economic growth. Part of the reason for this is probably that these parts of Schumpeter's theory - especially his theory on long waves - have been considered with great skepticism by most economists. However, in the wake of the economic set-back in the industrial world after OPEC I, there has been a revival of interest for these parts of Schumpeter's work, and a considerable amount of new research has been initiated. Among the most important contributions from recent years are Mensch (1979), Clark, Freeman and Soete (1982), Freeman (1983) and Van Duijn (1983). In the following we shall have a closer look at some of these (neo-Schumpeterian) contributions in order to see to what extent they may be linked to the study of growth and trade.

A major point in neo-Schumpeterian theory is that the innovation process has certain laws of its own. For an innovation to occur, a set of needs (to which the innovation responds) and a set of selected, technological principles (by which the innovation is carried out) must exist. Dosi (1983) has coined the concept "technological paradigm" for the specific combination of needs and selected, technological principles which characterize a specific innovation. A technological paradigm is to a large extent assumed to define the possibilities for further developments (or "natural trajectories" as Nelson and Winter (1977, 1982) label them), such as the scope for improvements, applications of the innovation in new contexts, development of methods to reduce the costs attached to the exploitation of the innovation, etc.

Clark, Freeman and Soete (1982) have introduced the concept "technological system" to cover the dynamics of an interrelated set of technological paradigms, innovations and natural trajectories . A technological system will, according to this view, during its life span go through certain phases. The growth will - as outlined by Schumpeter - follow a S-curve with an introductory phase, a prosperity phase, a recession phase and a depression phase. Through this lifespan a change of emphasis will take place from product innovation to process innovation (cost-reducing innovation). The length of the different phases may, however, vary strongly between different technological systems, and the course of development may also be interrupted by new innovations (Van Duijn (1983)).

A long wave may originate because of a new technological system, if this is of great importance, or because of a complex of technological systems that reinforce one another, if their introductory phases coincide (Clark, Freeman and Soete (1982)).

It has been shown (Mensch (1979), Clark, Freeman and Soete (1982)) that fundamental innovations have had a tendency to cluster in certain periods of time (for example in the thirties). There are several possible causes for such coincidences that are discussed in the neo-Schumpeterian literature, from long-run cycles of investments in the production of raw materials (Rostow (1983)) or economic infra-structure (Van Duijn (1983)), to social and institutional barriers for innovativeness that are built up during the long wave and broken down in the crisis (Mensch (1979)), or, more general, interactions between technological and institutional systems with different dynamic properties (Perez(1983)). A more agnostic view can be found in Clark, Freeman and Soete (1982). According to these writers, long-run cycles in economic activity and innovativeness may be the outcome of several factors, of which some may be of a historically specific nature.

Most researchers on long waves - including those who are skeptical to the theory - agree that long-run periods of economic growth or stagnation may be defined. Even though there are different views on the periodization, most of them are no more than relatively small variations or updates of Schumpeter's initial proposal. It should be noted, also, that several researchers (see, for instance, Kleinknecht (1984)) in recent years have found evidence that Post-War growth could be described as a "Schumpeter-boom", characterized by a strong correlation between growth and innovation across industries. Thus, even if considerable disagreements remain on the timing and causation of long waves, there seems to be plenty of support for the (weaker) proposition that capitalist development is characterized by alternating long-run periods of growth and stagnation, where each growth period is linked to the diffusion of a specific set of technologies or technological systems.

1.5 SOME PRELIMINARY HYPOTHESES ON POST-WAR GROWTH

To what extent may the approach presented in the previous sections be applied to the problems outlined in the introduction to this chapter? This is the question to which we now turn.

A long wave, in the (weak) sense outlined above, may be seen as a disequilibrium process along two connected dimensions. The first dimension relates to disequilibria between industries: Some industries, related to new technological systems, grow much faster than the average. Examples from the Post-War period are electronics, chemicals and consumer durables.[9] The second dimension relates to disequilibria between countries and regions: Not only does growth depend more on some technological systems than others, but these growth-inducing technological systems are also more strongly related to certain countries or regions than to others. Thus, there is a coupling between economics and geography[10] that we may label a "centre-periphery" dimension

[9] See chapter 4.2 for a more thoroughgoing treatment of this question.

[10] It should be noted that this coupling between economical and spatial factors has for long been in the focus of interest of regional economics, see especially the contribution by Perroux(1955).

within the long wave. In the Post-War period, the United States, though increasingly contested by Japan and some European countries, has played the role of "centre country" in the above sense.

The countries in the centre, the "technological frontier" countries, are characterized by a developed technological infrastructure and a high level of institutionalized innovative activity. They specialize in innovative, skill-intensive goods with a high unit-value. Because of this, they have to, and can afford, to pay high wages compared to most other countries. Since the demand for these goods generally grows faster than average, the changing commodity composition of international trade should be expected to be favourable for these countries.

Countries in the periphery, on the other hand, are at the outset in a less favourable position. They produce goods for which demand generally tends to grow more slowly than the average, and are in this sense unfavourably affected by the structural changes in international trade. To some extent, they can compensate for this by winning market shares in declining markets. However, if the purpose is to increase the level of income in the country, this is no viable strategy in the long run, because of the increasing price competition that characterizes the drive towards maturity. What they have to do, therefore, is to transform their industrial structure by imitating the countries in the centre and increasing their own innovative efforts. If successful in this process, they may in the long run be able to approach the economic and technological level of the leader countries, and, eventually, surpass them. Thus, countries that succeed in increasing their innovative activities and other efforts related to the economic exploitation of innovation and diffusion faster than other countries, should also be expected to grow faster than other countries on a comparable level of development.

The extent to which a country manages to take part in the international process of innovation and diffusion should also be expected to have crucial effects for its export performance. A country that does not succeed in this, runs the risk of losing market shares both domestically and abroad. Firstly, because the industrial structure of the country will be gradually less adapted to the structure of demand both domestically and abroad. Secondly, these problems are likely to be accentuated further because price competition usually hardens as industries mature. In the long run this is likely to cause chronic balance-of-payments problems, often combined with repeated devaluations, and slower growth than in other countries. This will in turn provide less room for increased growth in factor rewards. Thus, we should not necessarily be surprised to find that a country that loses out in the international process of innovation and diffusion, may experience both declining market shares and declining relative unit labour costs, and vice versa. This is consistent with the findings of Kaldor (1978) mentioned earlier (the so called "Kaldor paradox").

To what extent a country in the periphery succeeds in taking part in the international process of diffusion will also have important implications for its pattern of specialization in international trade. In the early phases of the diffusion process, successful "catching up" through imitation will show up in reduced import dependency. If successful, then, on the domestic market, firms are likely to exploit the accumulated experiences to engage in exports, first to regional markets, then to other markets. Empirically, this will show up declining export specialization and increasing intra-industry trade. As pointed out earlier, this is consistent with what is actually observed in the Post-War period(the "specialization paradox").

Thus, following a Schumpeterian perspective, what seems paradoxical from the viewpoint of established neoclassical orthodoxy, is not necessarily so paradoxical after all. What remains to be seen, of course, is to what extent the preliminary hypotheses outlined here can be developed into testable models and to what degree these can be shown to be supported by empirical evidence. This is what we attempt to find out in the chapters that follow.

CHAPTER 2

'WHY GROWTH RATES DIFFER'

2.1 INTRODUCTION

This chapter focuses on the importance of creation and diffusion of technology for differences in economic growth across countries.

The question of how technology and growth relate is not a new one. Already the classical economists discussed this question extensively. But attempts to study this relation empirically are of much more recent date. In fact, with one exception (Tinbergen(1942)), the first attempts were made in the mid/late 1960s (Domar et al.(1964), Denison(1967)). The next section discusses how this question is treated in some influential Post-War studies on "why growth rates differ" between countries. Generally, these studies either ignore technological differences between countries or treat them as accidental and transitory. Diffusion is assumed to take place relatively automatically, either as free knowledge or through the addition of new vintages of capital to the capital stock . The role of innovation is normally ignored, except in the case of the technological leader country, and then treated in a very superficial way. Thus, the models underlying these studies can generally be characterized as "convergence-to-equilibrium models". No surprise, then, that these studies have difficulties in explaining phenomena such as "changes in technological leadership" or the existence of "laggards.

This chapter develops a simple model of "why growth rates differ" in which economic growth is assumed to depend on three factors: diffusion of technology from abroad, growth in the country's own technological activities and growth in the country's capacity to the exploit the possibilities offered by available technology, whether domestically created or diffused to the country from the international economic environment. In contrast to many other approaches to the subject, this model does in principle allow for both convergence and divergence between countries. In the final part of the chapter, the model is tested on a sample containing data for 27 developed and semi-industrialized countries between 1973 and 1983.

2.2 LESSONS FROM PREVIOUS RESEARCH

Studies of why growth rates differ between countries may roughly be divided in three groups: (a) "catch-up" analysis, (b) "growth accounting" and (c) "production-function" studies. Let us consider these approaches one at a time[1].

[1] The purpose of the following is to discuss some main characteristics of post-war research in this field, not to give a complete survey. For survey articles covering the whole or parts of this field, the reader is referred to Chenery(1986), Choi(1983), Kendrick(1981a), Maddison(1987), and Nelson(1981).

(a) "Catch-up" analysis

The idea that differences in economic growth between countries are related to differences in the scope for imitation is normally attributed to Veblen(1915). Since then, several economic historians have analysed problems related to industrialization and growth from this perspective[2].

More recently, Abramovitz(1979, 1986) and Maddison (1979, 1982, 1984, 1987) have applied this perspective to the differing growth performance of a large sample of industrialized countries. According to these writers, large differences in productivity levels between countries (technological gaps) tend to occur from time to time, mainly for historical reasons (wars etc). When a technological gap is established, this opens the possibility for countries on a lower level of economic and technological development to "catch up" by imitating the more productive technologies of the leader country. Since these writers hold technological progress to be partly capital embodied, they point to investment as a critical factor for successful "catch up". They also stress the rôle of demand factors, since demand is assumed to interact in various ways with investment and the pace of structural change in the economy. For instance, the deceleration of productivity growth in the last decade is partly explained in this way. They mention the importance of

[2] See, for instance, the works by Gerschenkron(1962) and Landes(1969).

institutions, but do not discuss this in detail, because of the methodological difficulties that are involved.

The works by Abramovitz and Maddison are to a large degree descriptive, and as such they are very useful. They convincingly support their arguments by comparing data for productivity levels and economic growth/productivity growth across countries, and these comparisons are sometimes supplemented by descriptive statistics/simple statistical tests. Other scholars working in this tradition have extended these tests in various ways and reached similar results (Singer and Reynolds(1975), Cornwall(1976,1977)). However, they all concentrate on diffusion processes and ignore innovation aspects. As pointed out already by Ames and Rosenberg(1963), writers in this tradition have great difficulties in analysing phenomena such as developments in leader countries[3], changes of leadership[4] and the existence of "laggards".

(b) "Growth accounting"

For many years, Kuznets and his colleagues devoted much effort to the construction of historical time series for GDP and its major components (national accounts). Post-War "Growth accounting" studies grew to some extent naturally out of this work. While

3 "..the forces animating growth in the lead countries are more mysterious and autonomous than in the follower countries,.." (Maddison(1982), p.29)

4 See, however, Abramovitz' instructive, but inconclusive discussion of possible factors influencing change of leadership in Abramovitz(1986),p.396-405.

national accounts presented decompositions of GDP, growth accounts attempted to decompose the growth of GDP. The first Post-War analysis of this type was carried out by Abramovitz(1956) in a historical study of the US. What he did was to sum up the growth of inputs (capital and labour), using "prices" or factor shares as weights, and compare the result with the growth of output as conventionally measured. The result, that about one half of actual growth[5] could not be explained in this way, and had to be classified as unexplained total factor productivity growth, surprised many, including Abramovitz himself:

> "This result is surprising ... Since we know little about the causes of productivity increase, the indicated importance of this element may be taken to be some sort of measure of our ignorance about the causes of economic growth." (Abramovitz(1956),p.11)

Abramovitz discussed briefly possible explanatory factors behind this large residual, emphasizing research, education, learning by doing and economies of scale. From this, researchers have followed different paths in "squeezing down the residual", as Nelson(1981) puts it. One has been to embody as much as possible of technological progress into the factors themselves, as suggested by Jorgensen and Griliches(1967)[6]. Another, following

[5] According to the numbers presented by Abramovitz, US NNP-growth over the period 1869/78 to 1944/53 equaled 3.5 %, of which 1.8% could be attributed to growth of inputs, and 1.7% was left as unexplained. Similar, if not identical, results were reported by Solow(1957), Kendrick(1961) and Denison(1962).

[6] Jorgensen and Griliches originally claimed that the residual could be eliminated altogether, but later retreated from this position. See the debate between them and Denison(Denison(1969), Jorgensen and Griliches(1972)) on this

Abramovitz's suggestions, has been to add other explanatory variables, thereby reducing the unexplained part of the residual, which, following Solow(1957), is normally attributed to technical change.

Denison was the first to apply this latter methodology to the study of why growth rates differ between countries(Denison(1967), Denison and Chung(1976))[7]. Regarding technology, Denison's works rest on a view very similar to the one which characterizes most "catch-up" analysis. For instance, differences in innovation between countries are completely ignored[8]. But his interpretation of the sources of Post-War growth differs to some extent from Abramowitz and Maddison. Some of Denison's main results are summarized in table 1 below.

subject.

[7] The study by Domar et al., published a few years earlier(1964), did not take into account other factors than growth in capital and labor.

[8] Cf. for instance the following programmatic remark by Denison: "Because knowledge is an international commodity, I should expect the contribution of knowledge - as distinct from the change in the lag - to be of about the same size in all the countries examined in this study." (Denison(1967),p.282)

TABLE 1. "WHY GROWTH RATES DIFFER" (DENISON)

	1950 - 1962			1953-1961
	US	Western Europe(1)	Italy	Japan
Growth(2)	3.4	4.7	6.0	8.1
Of which:				
Labour	1.1	0.8	1.0	1.9
Capital	0.8	0.9	0.7	1.6
Residual(TFP)	1.4	3.0	4.3	4.6
Of which:				
Technology	0.8	1.3	1.7	1.4
Resource allocation	0.3	0.7	1.4	1.1
Scale factors	0.4	0.9	1.1	2.0
For comparison: National income per person employed(3)	100	59	40	55

(1) Belgium, Denmark, France, Germany, Netherlands, Norway and United Kingdom.
(2) The columns do not always add up because of rounding errors and other minor adjustments not reported here.
(3) In 1960 US prices (except Japan 1970)
Sources: Denison(1967), ch. 21, and Denison and Chung(1976), ch. 4 and 11.

As is apparent from table 1, the results indicate a close connection between the size of the residual and the level of development. This could of course be interpreted in support of the catch-up approach. But Denison attributes about 2/3 of the differences in residuals between the United States and the rest of the countries covered by his investigation to other factors (improvements in resource allocation and the exploitation of economies of scale). In fact, when these factors are adjusted for, only France and Germany among the Western European countries seem to catch up in terms of technology. In his 1967 study, he therefore concludes[9]:

> "On the surface, to reduce the gap greatly would not seem very difficult if the businessmen, workers and governments of a country really wished and were determined to do so.(..) In contrast to this a priori impression of possibilities, the historical record up to the early 1960's, at least, suggests that either the desire is lacking or imitation is a very difficult thing; most countries seem to have made little progress." (Denison(1967), p. 340)

However, when Denison discusses the contribution from increased exploitation of economies of scale, what he mainly refers to is increased aggregate productivity caused by increased productivity in the production of durable consumer goods. But where does the technology used to produce consumer durables come from, if not from the United States? In fact, the 1950s and 1960s are exactly the periods when the production of consumer durables spreads from the United States to Europe and Japan. A similar argument can be made for structural changes. Without the growth of new industries based on imported technology, such as, for instance, consumer durables, would these changes have taken place to the same extent? Thus we will argue that Denison's conclusions rest on rather shaky assumptions, and that it is quite probable that he

[9] However, in his 1976 study of Japan, he acknowledges that in this case, "There was, in other words, a major element of "catching up".."(Denison and Chung(1976),p.49)

seriously understates the importance of diffusion of technology from the United States to Europe and Japan in this period[10].

On a more general level, the preceding discussion illustrates a major weakness in growth-accounting analysis. As pointed out by Nelson(1973,1981), most of the variables which the growth accountants take into account are interdependent, and without a theory of how these variables interact, decompositions cannot claim to be more than mere illustrations of the growth process[11]. To explain differences in growth between countries, it would be necessary to distinguish between "active factors" ("engines of growth"), and more "passive factors", which, though permissive to growth, cannot themselves be regarded as causal, explanatory factors, and the relations between the various factors would have to be worked out. Furthermore, the contribution of innovation to economic growth, not only in the US, but everywhere, would have to be included in the analysis[12].

10 More recently, Kendrick(1981b) has published a study of the growth of nine OECD countries between 1960 and 1979. This study is based on Denison's methodology, but contrary to Denison's analysis, it attributes a large part of the final residual to "catching up", especially in the period 1960-1973.

11 "..some of the recent studies seem to imply that somehow the growth accounts really explain growth. I do not see how they can. A growth accounting is not a tested theory of growth."(Nelson(1973), p.466)

12 It should be noted that Kendrick(1981b) in a growth-accounting study of nine OECD countries between 1960 and 1979, made an attempt to quantify the contribution to growth in each country from cumulative national R&D outlays, but according his calculations, this contribution was negligible.

(c) "Production-function" studies

As noted, the growth accounting exercises relate the growth of output to various input factors. Solow(1957) was the first to provide a formal theoretical framework for this type of analysis[13]. Following standard neoclassical equilibrium assumptions (perfect competition, full capacity utilization, full employment, no economies of scale etc), he assumed that production (Q) could be related to technology (A) and the factors of production (capital(K) and labour(L)) in the following way:

$$(1) \quad Q(t) = A(t)\ F(K(t),L(t))$$

Let small case letters denote rates of growth. By differentiating, dividing through with Q, and substituting the partial elasticities of output with respect to capital and labour, El_{QK} and El_{QL}, into the equation, we arrive at:

$$(2) \quad q = a + (El_{QK})k + (El_{QL})l\ ,$$

Since under neoclassical assumptions the partial elasticity of output with respect to labour, El_{QL}, equals the workers' share

[13] The purpose of what follows is only to discuss some problems related to applications of neoclassical production functions to cross country samples. I do not in any way attempt to survey the development of neoclassical growth theory or the theoretical controversies that followed. For a good (but old) survey of growth theory, see Hahn and Matthews(1964). Pasinetti(1974) provides an exciting introduction to both to the development of the neoclassical growththeory and the subsequent controversy from a post-Keynesian point of view.

(s_L), and the partial elasticity of output with respect to capital, El_{QK}, the capitalists' share (s_K) of net output, the rate of growth can now be written as the sum of the rate of growth in the capital stock, weighted by the capitalists' share in net output, the rate of growth in the labour force, weighted by labour's share in net output, and the rate of growth of "technology" (or "total factor productivity growth"):

(3) $q = a + s_K k + s_L l$

Equation (3) obviously provides a theoretical justification for growth accounting, even if the underlying assumptions are much stronger than those which underlie most applied work in this area. But Solow's work did also represent the starting point for econometric studies of "why growth rates differ" between countries. Chenery(1986) provides a summary of some of the main results from econometric applications of production functions on cross-country samples consisting of less developed, semi-industrialized or developed countries. One result is that Solow-type production-function models explain very little of the observed differences in growth between semi-industrialized or less-developed countries. According to Chenery, the main reason for this is that the equilibrium conditions which underlie the neoclassical approach do not hold for these countries. He concludes that

> "In particular, disequilibrium phenomena are shown to be more significant for the former(semi-industrialized) than for the latter(developed). Thus, although neoclassical theory is a useful starting point for the study of growth,

> it must be modified substantially if it is to explain the essential features of economies in the process of transformation"(Chenery(1986),p.13-14)

Following this line of argument, several attempts have been made to extend the production function approach by adding other explanatory variables, reflecting various types of disequilibria which exist within countries[14]. The main arguments in favour of this may be summarized as follows. Many countries, especially developing countries, are often assumed to have a "dual" economy, consisting of a high-productivity modern sector and a low-productivity traditional sector. In this case, it is argued, a mere transfer of resources from the traditional sector to the modern sector should raise growth. A similar perspective is often applied to the relation between the export sector and the rest of the economy, because the export sector is often assumed to be more productive than other sectors.

A recent application of this methodology to a sample of semi-industrialized countries may be found in Feder(1986). He estimates a neoclassical production function, with variables reflecting the development of exports and manufacturing production added, on a cross-country data set for the period 1964-1973. When compared with Denison's estimates for countries on a comparable level of development (Italy and Japan in the fifties), some important differences emerge. First, the combined contribution of capital and labour explains about 2/3 of actual growth, compared to between 1/3 and 1/2 in Denison's

[14] For reviews of this literature, as well as empirical evidence, see Choi(1983), ch.5-6 and Chenery(1986).

calculations. Second, the contribution of capital is relatively more important in Feder than in Denison. Third, Feder does not distinguish between economies of scale and other factors related to reallocation of resources. Fourth, Feder totally ignores the contribution of innovation and diffusion. The latter is of course the most striking. Following this approach, the question of "why growth rates differ" between countries can be answered without any references to technology.

TABLE 2. SOURCES OF GROWTH IN SEMI-INDUSTRIALIZED COUNTRIES 1964-1973(FEDER)

	Regression coefficient	Contribution to growth
Growth		6.4
Of which		
Labour	0.766 (3.73)	1.8
Investment	0.135 (2.96)	2.7
"Residual"		1.9
Of which		
Exports	0.246 (2.96)	0.5
Manufacturing	0.809 (3.68)	1.5
"Constant"	-0.002 (0.132)	-0.2

R^2(adjusted) = 0.75
N = 29

The contributions do not add up because of rounding errors.
The numbers in brackets are t-values.
Source: Feder(1986), tables 9.9-9.10, Model V'.

However, there are important methodological problems here. To what extent can the introduction of disequilibrium conditions be defended within a framework which assumes equilibrium from the start? The pure neoclassical growth model, as set out by Solow and others, pretends to explain economic growth from factor growth and technological progress. But the explanatory power of the model rests solely on the underlying equilibrium assumptions. If these assumptions do not hold, it is not at all clear how an estimated neoclassical growth model should be interpreted. For instance, in a situation when unemployment prevails, it is not obvious that growth in the labour force should be assumed to add anything to economic growth[15]. Furthermore, to what extent can structural changes, though facilitated by the existence of large low-productivity sectors, populated by "surplus labour", be counted as independent, explanatory factors of growth in the same sense as capital accumulation or innovative efforts? Why is it not the other way around, that structural changes are caused by capital accumulation, innovative efforts and growth? Thus, neoclassical students of why growth rates differ seem to be faced

[15] Of course, the labour force variable may still turn up with the expected sign significantly different from zero at the chosen level of significance. But this may simply reflect that the growth of labour force is correlated with other variables that affect growth positively, as, for instance, the level of development.

The correlation between growth in labour supply(POP) and GDP per capita measured in PPPs(T), a much-used proxy for the potential for technology transfer, for the 27 countries included in our sample(see the next sections) was(the numbers in brackets are t-statistics, one star denotes significance of test at the 1% level):

$$\underset{(9.54)^{*}}{POP = 3.16} - \underset{(-5.70)^{*}}{0.23T}, \quad R^2=0.56(0.55)$$

with the following dilemma: Either stick to the traditional neoclassical assumptions. This produces a logically coherent explanation that predicts poorly. Or add additional variables that destroy the original equilibrium assumptions. Then predictions become much better, but the model ceases to explain anything.

Chenery and others should be credited for having shown that the equilibrium conditions on which the production function approach is built, cannot be defended in studies of why growth rates differ. However, they miss their point when they mix together a model built on equilibrium assumptions and factors reflecting disequilibrium conditions, without showing explicitly how the various factors interact and what the fundamental causal factors are. It is disappointing, also, that they generally ignore aspects related to differences in the scope for imitation and innovative performance across countries[16]. In our view, what needs to be done is to study "why growth rates differ" from a theoretical framework which assumes disequilibrium conditions right from the start.

16 I should be mentioned here that there are a few examples of researchers who have estimated neoclassical growth models with some kind of "development-level" variable included (Chenery, Elkington and Sims(1970), Parvin((1975)).

2.3 A TECHNOLOGY GAP THEORY OF ECONOMIC GROWTH

Essentially, the technology-gap theory of economic growth is an application of Schumpeter's dynamic theory of capitalist development, which was developed for a closed economy, to a world economy characterized by competing capitalist nation-states. Following Schumpeter, the technology gap theorists[17] analyse economic development as a disequilibrium process characterized by the interplay of two conflicting forces: Innovation, which tends to increase economic and technological differences between countries, and imitation or diffusion which tends to reduce them. Thus, whether a country behind the world innovation frontier succeeds in reducing the productivity gap vis-a-vis the frontier countries, does not only depend on its imitative efforts, but also on its innovative performance, and on the innovative performance of the frontier countries. Furthermore, even if a country behind the world innovation frontier may succeed in reducing the productivity gap through mainly imitating activities, it cannot surpass the frontier countries in productivity without passing them in innovative activity as well. In general, the outcome of the international process of innovation and diffusion - with regard to the development levels of different countries - is uncertain. The

[17] The major contributors to this development were Gomulka(1971) and Cornwall(1976,1977), but the main arguments were outlined much earlier by Posner(1961), even if Posner's main concern was specialization, not growth. For a more thorough treatment of Posner's work, see chapter 1. More recently Krugman(1979) has constructed a formal model of north-south trade based on similar arguments.

process may generate a pattern where countries follow diverging trends, as well as a pattern where countries converge towards a common mean.

Assume that the level of production in a country (Y) is a multiplicative function of the level of knowledge[18] diffused to the country from abroad (Q), the level of knowledge created in the country (T), the country's capacity for exploiting the benefits of knowledge (C), whether internationally or nationally created, and a constant (Z):

(4) $Y = Z\, Q^a T^b C^e$, where Z is a constant.

By differentiating and dividing through with Y:

(5) $\frac{dY}{Y} = a\frac{dQ}{Q} + b\frac{dT}{T} + e\frac{dC}{C}$

Assume further, as customary in the diffusion literature, that the diffusion of internationally available knowledge follows a logistic curve. This implies that the contribution of diffusion of internationally available knowledge to economic growth is an increasing function of the distance between the total level of knowledge appropriated in the country and that of the country on the technological frontier(for the frontier country, this

[18] In the present context, knowledge means "technological know-how" (knowledge and skills on how to produce goods and services).

contribution will be zero). Let the total amount of knowledge, adjusted for differences in size, in the frontier country and the country under consideration be Q_f and Q^*, respectively:

$$(6)\quad dQ/Q = h - h(Q^*/Q_f)$$

By substituting (6) into (5) we finally arrive at:

$$(7)\quad \frac{dY}{Y} = ah - ah\frac{Q^*}{Q_f} + b\frac{dT}{T} + e\frac{dC}{C}$$

Thus, following this approach, economic growth depends on three factors:

- The diffusion of technology from abroad. The contribution of this factor increases with the distance from the world innovation frontier.

- The growth in nationally produced knowledge

- The growth in the country's capacity for exploiting the benefits offered by available technology, whether created within the country or elsewhere.

The model developed above does of course present a very simplified picture of reality. To do full justice to the Schumpeterian theory outlined above, the world economy should be modelled both from the technology side, characterized by creation, diffusion and contraction of competing technological systems, and from the side of competing nation-states, characterized by different technological levels and trends, institutional settings, and internal structural disequilibria. However, the model differs from the one which until now has dominated most empirical work on technological gaps and economic growth in at least one respect, it incorporates the effects of national innovative performance. As pointed out by Pavitt(1979/1980) and Pavitt and Soete(1982), the omission of the innovation variable in most applied work makes it difficult to explain diverging trends, whether represented by laggards, or related to the question of changes in technological leadership. However, the reasons for this neglect are probably not only rooted in the deep influence of equilibrium or convergence assumptions on current economic thinking, but also on problems related to the measurement of innovation and diffusion of technology across countries. The latter problem will now be considered more closely.

2.4 PRODUCTIVITY, PATERNTS AND R&D

In the preceding section, we defined two concepts related to a country's level of economic and technological development, the total level of knowledge appropriated in the country(Q*), and the level of knowledge created within the country(T).

The first concept (Q^*) refers to the total set of techniques in use in the country, whether invented within the country, or diffused to the country from the international economic environment. Q^* cannot be measured directly. What can be measured, is the resources associated with the use of these techniques ("technology-input-measures") or the output of the process in which these techniques are used("technology-output-measures"). Of the former type, expenditures on education, research and development(R&D) and employment of scientists and engineers may be mentioned. But these data are often of low quality, especially for non-OECD countries. Among the latter, data on patents and productivity may be mentioned. However, since patents primarily reflect innovative (or inventive) activity, not imitation, patent-based measures should be expected to give biased estimates of the level of technological development for countries which rely mainly on imitation as, for instance, semi-industrialized countries. We have, therefore, chosen to use Real GDP per capita as a proxy for Q^*. Since, current prices and exchange-rates are known to produce downward biased estimates of Real GDP per capita for countries with productivity levels well below the world productivity frontier, we adjusted the data on

GDP per capita accordingly on the basis of results obtained by the "United Nations International Comparison Project"[19].

The second concept(T) refers to the amount of technology created within the country, or its domestic "technology base" as opposed to its use of "imported technology". We will label this "national technological activity". This cannot be measured directly either. The most obvious proxies are R&D and patents. R&D reflects to some degree both innovation and imitation, since a certain scientific base is a precondition for successful imitation in most areas(Freeman(1982), Mansfield(1982)), while patents as noted primarily reflect innovation, not imitation. Since patent data also are of a better quality then R&D data for the countries covered by the investigation, patents will in general be preferred. To make the data comparable across countries, we used

[19] The UN study (Kravis et al.(1982)) provides estimates for Real GDP (Nominal GDP adjusted for differences in the purchasing power of currencies) and Nominal GDP for 34 developing, semi-industrialized and developed countries for the year 1975. Since many of the countries included in our sample are not covered by the UN study, we used one of the short-cut methods developed there to estimate a relation between Real and Nominal GDP per capita(r and n) for a sample of countries comparable to ours, and then used this estimated relation to predict Real GDP per capita for the countries of our sample. The estimated relation was (with a dummy for Jamaica (an extreme deviant) included):

$$\ln r = \underset{(1.52)}{1.14} + \underset{\underset{*}{(5.70)}}{1.229} \ln n - \underset{\underset{*}{(-2.82)}}{0.042} (\ln n)^2 - \underset{\underset{*}{(-3.49)}}{0.372} \text{ JAMAICA}$$

N=27
R^2 = 0.99(0.98)

(The numbers in brackets under the estimates are t-statistics, one star denotes significance at the 1% level) a method developed by Soete(1981)[20], which implies that we limit the analysis to patenting activities of different countries in one common (foreign) market. Contrary to Soete who used patenting in the US as indicator, this study uses patenting on the world market[21], which has the advantage that it gives data for the US.

It may be noted that while both Q and T are defined in term of levels of activity (or "stocks"), the chosen proxies are both measures of the output of these activities (or "flows"). The implicit assumption, then, is that the (unmeasurable) stocks are reflected in the (measureable) flows so that, for any pair of countries, a higher stock value means a higher flow value. This is consistent with the view that "stocks" of means of production should be measured in terms of their capacity to produce output (Pasinetti(1973)).

Let us take a closer look at the relation between the proxies. What we should expect, following the technology-gap argument, is that the technologically most advanced countries, in terms of high levels of national technological activity, also are the economically most advanced, in terms of GDP per capita. Since the relation between own and foreign-produced technology should be expected to increase rapidly as the country moves towards the world innovation frontier, the relation between GDP per capita

[20] Soete's works are discussed in more detail in chapter 1.3.

[21] That is: Total patent applications of residents in country x in all countries which report patent applications to WIPO(World Intellectual Property Organization) less patent applications by residents of x in country x.

and measured technological activity should be expected to be log-linear rather than linear, and steeper for patent-based than for R&D-based indices, since the latter to a large degree reflects both imitation and innovation processes.

These hypotheses are tested on cross-sectional data (yearly averages) from the 1973-1983 period. The sample consists of 27 developed and semi-industrialized countries for which data are available (24 for R&D). The following variables are used:

PROD = GDP per capita in constant 1980 US dollar (adjusted for differences in purchasing power of currencies)

RD = Civil R&D as o/oo of GDP

EPA = External patent applications per billion of exports (constant 1980 dollars)

For the sake of comparison with other variables, we have to deflate the total numbers of patent applications filed in other countries (external patent applications) by some measure of size. Soete(1981) used population as deflator, but since the number of patent applications filed in other countries is likely to depend on the importance of the export sector relative to the economy as a whole, this may bias the index (as a measure of national technological activity) upwards for countries where the share of exports in GDP is high, and downward for countries where the share of exports in GDP is low(as for instance the US and India).

Thus, if population is to be used as deflator, such differences in export orientation should be adjusted for. This is the approach adopted in Fagerberg(1987) and chapters 3-4 of this study. However, since this adjustment may produce an arteficial correlation between GDP per capita and the adjusted patent measure, we have in this section chosen to deflate external patent applications by exports.

The results are given in table 3. First, whatever the form of the independent variable, a positive relation between productivity and technological activity exists, significantly different from zero at a 1% level. Second, as expected, the best results are obtained for log-linear models (log for R&D and double-log for patents, which implies a steeper curve in the latter case). Third, the correlation between productivity and patenting is much closer than between productivity and R&D. Note also that in the data matrix, the observations for the countries enter in descending order of GDP per capita (as it was in the early sixties, though). This implies that the Durbin-Watson statistics can be given a special interpretation: It shows whether countries on approximately the same level of GDP per capita tend to have correlated residuals. As is evident from table 3, this is indeed the case for R&D, but not for patents.

Table 3. THE RELATION BETWEEN PRODUCTIVITY AND TECHNOLOGICAL ACTIVITY

(1) PROD = 5.72 + 0.02EPA, R^2=0.45(0.42), SER=2.14, DW=0.72
(9.80)* (4.49)*

(2) PROD = -1.44 + 2.14 lnEPA, R^2=0.72(0.71), SER=1.52, DW=1.58
(-1.25) (8.06)*

(3) PROD = -4.28 + 8.45 lnlnEPA, R^2=0.75(0.74),SER=1.44, DW=1.79
(-3.07)* (8.69)*

(4) PROD = 4.16 + 0.32RD, R^2=0.53(0.51), SER=1.89, DW=1.27
(4.84)* (4.98)*

(5) PROD = 0.49 + 3.21 lnRD, R^2=0.55(0.53), SER=1.85, DW=1.21
(0.33) (5.18)*

(6) PROD = 3.65 + 5.41 lnlnRD, R^2=0.45(0.43),SER=2.04,DW=1.03
(3.33)* (4.27)*

N(1-3)=27, N(4-6)=24

* = Significance at the 1% level at a two-tailed test

SER = Standard error of regression

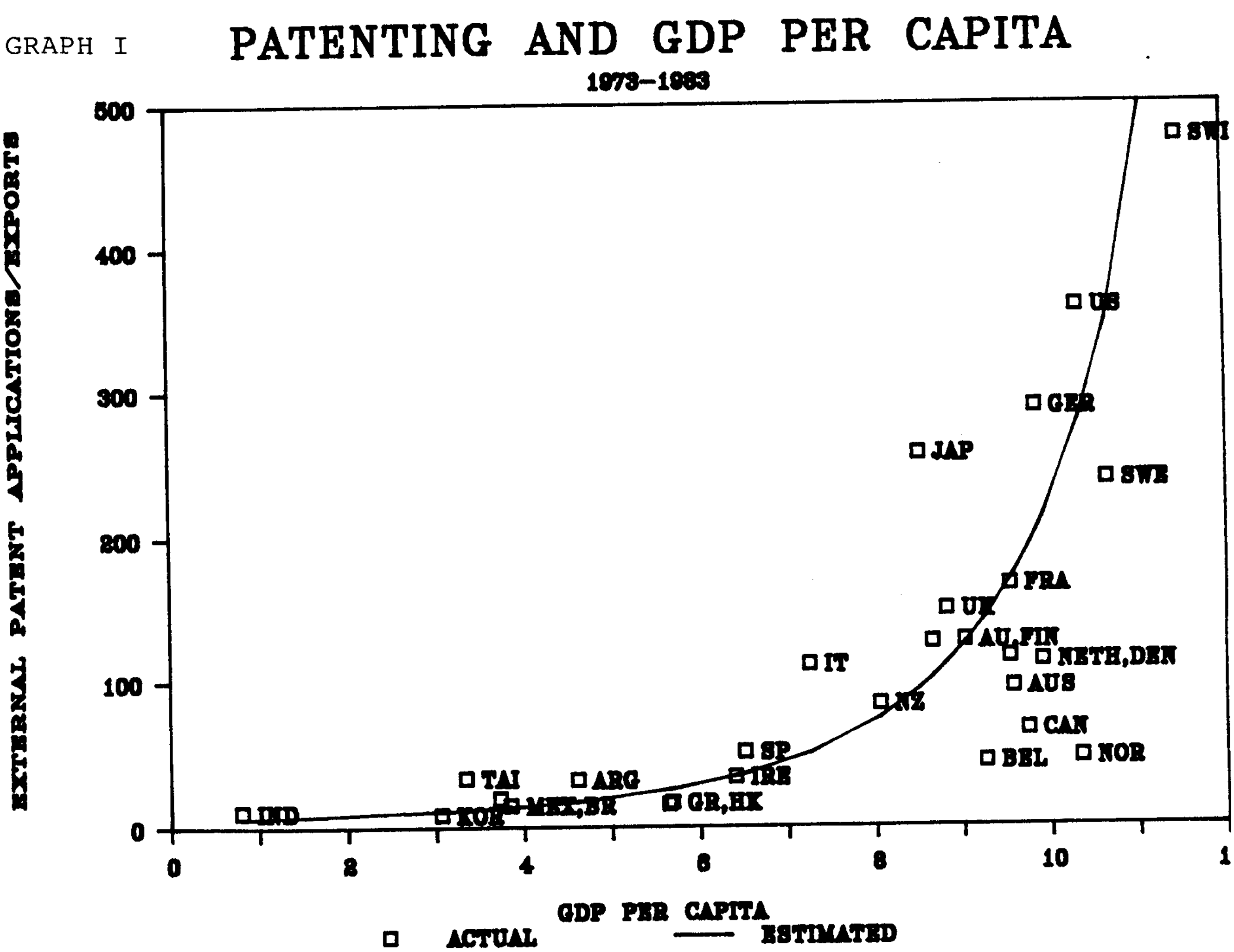
DW = Durbin-Watson statistics

The numbers in brackets under the estimates are t-statistics.

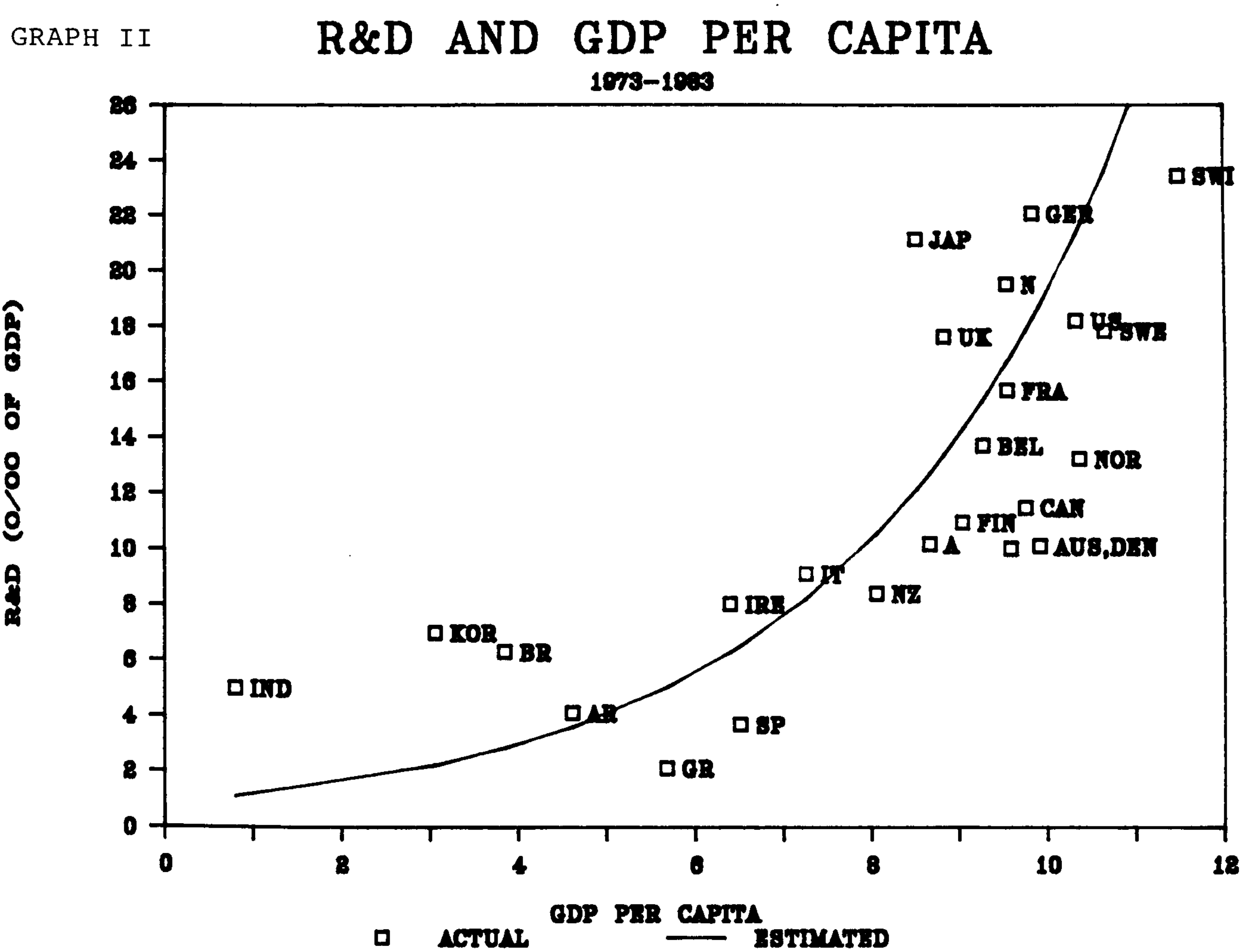
The numbers in brackets after R^2 are R^2 adjusted for degrees of freedom.

Graph 1 plots the actual and estimated number of patents per billion of exports against GDP per capita (model 3 above). As can be seen from the graph, with some exceptions, the countries of our sample fit the regression line quite well. The main source of variance is Japan and a group of small, developed countries headed by Norway. Graph 2, which plots actual and estimated R&D against GDP per capita (model 5 above), shows that the variance in this case is larger. In addition to Japan and the group of small, developed countries referred to above, the variance comes from the semi-industrialized countries, which in most cases show much higher levels of R&D than should be expected, given their levels of GDP per capita. This latter phenomenon is in accordance with the fact that a certain level of R&D is a necessary condition for imitation.

GRAPH I


PATENTING AND GDP PER CAPITA
1973-1983
EXTERNAL PATENT APPLICATIONS/EXPORTS
500
400
300
200
100
0
0
2
4
6
8
10
SWI
US
GER
JAP
SWE
FRA
UK
AU,FIN
NETH,DEN
IT
AUS
NZ
CAN
SP
BEL
NOR
TAI
ARG
IRE
IND
KOR
MEX,BR
GR,HK
GDP PER CAPITA
ACTUAL
ESTIMATED

GRAPH II



R&D AND GDP PER CAPITA
1973-1983
R&D (O/OO OF GDP)
GDP PER CAPITA
ACTUAL
ESTIMATED
SWI
GER
JAP
N
US
SWE
UK
FRA
BEL
NOR
CAN
FIN
A
AUS,DEN
IT
NZ
IRE
KOR
BR
IND
AR
SP
GR
0
2
4
6
8
10
12
14
16
18
20
22
24
26

2.5 PATTERNS OF DEVELOPMENT AND GROWTH

The general picture which emerges from graph 1 and 2 suggests that the countries of our sample may be divided in three or four "groups" depending on the relation between productivity and technological activity:

Group A consists of four countries with high levels of productivity and high levels of technological activity: Switzerland, the United States, Germany and Sweden. These countries are the typical "technological frontier" countries of our sample.

Group B consists of seven countries with medium levels of productivity and medium levels of technological activity: France, UK, the Netherlands, Austria, Finland, Italy and New Zealand. This group of countries is less homogeneous than the other groups. In terms of R&D some of them (France, United Kingdom and the Netherlands) are close to the leader countries, but they patent less, while others have more in common with the semi-industrialized countries or the countries in group C below .

Group C consists of five countries that have high levels of productivity, but relatively low levels of technological activity: Norway, Belgium, Canada, Australia and Denmark (Belgium is close to group B in terms of R&D, but not in terms of patenting). What the majority of these countries have in common, in addition to high productivity and low technological activity, is small size and an industrial structure where production based on natural resources plays an important role.

Group D consists of the semi-industrialized countries of the sample(except India): Spain, Ireland, Greece, Hong Kong, Argentina, Brazil, Mexico, Taiwan and Korea. They have low levels of productivity and patenting, but their R&D efforts vary considerably.

Finally, Japan and India are in a sense "freak cases". In terms of level of technological activity, Japan joins the frontier countries in group A, but GDP per capita is much lower than should be expected. India fits the characteristics of group D in terms of technological activity, but in this case too the level of productivity is much lower than should be expected.

Table 4 gives some further evidence on the patterns of growth of these countries in the last decade. This evidence confirms the type of interpretation of history that normally comes out of applied work on technological gaps and "catch-up" processes. The frontier countries in group A show on average the weakest performance in nearly every respect: Group A countries have lower economic growth, lower level of investments, lower growth in the labour force and less structural change than other countries. The medium-technology countries in group B, and the small, natural-resource based economies of group C, come second and third worst, respectively, in most respects: Economic growth, investments and growth of labour force. (But group B countries compete favourably with group C in two respects, growth of patenting activity and structural change.) However, all developed countries become "laggards" compared to the semi-industrialized countries of group D. On average, group D countries have rates of growth of GDP, patenting activity and labour force between two and three times that of the developed countries, and they also have much higher levels of investments and faster structural change.

It is important to note, however, that there are large differences in growth patterns within group D: The Asian NICs show a much better performance in all respects than Latin American and European NICs, even if the latter countries still have better performance than the developed countries in most areas (though not patent growth). But the distance is not all that large, especially not to group C countries.

The growth pattern of Japan is an interesting mix of the patterns discussed so far. In terms of level of technological activity (and growth of labour supply too), Japan belongs to group A, but in terms of productivity and structural change to group B. However, when it comes to GDP growth, patent growth and investment behavior, Japan shares many of the characteristics of group D countries. In fact, the share of investments in GDP is even higher than that of the Asian NICs.

TABLE 4. PATTERNS OF GROWTH 1973-1983

	GDP growth	Patent growth(1)	Investment share in GDP	STRUCTURAL CHANGE(2) Change in Export-share in GDP	Change in Agriculture as a share of GDP	Population growth	LEVEL OF DEVELOPMENT GDP per capita(3)	External patenting/ exports(3)	R&D per capita
All countries	2.8	5.0	23.6	6.0	-3.6	1.4	1.0	1.0	
Group A	1.3	1.3	20.5	4.8	-1.0	0.8	1.4	3.0	2.0
Group B	1.8	4.6	22.1	7.3	-2.2	0.9	1.2	1.1	1.3
Group C	2.3	3.0	23.2	3.4	-2.0	1.1	1.3	0.6	1.2
Group D	4.4	8.1	25.6	7.5	-5.2	2.1	0.6	0.2	
Of which									
European Nics	2.7	1.1	23.2	8.8	-4.7	1.3	0.8	0.3	0.5
Latin-Am. Nics	3.2	0.8	24.3	3.2	-1.8	2.2	0.5	0.2	
Asian Nics	7.3	22.4	29.1	10.4	-9.2	2.9	0.5	0.2	
Japan	3.7	9.0	31.4	7.9	-2.6	0.8	1.1	2.2	2.1

(1) Growth in external patent applications relative to the frontier country(Switzerland)
(2) Annual change in 0/00
(3) Average = 1

2.6 TESTING THE TECHNOLOGY-GAP MODEL

In the following we are going to use the data just presented to test the technology gap theory of economic growth. As most other studies on "why growth rates differ" between countries, we will do this in the form of a cross-country regression, using ordinary least squares (OLS).

One possible objection to the test is that there may be left-out variables that should have been taken into account. The most obvious candidates, to be considered below, are growth in labour supply (the neoclassical candidate) and changes in the sectoral composition of output and employment(the structural candidate). The neoclassical candidate has already been discussed in some length. Our argument was that the existence of excess labour, or growth of labour supply, though permissive to growth, cannot be regarded as a causal factor in the same sense as the technology-gap variables, especially not as long as unemployment prevails[22]. By the same token, it may be questioned whether there is a real need for additional factors reflecting structural changes in the model, even if one accepts the "dual-economy argument" of large and persistent differences in productivity between sectors. As pointed out earlier on, these changes cannot be analysed independently of the process of technology transfer from abroad

22 This is not to deny that limitations in labor supply may restrict the growth of certain countries in certain periods, but this is not considered relevant in the period under consideration here (1973-1983). Cornwall(1977), however, argues that it was not relevant in the pre-1973 period either.

(diffusion), and the amount of national efforts mobilized in the economic exploitation of technology (investments). Rather than causal factors, such changes should in general be regarded as outcomes of the growth process, much in the same way as growth of GDP itself. However, it may be argued that if institutional obstacles for transfer of resources from one sector to another exist, this may restrain growth. Thus, what we will do is to test the basic technology-gap model with and without variables reflecting structural changes, in order to decide to what degree these variables add something to the explanatory power of the model. However, since it is difficult to test for causation in cross-sectional analyses, these results should be interpreted with care.

The discussion in the preceding paragraph relates the problem of interdependence between variables. For instance, as pointed out by Michaely(1977), growth of gdp and growth of exports (or agricultural production for that sake) should be expected to be correlated, simply because exports (or agricultural production) are included in gdp. But other forms of interdependence are also possible. For example, economic growth may feed back on investments (the accelerator mechanism). Even if this may be true to some extent, and should be taken into account when interpreting the results, available evidence indicates that this feedback mechanism is not sufficient to explain the large and persistent differences in investment ratios across countries.[23]

[23] See chapter 3 for an empirical verification of this on a somewhat smaller sample of countries.

Another possible, though not necessarily probable, form of interdependence runs from the other variables to growth in national technological activity. This, it may be noted, would not be consistent with the Schumpeterian emphasis on innovation as the source of growth (see chapter 1). Furthermore, the observed differences in growth of national technological activities within and between different groups of countries (see section 2.5 and appendix) seem to indicate that growth in national technological activity cannot be reduced to a mere reflection of the growth process itself and the other factors that take part in it. Thus we will continue to regard growth in national technological activity as exogenous with regard to the other variables of the model.

Following the discussion of the previous subsections, we use growth in external patent applications(PAT) as a proxy for growth in domestically created knowledge or "national technological activity", and GDP per capita adjusted for differences in purchasing power of currencies (PROD), as a proxy for the total level of knowledge appropriated in a country. To test for the sensitivity of shift in technology proxies, we have included an additional test with the level and growth of R&D (RD and RDG) as technology proxies. The result, however, should be interpreted with care, since we have fewer observations for R&D than for patents, and R&D data in many cases are of low quality. As in most other studies, the investment share(INV) was chosen as an indicator of the growth of the capacity to exploit the benefits of technology, whether domestically created or diffused to the country from abroad. To avoid spurious correlation, we - following Michaely (1977) - chose the change in the shares of agriculture and exports in GDP (instead of growth of agriculture and exports) as proxies for structural changes.

The following variables were used:

GDP = Average annual growth of GDP at constant prices,

PROD = GDP per capita at constant 1980 prices (dollars) adjusted for differences in the purchasing power of currencies,

PAT = Average annual growth in external patent applications (abroad),

INV = Investments as a share of GDP at constant prices,

RD = Civil R&D expenses as a percentage of GDP

RDG = Annual average growth in Civil R&D expenses (inflation adjusted)

AGR(EXP) = Annual average change in the share of agriculture(exports) in GDP(o/oo).

The results of the test follow in table 5 below.

TABLE 5. THE MODEL TESTED (27 countries, 1973-1983)

1. Basic model

$$GDP = \underset{(0.25)}{0.38} - \underset{\underset{*}{(-3.74)}}{0.24PROD} + \underset{\underset{*}{(4.02)}}{0.12PAT} + \underset{\underset{*}{(3.47)}}{0.20INV}$$

R^2=0.83(0.81)
SER=0.85
DW=2.12
N=27

2. Basic model with dummy for Japan

$$GDP = -\underset{(-0.35)}{0.60} - \underset{\underset{*}{(-3.40)}}{0.22PROD} + \underset{\underset{*}{(3.84)}}{0.11PAT} + \underset{\underset{*}{(3.67)}}{0.23INV} - \underset{(-1.24)}{1.22JAP}$$

R^2=0.84(0.81)
SER=0.84
DW=2.24
N=27

3. Test for effects of changes in agriculture as a share of GDP

$$GDP = \underset{(0.26)}{0.47} - \underset{\underset{*}{(-2.88)}}{0.25PROD} + \underset{\underset{*}{(3.68)}}{0.12PAT} + \underset{\underset{*}{(3.35)}}{0.20INV} + \underset{(0.10)}{0.005AGR}$$

R^2=0.83(0.80)
SER=0.87
DW=2.10
N=27

4. Test for effects of changes in exports as a share of GDP

$$GDP = \underset{(0.53)}{0.81} - \underset{\underset{*}{(-3.85)}}{0.24PROD} + \underset{\underset{*}{(4.54)}}{0.14PAT} + \underset{\underset{*}{(3.65)}}{0.20INV} - \underset{\underset{**}{(-1.74)}}{0.07EXP}$$

R^2=0.85(0.82)
SER=0.82
DW=1.85
N = 27

5. Test for shift of technology proxies

$$GDP = \underset{(0.30)}{0.45} - \underset{\underset{*}{(-2.75)}}{0.18PROD} + \underset{\underset{*}{(3.21)}}{0.11PAT} + \underset{\underset{*}{(3.09)}}{0.17INV}$$

R^2=0.76(0.82)
SER=0.78
DW=1.43
N=22

$$GDP = \underset{(-1.55)}{-1.98} - \underset{\underset{**}{(-2.14)}}{0.62\ RD} + \underset{\underset{*}{(3.55)}}{0.20RDG} + \underset{\underset{*}{(3.08)}}{0.17INV}$$

R^2=0.73(0.69)
SER=0.83
DW=1.75
N=22

* = Significant at a 1% level(two-tailed test)
** = Significant at a 10% level(two-tailed test)
R^2 in brackets = R^2 adjusted for degrees of freedom
SER = Standard error of regression
DW = Durbin-Watson statistics
N = Number of observations included in the test

Generally, the results give strong support to the basic technology-gap model as a model of "why growth rates differ" between countries. The degree of explanation is very high, above 80%, and all variables turn up with the expected signs, significantly different from zero at the 1% level. Since Japan is often regarded as a special case, we also estimated the model with a dummy for Japan, but this did not influence the results. In the case of structural changes, both variables turned up with signs opposite of what should be expected, in the case of exports significantly different from zero at the 10 % level. One possible interpretation of this result is that the slow growth in world demand during this period more than outweighed the the economic benefits from increased export orientation.

Table 6 decomposes the differences in growth between the frontier countries (Group A) and the others (model 1). The following picture emerges:

(1) Differences in growth between the frontier countries and the other groups of developed countries were rather small in the period under consideration, about 1% as a maximum (group C-group A), when Japan is excluded. It is difficult to attribute these differences to specific factors.

TABLE 6 ACTUAL AND ESTIMATED DIFFERENCES IN GROWTH 1973-1983

	Actual difference in growth	Estimated difference in growth	EXPLANTORY FACTORS Diffusion	Innovative activity (growth)	Investment (level)
Group A	0.0	0.0	0.0	0.0	0.0
Group B	0.5	1.1	0.4	0.4	0.3
Group C	1.0	0.9	0.2	0.2	0.5
Group D	3.0	3.2	1.4	0.8	1.0
Of which					
European Nic's	1.3	1.5	1.1	-0.0	0.5
Latin-am. Nic's	1.9	2.3	1.6	-0.1	0.8
Asian Nic's	6.0	5.8	1.6	2.5	1.7
Japan	2.4	3.6	0.5	0.9	2.2
All countries	1.5	1.8	0.7	0.4	0.6

(2) When Japan is included, the differences were larger, about 2.4% (actual) or 3.6% (estimated). The model attributes the higher growth of Japan compared to other western countries mainly to Japan's high growth in national technological activity and the high share of resources devoted to investments.

(3) Within the group of semi-industrialized countries, two distinctly different growth patterns may be observed. The European and Latin-American NICs grow on average 1.5-2% faster than the frontier countries, primarily because of diffusion of technology, but partly also because of a higher share of resources devoted to investments. The Asian NICs, however, grow on average about 6% faster than the frontier countries, and 3-4% faster than the other NICs. The model attributes this latter difference to the rapid growth of the Asian NICs' own technological activities, in combination with high levels of investments.

2.7 CONCLUDING REMARKS

Most studies of "why growth rates differ" between countries have in common that they ignore innovation-aspects and lack a systematic theory of what causes growth to differ. Thus, while useful as descriptions, they do not really explain differences in growth performance across countries.

This chapter has developed a simple, testable, model of economic growth based on Schumpeterian logic. Both this logic, and the subsequent test, point strongly in the direction of a close relation between economic growth and growth of national technological activities. Thus, to catch up with the developed countries, the results obtained here suggest that semi-industrialized countries cannot rely only on a combination of technology import and investments, but have to increase their own technological activities as well.

However, the limitations should also be stressed. For instance, the result that change in export orientation does not add much to the explanation of differences in economic growth across countries in the period under consideration, cannot be interpreted in support of the view that autarky is a viable strategy. What it shows, probably, is that the factors that influence economic growth also influence the growth of exports, or "competitiveness". However, to study the interaction between economic growth, competitiveness and factors influencing the growth process, a more elaborated framework is needed. This is the question to be considered in the next chapter.

APPENDIX

Methods

Growth rates are calculated as geometric averages for the period 1973-1983, or the nearest period for which data exist. Levels and shares are calculated as arithmetic averages for the period 1973-1983, or the nearest period for which data exist. Changes in shares are calculated as total change in the share between 1983 and 1973, divided by the number of years(normally ten) ((s(t1)-s(t0))/n).

Sources

A.

Real GDP per capita, 1980 market prices in US $,
Growth of gross domestic product at constant prices,
Agriculture, Exports and Gross fixed capital formation as a share of GDP:

OECD countries: OECD Historical Statistics 1960-1983

Taiwan: Statistical Yearbook of the Republic of China 1984

Other countries: IMF Supplement on Output Statistics and UN Monthly Bulletin of Statistics

For Switzerland and New Zealand, data for Agriculture as a share of GDP were not available, so the data for these countries are estimates(based on employment).

B.

External patent applications:

OECD countries: OECD/STIIU DATA BANK

Other countries: World International Property Organization(WIPO): Industrial Property Statistics, various editions and unpublished data

The OECD data are adjusted WIPO data. Data for the non-OECD countries are compiled from published WIPO statistics except for Hong Kong, Korea and Taiwan 1975-1983 where data are compiled by WIPO from unpublished sources.

C.

R&D :

The R&D data are estimates based on the following sources:

OECD countries: OECD Science and Technology Indicators, Basic Statistical Series (vol B(1982) and Recent Results(1984)).

Other countries: UNESCO Statistical Yearbook(various editions) and various UNESCO surveys on resources devoted to R&D.

Military R&D expenditures were, following the OECD, assumed to be negligible in all countries except the US, France, Germany, Sweden and the UK. The R&D data for these countries were adjusted downward according to OECD estimates. The estimates were taken from OECD, Directorate for Science, Technology and Industry: The problems of estimating defence and civil GERD in selected OECD member countries(unpublished). For other countries, civil and total R&D as a percentage of GDP were assumed to be identical.

D.

Growth of labour force (Population between 15 and 64):

OECD Historical Statistics 1960-1983, OECD National Accounts(various editions), UN Monthly Bulletin of Statistics(various editions) and Statistical Yearbook of the Republic of China 1984.

Table A1 DATA USED IN REGRESSIONS (Chapter 2)

	PROD	EPA	RD	PAT	RDG	INV	AGR	EXP	GDP
US	10.32	3708.80	1.82	-5.38	6.25	17.94	-1.90	0.56	1.84
GER	9.84	2844.45	2.21	-7.50	7.17	21.14	-0.90	6.76	1.64
FRA	9.54	1591.75	1.57	-5.58	6.39	21.98	-2.70	5.67	2.30
UK	8.83	1322.29	1.76	-6.58	4.37	18.40	-0.90	3.84	1.00
CAN	9.75	647.01	1.15	-4.70	6.91	22.46	-1.30	1.55	2.36
AU	8.66	1100.08	1.02	-5.60	7.46	25.44	-2.10	12.21	2.34
BEL	9.26	409.38	1.37	-6.98	1.17	20.46	-1.50	7.83	1.68
DEN	9.91	1126.47	1.01	-4.64	3.02	19.94	-1.40	6.78	1.50
NETH	9.54	1109.31	1.95	-6.44	0.14	20.22	-1.20	5.74	1.38
NOR	10.35	486.76	1.32	-6.64	4.32	30.06	-1.90	0.49	3.86
SWE	10.65	2545.56	1.78	-5.86	9.68	20.04	-0.60	4.17	1.56
SWI	11.49	5476.25	2.34	-8.02	0.82	23.06	-0.42	7.82	0.32
FIN	9.03	1154.94	1.09	4.08	7.00	26.28	-2.00	4.85	2.76
AUS	9.58	914.70	1.00	-2.10	NA	22.86	-3.83	0.31	2.24
NZ	8.06	677.52	0.84	0.06	2.93	22.48	-4.60	8.92	1.20
JAP	8.52	2189.21	2.11	0.94	10.63	31.36	-2.60	7.86	3.72
IT	7.26	809.34	0.91	-3.66	3.72	19.68	-2.00	9.76	1.80
IRE	6.40	217.41	0.80	-4.24	3.64	26.34	-7.63	16.45	3.64
GR	5.68	94.17	0.21	-11.31	2.72	22.40	-2.40	4.79	2.38
SP	6.51	332.73	0.37	-5.22	3.13	20.76	-4.10	5.20	1.98
BR	3.85	56.90	0.63	-5.64	NA	25.37	-3.18	1.10	4.40
ARG	4.61	148.86	0.41	-10.80	3.49	23.23	0.36	4.43	0.62
HK	5.65	87.74	NA	8.80	NA	29.98	-1.00	4.56	7.66
TAI	3.35	113.23	NA	16.90	NA	28.00	-16.82	10.53	7.04
MEX	3.73	73.85	NA	-5.31	NA	24.43	-2.48	3.93	4.58
IND	0.80	8.57	0.50	-8.45	5.35	23.07	-17.80	-0.17	3.87
KOR	3.06	26.41	0.70	17.57	16.01	29.46	-9.90	16.07	7.20

CHAPTER 3

INTERNATIONAL COMPETITIVENESS

3.1. INTRODUCTION

This chapter focuses on the interaction between technology, economic growth and international competitiveness.

Measures of the international competitiveness of a country relative to other countries are frequently used, especially in mass media, governmental reports and discussions of economic policy. But, in spite of this, it is rather rare to see the concept of international competitiveness of a country defined. However, few would probably disagree with the view that it refers to the ability of a country to realize central economic policy goals, especially growth in income and employment, without running into balance-of-payments difficulties. Following this, what a theory of international competitiveness must do is to establish the links between the growth and balance-of-payments position of an open economy and factors influencing this process.

Even if there exist many measures of the international competitiveness of a country[1], by far the most popular and

[1] These measures range from indicators of economic performance(market shares (Chesnais(1981), profitability (Eliasson(1972))), single-factor indicators based on price or cost development, to complex composite indexes reflecting economic, structural and institutional factors(EMF 1984).

influential is "growth in relative unit labour costs"(RULC[2]). In the small open economies of Western Europe this measure seems to be as important for policy-making as certain monetary aggregates have been in the United States and the United Kingdom in recent years. If unit labour costs grow more than in other countries, it is argued, this will reduce market shares at home and abroad, hamper economic growth and increase unemployment. However, available empirical evidence shows that the fastest growing countries in terms of exports and GDP in the post-war period have at the same time experienced much faster growth in relative unit labour costs than other countries, and vice versa[3]. This fact, sometimes referred to as the "Kaldor paradox" after Kaldor(1978), indicates that the popular view of growth in unit labour costs determining international competitiveness is at best too simplified. But why?

The following section discusses the main theoretical arguments in favour of a detrimental effect of "growth in relative unit labour costs" on market shares and growth. It also considers an alternative, although closely related, approach advocated by

[2] Unit labour costs(ULC) in manufacturing are wages and social costs for workers at current prices divided by gross product at constant prices. Relative unit labour costs(RULC) are ULC converted to an international currency and divided by the average ULC for the country's trading partners. RULC may grow (1) because wages and social costs for workers in national currency are rising faster than in other countries, (2) because the exchange rate is improving relative to other countries, or (3) because productivity growth is lower than in other countries.

[3] Several studies, including Fetherston et al.(1977), Kaldor(1978) and Kellman (1983) have shown that the effects of growing relative costs or prices on exports or market shares seem to be rather weak and sometimes "perverse".

Thirlwall(1979), which focuses on differences between countries in "income elasticities of demand" as a possible source of international growth rate differentials. The common shortcoming of these approaches, we shall argue, is that they fail to take factors other than price competition and demand explicitly into account. Sections 3 and 4, then, develop a model of international competitiveness which relates growth in market shares to three sets of factors: the ability to compete in technology, the ability to compete in price, and the ability to compete in delivery(capacity). The remaining part of this chapter presents a test of the model on pooled cross-sectional and time-series data from 15 OECD countries between 1961-1983. The results indicate that factors related to technology and capacity are indeed very important for medium and long run differences across countries in growth of market shares and GDP, while cost-competitiveness plays a more limited role than commonly assumed. These results are shown to provide a reasonable explanation for the seemingly paradoxical findings by Kaldor and others.

3.2. TRADITIONAL WISDOM QUESTIONED

The most popular approach to international competitiveness is that which focuses on the detrimental effects of growth in relative unit labour costs(RULC) on market shares and growth. What are the theoretical arguments in favour of this view? Firstly, it may be noted that this approach is incompatible with neoclassical equilibrium theory. In perfect competition, prices and quantities will always adjust, resources (including labour) be fully utilized and balance-of-payments equilibrium ensured. Thus, economists defending the hypothesis of the detrimental effects of growing relative unit labour costs, have always had to assume some degree of imperfect competition or disequilibrium.

For instance, let us assume that each country produces one good which is an imperfect substitute for the goods produced by the other countries. As a consequence, each country faces a downward sloping demand curve both at home and abroad. To bring unit labour costs into the picture, assume that prices are determined by unit labour costs with a mark-up(other cost factors than labour costs ignored), and that unit labour costs are determined outside the model. The model is closed by assuming balanced trade.

The following symbols will be used:

Y = GDP(volume),

X = Exports(volume),

M = Imports(volume),

W = World demand(volume),

P = Price per nationally produced product (dollar),

P_W= World market price(dollar),

U = Unit labour costs at home(dollar) and

U_W = Unit labour costs abroad(dollar).

The coefficients a and b are the price elasticities of demand on the world market and the national market respectively, while c and h are the corresponding income elasticities.

(1) $X = A\,(P_w/p)^a\,W^c$, where A,a and c are constants

(2) $M = B\,(P/P_w)^b\,Y^h$, where B,b and h are constants

(3) $XP = MP_w$ (The balance-of-trade restriction)

(4) $P_i = U_i(1+t)$, where t is a constant (i=home, world)

This way of modelling export and import growth (equation 1-2) has a long tradition in applied international economics, and examples may be found in many national and international macroeconomic models, including, for instance, the OECD INTERLINK model (Samuelson(1973)). In its present version (equation 1-3), it was first presented by Thirlwall(1979). The main lesson to be learned from the model is set out in equations (5)-(6) below.

$$(5)\quad \frac{dY}{Y} = \frac{1-(a+b)}{h}\left(\frac{dP}{P} - \frac{dP_w}{P_w}\right) + \frac{c}{h}\frac{dW}{W}$$

By substituting 4 into 5 we get:

$$(6)\quad \frac{dY}{Y} = \frac{1-(a+b)}{h}\left(\frac{dU}{U} - \frac{dU_w}{U_w}\right) + \frac{c}{h}\frac{dW}{W}$$

Thus, on these assumptions, economic growth may be written as a function of growth in relative unit labour costs and world demand. However, this model has given rise to rival interpretations. The most common is no doubt that higher growth in relative unit labour costs than in other countries decreases exports, increases imports and slows down economic growth. As is evident from equation (6) above, a necessary condition for this is that the Marshall-Lerner condition is strictly satisfied(a+b>1). This is often taken for granted, but, as noted in the introduction, several studies indicate that the effects of growing relative unit labour costs on exports or imports are rather weak. For instance, a report from the British Treasury points out:

> "Recent experience suggests that cost-competitiveness may have a significantly less important or more delayed influence on export volumes than was thought a few years ago"(Treasury(1983), p. 4)

According to this report, the long-term elasticities of growth in relative unit labour costs in the Treasury model were as a result adjusted downwards to 0.5 for exports and 0.3 for imports. Consider, also, the following regression of growth in relative unit labour costs(RULC) and growth in OECD imports(W) on GDP growth(GDP) on a pooled cross-country time-series data set[4] for the period 1961-1983 (95% confidence intervals in brackets):

$$GDP = \underset{(-0.08/1.36)}{0.64} + \underset{(-0.07/0.20)}{0.06RULC} + \underset{(0.38/0.60)}{0.49W},$$

R^2=0.60(0.58)
SER=1.36
DW(g)=1.23
N=60

Where R^2 in brackets is R^2 adjusted for the degree of freedom, SER is standard error of regression, DW(g) is the Durbin-Watson

[4] The data cover the 15 industrial countries for which data on unit labour costs exist. Average values of the variables covering whole business cycles were calculated, using the "peak" years 1968, 1973, 1979 and 1983(final year) to separate one cycle from the next. For further information on data and methods, see section 5 and appendix.

statistics adjusted for gaps[5] and N is the number of observations included in the test.

For the Marshall-Lerner condition to be strictly satisfied, the estimate of RULC should be negative and significantly different from zero at the chosen level of significance. The test suggests that this hypothesis should be rejected. Since serial correlation in the residuals of the cross-sectional units cannot be ruled out, an additional test was carried out including one dummy variable for each country. To test for the sensitivity of lags, a three year distributive lag of the RULC variable was introduced (because of lack of data, only 12 countries were included in the regression). However, neither of these additional tests changed the result.[6]

[5] This test, which is designed for first order serial correlation in the residuals within the cross sectional units, was suggested to me by Professor Ron Smith of Birkbeck College, London. For a more thoroughgoing discussion of serial correlation in regressions with pooled data sets, see section IV. The difference between this test and the one commonly used in time-series analysis, is that the differences between the residuals of different cross sectional units, and the corresponding residuals, are left out from both the numerator and the denominator of the Durbin-Watson statistics. This reduces the number of observations in the test by one per country.

[6] The results were:

GDP =	0.06RULC	+ 0.49W +	DUMMIES	R^2=0.84(0.78)
	(-0.04/0.16)	(0.41/0.57)		SER=0.98
				DW(g)=2.78
				N=60

GDP = 0.63	-	0.06LAGRULC	+ 0.51W,	R^2=0.60(0.59)
(-0.19/1.45)		(-0.25/0.05)	(0.39/0.63)	SER=0.60
				DW(g)=1.02
				N=48

GDP =	-0.0081LAGRULC	+ 0.51W + DUMMIES	R^2=0.86(0.80)
	(-0.13/0.11)	(0.42/0.60)	SER=0.95
			DW(g)=2.53
			N=48

The second interpretation (Thirlwall(1979)) starts off with the assumption that relative prices in the long run will be roughly constant[7], so the first term can be neglected. On this assumption, equation 6 reduces to:

$$(7) \quad \frac{dY}{Y} = \frac{c}{h}\frac{dW}{W}$$

or, alternatively

$$(8) \quad \frac{dY}{Y} = \frac{1}{h}\frac{dX}{X}$$

In this case differences in economic growth between countries will be determined exclusively by differences in income elasticities of exports and imports(7), or, in the case of exogenously given export growth, by differences in income elasticities of imports alone(8). Using estimates of income elasticities from Houthakker and Magee(1969), Thirlwall (1979) showed that equation (8) gave fairly good predictions of the differences in growth rates between countries. However, his interpretation of these results, that they support the assumption of constant relative prices and balance of payments constrained growth, has been subject to some controversy[8]. Firstly, it is pointed out that the test carried out by Thirlwall, a nonparametric one, is rather weak, and that more appropriate methods of testing raise doubts about the correctness of his own

[7] This is a strong assumption which may be difficult to justify (and deserves to be tested). For a discussion of this point, see McGregor and Swales(1985,1986) and Thirlwall(1986).

[8] See McCombie(1981), Thirlwall(1981, 1986) and McGregor and Swales(1985,1986).

interpretation of his results.[9] Secondly, it is argued that open economy models based on very different theoretical assumptions could lead to a reduced form equation such as (8), so that not much could be said from a test of this equation alone.

Another fundamental problem, which relates to the model as such and not only Thirlwall's interpretation, is what meaning should be attached to the "income elasticities of demand" in equation (1)-(2). Why, for instance, is the estimated income elasticity for imports to the United Kingdom so much higher, and the estimated income elasticity for exports from the United Kingdom so much lower, than for other countries on approximately the same level of income per capita? One possible answer to this question is, as indicated by Thirlwall(Thirlwall(1979, pp. 52-53), that UK producers did not manage to compete successfully on non-price factors during the period for which the estimation was carried out, and that the estimates of c and h capture the effects of this. Thus, rather than estimates of "income elasticities of demand", the estimates of c and h should be regarded as estimates of differences between countries with regard to non-price competitiveness . As pointed out by Kaldor(1981), this implies that these elasticities should be regarded as endogenous

[9] McGregor and Swales estimated the equation $\log(dY/Y)=const+k_1\log(h)+k_2\log(dX/dX)$ on two different data sets and got a point estimate of k_1 of -0.50/-0.58, significantly less than the expected value (-1) at a 5%level. Thus, the income elasticity of import was found to be an important explanatory factor of international growth rate differences, as postulated by Thirlwall, but less so than should be expected given Thirlwalls assumptions. The explanation is probably that one or more of these assumptions, as for instance the assumption of no changes in relative prices, does not hold 100%.

variables rather than given constants. According to his view, the income elasticities of this model reflect "the innovative ability and adaptive capacity" of the producers in different countries(Kaldor(1981, p. 603))

At this point it becomes increasingly clear what the major weakness of the model is. It is probably not the assumption of balanced trade, which would be found in most medium- or long-run models of an open economy, regardless of theoretical underpinnings. The major weakness of the model, we will argue, is the exclusion of non-price factors of competitiveness from the equations for exports and imports.[10] The crucial question is what to do about it. This is the theme for the next section.

3.3 TECHNOLOGY, COSTS AND CAPACITY

Economic historians, lecturers in business schools and managers have long been aware of a fact often forgotten by economists, that competition is not only price competition, but also technological competition. The reason for this is probably that the main focus in economics until recently has been on perfect competition, an abstraction which is now widely recognized to be a poor description of how international markets function. However, this is now rapidly changing, especially in the field of international economics. A logical conclusion from this would be to include both technological competitiveness and price

[10] On this, see also Fagerberg(1985) and McGregor and Swales(1986).

competitiveness in the exports and imports functions. The main reason why this is not normally done is, apart from the reasons referred to above, probably lack of reliable indicators. We will postpone the discussion of the latter to section 5 of this chapter.

However, even if a country is very competitive in terms of technology and prices, it is not always able to meet the demand for its products because of a capacity constraint. Similarly, lack of competitiveness in terms of technology or prices may sometimes be compensated by a high ability to meet demand, if some other country faces a capacity constraint. Thus, the growth in market shares for a country at home and abroad does not only depend on technology and prices, but also on its ability to deliver. We will assume that the rest of the world's ability to deliver is unlimited, i.e. that there is always some country which is able to deliver if the national producers face a capacity constraint.

Let the technological competitiveness of a country be T/T_W, price competitiveness P/P_W, capacity C and the market share for exports be $S(X) = X/W$. In the usual multiplicative form, S(X) may be written:

(9) $S(X) = AC^v(T/T_W)^e(P/P_W)^{-a}$,

where A,v,e and a are positive constants

By differentiating with respect to time this may be written:

$$(10)\quad \frac{dS(X)}{S(X)} = v\frac{dC}{C} + e\left(\frac{dT}{T} - \frac{dT_w}{T_w}\right) - a\left(\frac{dP}{P} - \frac{dP_w}{P_w}\right)$$

We will assume that growth in the ability to deliver depends on three factors: (a) the growth in technological capability and know-how that is made possible by diffusion of technology from the countries on the world innovation frontier to the rest of the world (dQ/Q), (b) the growth in physical production equipment, buildings, transport equipment and infrastructure (dK/K) and (c) the rate of growth of demand (dW/W). Demand enters the function because capacity at any given point of time is given, while demand may vary[11]. If demand outstrips the given level of capacity, exports will remain constant, but the market share for exports will decrease, because other countries will increase their exports. If we assume a multiplicative form as above, the growth in the ability to meet demand may be written:

$$(11)\quad \frac{dC}{C} = z\frac{dQ}{Q} + r\frac{dK}{K} - l\frac{dW}{W},$$

where z,r,l are positive constants.

As is customary in the literature on diffusion, we will assume that growth in free knowledge follows a logistic curve:

$$(12)\quad \frac{dQ}{Q} = h - h\frac{Q^*}{Q_f},$$

[11] Since these constraints (or critical levels of demand) vary across the different export sectors, the relation between S(X) and W is likely to be continuous, as in equation (11) below.

where h is a positive constant, and Q^*/ Q_f is the ratio between the country's own level of technological development and that of the countries on the world innovation frontier. This contribution will be zero for the frontier countries. By substituting (11)-(12) into (10) we finally arrive at the following:

$$(13)\quad \frac{dS(X)}{S(X)} = vzh - vzh\frac{Q^*}{Q_f} + vr\frac{dK}{K} - vl\frac{dW}{W} + e\left(\frac{dT}{T} - \frac{dT_w}{T_w}\right) - a\left(\frac{dP}{P} - \frac{dP_w}{P_w}\right)$$

For the sake of exposition, this exercise was carried out for the market share for exports only. But exactly the same logic applies to the import share, or the "rest of the world"'s market share in a specific country's home market, with the exception that the demand variable in this case is GDP(Y). However, all effects now enter the equation with the opposite signs of those in (13). For instance, growth in relative prices decreases the export share, but increases the import share etc. Carrying out the same exercise for the import share S(M), using bars to distinguish the coefficients in the two equations, leaves us with the following equation:

$$(14)\quad \frac{dS(M)}{S(M)} = -\overline{vzh} + \overline{vzh}\frac{Q^*}{Q_f} - \overline{vr}\frac{dK}{K} + \overline{vl}\frac{dY}{Y} - \bar{e}\left(\frac{dT}{T} - \frac{dT_w}{T_w}\right) + \bar{a}\left(\frac{dP}{P} - \frac{dP}{P}\right.$$

Thus, equations (13)-(14) state that growth in the market shares for exports and imports depends on technological factors (scope for imitation, growth in technological competitiveness), growth in physical production capacity, growth in relative prices and growth of demand.

3.4. COMPETITIVENESS AND GROWTH

This section focuses on the relation between market shares for exports and imports and economic growth. Firstly, how do changes in market shares affect economic growth? Secondly, how does economic growth feed back on market shares?

The first question relates to the assumption of balanced trade made in section 2 of this chapter:

$$(3) \quad XP = MP_W$$

Following the previous section, define the export share as $S(X) = X/W$ and the import share as $S(M) = M/Y$. By substituting these expressions into (3), differentiating with respect to time and rearranging, (3) may be written:

$$(15) \quad dY/Y = dS(X)/S(X) - dS(M)/S(M) + (dP/P - dP_W/P_W) + dW/W$$

Basically, what is assumed is that countries do not wish, or are not able, to continually increase debts or claims to the rest of the world, so that the balance-of-payments, with the exception of short run fluctuations, will have to balance through its current account[12]. This implies that, in the medium and long run, actual

[12] It should be noted, though, that the United States is in a special position because of the demand for dollars for international monetary transactions.

growth has to adjust to balance-of-payments equilibrium growth rate, or the growth rate "warranted" by the current account, to use a Harrodian term. We will assume that the government plays an important role in this process by adjusting fiscal and monetary policies towards this end.

The second question refers to the possible feedbacks of economic growth on factors influencing the growth of market shares for exports and imports. For instance, higher economic growth is likely to lead to higher growth in both wages and productivity. However, with respect to unit labour cost, these effects tend to counteract each other. The net effect will crucially depend on the institutions and the working of the national system of income distribution, which we in the present context have chosen to regard as exogenously determined.

Furthermore, economic growth may influence technological competitiveness through demand-induced innovation (Schmookler(1966)). The importance of demand-induced relative to supply-induced innovation has been subject to much debate in recent years. The available evidence shows that there is no easy link between changes in demand conditions and innovative activity. Clusters of innovations have appeared in booms as well as in slumps, and on the whole innovative activity seems to depend more on technological opportunity and the quality and quantity of the resources devoted to innovation than on demand conditions(Clark et al.(1982)).

Finally, economic growth may affect the ability to compete in delivery. An increase in domestic demand may lead to a situation where demand outstrips capacity in certain sectors, and as a consequence domestic suppliers may lose market shares to foreign suppliers, and vice versa. This has already been taken into account in the import share function (14). But the effect of increased demand on capacity utilization may also have a secondary effect on the ability to deliver, by stimulating investments in new productive capacity. This effect is supported by economic theory and should be taken into account in the model. For instance, the effect of growth in demand on investment may be represented by a simple accelerator mechanism:

(16) $dK/K = dY/Y$

However, viewed as an explanation of differences between countries in investment behaviour, this model will not suffice, because investment behaviour is also influenced by other factors. According to the approach of this study, investment in physical production capacity should be analysed as a complementary asset to other factors necessary for generating technological capability, such as the number of scientists and engineers, R&D facilities, advanced electronic equipment etc. Some of these are scarce, and to the extent that the government succeeds in attracting these at the expense of the market sectors of the economy, this may hamper investment in physical production capacity too. As pointed out by Kaldor et al.(1986), the probability for this to happen is much larger for the military than for other types of governmental activities, since the former to a much larger extent than the latter competes with the private sector in attracting scientists and engineers and other resources necessary for generating technological capability. Thus, following Smith(1977) and Cappelen, Gleditsch and Bjerkholt(1984), we have chosen to include the shares of output devoted to military and non-military governmental expenditures ("welfare state expenditures") in the accelerator-based investment function. What we should expect, then, is that military expenditures have a significantly more negative effect on investment behaviour than welfare-state expenditures.

Let us take a brief look at the model as developed so far. It consists of five equations:

(15) $$dY/Y = dS(X)/S(X) - dS(M)/S(M) + (dP/P - dP_w/P_w) + dW/W$$

(13) $$\frac{dS(X)}{S(X)} = vzh - vzh\frac{Q^*}{Q_f} + vr\frac{dK}{K} - vl\frac{dW}{W} + e\left(\frac{dT}{T} - \frac{dT_w}{T_w}\right) - a\left(\frac{dP}{P} - \ldots\right.$$

(14) $$\frac{dS(M)}{S(M)} = -\overline{vzh} + \overline{vzh}\,\frac{Q^*}{Q_f} - \overline{vr}\,\frac{dK}{K} + \overline{vl}\,\frac{dY}{Y} - \bar{e}\left(\frac{dT}{T} - \frac{dT_w}{T_w}\right) + \bar{a}\left(\frac{dP}{P} - \frac{dP_w}{P_w}\right)$$

(17) $$dK/K = - g\,MIL - f\,WELF + dY/Y ,$$

where MIL and WELF are the shares of military and non-military governmental expenditures in total output, respectively.

From (4) we have:

(18) $$dP_i/P_i = dU_i/U_i \qquad (i=\text{home, world})$$

The working of the model is as follows.

Growth in relative prices is determined by growth in relative unit labour costs(18). Together with technological factors, growth in physical production and demand, growth in relative prices determine the growth in market shares for exports and imports(13-14). Growth in market shares, growth in relative prices and growth of world demand determine jointly the balance-of-payments equilibrium growth rate, to which the actual growth rate is assumed to adjust(15). The actual growth rate then feeds back on the import share(14) and the growth of physical production equipment etc(17).

The actual outcome of the adjustment process depends on the relative strength of the two feedback effects, since they counteract each other. For example, let us assume that the balance-of-payments equilibrium growth rate, y_b, is below the actual growth rate, y_a, and that the government seeks to adjust the actual growth rate to the balance-of-payments equilibrium growth rate by successive incremental changes in demand of given size until a new equilibrium ($y_a=y_b=y_*$) is reached[13]. The new

[13] The condition for a stable solution is:

$$1 > |(\bar{vr}+\bar{vr})-vl|$$

equilibrium y* will be between the initial values of y_a and y_b provided that the positive effect on the balance-of-payments of reduced imports outweighs the negative effect of reduced capacity, or formally:

(19) $0>((vr+\bar{v}\bar{r})-\bar{v}\bar{l})$

If on the contrary the negative effect of reduced capacity outweighs the positive effect of reduced imports, we will have a "vicious" circle, with the new equilibrium below the initial value of y_b, or formally:

(20) $1>((vr+\bar{v}\bar{r})-\bar{v}\bar{l})>0$

3.5 TESTING THE MODEL

a) Data

The model was tested on pooled cross-country and time-series data for the period 1960-1983 covering the 15 industrial countries for which data on unit labour costs exist. Average values of the variables covering whole business cycles were calculated, using the "peak" years 1968, 1973, 1979 and 1983(final year) to separate one cycle from the next.

The following variables were used:

GDP_i = Growth in gross domestic product in country i at constant prices

ME_i = Growth in export market share (volume) for country i on the world market

MI_i = Growth in import share(volume) in country i

$TERMS_i$ = Growth in terms of trade for country i

$RULC_i$ = Growth in relative unit labour costs in common currency for country i

W = Growth of world trade at constant prices

TL_i = Technological level of country i relative to the most advanced country of the sample(=1)

TG_i = Growth in country i's technological competitiveness relative to other countries

$WELF_i$ = Non-military governmental consumption as percentage of GDP in country i

INV_i = Gross fixed investment in country i as percentage of GDP in country i

MIL_i = Military expenditure as a percentage of GDP in country i.

Most of these variables, with an exception for the technology variables, are self-explanatory(the reader is referred to the appendix for details on sources and methods). Chapter 2, as many other studies, used GDP per capita as a proxy for the level of technological development. While defendable when comparing countries on very different levels of development, this practice becomes more questionable for a sample of developed countries only. In contrast to less developed countries, most developed countries also regularly publish data on technological activities which can be used to construct a proxy for the level of technological development.

The advantages and problems of different types of data on technological activities are discussed in more detail in the previous chapter and will not be repeated here. As pointed out there, the most obvious proxies are R&D and patents. However, both R&D and patent statistics are imperfect measures in the sense that they neglect important aspects of technological activity. For instance, some sectors of the economy do a lot of R&D, but do not patent, while others patent a lot without being especially R&D-intensive. At the national level, however, cross-country studies show a close correlation between levels of R&D and levels of patenting activity (Soete(1981), Fagerberg(1987)). If both variables were to be included in the same model, a high degree of multicollinearity should be expected. These considerations seem to suggest that the best measure of technological activity would be a weighted average of R&D-based and patent-based measures. This is the approach adopted in this chapter. In principle we would have given the two variables an equal weight, but since the variances of the two variables differ substantially, we used weights that adjusted for these differences. For details on how this was done, the reader is referred to the appendix to this chapter.

Thus, the proxy for technological development, TL, is a weighted average of (a) civil R&D as a percentage of GDP, and (b) external patent applications per capita adjusted for differences in the openness of the economy[14]. Following the discussion in section 3 of this chapter, both variables were divided by the highest value found in the sample in each period. The index, then, varies between 1 (the country on the world innovation frontier) and 0 (a hypothetical country with no technological activity). In a similar way, a proxy for growth in technological competitiveness relative to other countries, TG, can be constructed as a weighted average of (a) annual percentage growth in Civil R&D[15]

[14] To arrive at a patent based index of technological development, we adjusted for the size and openness of the economy (the number of patent applications filed abroad reflect both the size of the country and the importance of foreign markets relative to the domestic market. For a more thoroughgoing treatment, see chapter 3 and Fagerberg(1987). For details, see the appendix to this chapter.

[15] Annual data for R&D were available for a few countries only, so we had to use a proxy for growth in civil R&D. In general, R&D efforts (as a percentage of GDP) and income per capita tend to be closely correlated (Soete(1981), Fagerberg(1987)). If the R&D efforts of a country are much above what should be expected from the level of income in the country, this may be interpreted as an effort by the country to upgrade its technological level, and vice versa. Following this, the proxy chosen is the difference between actual R&D (as a percentage of GDP)and what should be expected assuming a linear relation between R&D and income per capita. See the appendix to this chapter for further details,

for country i, less the average growth for the countries in the sample, and (b) annual percentage growth in external patent applications for country i, less the average growth for the countries in the sample. This index, then, has a zero average in each period.

Regarding the growth of "physical production equipment, transport equipment and infrastructure", we would have preferred a proxy based on some measure of physical capital, but unfortunately no such measure was available for all the countries concerned and for sufficiently long time spans. As a number of other studies, therefore, we chose to use gross investment as a percentage of GDP as a proxy.

b) The empirical model

The model tested is the one set out in the previous section subject to a few modifications.

First, in order to test the assumption of a one-to-one correlation between actual growth and the balance-of-payments equilibrium growth rate (BAL), we introduced a separate equation for this (in addition to the balance-of-payments equilibrium growth rate identity). Second, in actual practice growth in relative prices (terms of trade) is influenced by a number of factors, many of them country specific, that do not relate to the price- or cost-competitiveness of firms. Since we believe growth in relative unit labour costs to be a better measure of price-and cost-competitiveness of firms than growth in terms of trade, we have substituted growth of relative unit labour costs into the two equations for growth in market shares, and introduced a separate equation where growth in terms of trade is set out to be a function of growth in relative unit labour costs, country dummies(see later) and a POST-73 dummy. The POST-73 dummy is supposed to catch the effect of the loss in terms trade that most of these countries experienced because of the oil price shocks.

The empirical model, then, is the following:

(21) $GDP = a_{10} + a_{11}BAL$, where we expect $a_{10}=0$, $a_{11}=1$

(22) $BAL = ME - MI + TERMS + W$

(23) $TERMS = a_{31}RULC - a_{32}POST73 + DUMMIES$

(24) $ME = a_{40} - a_{41}TL + a_{42}INV - a_{43}W + a_{44}TG - a_{45}RULC$

(25) $MI = a_{50} + a_{51}TL - a_{52}INV + a_{53}GDP - a_{54}TG + a_{55}RULC$

(26) $INV = a_{60} - a_{61}MIL - a_{62}WELF + a_{63}GDP$

Since all coefficients are defined as positive, the expected signs are the ones above. Note, however, that since we use a proxy for growth in physical production capacity, we cannot any longer make inferences from the theoretical model about the expected signs of the constant terms in (24)-(26).

c) Estimation

To avoid simultaneous equation bias, the two stage least squares method (2SLS) was adopted. To test for first-order serial correlation within the cross-sectional units, we used the Durbin-

Watson statistics adjusted for gaps, to test for heteroscedasticity, we applied a Glejser test. Furthermore, to test for the possibility of structural change, a Chow test was used.

There is a special problem involved in estimation on pooled cross-country time-series data. For instance, assume that there is one time-invariant omitted variable for each country, representing country-specific factors such as differences in culture, institutions, composition of output etc. In this case we would expect least-squares methods to produce results where the residuals of each country are serially correlated. If this type of serial correlation is a serious one, more efficient estimates may be obtained by methods that adjust for the part of the total variance which can be attributed to country-specific factors.

Several methods are available. The most widely used is to introduce country dummies (the LSDV method). This method automatically leaves out the part of the total variance which refers to differences in country-variable means, and is therefore not applicable in cases where these differences are considered to be relevant. Another class of methods treats the country specific effects as random variables[16] (random effects method). The

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[16] In the case of a linear relation between a dependent and an independent variable, let the dependent variable be denoted by y_{jt} (country j, period t), the independent variable by x_{jt}, the "adjustment-factor" by c (1>c>0) and let "bar" denote within-country mean of a variable. It is suggested, then, that estimates obtained by estimating the equation

$$(y_{jt} - c\,\bar{y}_j) = b\,(x_{jt} - c\,\bar{x}_j)$$

will give more efficient estimates than estimates obtained by ordinary least squares. Let the disturbance term be problem in this case is that the "true" variances are not known and have to estimated.

The choice of estimation method depends crucially on the nature of the hypothesis under test. Consider, for instance, the relation between growth in terms of trade and growth in relative unit labour cost(23). Ordinary least squares implies a test of the hypothesis that growth in terms of trade is determined by growth in relative unit labour costs (and the POST-73 dummy) only. To apply the LSDV method implies a test of the hypothesis that growth in terms of trade is determined by country-specific trends, reflecting differences in specialization patterns and other time-invariant factors, but that deviations from these trends are determined by growth in relative unit labour costs (and the POST-73 dummy). Since we, as pointed out in the previous

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u(j,t) = b(j) + w(j,t), where b(j) is the country-specific "random effect", and let the expected variance of the country-specific effects and the rest of the disturbance term be V(b) and V(w), respectively. The adjustment factor may then be written:

$$c = 1-[V(w)/(V(w)+T\ V(b))]^{0.5},$$

where T is the number of time periods(Maddala(1971, 1977), Johnston(1984)). The limiting cases c=1 and c=0 correspond to LSDV and ordinary least squares, respectively(Johnston(1984)).The problem is that the true variances are not known and have to be estimated. Several methods are suggested in the literature, but Monte Carlo studies show that the differences between the estimates obtained by the various methods are small(Nerlove(1971), Maddala(1973)). The estimates of V(b) and V(w) used in this paper are based on the 2SLS residuals, with

$$V(b) = (Sum(j)\ \bar{u}(j)^2)\ /\ (n-1) \text{ and}$$

$$V(w) = [Sum(j,t)(u(j,t)-\bar{u}(j))^2]\ /\ [n(T-1)],$$

where n is the number of countries and $\bar{u}(j)$ within-country means of the observed residuals u(j,t).

subsection, hold the latter to be the most likely, the LSDV method is the most appropriate method in this case.

Similar arguments may be put forward for the relation between actual growth and the balance-of-payments equilibrium growth rate (21). To use 2SLS without dummy variables implies a test of the hypothesis that the balance-of-payments equilibrium growth rate and the actual growth rate are identical. This is a strong hypothesis, that may be contested. For instance, the United States is in a special position, because of the demand for dollars for international monetary transactions. Furthermore, large, unexpected changes in the balance-of-payments position may lead to very long adjustment processes, as the experiences of many oil-producing countries suggest. The use of two-stage LSDV, then, allows for the existence of stable, country-specific deviations from the balance-of-payments equilibrium growth rate. This implies a test of the weaker hypothesis that a change in the balance-of-payments equilibrium growth rate will be accompanied by an equal change in the actual growth rate. Since both hypotheses are interesting, we report both estimates.

In the case of the equations for growth in market shares for exports and imports (24-25), the hypotheses under test suggest a different procedure. For instance, would we consider a large scope for imitation, or a high investment share, compared to other countries throughout the period to be irrelevant to the growth in market shares? Certainly not. To apply the LSDV method in this case would mean wrongly attributing a large part of the effects of these variables to unknown country-specific factors. A similar argument may be put forward in the case of the investment equation (26). In these cases, if serial correlation in the residuals within the cross-sectional units is considered to be important, it is better to re-estimate the equation by the random effects model discussed above.

d) Results

Table 1 reports results from the test. For the sake of space, we do not report the estimates of the country dummies.

The test suggests that even though the balance-of-payments equilibrium growth rate and the actual growth rate are strongly correlated, the assumption of strict equality between the two does not hold. However, the introduction of two dummies, one for the United States and one for Norway, the "Kuwait" of the North, is enough to change this (95% confidence intervals in brackets):

$$GDP = \underset{(-0.97/1.39)}{0.21} + \underset{(0.59/1.15)}{0.87}\,BAL + 2.00\,US - 1.96\,NORWAY \qquad (2SLS)$$

Furthermore, the test suggests that we can accept the weaker hypothesis of a one-to-one correlation between changes, or deviations, in the balance-of-payments equilibrium growth rate and changes, or deviations, in the actual growth rate.

In the case of the equations for growth in the market shares for exports and imports, all coefficients turned up with the expected signs, most of them significantly different from zero at the 1%level[17]. Furthermore, the estimates of the coefficients in the two equations did not differ significantly, except for the demand variables. The latter result is in accordance with the fact that world trade in the post war period has grown more than twice as fast as GDP. In the case of the equation for growth in the export market share, the Glejser test indicated violation of the assumption of homoscedasticity. To check the implications for the estimates, we re-estimated the equation with weighted least squares, but this did not change the result significantly. For the equation for growth in the import share, the test for serial correlation was inconclusive, so we re-estimated the equation with the random effects method to check whether this would affect the estimates (it did not).[18]

For investment, 2SLS produced serial correlation between the residuals within each cross-sectional unit. The random effects method gave a lower estimate of the feedback of economic growth on investment. In both cases military expenditures had a significantly larger negative effect on investments than welfare state expenditures.

17 Except for the constant terms, for which no assumptions could be made, due to the introduction of proxies.

18 Note that since these additional tests imply a transformation of the whole data set, the estimate of the constant term cannot be compared to 2SLS.

TABLE 1. THE MODEL TESTED(N=60)

(21) 2SLS

$$GDP = \underset{(2.13)}{0.96} + \underset{(6.43)}{0.67BAL}$$

R^2=0.31(0.30)
SER=1.76
DW(g)=1.62
DF=58

(21) 2SLS-LSDV

$$GDP = \underset{(4.01)}{1.16BAL} + DUMMIES$$

R^2=0.41(0.19)
SER=2.66
DW(g)=2.47
DF=44

(22) 2SLS-LSDV

$$TERMS = \underset{(3.02)}{0.23RULC} - \underset{(-2.45)}{0.92POST73} + DUMMIES$$

R^2=0.50(0.30)
SER=1.45
DW(g)=2.03
DF=43

(24) 2SLS

$$ME = \underset{(-1.16)}{-2.03} - \underset{(-2.31)}{2.70TL} + \underset{(3.56)}{0.24INV} - \underset{(-4.56)}{0.35W} + \underset{(4.49)}{0.27TG} - \underset{(-3.14)}{0.29RULC}$$

R^2=0.55(0.51)
SER=1.81
DW(g)=2.09
DF=54

(24) 2SLS-WLS

$$ME = \underset{(-2.25)}{-3.25} - \underset{(-2.98)}{2.64TL} + \underset{(5.01)}{0.30INV} - \underset{(-5.42)}{0.36W} + \underset{(4.68)}{0.25TG} - \underset{(-4.59)}{0.34RULC}$$

R^2=0.67(0.63)
SER=1.10
DW(g)=1.97
DF=54

(25) 2SLS

$$MI = 2.65 + 3.47TL - 0.27INV + 1.22GDP - 0.17TG + 0.23RULC$$
(1.47) (2.75) (-3.39) (7.20) (-2.55) (2.45)

R^2=0.47(0.42)
SER=1.85
DW(g)=1.58
DF=54

(25) 2SLS-RANDOM EFFECTS METHOD

$$MI = 0.88 + 3.46TL - 0.23INV + 1.25GDP - 0.21TG + 0.21RULC$$
(0.62) (1.84) (-2.00) (7.72) (-2.34) (2.38)

R^2=0.54(0.49)
SER=1.59
DW(g)=2.33
DF=54

(26) 2SLS

$$INV = 28.52 - 1.48MIL - 0.23WELF + 0.75GDP$$
(13.01) (-6.95) (-2.34) (3.60)

R^2=0.65(0.64)
SER=2.48
DW(g)=0.75
DF=56

(26) 2SLS-RANDOM EFFECTS MODEL

$$INV = 9.21 - 1.32MIL - 0.29WELF + 0.50GDP$$
(12.47) (-4.33) (-2.78) (3.09)

R^2=0.55(0.52)
SER=1.45
DW(g)=1.89
DF=56

R^2 in brackets = R^2 adjusted for degrees of freedom
SER = Standard error of regression
DW(g) = Durbin-Watson statistics adjusted for gaps
N = Number of observations included in the test
DF= Degrees of freedom
The numbers in brackets below the estimates are t-statistics.

Finally, to test for the possibility of structural change, we tested the assumption that the 15 post-1979 observations are not generated by the same model as the entire data set, using a Chow test. Table 2 reports the results of the test for the regressions in table 1 above (except the additional WLS and random-effects tests). The test suggests that in all cases, the assumption of structural change can be rejected at the 1% level of significance.

Table 2. CHOW TEST OF STRUCTURAL CHANGE(F-statistics)

GDP	GDP(lsdv)	Terms(lsdv)	ME	MI	INV
1.73 (*)	2.48 (*)	2.01 (*)	0.74 (*)	1.80 (*)	0.47 (*)

* denotes rejection of the assumption of structural change at the 1% level of significance

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3.6. "THE KALDOR PARADOX" ONCE MORE

We will now return to the seemingly paradoxical findings by Kaldor and others. What Kaldor(1978) did was to compare growth in relative unit labour costs and growth in market shares for exports, when measured in value, for 12 countries over the period 1963-1975. He found that for some of these countries, the relation between growth in relative unit labour costs and growth in market shares seemed to be positive, or the opposite of what is commonly assumed ("perverse"). Table 3 reproduces Kaldor's findings for three countries[19] for which he found a strong

[19] Kaldor found four examples of a strong "perverse" relationship, Japan, Italy, the UK and the US. Our model does predict this for all but one (Italy). A closer look at the export

"perverse" relationship, Japan, the UK and the US, and compares these findings with the same relationship as predicted by the model[20].

TABLE 3. THE KALDOR PARADOX

COUNTRY	Kaldor 1963-1975 RULC	Kaldor 1963-1975 Growth in market share for exports (value)	Our 1961-1973 RULC	Our 1961-1973 Growth in market share for exports (value(predicted))
JAPAN	27.1	72.0	31.0	103.3
UK	-21.4	-37.9	-25.7	-16.2
USA	-43.7	-17.8	-33.9	-29.8

Thus, in these cases, the model actually predicts a strong "perverse" relationship between growth in relative unit labour costs and market shares for exports (value). To see how this may be explained, consider table 4 below. The decomposition suggests that Japan's large gains in market share during this period should be explained by a combination of (a) a rapid increase in technological competitiveness, (b) a large scope for imitation,

performance of Italy shows a very erratic development (an export boom in the sixties followed by a weak performance in the late sixties and early seventies) which our model fails to replicate.

[20] The predicted growth in the market share for exports measured in value was obtained as the sum of the predicted growth in the market share measured in volume and the predicted growth in the terms of trade(country-dummies not included). The coefficients were taken from the 2SLS-estimates given in table 1. Note that the predictions are for total exports, while Kaldor reported data for manufacturing only. For these and other reasons, predicted and actual export performance(as reported by Kaldor) should only be expected to show a similar pattern, not coincide.

and (c) a high level of investment. Note, also, that since the estimated (negative) effect of growth in relative unit labour costs on the market share for exports measured in volume, is not significantly different from the estimated (positive) effect of growth in relative unit labour costs on relative prices(terms of trade), the net effect of growth in relative unit labour costs on the growth of market shares for exports measured in value turns out be negligible.

In the case of the United States, it may be argued that a certain loss in market share would have been difficult to avoid, given the cost of being close to the world innovation frontier in a number of areas. This is also partly confirmed. However, for both the US and the UK, the main factor behind the losses in market shares during this period seems to have been slow growth in productive capacity caused by the unusually low shares of national resources devoted to investments. The model (equation (26)) suggests that the main factor behind the low investment shares in these two countries is the high share of national resources used for military purposes.

3.7. CONCLUDING REMARKS

The most commonly held approach to international competitiveness focuses on differences in the growth of relative unit labour costs(RULC) as the major factor affecting differences in competitiveness and growth across countries. However, as several studies have pointed out, this view is at best too simplified.

TABLE 4. AN EXPLANATION OF THE KALDOR PARADOX

COUNTRY	(1)+(2)+(3) Growth in market share for exports (value(predicted))	(1) Technology (TG)	(2) Costs (RULC)	Of which trough effects on volume (ME)	Of which trough effects on terms of trade (TERMS)	(3) Delivery (total)	Of which due to diffusion (TL)	Of which due to investment and demand (INV,W)
JAPAN	103.3	66.9	-0.9	-7.8	6.9	37.4	20.9	16.5
UK	-16.2	6.9	0.8	7.9	-7.1	-23.9	15.9	-39.8
USA	-29.8	-0.6	1.6	12.4	-10.8	-30.8	7.3	-38.2

According to the results obtained in this chapter, the main factors influencing differences in international competitiveness and growth across countries are technological competitiveness and the ability to compete on delivery. Regarding the latter, this chapter especially points out the crucial role played by investments, and factors influencing investments, in creating new production capacity and exploiting the potentials given by diffusion processes and growth in national technological performance.

One implication of these results is that polices aimed at curbing growth in wages and prices are not sufficient to strengthen international competitiveness and increase economic growth in the medium or long run. To achieve these goals, policies should aim at increasing national technological competitiveness and the amount of efforts devoted to the economic exploitation of diffusion and innovation. By necessity, such policies are of a long run nature.

APPENDIX

1. Definitions and methods

Growth rates are calculated as geometric averages for the periods 1960-1968, 1968-1973, 1973-1979 and 1979-1983, while levels and shares are calculated as arithmetic averages for the periods 1960-67, 1968-1973, 1974-1979 and 1980-1983, or the nearest period for which data exist.

The growth of the export market share of a country is defined as the growth of exports less the growth of world trade(OECD imports), both in constant prices.

The growth of the import share of a country is defined as the growth of imports less the growth of GDP, both in constant prices.

The technological level of a country i (TL_i) is defined as the weighted average of a patent-based index(P_i) and a R&D-based index (R_i), using the standard deviations as weights:

$$TL_i=(std(R)/(std(P)+std(R)))P_i+(std(P)/(std(P)+std(R)))R_i$$

The patent-based index(P) is defined as the number of external patents application(PAT), divided by the number of inhabitants in the country(POP) and the degree of the openness of the economy, measured through exports as a percentage of GDP(XSH), $P_i=PAT_i/(POP_i*XSH_i)$. The R&D-based index (R) is defined as civil research and development expenditures as a percentage of GDP. Each index is normalized to the range 0,1 by dividing all observations from period t with that observation from period t which has the highest value.

The growth in country i's technological competitiveness relative to other countries(TG_i) is defined as the weighted average of a patent-based index (PG_i) and a R&D based index (RG_i), using the standard deviations as weights:

$$TG_i=(std(RG)/(std(PG)+std(RG)))PG_i+(std(PG)/(std(PG)+std(RG)))RG_i$$

The patent-based index(PG) is defined as growth in external patent applications for country i, less the average growth rate for all countries. The R&D based index (RG) is defined as the ratio between civil R&D expenditures as a percentage of GDP (RD) and GDP per capita (T) for country i, less the average ratio for all countries in each period. Let "bar" denote within-period mean. Then

$$RG_i = RD_i/T_i - \overline{(RD_i/T_i)}$$

The TG index, then, has a zero average in each period.

2. Sources

Growth in relative unit labour costs in common currency:
IMF International Financial Statistics and OECD(Finland).

External patent applications:
OECD/STIIU DATA BANK and World International Property Organization(WIPO):Industrial Property Statistics

The R&D data are estimates based on the following sources:

OECD Science and Technology Indicators, Basic Statistical Series (vol. B(1982) and Recent Results(1984)).

Military R&D expenditures were, following the OECD, assumed to be negligible in all countries except the US, France, Germany, Sweden and the UK. The R&D data for these countries were adjusted downward according to OECD estimates. The estimates were taken from OECD, Directorate for Science, Technology and Industry: The problems of estimating defence and civil GERD in selected OECD member countries(unpublished). For other countries, civil and total R&D as a percentage of GDP were assumed to be identical.

Military expenditure as percentage of GDP:
SIPRI Yearbook

Non-military governmental consumption as percentage of GDP:
SIPRI Yearbook and OECD Historical Statistics

Other variables:
OECD Historical Statistics and OECD National Accounts

3. Supplementary tables

TABLE A1. DATA USED IN REGRESSIONS (CHAPTER 3)

COUNTRY	GDP	W	ME	MI	INV	MIL	WELF	RULC	TERMS	BAL	TL	TG	LAGRULC
USA 1	4.5	8.1	-2.3	4.1	18.0	8.7	9.1	-1.3	0.7	2.4	0.78	0.5	-1.3
USA 2	3.3	9.4	-0.7	3.0	18.3	7.6	11.1	-6.2	-1.7	4.0	0.79	-0.9	-1.5
USA 3	2.6	4.0	1.2	1.2	18.3	5.6	12.7	-2.6	-3.6	0.4	0.66	-0.6	-4.8
USA 4	0.7	1.3	-2.8	3.1	17.4	6.0	12.5	7.2	0.4	-4.2	0.76	0.5	3.5
JAPAN 1	10.5	8.1	6.6	3.3	31.3	0.9	7.0	0.9	-1.0	10.4	0.42	15.8	-1.5
JAPAN 2	8.8	9.4	3.6	5.6	34.7	0.8	7.0	4.0	1.3	8.7	0.51	12.8	1.1
JAPAN 3	3.6	4.0	6.1	0.7	32.0	0.9	8.9	-1.5	-6.1	3.3	0.55	8.9	2.1
JAPAN 4	3.9	1.3	8.9	-5.4	30.4	1.0	9.1	-2.8	-4.0	11.6	0.73	13.4	-7.5
GERMANY 1	4.2	8.1	-0.4	3.5	25.2	4.3	10.6	-0.1	0.9	5.1	0.55	0.8	0.5
GERMANY 2	4.9	9.4	-1.7	5.4	24.4	3.4	13.0	5.5	1.8	4.1	0.65	3.4	2.7
GERMANY 3	2.4	4.0	0.6	3.0	20.9	3.4	16.4	0.4	-1.4	0.2	0.67	2.6	2.2
GERMANY 4	0.5	1.3	2.8	0.9	21.5	3.4	17.0	-2.1	-2.0	1.2	0.75	3.8	0.7
FRANCE 1	5.4	8.1	-1.2	4.1	22.3	5.5	7.7	0.3	0.9	3.7	0.50	3.1	-2.2
FRANCE 2	5.9	9.4	4.1	7.2	23.3	4.2	9.1	-2.5	0.3	6.6	0.47	1.3	-2.0
FRANCE 3	3.1	4.0	2.9	3.0	22.7	3.8	10.7	0.8	-1.2	2.7	0.44	-0.3	1.2
FRANCE 4	1.1	1.3	1.0	2.1	20.9	4.1	11.6	-2.8	-1.8	-1.6	0.50	0.2	1.2
U.K. 1	3.1	8.1	-3.7	1.0	17.8	6.0	10.9	-3.0	0.6	4.0	0.51	1.7	0.0
U.K. 2	3.2	9.4	-2.9	3.5	19.2	5.1	12.7	-1.2	-3.8	-0.8	0.50	2.9	-1.3
U.K. 3	1.4	4.0	0.0	0.6	19.4	4.8	15.7	3.6	0.9	4.3	0.45	1.0	0.7
U.K. 4	0.4	1.3	-1.4	-0.1	16.9	5.1	16.7	1.5	0.7	0.7	0.54	7.4	7.4
ITALY 1	5.7	8.1	3.7	4.0	21.7	3.2	10.7	2.2	-1.1	6.7	0.22	0.3	-0.1
ITALY 2	4.6	9.4	-1.7	7.1	20.6	2.9	12.0	-0.5	-1.2	-0.6	0.25	0.7	1.6
ITALY 3	2.6	4.0	4.8	1.7	20.0	2.5	12.9	0.1	-2.4	4.7	0.23	1.9	-0.2
ITALY 4	0.6	1.3	-0.1	0.8	19.2	2.5	15.2	2.4	-1.5	-1.1	0.28	-1.6	1.1
CANADA 1	5.6	8.1	1.2	1.8	22.1	3.5	11.6	-1.0	0.0	7.5	0.33	-0.8	-3.0
CANADA 2	5.6	9.4	-1.5	3.5	21.6	2.3	16.2	-0.7	1.4	5.8	0.31	-1.9	-1.3
CANADA 3	3.4	4.0	-0.4	0.9	22.9	1.9	17.8	-1.7	0.2	2.9	0.28	-3.5	-3.3
CANADA 4	0.8	1.3	0.8	-2.2	21.8	1.9	18.2	5.1	-0.8	3.5	0.34	-3.0	3.1
AUSTRIA 1	4.2	8.1	-1.0	3.4	26.4	1.2	12.1	0.8	-0.8	2.9	0.16	-4.8	na
AUSTRIA 2	5.9	9.4	2.2	5.3	27.2	1.1	13.7	0.7	0.9	7.2	0.20	-4.4	na
AUSTRIA 3	2.9	4.0	2.5	3.0	26.4	1.2	16.2	0.5	-0.6	2.9	0.27	-2.4	na
AUSTRIA 4	1.5	1.3	3.7	1.8	24.0	1.2	17.1	-1.4	-1.1	2.1	0.34	-3.0	na
BELGIUM 1	4.5	8.1	0.3	3.3	21.6	3.3	9.4	0.7	0.0	5.1	0.31	0.3	6.7
BELGIUM 2	5.6	9.4	1.6	5.2	21.7	2.9	11.1	-1.6	0.4	6.2	0.35	-1.8	0.1
BELGIUM 3	2.2	4.0	-0.6	1.8	21.9	3.1	13.5	0.2	-1.0	0.6	0.34	-1.8	2.2
BELGIUM 4	0.9	1.3	1.3	-1.4	18.3	3.4	14.9	-8.5	-2.4	1.6	0.34	-1.4	-2.5

DENMARK	1	4.6	8.1	-1.5	2.5	23.4	2.8	12.8	0.3	0.0	4.1	0.20	-3.4	0.5
DENMARK	2	4.0	9.4	-3.3	3.0	24.4	2.4	17.8	-1.0	1.1	4.2	0.29	-6.5	1.0
DENMARK	3	1.9	4.0	-0.8	-0.1	22.1	2.3	21.9	-0.2	-2.2	1.1	0.30	-4.4	1.8
DENMARK	4	0.9	1.3	3.5	-2.2	16.7	2.4	25.0	-4.0	-2.1	4.9	0.32	-4.9	-2.1
NETHERL	1	4.8	8.1	-0.9	3.9	25.0	4.1	10.3	2.6	0.5	3.8	0.53	2.2	1.6
NETHERL	2	5.3	9.4	2.9	4.8	25.0	3.5	12.1	0.8	-1.5	6.0	0.57	4.5	1.6
NETHERL	3	2.5	4.0	-1.0	0.8	20.9	3.2	14.2	0.7	-1.1	1.1	0.52	3.4	2.4
NETHERL	4	-0.3	1.3	0.6	0.0	19.2	3.2	14.6	-3.6	-0.1	1.8	0.51	1.0	-1.5
NORWAY	1	4.4	8.1	-1.0	3.0	29.0	3.5	10.9	1.8	0.4	4.5	0.21	-5.4	1.1
NORWAY	2	4.1	9.4	-3.7	2.8	27.4	3.4	14.0	1.3	0.1	3.0	0.30	-1.0	2.0
NORWAY	3	4.9	4.0	0.9	-3.0	32.9	3.1	16.5	2.1	1.3	9.2	0.34	-2.7	4.4
NORWAY	4	2.3	1.3	1.3	-0.4	25.8	3.0	16.1	2.3	6.3	9.3	0.33	-6.4	1.3
SWEDEN	1	4.4	8.1	-1.1	1.6	23.9	4.0	13.4	0.8	-0.1	5.3	0.40	-3.9	0.4
SWEDEN	2	3.7	9.4	-0.5	2.3	22.6	3.7	18.4	-1.3	0.1	6.7	0.47	-4.3	0.2
SWEDEN	3	1.8	4.0	-1.5	0.9	20.6	3.3	22.6	0.7	-1.0	0.6	0.56	-1.3	1.9
SWEDEN	4	1.2	1.3	2.5	-1.9	19.2	3.3	25.8	-6.6	-1.2	4.5	0.67	-1.0	-1.3
SWITZER	1	4.4	8.1	-1.6	2.9	28.0	2.7	7.4	1.2	1.9	5.5	1.00	0.8	na
SWITZER	2	4.5	9.4	-1.8	4.8	27.9	2.2	8.5	0.3	-0.4	2.4	1.00	-0.3	na
SWITZER	3	-0.4	4.0	-0.9	3.9	22.7	2.1	10.6	2.8	0.8	0.0	1.00	-0.2	na
SWITZER	4	1.4	1.3	0.6	0.5	23.6	2.1	10.8	-0.4	0.7	2.1	1.00	-2.2	na
FINLAND	1	3.9	8.1	-2.1	0.7	26.6	1.8	11.6	-1.5	0.1	5.4	0.12	-3.2	na
FINLAND	2	6.7	9.4	-0.4	4.8	26.2	1.5	13.7	0.8	0.2	4.4	0.24	-0.9	na
FINLAND	3	2.4	4.0	0.8	0.4	27.2	1.4	16.5	0.2	-0.8	3.6	0.29	1.3	na
FINLAND	4	3.3	1.3	2.9	-0.7	24.9	1.6	17.7	0.6	-0.9	4.0	0.39	0.9	na

TABLE A2 GROWTH IN EXTERNAL PATENT APPLICATIONS

	1960-68	1968-73	1973-79	1979-83
USA	6.7	-1.7	-6.1	-4.3
JAPAN	22.8	10.9	0.9	1.0
GERMANY	5.2	0.7	-6.7	-8.7
FRANCE	6.3	0.5	-6.1	-4.8
UK	3.1	-2.4	-9.5	-2.2
ITALY	5.9	0.6	-0.3	-8.7
CANADA	5.7	2.9	-5.7	-3.2
AUSTRIA	4.5	3.0	-5.0	-6.5
BELGIUM	5.9	-5.8	-8.7	-4.4
DENMARK	8.6	-3.0	-5.8	-2.9
NETHERLANDS	2.2	-1.4	-4.6	-9.2
NORWAY	1.2	5.9	-6.2	-7.3
SWEDEN	5.3	0	-4.5	-7.9
SWITZERLAND	5.2	0.6	-7.3	-9.1
FINLAND	10.0	8.1	4.0	4.2

TABLE A3 EXTERNAL PATENT APPLICATIONS PER CAPITA(INDEX)

	1960-1967	1968-1973	1974-1979	1980-1983
USA	3.19	2.96	2.15	2.18
JAPAN	0.32	0.70	0.92	1.32
GERMANY	1.60	1.58	1.63	1.43
FRANCE	0.96	0.92	0.86	0.82
UK	0.91	0.77	0.63	0.70
ITALY	0.33	0.32	0.31	0.38
CANADA	0.34	0.31	0.35	0.36
AUSTRIA	0.48	0.48	0.54	0.52
BELGIUM	0.30	0.24	0.23	0.45
DENMARK	0.46	0.54	0.67	0.54
NETHERLANDS	0.65	0.60	0.61	0.55
NORWAY	0.19	0.21	0.30	0.25
SWEDEN	1.57	1.40	1.58	1.43
SWITZERLAND	3.50	3.67	3.72	3.31
FINLAND	0.20	0.32	0.50	0.76

1) Adjusted for differences in the openness of the economy, mean = 1 in each period.

TABLE A4 CIVIL R&D EXPENDITURES AS A PERCENTAGE OF GDP

	1963-1967	1968-1973	1974-1979	1980-1982
USA	1.67	1.77	1.74	1.94
JAPAN	1.50	1.79	1.95	2.36
GERMANY	1.45	1.91	2.08	2.40
FRANCE	1.55	1.52	1.50	1.67
UK	1.60	1.71	1.65	1.93
ITALY	0.71	0.88	0.87	0.97
CANADA	1.15	1.14	1.07	1.26
AUSTRIA	0.40	0.61	0.92	1.16
BELGIUM	1.10	1.37	1.37	1.17
DENMARK	0.60	0.95	0.97	1.07
NETHERLANDS	1.80	2.09	2.00	1.88
NORWAY	0.75	1.17	1.35	1.28
SWEDEN	0.89	1.25	1.62	2.03
SWITZERLAND	2.38	2.30	2.38	2.29
FINLAND	0.38	0.84	1.01	1.22

CHAPTER 4

INNOVATION-DIFFUSION, STRUCTURAL CHANGES IN INTERNATIONAL TRADE AND EXPORT PERFORMANCE

4.1 INTRODUCTION

The two preceding chapters have focused on how differences in the scope for imitation, growth of national technological activities and efforts to exploit technology in production affect differences in competitiveness and economic growth across countries. However, the discussion has essentially been carried out within the framework of one-sector growth-models. Even though the analyses of these chapters have incorporated many important Schumpeterian insights, it is one major aspect which necessarily gets lost at this level of aggregation: the relation between innovation-diffusion and structural changes in production and trade.

The implications of Schumpeter's analyses of innovation-diffusion and structural changes for the analysis of international trade have already been discussed at some length in the introductory chapter. According to the Schumpeterian perspective presented there, capitalist development tend to be characterized by alternating long-run periods off growth and stagnation. Each growth period, then, can be shown to be related to the diffusion of a specific set of technologies or "technological systems" from the countries on the world innovation frontier ("centre countries") to the rest of the world. Because world demand for products and technologies belonging to these technological systems tend to grow faster than the average, while production, in the initial phase at least, tends to be concentrated in a few countries only, trade in these products and technologies will grow much faster than the average. This will cause radical changes in the commodity composition of world trade, changes that will affect countries quite differently depending on their specialization patterns. For instance, a country that produces products belonging to the expanding technological systems, should be expected to be favourably affected, while these changes should be expected to be less favourable for a country that mainly produces mature[1] products (for which demand is assumed to grow slower than the average). Thus, the relation between the composition of a country's exports and that of world demand enters as an important determinant of export performance.

To analyse this issue further, however, a shift in the level of analysis, from a one-sector to a multi-sector framework, is needed. This is what we attempt to do in this chapter. The next section analyses the structural changes in OECD trade between 1961 and 1983 from the perspective outlined above. The data are then used to decompose the export performance of 18 OECD countries on the OECD market into effects of <u>structural changes in OECD trade</u>, <u>the ability to adapt the export structure</u> to these changes, and the <u>ability to compete for market shares within</u>

[1] By mature products we mean products where both product characteristics and production technology are fairly standardized.

individual commodity groups. Finally, various economic, institutional and technological factors influencing these different aspects of export performance are discussed and tested.

4.2 STRUCTURAL CHANGES IN OECD TRADE 1961-1983

According to the Schumpeterian perspective outlined in chapter 1, new products and technologies, originating in R&D-intensive industries and firms, tend grow faster than average, causing the structure of production and trade to change in a systematic way. Following this we should expect the fastest-growing commodities in OECD trade in the post-war period to be relatively "new" compared to other commodities and to originate in science-based, R&D-intensive industries or sectors of the economy. To analyse the structural changes in OECD trade in this period, and the consequences of these changes for different types of countries, we have constructed a database on OECD trade for selected years 1961-1983, consisting of all OECD countries for which data were available[2]. Great care was taken to ensure that research- and development-intensive products and products based on important, commercially successful innovations in the not too distant past were specified as separate products. More mature products, on the other hand, like raw materials, semi-finished products and a

[2] The database used in the study was constructed jointly by Bent Dalum, University of Aalborg, and the author from the OECD-trade series C. It consists of data on exports and imports (value)for all OECD-countries less Australia and New Zealand for selected years 1961-1983. For Finland and Japan, which had not joined OECD(OEEC) in 1961, we had to supplement the data for 1961 from national sources.

number of rather unsophisticated manufactures, were treated in a more aggregative way.

The construction of the data base was complicated by the fact that many countries, mainly for industrial security reasons, do not report a complete country and commodity breakdown of their exports and imports, and that the international trade classification (SITC) changed during the period of observation. For instance, we found that a country like Sweden for industrial security reasons does not report a complete country and commodity breakdown of its exports of pharmaceuticals on any level of aggregation below the three-digit level of the SITC. Thus, if a more disaggregated level had been used in the analysis, Swedish exports of pharmaceuticals would have disappeared from the analysis. Similar problems arise for other countries, the most prominent example being the US, and these problems are further complicated by changes in the classification system during the period. Thus, in order to get reliable results, these problems must be taken explicitly into account when making a decision on which level of aggregation to use. Needless to say, this put limits on the choice of aggregation.

Like most trade studies, this study uses value data (OECD Trade Series C), which is the only type of data available on a sufficiently disaggregated level. It is often suggested that it would be preferable to use volume data instead of value data, but this is, as pointed out by Rotchild(1985), not always the case. There are two reasons for this. First, value data reflect better than volume data the effects of changes in export performance on the balance of trade. Second, volume data are problematic in cases where substantial technological changes occur and become, for the very same reason, less reliable when the time span under consideration grows.

The data (table 1) are organized on two levels, sector and product(or commodity) level. The sectors are Products based on natural resources, Oil and gas, Chemicals, Machinery and Traditional manufacturing products. Each sector, then, (except oil and gas) is further divided into a number of specified products and a residual category[3]. The residual categories contain a number of products that were not considered important enough to be specified as separate commodities according to the purpose of the investigation. As a guiding principle, we tried to classify products according to industry, where an industry is defined by either use of a specific raw material, a specific technology, market- or product- characteristics or combinations of these factors. In general, products based on natural resources (and oil-gas) are mainly classified according to raw material, chemicals according to technology and product characteristics, and other manufacturing products according to technology, product and market characteristics.

[3] The most important of these groups were "other products based on natural resources" and "other industrial products not elsewhere classified". Within chemicals and machinery these groups turned out to be negligible.

TABLE .1

CLASSIFICATION OF PRODUCTS

101 PRODUCTS BASED ON NATURAL RESOURCES

1	Animals, meat and meat preparations
2	Dairy products and eggs
3	Fish and fish preparations
4	Cereals and cereal preparations
5	Feeding-stuff for animals
6	Skins and leather manufactures
7	Wood and wood manufactures
8	Pulp and paper
9	Textiles
10	Iron ore
11	Iron, steel and ferro-alloys
12	Aluminum
13	Other products based on natural resources

102 OIL AND GAS

14	Oil and gas

103 CHEMICALS

15	Organic chemicals
16H	Inorganic chemicals
17	Dyestuffs, coloring materials
18H	Pharmaceuticals
19	Fertilizers
20H	Plastics
21	Other chemicals

104 ENGINEERING, ELECTRONICS AND TRANSPORT EQUIPMENT

22H	Power generating machinery
23	Machinery for special industries or processes
24	Heating and cooling equipment
25	Pumps and centrifuges
26H	Typewriters and office machines
27H	Computers and peripherals
28H	Semiconductors
29H	Telecommunications
30H	Machinery for production and distribution of electricity
31H	Consumer electronics
32	Domestic electrical equipment
33H	Scientific instruments, photographic supplies, watches and clocks
34H	Road motor vehicles
35H	Aircraft
36	Ships and boats (incl. oil rigs)
37	Other engineering products

105 TRADITIONAL MANUFACTURING PRODUCTS

38	Manufactures of metal
39	Furniture
40	Clothing
41	Industrial products n.e.c.

The classification of products according to research and development intensity (expenditures on research and development as a share in output or sales) was based on other studies, especially Kelly(1977), Aho and Rosen (1980) and OECD(1985). While the two earlier studies were based on US data only, the last one uses data for a group of OECD countries. However, with a few exceptions, these studies end up with rather similar rankings according to R&D intensity[4]. It should be noted, though, that a few products that were classified as research and development intensive in the two earlier studies, do not fulfill the requirements according to the last study. Even if this cannot be established with absolute certainty, it is probable that this difference refers as much to the difference in time span as to the difference in methodology between the two earlier and the last study. In our classification, the relevant products are typewriters and other(non-electronic) office machines, consumer electronics and road motor vehicles. We have chosen to regard these products as R&D intensive prior to 1973, but not later.
In table 1, products with high R&D-intensity are marked with "H".

[4] Pavitt(1982) has developed an entirely different approach to ranking according to technology intensity. Instead of ranking commodities according to R&D intensity, he proposes to rank commodities according to the importance of technological competition, measured through the statistical significance of the correlation between per capita exports and per capita US patents for different countries within the same commodity group. This method has the disadvantage that it does not allow for the inclusion of the US in the investigation. However, the results are not very different from the OECD study, with the exception that Pavitt includes a larger part of the engineering sector (and excludes aircraft) from the list of technology-intensive products(the "upper third" in Pavitt's ranking).

Table 2 and 3 rank growth of total OECD imports by commodity (intra-OECD trade included) in the periods 1961-1973 and 1973-1983, respectively, from highest growth to lowest growth. The fastest-growing commodities in OECD trade between 1961 and 1973 may be roughly divided into three groups. First, a group of R&D-intensive commodities related to relatively recent innovations in electronics (semiconductors, computers, telecommunications, consumer electronics and scientific instruments). Second, some R&D-intensive chemicals related to innovations in the interwar and post-war periods (plastics(synthetic fibers) and pharmaceuticals). Third, commodities related to the diffusion of the lifestyle and pattern of consumption that developed in the US in the first half of this century ("the American way of life") and to the rapid growth in private consumption in this period (cars, electrical household equipment, consumer electronics (already mentioned), clothing and furniture). A common characteristic of the two latter commodities in this period is the introduction of new materials in the process of production(synthetic fibers and light metals).

TABLE 2. GROWTH OF OECD IMPORTS 1961-1973.
(Value, yearly average value, percentage)

Rank	R&D intensity	Commodity	Growth rate
1.		Furniture (39)	26.54
2.	H	Consumer electronics (31)	24.87
3.	H	Semiconductors (28)	23.77
4.	H	Road motor vehicles (34)	23.18
5.		Clothing (40)	22.40
6.	H	Computers and peripherals (27)	21.15
7.	H	Typewriters and office machines (26)	21.14
8.	H	Plastic materials (20)	21.07
9.	H	Telecommunications (29)	19.08
10.	H	Scientific instruments, photographic supplies, watches and clocks (33)	18.84
11.	H	Pharmaceuticals (18)	18.83
12.		Organic chemicals (15)	18.43
13.		Domestic electrical equipment (32)	18.41
14.		Pumps and centrifuges (25)	18.33
15.		Other engineering products (37)	18.33
16.	H	Power generating machinery (22)	17.92
17.	H	Machinery for production and distribution of electricity (30)	17.72
18.		Feeding-stuff for animals (5)	17.06
19.		Heating and cooling equipment (24)	16.92
20.		Other industrial products (41)	16.45
21.		Manufactures of metal (38)	16.44
22.		Oil and gas (14)	15.86
23.		Dyestuffs, coloring materials (17)	15.82
24.		Fish and fish preparations (3)	14.98
25.		Other chemicals (21)	14.90
26.		Wood and wood manufactures (7)	14.71
27.		Animals, meat and meat preparations (1)	14.65
28.		Aluminum (12)	14.05
29.		Iron, steel and ferro alloys (11)	14.04
30.	H	Aircraft (35)	13.67
31.	H	Inorganic chemicals (16)	13.66
32.		Ships and boats (incl. oil rigs) (36)	13.52
33.		Machinery for special industries or processes (23)	13.32
34.		Pulp and paper (8)	11.19
35.		Other products based on natural resources (13)	11.06
36.		Skins and leather manufactures (6)	10.95
37.		Dairy products and eggs (2)	10.76
38.		Cereals and cereal preparations (4)	10.32
39.		Fertilizers (19)	10.27
40.		Iron ore (10)	9.92
41.		Textiles (9)	9.82

In comparison:
All commodities: 14.49

TABLE 3. GROWTH OF OECD IMPORTS 1973-1983.
(Value, yearly average, percentage)

Rank	R&D intensity	Commodity	Growth rate
1.	H	Computers and peripherals (27)	21.30
2.		Oil and gas (14)	19.72
3.	H	Semiconductors (28)	15.64
4.	H	Aircraft (35)	15.36
5.		Organic chemicals (15)	14.78
6.		Aluminum (12)	14.57
7.	H	Telecommunications (29)	14.31
8.		Other chemicals (21)	13.88
9.	H	Scientific instruments, photographic supplies, watches and clocks (33)	13.14
10.		Other industrial products (41)	13.04
11.	H	Plastic materials (20)	12.94
12.		Furniture (39)	12.63
13.		Fertilizers (19)	12.55
14.		Clothing (40)	12.44
15.		Road motor vehicles (34)	12.32
16.	H	Pharmaceuticals (18)	12.10
17.	H	Machinery for production and distribution of electricity (30)	11.91
18.	H	Inorganic chemicals (16)	11.80
19.	H	Power generating machinery (22)	11.52
20.		Consumer electronics (31)	11.36
21.		Fish and fish preparations (3)	11.31
22.		Pumps and centrifuges (25)	11.06
23.		Domestic electrical equipment (32)	10.86
24.		Pulp and paper (8)	10.16
25.		Manufactures of metal (38)	9.65
26.		Dairy products and eggs (2)	9.47
27.		Dyestuffs, coloring materials (17)	9.17
28.		Other engineering products (37)	9.06
29.		Other products based on natural resources (13)	8.18
30.		Heating and cooling equipment (24)	8.09
31.		Feeding-stuff for animals (5)	8.08
32.		Machinery for special industries or processes (23)	7.39
33.		Iron, steel and ferro alloys (11)	6.35
34.		Skins and leather manufactures (6)	5.96
35.		Cereals and cereal preparations (4)	5.32
36.		Textiles (9)	5.16
37.		Iron ore (10)	4.64
38.		Wood and wood manufactures (7)	4.33
39.		Animals, meat and meat preparations (1)	4.17
40.		Ships and boats (incl. oil rigs) (36)	3.85
41.		Typewriters and office machines (26)	0.38

In comparison:
All commodities: 11.43

Booming oil-prices during the seventies caused high growth in OECD trade with oil and gas and other energy-intensive products between 1973 and 1983. But electronics, and to some degree chemicals, continued to be strong growth sectors in OECD trade. It should be noted, though, that the rate of growth in consumer electronics declined markedly both in absolute terms and compared with other commodities. The same is true for non-electronic office machines, cars and electrical household equipment. What happened, probably, is that many of these commodities, especially those linked to the diffusion of "the American way of life", during the seventies approached the mature phase.

However, the Schumpeterian suggestion, that R&D-intensive products linked to relatively recent innovations grow much faster then other products, holds good in both periods:

TABLE 4. TEST OF DIFFERENCES IN GROWTH RATES BETWEEN R&D-INTENSIVE PRODUCTS AND OTHER PRODUCTS

	1961-1973		1973-1983	
	R&D	REST	R&D	REST
Number	13	28	10	31
Growth	19.1	15.0	14.0	9.4
F-test(1,39)	13,27 (*)		11.03 (*)	

* Denotes significance of F-test at the 1% level

In summary, this section shows that OECD trade during the sixties and seventies underwent radical structural changes. Generally, commodities from R&D-intensive industries, especially electronics and chemicals, increased their share of OECD trade at the expense of raw materials, semi-finished products and mature manufactured products. As noted in the introduction to this chapter, this process should be expected to affect countries quite differently depending on their specialization patterns. In the following, we are going to discuss the relation between these changes and the export performance of different OECD countries during this period.[5]

4.3 STRUCTURAL CHANGE AND EXPORT PERFORMANCE

Export performance is normally measured through changes in market shares. A country's share of the world market may change for three different reasons:

First, the market shares for individual commodities on the world market may change. This is often referred to as changes caused by competitiveness, but this implies a more narrow view on competitiveness than the one developed in this study (see chapter 3).

Second, the total market share may change even if market shares

[5] A similar analysis could in principle have been carried out for imports (the growth in a country's market share on its domestic market), but data are not easily available.

for individual commodities remain constant, because structural changes in international trade affect countries differently, depending on their specialization patterns. Such changes in the total market share of a country are often referred to as changes caused by structural change or commodity composition.

Third, changes in the export structure of a country may increase or decrease a country's market share on the world market depending on how well these changes correspond to the changes in world trade. This may be referred to as changes in the market share caused by a country's ability to adapt its export structure to changes in the composition of world trade.

In the following, we will calculate the importance of these three effects on the data presented in the preceding section. The method is a version of the so called "constant market shares analysis" (CMS), which, however, differs from the version commonly used, that of Leamer and Stern(1970), in several respects[6]. Contrary to Leamer and Stern, we are concerned with the change in the market share for exports, not export growth, and, since the purpose is to investigate the consequences of long-run changes in the commodity composition of OECD trade, we do distinguish between "commodity composition" and "country composition" effects. Furthermore, we allow for a separate "adaptability" effect, an effect which Leamer and Stern include

[6] For a more comprehensive discussion of different versions of the CMS method, the reader is referred to Fagerberg and Sollie(1987).

in the other effects in a rather arbitrary way. The following symbols will be used:

X_i = Country A's export of commodity i

M_i = The market's import of commodity i

a_i = Country A's market share for commodity i

b_i = Commodity i's share of the market

m = Country A's market share for all commodities

So that:

$$(1) \quad a_i = \frac{X_i}{M_i}$$

$$(2) \quad b_i = \frac{M_i}{\sum_i M_i}$$

$$(3) \quad m = \frac{\Sigma_i X_i}{\Sigma_i M_i}$$

By substituting (1) - (2) in (3) :

$$m = \frac{\sum_i \left(\frac{X_i}{M_i} \cdot M_i\right)}{\sum_i M_i} = \sum_i \left[\frac{X_i}{M_i} \cdot \frac{M_i}{(\sum_i M_i)}\right]$$

$$(4) \qquad m = \sum_i a_i b_i$$

Let superscript (0,1) denote two points in time:

$$(5) \qquad m^0 = \sum_i a_i^0 \, b_i^0$$

$$(6) \qquad m^1 = \sum_i a_i^1 \, b_i^1$$

By subtraction of (5) from (6) (Δ denotes difference)

$$\Delta m = \sum_i a_i^1 b_i^1 - \sum_i a_i^0 b_i^0$$

$$\Delta m = \sum_i (a_i^0 + \Delta a_i)(b_i^0 + \Delta b_i) - \sum_i a_i^0 b_i^0$$

$$\Delta m = \sum_i (\Delta a_i b_i^0 + \Delta b_i a_i^0 + \Delta a_i \Delta b_i)$$

(7) $$\Delta m = \underset{(I)}{\sum_i \Delta a_i b_i^0} + \underset{(II)}{\sum_i \Delta b_i a_i^0} + \underset{(III)}{\sum_i \Delta a_i \Delta b_i}$$

The first effect (I) is the changes in market shares for individual products weighted by the commodity composition of the market in the initial year (market share effect), while the second (II) is the changes in the commodity composition of the market weighted by the country's market shares in the initial year (commodity composition effect). The third effect (III) is the product of the changes in the market shares for individual products and the changes in the commodity composition of the market. This effect shows the degree of correlation between the changes in market shares and the changes in the composition of the market. We will therefore label it adaptability effect[7].

The interpretation of the latter effect may be understood quite intuitively, but we will nevertheless give the following proof:

[7] The original version of the CMS method, developed by Tyszynski(1951), contained only two effects, the commodity composition effect and a residual which he attributed to "competitiveness". Baldwin(1958) and Spiegelglas(1959) did independently point out that if Laspeyres indices are used throughout the calculation, a third "interaction effect" necessarily appears, but they did not attribute any economic significance to it. In his review of the method, Richardson(1971) pointed out the economic significance of this effect, and suggested that it should be viewed as "a second measure of competitiveness". However, this suggestion seems largely to have been ignored.

Lemma: The adaptability effect measures the correlation (covariance(cov)) between the changes in the market shares for individual products and the commodity composition of the market (number of commodities: i = 1,..,n).

Proof:

$$(8) \quad Cov(\Delta a, \Delta b) = \frac{1}{n} \sum_i \left[\Delta a_i - \left(\frac{\sum_i \Delta a_i}{n}\right)\right]\left[\Delta b_i - \left(\frac{\sum_i \Delta b_i}{n}\right)\right]$$

$$Cov = \frac{1}{n} \sum_i \left[\Delta a_i - \left(\frac{\sum_i \Delta a_i}{n}\right)\right] \Delta b_i \qquad (\text{since } \sum_i \Delta b_i = 0)$$

$$Cov = \frac{1}{n} \sum_i \Delta a_i \Delta b_i - \frac{1}{n} \sum_i \left[\left(\frac{\sum_i \Delta a_i}{n}\right) \Delta b_i\right]$$

$$Cov = \frac{1}{n} \sum_i \Delta a_i \Delta b_i - \frac{1}{n} \left(\frac{\sum_i \Delta a_i}{n}\right)\left(\sum_i \Delta b_i\right)$$

$$(9) \quad n \cdot Cov = \sum_i \Delta a_i \Delta b_i$$

The calculations were carried out for 18 OECD countries in the periods 1961-1973 and 1973-1983, using 1961 (for 1961-1973) and 1973 (for 1973-1983) as base years. The data and the commodity breakdown are the same as those used in the previous section (OECD Trade Series C), but we chose to exclude oil and gas from the calculations, because otherwise the calculations for the post 1973 period would have been totally dominated by the growth in oil prices. The results are given in tables 5 and 6.

Generally, structural changes in OECD trade had quite important consequences for the export performance of the OECD countries. The commodity composition effect was especially important for some of the most industrialized countries of the sample[8], for which it contributed positively, and for some of the least industrialized countries of the sample, for which it contributed negatively. It also contributed negatively for some industrialized countries with a relatively mature industrial structure dominated by production of raw materials and semi-finished goods.

However, even if the commodity composition effect was important, and in some cases decisive, for most countries the market share effect mattered most. The general picture was that Japan, joined by some of the least industrialized countries of the sample, won market shares within individual commodity groups at the expense of some of the more industrialized ones. The adaptability effect was generally of less importance than the other effects. But it was nonetheless quite important in some cases, especially for Japan and some of the least industrialized countries of the sample, for which it contributed positively. In general, for the least industrialized countries of the sample, negative commodity composition effects tended to be outweighed by positive market share and adaptability effects. After 1973, the commodity composition and adaptability effects became somewhat less important compared with the market share effect, but the general picture was the same in both periods.

[8] It was, surprisingly perhaps, less positive for USA than for many other industrialized countries. However, the explanation is fairly simple. USA is specialized in <u>both</u> R&D-intensive (high growth) products and agricultural (low growth) products.

TABLE 5. DECOMPOSITION OF CHANGES IN MARKET SHARES 1961-1973

Country	Commodity composition	Market shares	Adaptation	Total
USA	3.51	-18.58	-1.06	-16.13
JAPAN	22.11	61.11	33.99	117.21
GERMANY	27.31	6.49	-11.58	22.22
FRANCE	8.45	35.92	-8.16	36.21
UK	19.79	-17.60	-18.32	-16.13
ITALY	19.24	16.23	-7.94	27.54
CANADA	-16.20	-7.32	16.38	-7.14
AUSTRIA	4.84	-6.16	-3.90	-5.21
BELGIUM	1.22	29.42	-0.60	30.08
DENMARK	5.75	-15.72	-3.25	-13.21
NETHERLANDS	-1.16	39.51	-5.85	32.51
NORWAY	-6.79	14.03	-0.18	7.06
SWEDEN	7.70	-1.03	-3.11	3.56
SWITZERLAND	19.23	-4.64	-12.29	2.29
FINLAND	-11.76	-16.23	4.38	-23.60
IRELAND	-2.42	1.45	-2.39	-3.36
PORTUGAL	-11.33	68.09	3.30	53.46
SPAIN	-19.06	52.68	8.93	42.54

TABLE 6. DECOMPOSITION OF CHANGES IN MARKET SHARES 1973-1983

Country	Commodity composition	Market shares	Adaptation	Total
USA	4.18	-8.49	0.86	-3.46
JAPAN	9.68	42.25	8.63	60.55
GERMANY	5.36	-11.82	-1.62	-8.09
FRANCE	-0.28	-8.34	-1.16	-9.78
UK	4.12	-9.90	-0.93	-6.72
ITALY	6.90	15.49	-6.81	15.57
CANADA	1.16	3.77	-1.66	3.26
AUSTRIA	-4.79	19.54	-1.51	13.24
BELGIUM	-2.17	-15.89	-0.66	-18.72
DENMARK	-8.53	4.01	-4.79	-9.31
NETHERLANDS	-2.95	-2.22	0.96	-4.21
NORWAY	-3.43	-25.56	1.73	-27.25
SWEDEN	-1.50	-13.49	-2.44	-17.43
SWITZERLAND	7.14	2.76	-5.16	4.74
FINLAND	-8.10	2.54	-1.24	6.79
IRELAND	-9.08	39.64	16.38	46.94
PORTUGAL	-6.16	8.50	1.41	3.74
SPAIN	-1.88	25.83	0.92	24.87

As noted, the calculations were carried out using export data for individual countries and import data for the OECD area as a whole. Since data on exports and imports as, for instance, country A's exports of commodity i to country B and country B's imports of commodity i from country A, generally differ, the resulting calculations will not be totally consistent. To test the results for the way data were handled, we repeated the calculations on a data base constructed from import data only. The results were not qualitatively different from the ones presented here, and are therefore not reported.

4.4 ON THE EXPLANATION OF EXPORT PERFORMANCE

In the preceding chapter we tested a technology-gap model of aggregate export performance. In this section we will examine to what extent the different aspects of export performance discussed in this chapter can be shown to be related to technological, economic and institutional factors that differ between countries. As pointed out in chapter 1 (and verified in section 2 of this chapter), demand generally grows faster for new products and technologies originating in R&D-intensive industries and firms. Following this, we should expect structural changes in international trade to be more favourable for countries with a high level of innovative activity and R&D than for other countries.

As discussed in chapter 1, Vernon(1966), building on earlier work by Linder(1961), has developed this argument further by relating innovation to various economic aspects, such as the level of income in the country and the size of the market. A high level of income in a country, it is argued, implies a sophisticated demand structure, which in turn is assumed to feed back on the structure of production, giving the country a comparative advantage in "new", sophisticated goods. Furthermore, Vernon argues that since many such goods are produced under conditions of economics of scale, countries with access to large domestic markets should also be more likely to develop a comparative advantage in such goods than other countries. Thus, following these arguments, structural changes in international trade should be expected to affect countries with high levels of income and access to large domestic markets favourably.

However, even if structural changes in world trade in general favour countries on a high economic and technological level of development, it does not follow that these countries also are best placed when it comes to competing for market shares within individual commodity groups or adapting the export structure to the changing composition of demand. On the contrary, as pointed out in the preceding chapters, it is often suggested (Posner(1961), Gerschenkron(1962) and others) that countries on a comparatively low level of economic and technological development are for various reasons better placed in this respect (the "late-comer" hypothesis). Following this argument, "late comers" have the opportunity of building up new competitive export sectors, and increasing market shares within individual commodity groups, by imitating technologies developed elsewhere and by exploiting cost advantages. If correct, we should expect a negative relation between the level of economic and technological development and the adaptability and market share effects. Furthermore, as pointed out by several writers (Cornwall(1976), Abramovitz(1979)), the creation of new production capacity and new skills require resources. Following this, we should expect a positive relation between the adaptation and market share effects and the mobilization of resources for growth and structural change, as investments in production capacity, growth in national technological activities etc.

In the following, we are going to test the hypotheses outlined above. What we will do is to regress the effects calculated in the previous section on proxy variables related to hypotheses under test, using ordinary least squares. To increase the efficiency of the test, we pool the data for the two periods, but to allow for changes from one period to the next, we include a pre73-dummy. If not significant on a 20% level at a two-tailed test, the equation was re-estimated without time-dummy. Given the short time series, it is difficult to test for the possibility of serial correlation in the residuals of the cross-sectional units. However, to test for the significance of the inclusion of Japan in the sample, we re-estimated the same models with a dummy for Japan included.

The problem of how to find reliable indicators for the explanatory factors discussed above is already discussed at some length in the previous chapters. For the level of technological development, we used the two indicators discussed earlier: Civil R&D as a percentage of gross national product(RD) and External patents per capita adjusted for differences in the openness of the economy (PATENTING). For the level of income in the country we used GDP per capita in constant 1980 US dollars (PROD), for size the number of inhabitants (POP). For growth in national technological activity we had to rely on growth in external patenting only (PAT), because annual R&D statistics were not available for a sufficient number of countries and time spans. As earlier, we chose to use gross investments as a share of GDP (INV) as a proxy for growth in productive capacity. The results follows in tables 7 and 8 below. Data and sources are listed in the appendix to this chapter.

In general, all hypotheses under test receive some support from the data. In particular, the data give strong support to the Schumpeterian hypothesis of a positive relation between the commodity composition effect and the level of national technological activity measured through R&D or patent statistics. But also the Vernon-Linder view is supported, especially the assumption of a positive relation between the commodity composition effect and the size of the country. Thus the countries most favourably affected by the structural changes in OECD trade in the periods under consideration were large countries with a high level of national technological activity.

TABLE. 7 EXPLAINING ASPECTS OF EXPORT PERFORMANCE

The commodity composition effect(COM)

The Schumpeterian view:

COM =	-14.30	+	9.93RD	+	6.99TIME	R^2=0.35(0.31)
	(-3.53)		(3.95)		(2.32)	SER=8.84
	*		*		**	N=36

COM =	-39.32	+	5.73lnPATENTING	R^2=0.32(0.30)
	(-3.64)		(3.89)	SER=8.91
	*		*	N=34

The Vernon-Linder view:

COM =	-21.94	+	1.04PROD	+	4.01lnPOP	+	7.32TIME	R^2=0.34(0.27)
	(-3.40)		(2.02)		(3.26)		(2.24)	SER=9.06
	*		**		*		**	N=36

The market share effect(MAR)

The "catch-up" hypothesis:

MAR =	20.99	-	9.94RD	R^2=0.08(0.04)
	(2.30)		(-1.51)	SER=23.64
	**		***	N=36

MAR =	49.66	-	5.91lnPATENTING	R^2=0.08(0.05)
	(1.87)		(-1.63)	SER=21.90
	**		***	N=34

MAR =	44.52	-	4.39PROD	R^2=0.35(0.33)
	(4.93)		(-4.28)	SER=19.68
	*		*	N=36

The "efforts" hypothesis:

MAR =	-40.92	+	2.11INV	R^2=0.11(0.09)
	(-1.69)		(2.07)	SER=23.01
	**		**	N=36

$$MAR = \underset{\substack{(2.11)\\ **}}{15.11} + \underset{\substack{(2.31)\\ **}}{2.38PAT} - \underset{\substack{(-1.36)\\ ***}}{16.85TIME}$$

R^2=0.16(0.11)
SER=21.16
N=34

The adaptability effect(ADA)

<u>The "catch-up" hypothesis:</u>

$$ADA = \underset{(0.82)}{2.86} - \underset{(-0.99)}{2.47RD}$$

R^2=0.03(0.00)
SER=8.98
N=36

$$ADA = \underset{\substack{(2.16)\\ **}}{2.85} - \underset{\substack{(-2.22)\\ **}}{3.20 \ln PATENTING}$$

R^2=0.13(0.11)
SER=8.72
N=34

$$ADA = \underset{\substack{(1.57)\\ ***}}{6.27} - \underset{\substack{(-1.75)\\ **}}{0.79PROD}$$

R^2=0.08(0.06)
SER=8.73
N=36

<u>The "efforts" hypothesis:</u>

$$ADA = \underset{\substack{(-2.67)\\ *}}{-23.25} + \underset{\substack{(2.67)\\ *}}{0.98INV}$$

R^2=0.17(0.15)
SER=8.28
N=36

$$ADA = \underset{\substack{(3.21)\\ *}}{8.01} + \underset{\substack{(4.54)\\ *}}{1.63PAT} - \underset{\substack{(-3.91)\\ *}}{16.90TIME}$$

R^2=0.40(0.36)
SER=7.36
N=34

* = Significance at the 1% level at a two-tailed test
** = Significance at the 5% level at a two-tailed test
*** = Significance at the 10% level at a two-tailed test
**** = Significance at the 20% level at a two-tailed test

SER = Standard error of regression
The numbers in brackets under the estimates are t-statistics.
The numbers in brackets after R^2 are R^2 adjusted for degrees of freedom.

TABLE. 8 EXPLAINING ASPECTS OF EXPORT PERFORMANCE (with Japan dummy)

The commodity composition effect(COM)

The Schumpeterian view:

$$COM = -13.57 + 9.02RD + 6.77TIME + 9.30JAP$$

	Constant	RD	TIME	JAP	
t	(-3.37)	(3.53)	(2.28)	(1.42)	$R^2=0.39(0.33)$
	*	*	**	****	SER=8.70
					N=36

$$COM = -38.78 + 5.55\ln PATENTING + 12.99JAP$$

	Constant	lnPATENTING	JAP	
t	(-3.77)	(3.95)	(2.10)	$R^2=0.41(0.37)$
	*	*	**	SER=8.47
				N=34

The Vernon-Linder view:

$$COM = -21.41 + 1.13PROD + 3.31\ln POP + 7.51TIME + 10.59JAP$$

	Constant	PROD	lnPOP	TIME	JAP
t	(-3.38)	(2.24)	(2.56)	(2.34)	(1.52)
	*	**	**	**	****

$R^2=0.39(0.31)$
SER=8.88
N=36

The market share effect(MAR)

The "catch-up" hypothesis:

$$MAR = 24.39 - 15.09RD + 55.36JAP$$

	Constant	RD	JAP	
t	(3.09)	(-2.60)	(3.64)	$R^2=0.33(0.29)$
	*	*	*	SER=20.26
				N=36

$$MAR = 51.68 - 6.59\ln PATENTING + 49.49JAP$$

	Constant	lnPATENTING	JAP	
t	(2.29)	(-2.13)	(3.64)	$R^2=0.35(0.31)$
	**	**	*	SER=18.62
				N=34

$$MAR = 39.61 - 4.05PROD + 38.90JAP$$

	Constant	PROD	JAP	
t	(4.78)	(-4.36)	(3.00)	$R^2=0.49(0.46)$
	*	*	*	SER=17.72
				N=36

The "efforts" hypothesis:

$$MAR = -12.62 + 0.82INV + 38.32JAP$$

	Constant	INV	JAP	
t	(-0.46)	(0.69)	(1.98)	$R^2=0.21(0.16)$
			***	SER=22.09
				N=36

	Constant	PAT	TIME	JAP	
MAR =	3.40	+ 0.49PAT	+ 1.63TIME	+ 42.89JAP	R^2=0.28(0.21)
	(0.40)	(0.38)	(0.11)	(2.22)	SER=19.93
				**	N=34

The adaptability effect(ADA)

<u>The "catch-up" hypothesis:</u>

	Constant	RD	JAP	
ADA =	4.45	- 4.88RD	+ 25.94JAP	R^2=0.45(0.42)
	(1.67)	(-2.49)	(5.05)	SER=6.85
	****	**	*	N=36

	Constant	lnPATENTING	JAP	
ADA =	23.79	- 3.53lnPATENTING	+ 24.00JAP	R^2=0.52(0.49)
	(2.97)	(-3.22)	(4.98)	SER=6.61
	*	*	*	N=34

	Constant	PROD	JAP	
ADA =	3.52	- 0.61PROD	+ 21.80JAP	R^2=0.40(0.36)
	(1.04)	(-1.61)	(4.14)	SER=7.19
		****	*	N=36

<u>The "efforts" hypothesis:</u>

	Constant	INV	JAP	
ADA =	-8.43	+ 0.30INV	+ 20.07JAP	R^2=0.36(0.32)
	(-0.92)	(0.76)	(3.10)	SER=7.40
			*	N=36

	Constant	PAT	TIME	JAP	
ADA =	4.62	+ 1.08PAT	- 11.56TIME	+ 12.37JAP	R^2=0.46(0.40)
	(1.51)	(2.35)	(-2.25)	(1.79)	SER=7.11
	****	**	**	***	N=34

* = Significance at the 1% level at a two-tailed test
** = Significance at the 5% level at a two-tailed test
*** = Significance at the 10% level at a two-tailed test
**** = Significance at the 20% level at a two-tailed test

SER = Standard error of regression
The numbers in brackets under the estimates are t-statistics.
The numbers in brackets after R^2 are R^2 adjusted for degrees of freedom.

The test also supports the hypotheses of a positive relation between the market share and adaptation effects on the one hand, and the scope for imitation, measured in terms of technological activity or income per capita, on the other hand. Interestingly, in most cases the results tend to be more significant when Japan is excluded from the sample. Thus, there is certainly no support for the suspicion that the "catch-up" effect might be due to the inclusion of Japan in the sample. It may be noted, also, that in the case of growth of market shares, income per capita tends to yield more significant results than technological activities as a proxy for "the scope for imitation". One intuitive interpretation of this result is that the income-per-capita indicator is more powerful because it in addition to a large scope for imitation also reflects absolute cost-advantages (a low level of income per capita indicate a low level of wages per produced unit).

It is one case, however, where the introduction of a Japan dummy had a large influence on the result: the hypotheses of a positive relation between the market share and adaptability effects and "efforts" (investment and patent growth). When Japan was included, these variables were found to be significant, when Japan was excluded, they were, with one exception (the adaptability effect and patent growth), not significant. Similar, though not identical, results have been reached in earlier studies (Cornwall(1976, 1977), Fagerberg(1987)). However, these results do not necessarily imply that these hypotheses should be rejected. What these results show is that these "efforts" do contribute to the explanation of the differences in export performance between Japan and the other countries of our sample, but not to the explanation of the (much smaller) differences in export performance between the remaining countries of our sample. The results of chapter 2 lead us to believe that the significanse of the relation between export performance and "efforts" would have been reinforced if other fast-growing countries - as the Asian NIC's -had been included in the sample. Given the availability of data, this was not possible.

4.5 CONCLUDING REMARKS

This chapter has extended the analysis of export performance in the preceding chapter by taking into account the relation between the process of innovation-diffusion and structural changes in international trade. Between 1961 and 1983, the structure of OECD trade changed quite radically. The main source of these changes was found to be the creation and subsequent diffusion of new products and technologies originated in R&D-intensive industries, especially the electronics and chemical industries. These changes were shown to favour large countries with a high level of national technological activity, measured through R&D or patent statistics, and disfavour small countries with a less well developed indigenous technological base.

However, the growing international trade in this period did at the same time allow countries on a low level of economic and technological development to catch up and increase market shares through imitation, exploitation of cost advantages and changes in export structure (adaptation). On balance the latter type of effects outweighed the former.

Thus, Post-War growth seems to a game with two winners: the large, technologically advanced countries on the one hand, and the semi-industrialized (low-cost) countries on the other. However, there are countries that do not belong to either group, among them many small, developed countries, characterized by high levels of income (and wage-costs), but relatively low levels of national technological activity. In the next chapter, we will consider the trade performance of some of these countries in this period in more detail.

APPENDIX

Sources

Trade statistics:
OECD Trade Series C and national sources(Finland and Japan(1961))

Real GDP per capita (1980 market prices in US $):
IMF International Financial Statistics

External patent applications:
OECD/STIIU DATA BANK and World International Property Organization(WIPO):Industrial Property Statistics

The R&D data are estimates based on the following sources:
OECD Science and Technology Indicators, Basic Statistical Series (vol B(1982) and Recent Results(1984)), UNESCO Statistical Yearbook and various UNESCO surveys on resources devoted to R&D.

Military R&D expenditures were, following the OECD, assumed to be negligible in all countries except the US, France, Germany, Sweden and UK. The R&D data for these countries were adjusted downward according to OECD estimates. The estimates were taken from OECD(1983), Directorate for Science, Technology and Industry: The problems of estimating defence and civil GERD in selected OECD member countries (DSTI/SPR/83-2). For other countries, civil and total R&D as a percentage of GDP were assumed to be identical.

Data on population and export shares in GDP were taken from:
OECD Historical Statistics 1960-1983, OECD National Accounts(various editions), IMF Supplement on Output Statistics, UN Monthly Bulletin of Statistics(various editions) and Statistical Yearbook of the Republic of China 1984.

Growth in relative unit labour costs:
IMF Financial Statistics

Growth in relative export unit values:
UN International Trade Statistics Yearbook

Methods

Growth rates are calculated as geometric averages for the periods 1960-1973 and 1970-1983, or the nearest period for which data exist. Levels and shares are calculated as arithmetic averages for the periods 1960-1973 and 1974-1983, or the nearest period for which data exist.

Table A 1

CLASSIFICATION OF PRODUCTS	SITC. REV. 1	SITC. REV.2
101 PRODUCTS BASED ON NATURAL RESOURCES		
1 Animals, meat, and meat preparations	00, 01, 091.3, 411.3	00, 01, 091.3, 411.3
2 Dairy products and eggs	02	02
3 Fish and fish preparations	03, 411.1	03, 411.1
4 Cereals and cereal preparations	04	04
5 Feeding-stuff for animals	08	08
6 Skins and leather manufactures	21, 61	21, 61
7 Wood and wood manufactures	24, 63	24, 63
8 Pulp and paper	25, 64	25, 64
9 Textiles	26, 65	26, 65
10 Iron ore	281	281
11 Iron, steel and ferro alloys	67	67
12 Aluminum	684	684
13 Other products based on natural resources	05, 06, 07, 091.4, 099, 11, 12, 22, 23, 27, 282, 283, 284, 285, 286, 29, 32, 35, 42, 43, 62, 66, 681, 682, 683, 685, 686, 687, 688, 689	05, 06, 07, 091.4, 098, 11, 12, 22, 23, 27, 282, 286, 287(-:32), 288, 289, 29, 32, 35, 42, 43, 62, 66, 681, 682, 683, 685, 686, 687, 688, 689, 699.9
102 OIL AND GAS		
14 Oil and gas	33, 34	33(-:5.2), 34
103 CHEMICALS		
15 Organic chemicals	512	51
16 Inorganic chemicals	513, 514	522, 523, 287.32
17 Dyestuffs, coloring materials	53	53
18 Pharmaceuticals	54	54
19 Fertilizers	56	56
20 Plastic materials	581.1:2	582, 583, 893.91:2
21 Other chemicals	515, 52, 55, 57, 581.3:9, 59	335.2, 524, 55, 57, 584, 585, 59, 894.63, 899.39, 951.66
104 ENGINEERING, ELECTRONICS AND TRANSPORT EQUIPMENT		
22 Power generating machinery	711	711, 712, 713, 714, 718
23 Machinery for special industries or processes	712, 715, 717, 718, 719.3:5:8	72, 73(-:7.32) 744, 745.1

Heating and cooling equipment	719.1	741(-:31)
Pumps and centrifuges	719.2	742, 743
Typewriters and office machines	714.1:9	751.1:81:88, 759.11:15
Computers and peripherals	714.2:3	751.2, 752, 759.9
Semiconductors	729.3	776
Telecommunications	724.9	764(-:99)
Machinery for production and distribution of electricity	722, 723, 729.9	771, 772, 716, 773, 778.8(-:5), 737.32, 741.31
Consumer electronics	724.1:2, 891.1	761, 762, 763, 764.99
Domestic electrical equipment	725	775
Scientific instruments, photographic supplies, watches and clocks	726, 729.5:7, 861, 862, 864	751.82, 759.19, 774, 778.85, 87, 88(-:3)
Road motor vehicles	732	78(-:5(-:1:39))
Aircraft	734	792(-:83)
Ships and boats (incl. oil rigs)	735	793
Other engineering products	719.6:7:9, 729.1:2:4:6, 731, 733	745.2, 749, 778 (-:8), 785.2:31, 786,791
TRADITIONAL INDUSTRIAL PRODUCTS		
Manufactures of metal	69, 719.4, 812.1:3	69(-:9.9), 812.1
Furniture	82	82
Clothing	84	655.3, 658.98, 84(-:8.21)
Industrial products	812.2:4, 83, 85, 863, 891.2:4:8:9, 892, 893, 894, 895 896, 897, 899, 9	792.83, 812.2:4, 83, 848.21, 851, 883, 892, 893(-:91:92), 894(-:63),895, 896, 897, 898, 899.1:3 (-:9):4:6:7:8:9, 9
SUM OF ALL PRODUCTS		
Sum of all products		

es

The abbreviations should be read as the following examples show:

.1:3 should be read as 891.1+891.3.
.3(-:9) should be read as 899.3 - 899.39.

Commodity no. 14 (oil and gas) was not included in the calculations.

Table A2 Data used in regressions(Chapter 4)

Patents (level,adj)	R&D	Investment	GDP p.cap.	Patents (growth)	Population
10291.80	1.71	18.12	9.93	3.47	198.71
4373.65	1.82	17.94	12.23	-5.38	222.59
1569.83	1.61	32.61	4.92	18.22	99.92
2117.26	2.11	31.36	8.32	0.40	114.92
5292.36	1.63	24.89	8.05	3.47	59.29
3182.67	2.21	21.14	11.10	-7.50	61.33
3127.67	1.54	22.68	7.21	4.07	49.55
1725.23	1.57	21.98	10.40	-5.58	53.28
2842.43	1.64	18.34	7.21	0.98	54.93
1323.77	1.76	18.40	8.86	-6.58	55.90
1086.82	0.78	21.28	4.40	3.86	52.67
676.67	0.91	19.68	6.11	-3.66	56.13
1075.52	1.15	21.91	7.94	4.62	20.41
716.69	1.15	22.46	10.84	-4.70	23.55
1598.29	0.48	26.71	5.71	3.92	7.32
1082.27	1.02	25.44	8.59	-5.60	7.51
912.69	1.20	21.64	6.78	1.40	9.58
430.63	1.37	20.46	9.79	-6.98	9.83
1630.79	0.73	23.78	8.89	4.14	4.84
1269.69	1.01	19.94	11.22	-4.64	5.10
2101.80	1.91	25.00	7.76	0.82	12.60
1202.29	1.95	20.22	10.36	-6.44	13.94
653.86	0.91	28.38	8.59	3.01	3.79
575.65	1.32	30.06	12.36	-6.64	4.06
4997.68	1.03	23.40	10.32	3.26	7.87
3104.83	1.78	20.04	13.03	-5.86	8.28
11868.32	2.35	27.96	13.00	3.43	6.06
7287.42	2.34	23.06	15.35	-8.02	6.34
810.43	0.56	26.45	6.48	9.27	4.61
1184.37	1.09	26.28	9.33	4.08	4.75
204.55	0.62	20.47	3.58	9.44	2.90
163.88	0.80	26.34	4.84	-4.26	3.31
na	0.29	23.97	1.39	na	9.10
na	0.31	27.70	2.18	na	9.80
347.01	0.20	21.16	3.44	6.18	32.85
253.96	0.37	20.76	4.98	-5.22	36.78

For the order of countries, see table 5. (The first observation is USA in the first period, the second USA in the second period, the third Japan in the first period etc.)

CHAPTER 5

INTRA-REGIONAL TRADE AS AN ENGINE OF TECHNOLOGY DIFFUSION: THE SPECIAL PROBLEMS OF SMALL COUNTRIES[1]

5.1. INTRODUCTION

It is often suggested that access to a large, advanced and homogeneous domestic market is an important factor facilitating both innovation and diffusion of technology[2] and that small countries, as a result of this, face significant competitive disadvantages in new, advanced products and technologies. Consider, for instance, the data on export specialization[3] in

[1] It should perhaps be stressed that the discussion in this paper confines itself to the relation between country size and innovation-diffusion, and that other aspects of "country size" will not be discussed. For instance, there is no treatment here of whether small countries gain more (or less) from trade than others , to what extent trade makes small countries more "vulnerable" than others or questions related to trade-policy. For a recent discussion of some of these issues within a game-theoretic approach, which, incidentally, also considers Nordic economic cooperation, see Dixit (1987). For an overview of the research on relations between technology and small-country disadvantages in trade, see Walsh(1987).

[2] In the version discussed here (see section 2 of this chapter), this view may be attributed to Vernon(1966). Other proponents of the view that small countries face considerable disadvantages in advanced products (or manufacturing products in general) are Keesing (1968) and Kaldor (1979).

[3] The export specialization index for a commodity i on the world market (or "revealed comparative advantage" (Balassa, 1965)) is the ratio between the country's market share on the world market for that commodity and its market share for all commodities on the world market. If this ratio is above one, the country in question is said to be export specialized in that commodity.

high, medium and low technology products[4] in table 1 below. The table contains data for 20 OECD countries divided into three groups: large developed countries, small developed countries and semi-industrialized countries. Even though the specialization patterns differ both between and within the three groups of countries, with Switzerland (among the small developed countries) and Ireland (among the semi-industrialized countries) as extreme within-group-deviants,[5] there is nevertheless clear support for the proposition that the large developed countries tend to be far more specialized in high technology products than the small developed ones. Indeed, with one exception(Switzerland), all small developed countries are specialized in low technology products.[6]

[4] The division of products into high, medium and low technology products is based on R&D-intensities as reported by other sources. For a discussion of sources and methods, see section 2 of the preceding chapter, for a list of products ranked according to technology group, see appendix 1 to this chapter. Admittedly, a division of this kind must necessarily be rather rough, and can always be contested. It is brought here for illustratory purpose mainly.

[5] Switzerland has for historical reasons, which we will not attempt to explore here, developed a specialization pattern which differs from most other countries, with a strong emphasis on chemicals, instruments and mechanical engineering. The specialization pattern of Ireland was until recently not very different from the majority of semi-industrialized countries. For instance, in 1973, export specialization in high technology products was 0.62. In recent years, however, this has changed dramatically because foreign multinationals for various reasons have found it profitable to locate assembly plants for computers and other electronic products in Ireland.

[6] Note, however, that Sweden is export specialized in both medium-technology and low-technology products.

TABLE 1. EXPORT-SPECIALIZATION OF OECD-COUNTRIES, 1983

	Technology-intensity High	Medium	Low
Large, developed:			
USA	1.55	0.81	0.90
Japan	1.16	1.55	0.52
Germany	1.01	1.32	0.75
France	0.95	0.99	1.03
UK	1.08	0.75	1.15
Italy	0.71	0.95	1.17
Small, developed:			
Austria	0.82	0.88	1.17
Belgium	0.62	0.79	1.33
Canada	0.47	0.97	1.26
Denmark	0.55	0.77	1.37
Finland	0.38	0.77	1.45
Netherlands	0.76	0.63	1.38
Norway	0.32	0.43	1.73
Sweden	0.80	1.06	1.05
Switzerland	1.53	1.14	0.66
Semi-industrialized:			
Greece	0.19	0.22	1.94
Ireland	1.30	0.61	1.16
Portugal	0.50	0.54	1.57
Spain	0.44	0.88	1.34
Turkey	0.13	0.20	1.98
Means:			
Large developed	1.08	1.06	0.92
Small developed	0.69	0.83	1.27
of which Nordic	0.51	0.76	1.40
Semi-industrialized	0.51	0.49	1.60

Source: OECD-Trade Series C

For the classification of products, see appendix 1 to thi: ter.

This chapter focuses on the possibilities for small countries to take part in the international process of innovation and diffusion by means of a case-study of the Nordic countries in the period 1961-1983. In terms of empirical methodology, this represents a change compared to the previous chapters. While chapters 2-3 (and to some extent chapter 4 as well) used regression analysis to test highly aggregated formal models on data for a large number of countries, the analysis in this chapter is based on interpretation of relatively disaggregated, descriptive statistics for a small number of countries (Denmark, Finland, Iceland, Norway, Sweden and the Nordic countries as a group). The case-study methodology adopted in this and the following chapter, while less well suited for general conclusions on the working of the international economy, has the advantage that it allows us to study in detail how sector and country specific conditions for innovation-diffusion interact and evolve through time. For each country, a large number of descriptive tables was computed,[7] but to keep the discussion manageable, we focus mainly on the Nordic countries as a group.[8]

The following section extends the perspective developed in the preceding chapters by considering in more detail the opportunities and problems encountered by small countries in the international process of innovation and diffusion. In particular, an at-

[7] For a presentation of data, sources and commodity breakdown, see section 2 and appendix in chapter 4.

[8] The full set of tables on which the analysis of this chapter is based includes more than 100 pages. A smaller set, showing some main figures for each Nordic country, is included in the appendix to this chapter.

tempt is made to explore to what extent intra-regional trade between a group of small countries can help small countries to overcome the disadvantages of small domestic markets. The remaining part of the chapter analyses the development of the Nordic countries' trade patterns, with special emphasis on their mutual trade, from that perspective.

5.2. A SCHUMPETER-LINDER-VERNON APPROACH TO INTERNATIONAL DIFFUSION OF TECHNOLOGY

According to the Schumpeterian perspective outlined in chapter 1, innovations tend to cluster in special industries, located in special countries (geographical centre), from where they diffuse to other countries (geographical periphery) through trade and other means of knowledge transfer. To what degree countries in the periphery manage to take part in the international process of diffusion (or transfer of technology) by establishing domestic production, reducing import dependency and increasing exports, will be of crucial importance for the development of market shares (domestically and abroad) and, hence, economic growth.

What, then, are the conditions for countries with different sets of characteristics to exploit the possibilities offered by the international process of diffusion to establish new production and, hence, exports? As pointed out by Mansfield(1982, p.29), there has been relatively little research in this area. In fact, most diffusion studies have focused on process innovations or diffusion among users (not producers) of new products.[9] Probably, the most systematic attempts to cope with this issue are still those made by the so called "neotechnological" trade theorists in the 1960's (see chapter 1).

The seminal contribution by Linder(1961), though not focusing exclusively on diffusion aspects, provides a useful point of departure. According to Linder, a necessary condition for firms to engage in production of new products is that they receive signals from their traditional markets, in most cases the domestic market, that this is a profitable way to go. Following this, producers should be expected to start production by selling to the domestic market, and later - if successful there - exploit the accumulated experiences from the domestic market to engage in exports. As a consequence, learning[10] through domestic "user-producer" interaction (Lundvall(1988)) - enters as a crucial factor for the outcome of innovation and diffusion processes (and

[9] For recent overviews of diffusion theory and applied studies, see Davies(1979) and Stoneman(1983).

[10] On the importance of learning by "doing", "using", "interacting" etc see Arrow (1962), Rosenberg(1982) and Lundvall (1988).

specialization patterns in international trade[11]. Thus, following this view, the quality, composition and - in the case of economies of scale - size of the domestic market should be added to the list of important factors that influence a country's ability to enter new production areas.

Diffusion conditions do not only depend on factors related to the recipient country, but also on technological factors. Vernon(1966) was, as pointed out in chapter 1, among the first to present a systematic theory which reflected both(the "product life cycle" theory). Following Linder he assumed that most innovations would be carried out in the United States (due to the large domestic market for advanced products). Diffusion or transfer of production should, according to this view, be expected to take place relatively automatically as the product or technology in question moves through the three phases of the product life cycle (introduction, growth and maturity), starting with diffusion to other developed countries, and continuing with diffusion

[11] One implication of Linder's view is that since demand affects the composition of both exports and imports, countries with similar demand structures should be expected to trade more extensively with each other. If the structure of demand reflects the level of income, this implies that countries on approximately the same level of income should be more inclined to trade with each other than countries on different levels of income. This hypothesis, which is sometimes referred to as the Linder view, has undergone extensive empirical testing, of which the majority are supportive (for a recent test on a large data set including 100 countries, see Kleiman and Kop, 1984). Though empirically supported, we hold this to be a too narrow interpretation of Linder's view. In essence, Linder's argument is an evolutionary one, that specialization patterns evolve through learning processes related to (historically given) structures which (though related to the level of income) also differ among countries on comparable levels off income. For an earlier attempt to analyse export specialization in producer goods from this (latter) perspective, see Andersen et al.(1981a,b).

to less-developed, low-cost countries. If Vernon's view is correct, small developed countries should be expected to have a comparative disadvantage both in the introductory phase (because of small domestic markets for new products) and in the late phase (because of the increasing importance of economies of scale and low (wage) costs). To the extent that they succeed in increasing domestic production and exports through imitation, these gains should be expected to be of a transitory nature.

However, the product cycle theory, though relevant in many instances, is built on quite strong assumptions. To put it in the words of Van Duijn (1983), the product life cycle may be "extended" because new innovations (or technological competition) take place. In such cases, the competitive position of the innovator often remains strong relative to imitators, and diffusion (or transfer of production) may be delayed or blocked entirely, depending on the character of the technologies, industries and markets involved. One case refers to industries characterized by rapid technological shifts and increasingly complex technologies, delivering to customers all over the world, as, for instance, the aircraft industry and the computer industry (Rosenberg(1982), Porter(1986), Dalum et al.(1988)). These industries are often characterized by increasing dynamic and static economies of scale and, consequently, increasing disadvantages for small firms or (what often means the same thing) firms from countries with small domestic markets(Walsh,1987). However, when large technological shifts occur, new possibilities of entry will emerge, provided that the entrants react early enough ("early movers"). Another case refers to industries that produce "taylor-made"-products for user-specific needs or differentiated products in small series for customers throughout the world, as, for instance, the scientific instruments industry(Dalum et al, 1988). Here small-country disadvantages are less pronounced, but to the extent that learning curves are steep (dynamic economies of scale), significant "early mover" advantages should be expected.

Thus, even though small country disadvantages in new, advanced products and technologies exist, they are not uniformly distributed, either across industries or through time, and this opens possibilities that the small countries may exploit. As pointed out by Walsh (1987), small country disadvantages may in many cases be overcome through the adaptation of adequate strategies, as, for instance, by specializing in areas ("niches")[12] where economies of scale are relatively unimportant or where competent domestic users exist, by supporting the growth of national MNE's or by cooperation (including trade) between a group small countries. In general, these strategies are complements rather than alternatives, even though a conflict may arise between a global internationalization strategy based on the growth of national MNE's and a regional integration strategy based on close cooperation between a group of small neighbouring countries. The latter should be expected to be easiest in cases where similarities in tastes, cultures, income levels, institutions and markets exist,

[12] Walsh (1987) treats "specialization" and "finding niches in the markets" as separate strategies, but since the latter necessarily is a subgroup of the former, we have - following Lemola and Lovio (1987) - chosen to group them together.

and the level of protectionism is low. As small open economies, with many common features and free trade agreements, this view should be applicable to intra-Nordic trade.

5.3. THE NORDIC COUNTRIES' PATTERNS OF PRODUCTION AND TRADE AROUND 1960

In the 1950s and 1960s the United States was the uncontested centre of the capitalist world; technologically and economically. GDP per man-hour in the United States was in 1960 about twice as high as in Western Europe (Maddison(1982)). New products and technologies originated as a rule in the United States, from which they diffused at different speeds to Western Europe, Japan and other countries through trade and other means of knowledge transfer.

While the United States was a highly productive centre in the OECD area, so was Sweden in the Nordic area, even though the differences between the Nordic countries were less pronounced. In 1960, GDP per man-hour in Sweden was about 50% higher than in Finland and Iceland. Compared to Sweden, Finland and Iceland in the 1950s were industrially poorly developed, in the same way as most countries in Western Europe were industrially poorly developed in comparison with the United States.

TABLE 2 THE COMMODITY COMPOSITION OF NORDIC TRADE 1961-1983,value.

Nordic exports to the OECD (excl. Nordic countries)

	1961	1973[1]		1983[1]	
Products based on natural resources (101)[2]	78.6	60.0	(60.4)	42.7	(55.5)
Oil and gas (102)	0.0	0.6		23.1	
Chemical products (103)	2.5	3.5	(3.5)	5.2	(6.8)
Machinery and transport equipment (104)	14.7	28.7	(28.9)	22.8	(29.6)
Traditional industrial products (105)	4.2	7.1	(7.1)	6.1	(7.9)
	100	100	(100)	100	(100)

Nordic imports from the OECD (excl. Nordic countries)

	1961	1973[1]		1983[1]	
Products based on natural resources (101)	38.4	31.4	(33.3)	24.4	(27.4)
Oil and gas (102)	7.0	5.9	-	10.8	-
Chemical products (103)	8.7	10.0	(10.6)	11.7	(13.1)
Machinery and transport equipment (104)	38.2	44.2	(47.0)	41.6	(46.6)
Traditional industrial products (105)	7.7	8.6	(9.1)	11.5	(12.9)
	100	100	(100)	100	(100)

Intra-Nordic trade

	1961	1973[1]		1983[1]	
Products based on natural resources (101)	44.9	40.0	(41.2)	34.0	(40.2)
Oil and gas (102)	1.8	3.0		15.4	
Chemical products (103)	8.1	7.8	(8.0)	8.9	(10.5)
Machinery and transport equipment (104)	36.0	33.0	(34.0)	26.5	(31.3)
Traditional industrial products (105)	9.3	16.3	(16.8)	15.2	(18.0)
	100	100	(100)	100	(100)

1) The numbers in brackets are excl. oil and gas.
2) The numbering of products refers to the appendix in chapter 4
Sources: OECD Trade Series C

The low stage of industrial development of the Nordic countries compared to the United States, and to some extent also to other OECD countries, was clearly reflected in the specialization patterns of the Nordic countries on the OECD market. In 1961, three fourths of the Nordic countries' total exports to other OECD countries were made up of products based on natural resources, cf. table 2. The percentages were highest for the less developed countries. In the case of Iceland, 99.4% of its export to the other OECD countries[13] consisted of natural-resource based products (mainly fish and fishery products), while the share for Finland was 97.6% (forest products and pulp/paper). Also Norway and Denmark were highly specialized in natural-resource based products; for Norway the share was 83.9% (mainly metals, forest products and pulp/paper, and fish), and for Denmark 79.2% (agricultural products). Sweden too had a large share of natural-resource based products in 1961, 66.0% (metals, forest product and pulp/paper). However, Sweden also had a substantial export of more advanced products such as machinery and transport equipment (25.4% of the export to the other OECD countries in 1961).

The imports to the Nordic countries in the beginning of the 1960s were far more differentiated than the exports, reflecting the fact that the composition of demand was much more differentiated than the structure of production. Intra-Nordic trade also had a far larger share of industrial products than the

[13] With "other OECD countries" we mean OECD less the Nordic countries. This notion will be used throughout this chapter.

exports to the other OECD countries. At the outset this was especially important for Sweden and Denmark, which at that time were industrially the most advanced of the Nordic countries. For instance 50.0% of Sweden's and 35.6% of Denmark's exports to the Nordic countries in 1961 consisted of machinery and transport equipment, and the Nordic market absorbed in both cases approximately one third of total Swedish and Danish exports of these products. For some "new" products the share of the Nordic market of total exports was even larger. For instance, in 1961, the Nordic countries absorbed 44.4% of Swedish exports of pharmaceuticals, and 53.7% of Danish exports of consumer electronics.

5.4. DIFFUSION AND STRUCTURAL CHANGE 1961-1973: THE ROLE OF INTRA-NORDIC TRADE

Between 1961 and 1973, an extensive change in the traditional natural-resource based specialization pattern took place. The share of natural-resource based products in the Nordic countries' exports to the other OECD countries decreased from 78.6% to 60.0%, while the share of machinery and transport equipment doubled, from 14.7% to 28.7% . Except Iceland, all Nordic countries took part in this development, but the changes were especially marked for Denmark and Norway. The structure of the Nordic countries' imports and mutual trade, which at the outset were less natural-resource based, changed too, but less markedly than in the case of exports.

As discussed earlier on, diffusion (transfer of production) may be facilitated if the level and growth of demand for the product in the markets familiar to the producer are high. The Nordic market had a favourable effect in this respect because the demand structure was relatively advanced, i.e. Nordic consumers had already adapted their consumption patterns to a large number of new products which initially had been introduced in the United States, and because demand grew at a steady rate. However, for successful diffusion to take place, local producers must be able to compete favourably with competitors from the innovating country and other "early imitators". This means that there must exist local competitive advantages either in the form of customs or other trade restrictions, or in the form of norms on the demand side that the local producers are better placed to adapt to, or in the form of cost components (such as transport costs) that are lower for local producers. The Nordic market had several favourable features. First, all the Nordic countries were members of EFTA, which means that they to an increasing degree practiced free trade between themselves and towards other EFTA countries, but exercised some protection towards producers from the United States and the EEC. Second, common norms and mutually intelligible languages made it easy for Nordic producers to develop product variants which were considered attractive in the Nordic market. And thirdly, the geographical location of the Nordic countries (far away from the United States and the large European countries) provided an incentive to start local production in cases where transport costs were high.

To investigate the impact of intra-Nordic trade on the process of transfer of production from the more advanced OECD countries - primarily the United States - to the Nordic countries in this period, we shall consider more closely the development within ten selected product groups. These products have been chosen because they belong to the one third which increased most in OECD trade between 1961 and 1973 (see chapter 4), and because they (with one exception, electrical household appliances[14]) have a high research intensity. What we should expect, given the assumption of a positive relation between diffusion and intra-Nordic trade, is the following:

1) The Nordic market should be important for Nordic producers, i.e. a large share of total Nordic exports should go to other Nordic countries, especially at an early stage of the diffusion process.

2) Nordic producers should cover a small share of the Nordic market at the beginning of the diffusion process, but this share should soon start to increase.

3) Nordic market shares in the other OECD countries should initially be at a low level, but should after a while start to increase.

[14] The group of electrical household appliances was chosen because it includes many typical "American Way of Life" products that diffused from the United States to the Nordic countries in this period.

As is evident from tables 3-5, pharmaceuticals, plastics, telecommunications equipment, consumer electronics, electrical household appliances and motor vehicles follow a pattern quite close to the one predicted. For these products, the Nordic market was initially relatively important for Nordic producers, even though the Nordic producers had a relatively small share of the Nordic market. The Nordic producers' share of Nordic imports increased rapidly, however, and more so than the average for all products. For some products, the market shares in the OECD market decreased at an early stage, and then picked up again, while in other instances they increased from a low level as expected. A possible explanation of the former type of development is that it took Nordic producers some time to adapt to new technologies, and that during this period they lost market shares abroad.

Also for "scientific instruments" we find that the Nordic market purchased a relatively large share of total Nordic exports at the beginning of the 1960s, but the Nordic producers' share of the Nordic countries' import remained low. Internationally, however, their market share increased. A possible explanation of this may be the level of aggregation; this group contains both scientific instruments, photographic equipment and watches. If Nordic exports are concentrated in one of these groups (scientific instruments, probably), this may explain the low market share in the Nordic market.

However, office machinery, computers and semi-conductors do not conform to the pattern suggested by the "extended home market" hypothesis. For semi-conductors the market shares both domestically and abroad remained close to zero. For computers, the market shares in the Nordic market as well as the OECD market declined steadily from the early/mid 1960s onwards. The latter type of development reflects that Nordic producers gradually lost ground as mechanical and electromechanical solutions were replaced by electronic ones.[15]

Apart from Iceland, all Nordic countries took part in the rapidly increasing intra-Nordic trade in advanced products. In most instances, all Nordic countries increased their market shares in the Nordic market in all products. Typical areas where all countries increased their market shares were telecommunications equipment, consumer electronics and electrical household appliances. Within telecommunications equipment, Sweden acquired a leading position in the Nordic market with a market share of 27.1% in 1973. Other products where Sweden obtained a strong position were electrical household appliances (17.1%), motor vehicles (15.4%), plastics (14.5%) and consumer electronics (11.8%). Also Norway achieved a strong position within some of the new commodity groups, especially electrical household appliances (12.4%) and consumer electronics (7.6%). Denmark obtained a strong position among the Nordic countries within pharmaceuticals(10.3%) followed by Sweden (9.4%).

[15] The development(including export performance) of the Nordic electronic industries in this period is analysed in more detail in Dalum et al. (1988).

TABLE 3. INTRA-NORDIC TRADE AS A PERCENTAGE OF TOTAL NORDIC EXPORTS (Selected products, value)

	1961	1965	1969	1973	1979	1983
Pharmaceuticals (18)[1]	23.0	29.5	34.4	34.6	28.7	23.4
Plastics (20)	37.5	53.1	63.1	60.0	50.7	44.8
Office machinery (26)	13.4	16.8	11.8	17.6	13.7	14.6
Computers (27)	10.7	11.5	9.2	12.2	19.3	21.2
Semiconductors (28)	22.4	30.9	47.8	35.3	29.2	23.3
Telecommunications equipment (29)	24.6	31.2	25.0	27.2	22.0	19.3
Consumer electronics (31)	36.7	51.8	60.5	40.5	35.2	25.6
Scientific instruments (33)	21.5	22.0	20.4	18.9	15.6	14.8
Motor vehicles (34)	39.1	40.1	34.6	29.0	22.7	20.1
Electrical household appl. (32)	37.6	45.7	35.8	38.0	37.4	38.2
All products	18.2	22.3	24.5	25.1	23.0	20.4

TABLE 4. INTRA-NORDIC TRADE AS A PERCENTAGE OF TOTAL NORDIC IMPORTS (Selected products, value)

	1961	1965	1969	1973	1979	1983
Pharmaceuticals (18)	13.3	15.7	18.3	20.3	21.7	21.4
Plastics (20)	11.3	17.8	21.3	25.3	26.4	26.4
Office machinery (26)	6.7	6.9	6.6	9.3	9.9	7.4
Computers (27)	11.7	16.9	7.8	7.2	7.8	7.5
Semiconductors (28)	0.9	1.2	3.4	1.8	2.1	2.5
Telecommunications equipment (29)	15.1	20.0	26.6	38.7	31.8	26.7
Consumer electronics (31)	8.8	26.2	25.0	27.5	18.4	10.0
Scientific instruments (33)	5.5	6.6	7.2	8.0	7.9	7.7
Motor vehicles (34)	10.5	11.0	16.2	19.4	16.9	16.0
Electrical household appl. (32)	13.4	28.9	33.8	38.6	33.2	35.7
All products	15.2	18.9	21.7	23.2	21.2	21.3

TABLE 5. NORDIC MARKET SHARES ON THE OECD MARKET (Selected products, value)[1)]

	1961	1965	1969	1973	1979	1983
Pharmaceuticals (18)[2]	3.7	3.3	3.1	3.1	4.4	5.3
Plastics (20)	2.9	2.6	2.0	1.9	2.8	3.0
Office machinery (26)	3.5	2.6	2.8	2.4	2.9	2.8
Computers (27)	9.7	8.4	6.2	3.5	3.3	2.5
Semiconductors (28)	0.3	0.3	0.2	0.1	0.2	0.2
Telecommunications equipment (29)	4.4	4.1	5.2	6.8	5.0	3.9
Consumer electronics (31)	1.3	1.4	0.9	2.6	1.9	1.4
Scientific instruments (33)	2.5	2.3	2.5	2.8	2.9	2.8
Motor vehicles (34)	2.7	2.4	1.9	2.6	2.6	2.7
Electrical household appl. (32)	3.3	5.3	8.6	7.9	5.5	4.8
All products	4.8	4.6	4.1	4.1	3.6	3.9

TABLE 6. INTRA-NORDIC TRADE AS A PERCENTAGE OF TOTAL NORDIC IMPORTS (Main products, value)

	1961	1965	1969	1973	1979	1983
Products based on nat. resources (101)	15.7	19.4	24.4	25.9	26.0	25.7
Oil and gas (102)	3.0	5.5	6.9	7.5	9.5	17.7
Chemical products (103)	15.7	17.9	19.2	20.9	20.0	19.1
Machinery and transport eq. (104)	17.3	20.1	20.0	21.4	20.1	17.9
Traditional industrial products (105)	18.8	25.4	31.0	36.3	31.7	27.6
All products	15.3	18.9	21.7	23.2	21.2	21.3

1) Nordic exports(excl. intra-nordic trade) as a percentage of the imports of other OECD countries.
2) The numbering of products refers to the appendix in chapter 4.

However, it was not only in the process of technology transfer from the United States and other developed countries to the Nordic countries that the Nordic market played an important role. Equally important, perhaps, was the role of the Nordic market as a medium for a reduction of the technological and economic differences within the Nordic area, between Sweden on the one hand and the other Nordic countries on the other. This proved to be especially important for Finland, which by the early 1960s was at a much lower stage of industrial development than Norway and Denmark were. Through deliveries to the Nordic market, initially of relatively simple industrial products, such as clothing, but gradually also of more advanced products, a fundamental restructuring of Finnish production and foreign trade took place. Between 1961 and 1973, Finland's market share of clothing in the Nordic market rose from 0.5% to 16.1% . But also for the other Nordic countries, increased intra-Nordic trade in relatively traditional industrial products provided a stimulus to industrial development(for instance, within the furniture industry, to mention just one example).

5.5. POST 1973: NEW EXTERNAL CONDITIONS - NEW PROBLEMS

In the 1970s, the conditions that made the structural changes of the preceding decade in Nordic-OECD trade relationships and intra-Nordic trade possible, had changed in a number of respects. First, the technological differences both within the Nordic countries and between these countries and the most developed countries of the OECD area, were strongly reduced. A few main figures may serve as an illustration. Within the Nordic area: In 1960 GDP per man-hour in Sweden was 50% higher than in Finland - in 1970 25% higher. Between the Nordic countries and the United States: In 1960 GDP per man-hour in the United States was 64% higher than in Sweden - in 1970 only 27% higher. Furthermore, during this period, the structural differences between Nordic exports and OECD trade were much reduced, even though natural-resource based products continued to play a more important role in Nordic exports than in OECD trade.

Second, the structure of OECD imports was changed. The strong price increases on some raw materials, primarily oil, gas and some energy-intensive products, increased these products' share of OECD trade in value terms. Except for Norway, which at that time had just begun to produce oil on its continental shelf, this had a negative influence on the Nordic countries' market shares, terms of trade and external balances. Furthermore, as shown in chapter 4, some of the important "growth sectors" in OECD trade of the previous decade had now entered the phase where growth decreases relative to the other products and price competition increases, especially from producers in the "newly industrialized countries" (the NICs). This was of special importance for the Nordic countries because, to a considerable extent, it was precisely in these sectors that the Nordic countries had increased production most markedly and gained market shares in the 1960s.

Third, the institutional structure of intra-Nordic trade and Nordic economic co-operation was changed. Denmark entered the EEC in 1972, while the other Nordic countries remained in EFTA. However, great caution should be shown when estimating the economic impact of this, since the other Nordic countries soon negotiated free trade agreements with the EEC.

Nevertheless, it is a striking fact that after 1973, the trend towards increased intra-Nordic trade was broken. The Nordic countries' share of Nordic imports fell from 23.2% to 21.3% between 1973 and 1983, most markedly in machinery, transport equipment, and traditional industrial products (table 6). Within chemicals there was only a slight decrease, and no change for natural-resource based products, while the Nordic countries(e.g. Norway) - not surprisingly - increased their market share on the Nordic market for oil and gas. Thus, the recorded decrease in intra-Nordic trade as a share of total Nordic imports after 1973 was not caused by the simultaneous increase in oil and gas prices. Indeed, if oil and gas had been excluded from the calculations, the decrease would have been even larger.

If we study this development in more detail, we find that the decrease in intra-Nordic trade is concentrated in a few groups. First, it concerns consumer electronics where Nordic producers' share of the Nordic market share was dramatically reduced, from 27.5% in 1973 to 10.0% in 1983. Other groups where Nordic producers lost from 5 to 10% of the Nordic market between 1973 and 1983, are fertilizers, heating and cooling equipment, pumps and separators, telecommunications equipment, metal products and clothing.

Among the Nordic countries, Sweden, Denmark and Iceland were the main losers of market shares in the Nordic market throughout this period. For Sweden the decline was especially evident for machinery, in particular heating and cooling equipment, pumps and separators, telecommunications equipment, consumer electronics and motor vehicles, and for furniture. Denmark's loss in market shares was especially evident for ships, power machinery and engines, pumps and separators. For Iceland the decline took place for traditional raw-material based export products such as meat, fish and feeding stuff for animals. Norway's total share of the Nordic market held up well because of oil, but otherwise Norway lost market shares for a large number of industrial products, most markedly for fertilizers, consumer electronics, electrical household appliances and metal products. In contrast to the other countries, Finland continued to increase its market shares on the Nordic market for a large number of products, but for a mature group like clothing, Finland also lost market share (from 16.1% in 1973 to 10.6% in 1983).

Also in the OECD market the trend from the 1960s and the first part of the 1970s was broken. Unto 1973 (table 7), the Nordic countries lost market shares for natural-resource based products in the OECD market. The market shares for oil and gas, chemical products and traditional industrial products changed little between 1961 and 1973, whereas the market shares for machinery and transport equipment increased. After 1973 this process was reversed: the market share for natural-resource based products remained stable, the market shares for chemical products and oil and gas increased, whereas the market shares for machinery and transport equipment and traditional industrial products decreased drastically.

In chemicals, what is most striking is the strong increase in the Nordic countries's market shares in the OECD market for pharmaceuticals and plastics. In pharmaceuticals, it was especially Sweden and Denmark that increased market shares, for plastics it was Norway that showed the strongest increase. For machinery and transport equipment, where the Nordic countries as a whole lost market shares in the OECD market between 1973 and 1983, the decline was especially marked for ships, telecommunications equipment, electrical household appliances, pumps and separators, and consumer electronics. Apart from Iceland (which had nothing to lose) and Finland (for one commodity: pumps and separators), all Nordic countries lost market shares in the OECD market for these groups. The Nordic countries also lost market shares for traditional industrial products, especially clothing.

Even though the Nordic countries' total market share held up better in the OECD market than in the Nordic market between 1973 and 1983, there are strong similarities between the developments in the two markets. In both instances the Nordic countries' market shares fell markedly for machinery and traditional industrial products. To get an idea of what happened, it may be of some value to ask who actually won the market shares that the Nordic countries lost. To answer this, consider table 8 below, which covers the OECD market as a whole, with Nordic imports included. The answer is fairly unambiguous. In products where the Nordic countries lost market shares, the other OECD countries as a group lost market shares as well during this period, whereas countries outside of the OECD area (NIC countries, developing countries) gained.[16] Furthermore, it may be shown that in relative terms (growth-rates), Nordic losses were generally larger than those of the group of other OECD countries.[17] Thus, the Nordic countries appear to have been especially vulnerable to the increasing competition from non-OECD countries (and to some extent Japan as well) in the seventies and early eighties.

The tendency towards decreasing market shares for machinery was not limited to the Nordic and OECD markets, but characterized the Nordic countries' exports to the growing markets in NIC

[16] It may be noted that in contrast to the other OECD countries as a group, Japan gained market shares in the five machinery groups covered in table 8. In absolute terms, the gains were largest for consumer electronics (where Japan's market share of the OECD market exceeded 50% in 1983) and telecommunications equipment. However, for metal products, furniture and clothing, Japan too lost market shares.

[17] This holds, whether Japan is included in the group of other OECD-countries or not (though much less pronounced in the latter case), for 6 of the 8 products covered by table 7 (the exceptions are electrical household appliances and ships).

countries and developing countries as well. The Nordic countries' share of OECD's export to "the rest of the world" of machinery and transport equipment declined between 1973 and 1983 from 4.4% to 3.5%. Even though the markets shares for the other main products increased or remained stable, the Nordic countries' total share of OECD exports to these markets decreased, from 3.6% in 1973 to 3.3% in 1983. Thus, with one partial exception - Finland[18] - the Nordic countries did not succeed in their attempts to find new markets for their manufacturing exports.

5.6. CONCLUDING REMARKS

As pointed out in the first section of this chapter, the view that small developed countries face considerable comparative disadvantages in advanced products and technologies commands considerable support both on theoretical and empirical grounds. However, the perspective adopted in this study (section 2 of this chapter) suggests that these disadvantages, though existing, should be expected to differ considerably between industries and through time, and that this opens up possibilities for specialization that small countries may exploit. Following Walsh (1987) and others it was argued that the performance of small developed countries in advanced products and technologies also depends on how these possibilities are exploited (or the type of strategies adopted).

[18] Finland is in a special position because Finland's trade with the socialist countries has been regulated through agreements designed to ensure balanced trade.

The empirical evidence considered in this chapter is consistent with the view that small country disadvantages differ substantially between industries and through time. There are industries, such as the computer and semiconductor industries, where static and dynamic economies of scale seem to have prevented the Nordic countries from establishing production on a sufficiently large scale to meet the requirements of international competition. But the evidence seems to suggest that this is the exception rather than the rule. During the period considered by this study, the Nordic countries managed to reduce dependency and increase market shares within a whole range of manufacturing industries, some of which may be characterized as technologically demanding, such as telecommunications, scientific instruments, motor vehicles, pharmaceuticals and plastics. However, there is also a group of products, of which typewriters and consumer electronics are the most prominent examples, where an initial tendency towards reduced dependency and increased market shares was reversed later on. It was shown that the losses of market shares in these cases were matched by increased market shares by newly industrializing countries outside the OECD area (and to some extent Japan as well). Thus the performance of the Nordic countries within these groups conforms to the pattern described by Vernon.

With regards to strategies as "revealed" through the data examined in this chapter, the evidence indicates that up to the mid seventies, the performance of the Nordic countries in new, advanced products and technologies conforms to the "extended home market hypothesis" outlined in section two of this chapter. In general, Nordic firms seem to have used the Nordic market as an extended home market for the most advanced parts of their production and then, on the basis of accumulated experience from the Nordic market, engaged in exports to the rest of the OECD area. This points to the important role that intra-regional trade may play for small countries that want to catch up in technology and increase their manufacturing base. However, a similar pattern cannot be detected in the data from the post-1973 period, even though micro evidence suggests that Nordic cooperation and trade continued to have a favourable impact on the performance of Nordic firms in some specific high technology segments. One successful example of this from the last decade is the cooperation between the Nordic countries on a system for mobile telecommunication (the NMT system), which resulted in rapidly growing market shares for Nordic firms in this area both in the Nordic and the OECD markets.[19] However, in general, the Nordic governments seem to have been unable or unwilling to increase their cooperation along these lines, and the result has been a gradual disintegration instead of a further strengthening of Nordic economic cooperation.

[19] Among the companies that took advantage of these opportunities were Ericsson and NOKIA. This is a good example of how dependent many companies, even quite large and internationalized ones (as Ericsson and NOKIA), are on their "home markets" for successful product innovation. Another example from the same companies relates to the development of digital public switches (where Ericsson and NOKIA are among the few companies competing world wide) which in both cases were developed in joint ventures with, and with support from, the national governments/PTTs. See Dalum et al.(1988) for a more detailed account.

TABLE 7. NORDIC MARKET SHARES ON THE OECD-MARKET[1)] (Main products, value)

	1961	1965	1969	1973	1979	1983
Products based on natural resources (101)[2]	6.3	6.1	5.5	5.4	5.2	5.4
Oil and gas (102)	0.0	0.1	0.1	0.2	2.2	4.0
Chemical products (103)	2.4	2.5	2.7	2.2	2.4	2.7
Machinery and transport equipment (104)	4.0	4.1	3.7	4.4	3.5	3.2
Traditional industrial products (105)	2.9	2.8	2.5	2.9	2.4	2.2
All products	4.8	4.6	4.1	4.1	3.6	3.9

TABLE 8. SHARES OF OECD IMPORTS 1973-1983 (Selected products, value)[3)]

	Nordic countries	Nordic countries	OECD(excl. Nordic countries)	Socialist countries	Rest of the world
	Level	Change	Change	Change	Change
	1973	73-83	73-83	73-83	73-83
Pumps and separators (25)	10.0	-2.9	-4.6	+0.2	+7.3
Telecommunications equipment (29)	9.3	-4.3	-10.5	-0.2	+15.1
Consumer electronics (31)	4.2	-2.4	-4.5	-0.2	+8.6
Electrical household appl. (32)	8.5	-0.9	-11.7	+0.9	+11.2
Ships (36)	23.6	-1.2	-14.8	-3.1	+19.4
Metal products (38)	8.4	-1.9	-6.0	-0.6	+8.5
Furniture (39)	13.3	-1.7	-8.0	+0.2	+9.5
Clothing (40)	4.7	-2.1	-12.6	-1.2	+15.8
All products	5.6	-0.5	-4.6	+0.4	+5.9

1) Nordic exports to the other OECD countries as a percentage of OECD imports.
2) The numbering of products refers to the appendix in chapter 4.
3) The changes do not always add up because of lack of data for country of origin.

APPENDIX

1. CLASSIFICATION OF PRODUCTS ACCORDING TO TECHNOLOGY INTENSITY

	SITC, Rev. 1
201. HIGH TECHNOLOGY PRODUCTS	
16 Inorganic chemicals	513, 514
18 Pharmaceuticals	54
20 Plastic materials	518.1, 581.2
22 Power generating machinery	711
27 Computers and peripherals	714.2, 714.3
28 Semiconductors	729.3
29 Telecommunications equipment	724.9
30 Machinery for production and distribution of electricity	722, 723, 729,9
33 Scientific instruments, photographic supplies, watches and clocks	726, 729.5, 729.7, 861, 862, 864
35 Aircraft	734
202 MEDIUM TECHNOLOGY PRODUCTS	
15 Organic chemicals	512
17 Dystuffs, colouring materials	53
19 Fertilizers	56
21 Other chemicals	Rest 5
23 Machinery for special industries or processes	712, 715, 717, 718, 719.3, 719.5, 719.8
24 Heating and cooling equipment	719.1
25 Pumps and centriffuges	719.2
26[1]) Typewriters and office machines	714.1, 714.9
31[1]) Consumer electronics	724.1, 724.2, 891.1
32 Domestic electrical equipment	725
34[1]) Road motor vehicles	732
36 Ships and boats (incl. oil rigs)	735
37 Other engineering products	Rest 7 (excl. 719.4)
38 Manufactures of metal	69, 719.4, 812.1, 812.3

203 LOW TECHNOLOGY PRODUCTS

1	Animals, meat and meat preparations	00, 01, 091.3, 411.3
2	Dairy products and eggs	02
3	Fish and fish preparations	03, 411.1
4	Cereals and cereal preparations	04
5	Feeding-stuff for animals	08
6	Skins and leather manufactures	21, 61
7	Wood and wood manufactures	24, 63
8	Pulp and paper	25, 64
9	Textiles	26, 65
10	Iron ore	281
11	Iron, steel and ferro-alloys	67
12	Aluminium	684
13	Other products based on natural resources	Rest 0-4 (excl. 33, 34), 62, 66
14	Oil and gas	33, 34
39	Furniture	82
40	Clothing	84
41	Industrial products, n.e.s.	891.1

Note: 1) No. 26, 31 and 34 are high tech products 1961-69. In 1973-83 they are put in the medium tech group.

2. SUPPLEMENTARY TABLES ON EACH NORDIC COUNTRY

TABLE A1. DENMARK'S EXPORTS TO THE NORDIC COUNTRIES

	NUMBER	I961	I965	I969	I973	I979	I983
NATRES	101	42.92	39.67	39.00	36.71	34.07	32.50
OIL-GAS	102	.54	3.87	4.18	7.06	10.02	9.85
CHEMICAL	103	6.65	7.07	8.20	7.99	8.74	9.14
MACHINERY	104	35.63	31.61	27.63	28.53	25.49	24.83
OTHERIND	105	14.26	17.78	21.00	19.71	21.68	23.67
SUM	106	100.00	100.00	100.00	100.00	100.00	100.00

TABLE A2. DENMARK'S EXPORTS TO OECD-THE NORDIC COUNTRIES

	NUMBER	I961	I965	I969	I973	I979	I983
NATRES	101	79.15	74.31	62.60	60.77	60.51	56.26
OIL-GAS	102	.04	.15	.18	.37	1.73	3.65
CHEMICAL	103	2.72	3.21	6.89	4.48	6.04	6.61
MACHINERY	104	12.83	15.38	21.78	23.78	22.18	21.89
OTHERIND	105	5.26	6.95	8.55	10.60	9.54	11.58
SUM	106	100.00	100.00	100.00	100.00	100.00	100.00

TABLE A3. DENMARK'S EXPORT-SHARE IN THE NORDIC COUNTRIES' TOTAL IMPORT

	NUMBER	I961	I965	I969	I973	I979	I983
NATRES	101	3.29	4.04	5.15	5.12	4.80	5.02
OIL-GAS	102	.19	2.02	2.48	3.75	2.26	2.33
CHEMICAL	103	2.84	3.63	4.52	4.62	4.02	4.01
MACHINERY	104	3.76	4.09	4.32	3.99	3.71	3.43
OTHERIND	105	6.32	9.06	10.02	9.48	8.15	8.83
SUM	106	3.35	4.28	5.11	5.00	4.31	4.36

TABLE A4. DENMARK'S EXPORT-SHARE IN THE OECD-NORDIC COUNTRIES' TOTAL IMPORT

	NUMBER	I961	I965	I969	I973	I979	I983
NATRES	101	1.69	1.68	1.25	1.34	1.40	1.54
OIL-GAS	102	.01	.02	.02	.03	.07	.13
CHEMICAL	103	.68	.72	1.09	.69	.67	.73
MACHINERY	104	.95	.99	.84	.89	.73	.66
OTHERIND	105	.98	1.01	.88	1.06	.77	.91
SUM	106	1.30	1.27	.99	1.00	.82	.84

TABLE A5. FINLAND'S EXPORTS TO THE NORDIC COUNTRIES

	NUMBER	I961	I965	I969	I973	I979	I983
NATRES	101	87.53	70.94	53.11	41.86	36.36	34.98
OIL-GAS	102	.14	.08	.55	.33	7.17	12.65
CHEMICAL	103	1.70	3.01	3.46	4.18	5.45	5.42
MACHINERY	104	7.30	16.98	23.04	27.59	26.28	27.00
OTHERIND	105	3.34	9.00	19.84	26.04	24.74	19.96
SUM	106	100.00	100.00	100.00	100.00	100.00	100.00

TABLE A6. FINLAND'S EXPORTS TO OECD-THE NORDIC COUNTRIES

	NUMBER	I961	I965	I969	I973	I979	I983
NATRES	101	97.59	94.82	89.29	84.31	78.05	73.25
OIL-GAS	102	.01	.01	.55	.15	.83	5.69
CHEMICAL	103	.56	1.58	1.90	2.30	4.30	4.03
MACHINERY	104	1.16	2.27	5.03	7.64	10.67	10.89
OTHERIND	105	.68	1.32	3.23	5.60	6.15	6.14
SUM	106	100.00	100.00	100.00	100.00	100.00	100.00

TABLE A7. FINLAND'S EXPORT-SHARE IN THE NORDIC COUNTRIES' TOTAL IMPORT

	NUMBER	I961	I965	I969	I973	I979	I983
NATRES	101	2.87	2.62	3.65	3.63	4.66	4.37
OIL-GAS	102	.02	.01	.17	.11	1.47	2.42
CHEMICAL	103	.31	.56	.99	1.50	2.28	1.92
MACHINERY	104	.33	.80	1.87	2.40	3.48	3.01
OTHERIND	105	.63	1.66	4.92	7.79	8.44	6.02
SUM	106	1.43	1.55	2.66	3.11	3.91	3.53

TABLE A8. FINLAND'S EXPORT-SHARE IN THE OECD-NORDIC COUNTRIES' TOTAL IMPORT

	NUMBER	I961	I965	I969	I973	I979	I983
NATRES	101	1.49	1.23	1.11	1.01	1.10	1.10
OIL-GAS	102	-	-	.04	.01	.02	.11
CHEMICAL	103	.10	.20	.19	.19	.29	.24
MACHINERY	104	.06	.08	.12	.16	.21	.18
OTHERIND	105	.09	.11	.21	.31	.31	.26
SUM	106	.92	.73	.61	.55	.51	.46

TABLE A9. NORWAY'S EXPORTS TO THE NORDIC COUNTRIES

	NUMBER	1961	1965	1969	1973	1979	1983
NATRES	101	48.17	46.29	43.68	42.78	40.06	33.97
OIL-GAS	102	7.06	5.86	4.35	4.18	10.63	25.06
CHEMICAL	103	22.79	18.91	16.23	13.31	15.64	13.76
MACHINERY	104	15.59	20.60	25.68	27.48	22.38	19.31
OTHERIND	105	6.39	8.33	10.06	12.25	11.29	7.90
SUM	106	100.00	100.00	100.00	100.00	100.00	100.00

TABLE A10. NORWAY'S EXPORTS TO OECD-THE NORDIC COUNTRIES

	NUMBER	1961	1965	1969	1973	1979	1983
NATRES	101	83.94	80.62	74.05	63.52	34.06	21.83
OIL-GAS	102	.05	.31	.21	2.34	50.65	64.90
CHEMICAL	103	4.18	5.11	4.70	4.58	3.83	3.80
MACHINERY	104	8.67	10.69	18.22	25.95	9.15	8.00
OTHERIND	105	3.17	3.26	2.81	3.61	2.32	1.47
SUM	106	100.00	100.00	100.00	100.00	100.00	100.00

TABLE A11 NORWAY'S EXPORT-SHARE IN THE NORDIC COUNTRIES' TOTAL IMPORT

	NUMBER	1961	1965	1969	1973	1979	1983
NATRES	101	2.92	3.57	4.29	4.93	4.54	4.97
OIL-GAS	102	2.00	2.31	1.92	1.83	1.93	5.61
CHEMICAL	103	7.67	7.33	6.64	6.35	5.78	5.72
MACHINERY	104	1.30	2.02	2.98	3.18	2.62	2.53
OTHERIND	105	2.24	3.21	3.56	4.87	3.41	2.79
SUM	106	2.64	3.24	3.80	4.13	3.47	4.13

TABLE A12. NORWAY'S EXPORT-SHARE IN THE OECD-NORDIC COUNTRIES' TOTAL IMPORT

	NUMBER	1961	1965	1969	1973	1979	1983
NATRES	101	.97	1.02	1.09	.96	.80	.84
OIL-GAS	102	-	.02	.02	.14	1.97	3.37
CHEMICAL	103	.57	.64	.54	.48	.44	.60
MACHINERY	104	.35	.38	.52	.66	.31	.34
OTHERIND	105	.32	.26	.21	.25	.19	.16
SUM	106	.70	.71	.73	.69	.84	1.19

TABLE A13. SWEDEN'S EXPORTS TO THE NORDIC COUNTRIES

	NUMBER	I961	I965	I969	I973	I979	I983
NATRES	101	35.45	34.21	38.26	36.09	33.40	31.03
OIL-GAS	102	1.13	1.42	2.59	1.60	6.81	11.13
CHEMICAL	103	4.21	5.34	6.80	6.82	8.02	8.22
MACHINERY	104	50.02	48.80	38.46	40.94	36.98	34.89
OTHERIND	105	9.18	10.23	13.88	14.55	14.78	14.73
SUM	106	100.00	100.00	100.00	100.00	100.00	100.00

TABLE A14. SWEDEN'S EXPORTS TO OECD-THE NORDIC COUNTRIES

	NUMBER	I961	I965	I969	I973	I979	I983
NATRES	101	65.96	62.25	56.59	49.56	44.52	40.12
OIL-GAS	102	.06	.07	.32	.20	1.71	5.60
CHEMICAL	103	2.76	2.96	3.33	2.97	5.26	6.24
MACHINERY	104	25.41	27.98	32.79	40.06	40.22	41.23
OTHERIND	105	5.81	6.74	6.97	7.21	8.28	6.82
SUM	106	100.00	100.00	100.00	100.00	100.00	100.00

TABLE A15. SWEDEN'S EXPORT-SHARE IN THE NORDIC COUNTRIES' TOTAL IMPORT

	NUMBER	I961	I965	I969	I973	I979	I983
NATRES	101	6.27	7.47	9.66	10.93	10.30	10.66
OIL-GAS	102	.93	1.58	2.93	1.84	3.37	5.85
CHEMICAL	103	4.14	5.86	7.16	8.55	8.06	8.03
MACHINERY	104	12.18	13.52	11.49	12.44	11.78	10.72
OTHERIND	105	9.39	11.16	12.65	15.20	12.14	12.23
SUM	106	7.71	9.16	9.77	10.85	9.41	9.71

TABLE A16. SWEDEN'S EXPORT-SHARE IN THE OECD-NORDIC COUNTRIES' TOTAL IMPORT

	NUMBER	I961	I965	I969	I973	I979	I983
NATRES	101	2.01	2.05	1.94	1.93	1.74	1.79
OIL-GAS	102	.01	.01	.06	.03	.11	.34
CHEMICAL	103	.99	.96	.90	.81	.99	1.13
MACHINERY	104	2.68	2.62	2.17	2.64	2.23	2.04
OTHERIND	105	1.54	1.43	1.23	1.28	1.14	.88
SUM	106	1.85	1.85	1.69	1.77	1.40	1.38

TABLE A17. ICELAND'S EXPORTS TO THE NORDIC COUNTRIES

	NUMBER	I961	I965	I969	I973	I979	I983
NATRES	101	99.60	97.97	95.16	95.86	90.81	82.98
OIL-GAS	102	0	0	0	0	0	0
CHEMICAL	103	.29	1.15	.90	.42	.13	.01
MACHINERY	104	0	.11	.01	.10	3.37	4.12
OTHERIND	105	.11	.77	3.93	3.62	5.69	12.89
SUM	106	100.00	100.00	100.00	100.00	100.00	100.00

TABLE A 18. ICELAND'S EXPORTS TO OECD-THE NORDIC COUNTRIES

	NUMBER	I961	I965	I969	I973	I979	I98
NATRES	101	99.35	99.20	98.51	98.75	97.66	97.06
OIL-GAS	102	0	0	0	0	0	0
CHEMICAL	103	.56	.06	0	0	.03	.05
MACHINERY	104	-	.36	.49	.15	.31	.09
OTHERIND	105	.08	.38	.99	1.10	2.00	2.80
SUM	106	100.00	100.00	100.00	100.00	100.00	100.00

TABLE A19. ICELAND'S EXPORT-SHARE IN THE NORDIC COUNTRIES' TOTAL IMPORT

	NUMBER	I961	I965	I969	I973	I979	I983
NATRES	101	.35	.52	.31	.38	.27	.14
OIL-GAS	102	0	0	0	0	0	0
CHEMICAL	103	.01	.03	.01	.01	-	-
MACHINERY	104	0	-	-	-	.01	.01
OTHERIND	105	-	.02	.05	.05	.04	.05
SUM	106	.15	.22	.13	.14	.09	.05

TABLE A20. ICELAND'S EXPORT-SHARE IN THE OECD-NORDIC COUNTRIES' TOTAL IMPORT

	NUMBER	I961	I965	I969	I973	I979	I983
NATRES	101	.09	.13	.08	.13	.16	.17
OIL-GAS	102	0	0	0	0	0	0
CHEMICAL	103	.01	-	0	0	-	-
MACHINERY	104	-	-	-	-	-	-
OTHERIND	105	-	-	-	.01	.01	.01
SUM	106	.06	.07	.04	.06	.06	.05

CHAPTER 6

DIFFUSION OF TECHNOLOGY, SHIFTS IN COMPARATIVE ADVANTAGE AND INTRA-INDUSTRY TRADE

6.1 INTRODUCTION

In recent years, several authors have developed models which explain the existence of intra-industry trade. However, the question of what determines the development of intra-industry trade through time has largely been ignored. This is true not only for theoretical models, but also for most applied work in the field.[1]

The aims of this chapter are to show the following: First, that existing theories of intra-industry trade are not sufficent to explain the development of intra-industry trade through time. Second, that Schumpeterian views on innovation, diffusion and structural change have important implications for the development of intra-industry trade. Third, that the development of intra-industry trade between the Nordic countries and the OECD/Non-OECD countries between 1961 and 1983 to a large extent conforms to the Schumpeterian perspective.

[1] Petterson(1984)'s study of the development of Swedish intra-industry trade between 1871 and 1980 is a notable exception.

The next sections present a brief discussion of existing theories of intra-industry trade, their relation to empirical evidence and how intra-industry trade fits into the theoretical perspective of this study. The remaining part of the chapter analyses the development of intra-industry trade between the Nordic countries and the OECD/Non-OECD countries, respectively, from that perspective.

6.2 EXISTING THEORIES OF INTRA INDUSTRY TRADE

Both classical and neoclassical trade theory suggest that countries may increase their welfare by specializing in production - and exports - of certain goods according to structural characteristics that differ between countries, leaving the other goods to be imported (inter-industry trade). A wide range of empirical studies, on the other hand, show that developed countries to a large extent export and import the same goods (intra-industry trade).[2] Moreover, this tendency seems to have gained strength during the post-war period.

According to Finger(1975) and others, intra-industry trade is primarily a statistical phenomenon, caused by factors such as borders (economic and geographical borders differ), the inclusion of semi-finished goods (or parts) and finished goods in the same commodity classes, and that trade statistics are not organized according to the principle of factor intensity. However, even if

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[2] For an overview of empirical studies of intra industry trade, as well as theoretical contributions, see Tharakan(1983).

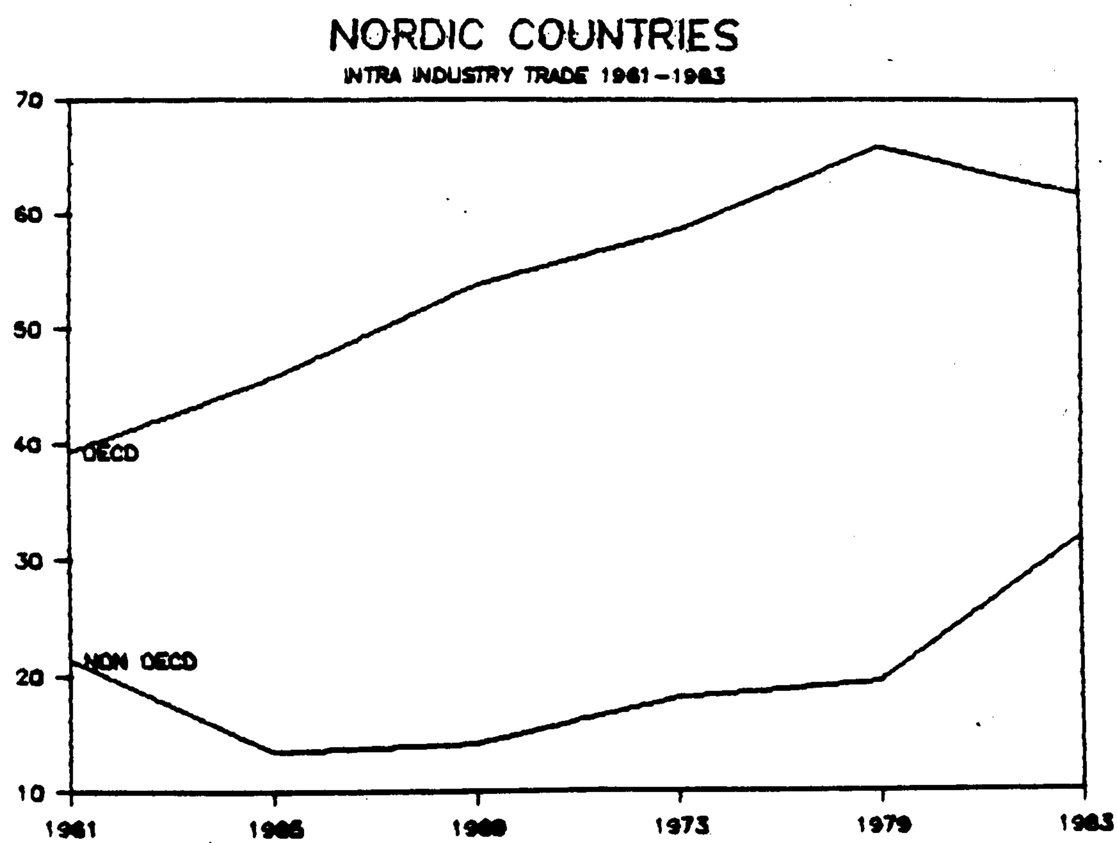
such factors may explain some intra-industry trade, it is most unlikely that the majority of international trade transactions can be explained in this way, as pointed out by Norman(1983). Thus, it has for some time been a quite widespread opinion among students of international trade that intra-industry trade represents a real challenge to traditional trade theory.

In a number of recent works, Lancaster(1980), Dixit and Norman(1980), Krugman(1981) and others have responded to this challenge by developing models which extend the theory of imperfect competition to international trade. The models suggest that in the case of differentiated products and economies of scale, countries may increase their welfare by specializing in different versions of the same good. Two qualifications are normally added to this: First, since the demand for differentiated products increases with the level of income, intra-industry trade should be expected to be more frequent between rich countries than between rich and poor countries. Second, since the scope for inter-industry trade depends on differences in factor endowments, intra-industry trade should be expected to be more important between countries with similar factor endowments, than between countries with different factor endowments.

Models of this type certainly go a long way in giving a theoretical explanation of <u>the existence of intra-industry trade</u>, which for a long time seemed to be incompatible with economic theory. But these models have one central characteristic in common with the factor-proportion theory: The static framework. Thus, they should not necessarily be expected to explain the development of intra-industry trade through time. However, since the level of intra-industry trade is assumed to increase with the level of income in the trading countries, one possible assumption from this could be that the level of intra-industry trade between developed countries should be expected to increase when the level of income increases. By the same token, the level of intra-industry trade between developed and developing countries could be expected to increase when the gap in income levels decreases. A brief look at the existing evidence does not seem to contradict these hypotheses (Petterson(1984), Culem and Lundberg(1986)).

Graph 1 gives a brief picture of the development of the Nordic countries' intra-industry trade with the OECD countries(mostly developed) and the Non-OECD countries(mostly less developed). The index used is the familiar Grubel-Lloyd index, adjusted for differences in trade imbalances through time, which measures intra-industry trade as a proportion of total trade. Further information regarding data and methods may be found in the fourth section of this chapter.

GRAPH 1.


NORDIC COUNTRIES
INTRA INDUSTRY TRADE 1961-1983
70
60
50
40
30
20
10
OECD
NON OECD
1961
1973
1979
1983

The graph shows that the level of intra-industry trade between the Nordic countries and the OECD countries grew steadily from the early 1960s to the late 1970s, but then declined. Contrary to this, the level of intra-industry trade between the Nordic countries and the Non-OECD countries has grown much faster during recent years than in the preceding periods. These developments cannot be easily explained by the approaches and hypotheses referred to above. Admittedly, economic growth slowed down both in the Nordic countries and in the OECD area as a whole after 1979, but GNP per capita did not decline, neither in the Nordic countries, nor in the OECD countries. Furthermore, it is true that the differences in the levels of income between the Nordic countries and the Non-OECD countries declined after 1979. But so it did in the preceding periods, also, when the level of intra industry trade grew much slower. Thus, to explain the development of intra-industry trade, the approaches discussed so far do not seem to suffice.

6.3 A SCHUMPETERIAN PERSPECTIVE ON INTRA INDUSTRY TRADE

In the following we are going to extend the perspective of the preceding chapters to include intra-industry trade. What we want to show is that the international process of innovation-diffusion has important implications for how intra-industry trade should be expected to develop. The consequences of this process for intra-industry trade may be shown to depend both on technological factors and the type of country under study. Several cases may be distinguished.

In cases where the assumptions of the product-cycle theory apply (the Vernon case), the diffusion process begins with diffusion from the centre(innovator) to other developed countries(early imitators) and continues with diffusion from the centre and other developed countries to less developed countries(late imitators). For the typical early imitator(developed) this implies that initially its import dependency, measured as net imports as a percentage of total trade with the product, will be reduced. But as late imitators(less developed) enter the scene, import dependency will start to increase again. As a consequence, for the typical developed country(early imitator), intra-industry trade in the product category will first increase and then decrease, because intra-industry trade per definition increases when net imports as a percentage of total trade decreases.[3]

If, on the other hand, the product life cycle is "extended" through new innovations (technological competition), the competitive position of the innovator is likely to continue to be strong relative to imitators(the Van Duijn -case). In such cases, the most likely outcome is that the innovator remains export-specialized and the other countries import-dependent for a considerable period of time. This implies that intra-industry trade in such products will remain on a low level.

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[3] This is easily seen from the indices of intra-industry trade discussed in the fourth section of this chapter.

In summary, the discussion in this and the preceding sections leaves us with the following classification scheme for when inter- or intra-industry trade should be expected to take place. First, the traditional Hecksher-Ohlin case, mostly limited to products based on natural resources, according to which trade should be expected to be inter-industry trade. Second, the Chamberlin case of differentiated products produced under economies of scale in which trade tends to be of the intra-industry trade type. Third, the Vernon case, where intra-industry trade first increases and then decreases. And fourth, the Van Duijn case, limited to products characterized by a high rate of innovation, where trade should be expected to be of an inter-industry trade character.

It may be noted that also Grubel and Lloyd (1975) discuss the consequences of diffusion for intra-industry trade (ch.7), but they blur the concepts somewhat by distinguishing between "technology gap trade", which they associate with process innovation, and "product cycle trade", which they associate with product differentiation, only. Their conclusion is that intra-industry trade connected to diffusion of product innovations and shifts in comparative advantage is of "no particular analytical or empirical importance". In the following we are going to show that this conclusion does not hold when confronted with empirical evidence from the Nordic countries between 1961 and 1983.

6.4 DATA AND METHODS

As noted in the introduction, it has been suggested that intra-industry trade is a purely statistical phenomenon, caused by a.o. the type of commodity classification and the level of aggregation used in the analysis. It is not surprising, therefore, that the choice of commodity classification and level of aggregation has been one of the main fields of interest in applied studies of intra-industry trade. However, for practical reasons, in most cases this has boiled down to a discussion of what aggregation level of the international trade classification (SITC) to use.[4] The empirical analyses that follow make use of the data base on international trade statistics described in more detail in chapter 4. As noted, this implied a quite radical regrouping of data on the 1-4 digit level of the SITC into 5 sectors, Products based on natural resources, Oil and gas, Chemicals, Machinery and Traditional industrial products. Each sector (except oil and gas) was further divided into a number of specified products and a residual category (see Table 1 and Appendix in chapter 6). As a guiding principle, products were classified according to industry, where an industry was defined by either use of a specific raw material, a specific technology, market- or

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[4] Petterson (1984) uses the BTN/CCCN classification, which he holds as superior to the SITC classification because it groups products according to factor of production, not purpose. Our own experience suggests that these two classifications are very similar in many respects, and that trade data classified according to the BTN/CCCN in most cases quite easily may be reclassified according to SITC.

product- characteristics or combinations of these factors.[5]

Measures of international specialization (or comparative advantage) and intra-industry trade are closely related, since a high degree of specialization implies a low degree of intra-industry trade and vice versa. Let exports and imports be denoted by X and M, respectively. The degree of international specialization of a country (S) in a certain product group (i) may then be written as

$$(1)\quad S_i = \left(\frac{X_i - M_i}{X_i + M_i}\right)100$$

S varies from +100 (completely export specialized) to -100 (completely import specialized). Intra-industry trade is at its maximum when exports equal imports, i.e. when S = 0. Thus, S may also be regarded as a measure of intra-industry trade. However, in studies of intra-industry trade it has become customary, following Grubel and Lloyd (1975), to use a modified version of S to measure intra-industry trade (I):

$$(2)\quad I_i = \left(1 - \frac{|X_i - M_i|}{X_i + M_i}\right)100$$

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[5] In general, products based on natural resources (and oil-gas) were classified according to raw material, chemicals according to technology and product characteristics, and other manufacturing products according to technology, product and market characteristics.

I varies from 100 (only intra-industry trade) to 0 (only inter-industry trade). On the product level it makes no difference whether I or S is used, but I has the advantage that it may be used to construct an overall measure of intra-industry trade (G) by adding up the I's, using the shares of each product in total trade as weights.

$$(3)\quad G = \sum_i \left[\left(1 - \frac{|X_i - M_i|}{X_i + M_i} \right) \frac{X_i + M_i}{X + M} \right] 100$$

There are different views in the literature of whether or not the intra-industry trade measures should be adjusted for trade imbalances. Grubel and Lloyd proposed to adjust G by dividing it with a measure of the overall trade imbalance (defined in such a way that the adjusted and unadjusted G's are identical when overall trade is balanced). Let the adjusted measure be G^*:

$$(4)\quad G^* = G \,/\, \left(1 - \frac{|X - M|}{X + M} \right)$$

Aquino(1978) criticized these measures on the ground that both G and G^* are biased measures of intra-industry trade, though in different directions, and proposed a new measure that adjusts for overall trade imbalances both at the product level and on aggregated levels. Greenaway and Milner(1981), on the other hand, hold that such adjustments may create more problems than they solve, because, in general, the "correct" (equilibrium) balance of trade is not easily defined, especially not in bilateral trade[6] or at the product or sector level. Empirical studies seem to indicate that the results(in terms of ranks) are not very sensitive to the type of measure used(Tharakan(1986)).

Graph 2 resembles graph 1, but in addition to the balance of trade adjusted index of intra-industry trade G^* (solid lines), it includes the non-adjusted index G as well (with symbols). The graph confirms Aquino's prediction that the adjusted index consistently shows higher values of intra-industry trade than the non-adjusted one. However, the trend is roughly the same, with a possible exception for the trade between the Nordic countries and the Non-OECD countries between 1979 and 1983, when the adjusted index grew much faster than the non-adjusted one. Why?

In 1973 and 1979 the trade between the Nordic countries and the Non-OECD countries was balanced, but in 1983 the Nordic countries ran a great surplus in their trade with the Non-OECD countries. This change in the balance of trade was mainly caused by increased trade surpluses, and reduced levels of intra-industry trade, within a few natural-resource-based products, especially animals and meat, cereals and wood and wooden manufactures. Since this phenomenon does not reflect a long-term shift in comparative advantage or balance of trade between these two groups of countries, it is the adjusted index which in this case most correctly mirrors the underlying trend.

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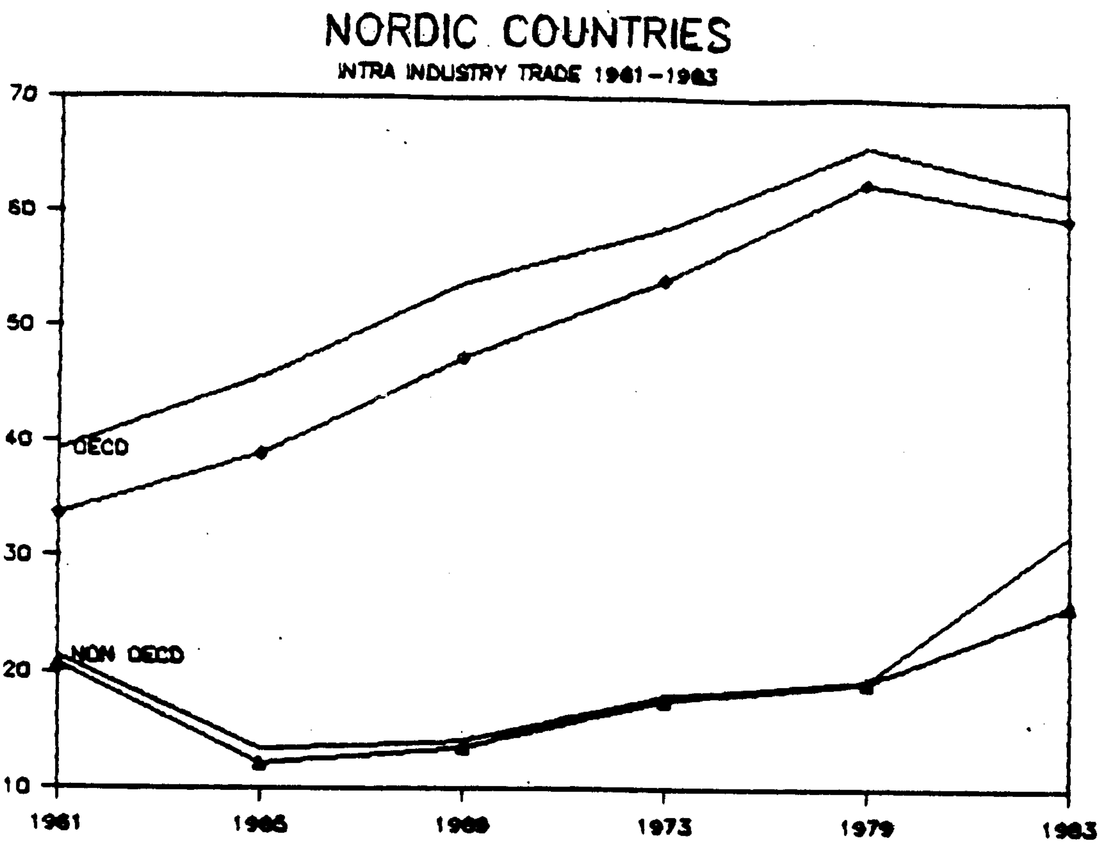
[6] According to Andersson and Tolonen(1985), the Aquino-index tends to be upward biased in cases where bilateral trade is very unbalanced.

GRAPH 2.


NORDIC COUNTRIES
INTRA INDUSTRY TRADE 1961-1983
70
60
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10
OECD
NON OECD
1961
1965
1968
1973
1979
1983

However, the main lesson to be learned from this is not that the adjusted index of intra-industry trade in general is better than the non-adjusted one, but that detailed knowledge of what happens within different sectors and products is indispensable for a correct interpretation of the development of intra-industry trade at the aggregate level.

6.5 THE CASE OF THE NORDIC COUNTRIES

The Nordic countries' trade with the OECD area

As a first step it may prove worthwhile to take a look at what happens at the sector level. This is done in Table 1 which reports weighted, unadjusted indices of intra-industry trade (G) between the Nordic countries and the OECD countries for selected years 1961-1983 at the sector level.[7]

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[7] The results for the oil and gas sector are excluded from table 1, partly because they are not in the focus of interest here, and partly because data are unreliable. However, the reader may find the results for this sector from table 3 and 6.

TABLE 1. INTRA INDUSTRY TRADE, NORDIC COUNTRIES VS.THE OECD AREA

	1961	1965	1969	1973	1979	1983
ALL	33.68	38.98	47.29	54.14	62.57	59.50
NATUR.RES.	28.91	33.61	39.68	41.32	45.05	45.86
CHEMICALS	35.36	39.17	47.06	46.04	55.90	65.02
MACHINERY	43.84	48.09	59.08	70.94	70.85	71.53
TRADITIONAL	50.02	54.95	57.05	71.43	64.30	60.48

Between 1961 and 1983, intra-industry trade between the Nordic and the OECD countries grew in all four sectors, but the pace of growth differed substantially between sectors. Growth was very strong in chemicals, considerable in machinery and products based on natural resources, and rather slow in traditional industrial products. Before 1973, the picture mirrors the one for the period as a whole, with the exception that growth of intra-industry trade was stronger in machinery than in the other sectors. After 1973, the development of intra-industry trade between the Nordic and the OECD countries changed both direction and pace. Within chemicals, growth of intra-industry trade accelerated during this period, while it levelled off in machinery and natural-resource-based products and declined markedly in traditional industrial products.

These developments have important bearings on attempts to explain intra-industry trade. First, even if the sector classification does not distinguish between consumer products and other products, growth of intra-industry trade seems to have been much stronger in sectors characterized by a high share of investment goods, semifinished goods or raw materials, than in sectors characterized by a high share of consumer goods. Second, after 1973, intra-industry trade in traditional industrial products (mostly consumer goods) declined markedly. Obviously, this does not conform to what should expected from a Lancaster-type perspective, where consumer demand diversity and economies of scale cause intra-industry trade in consumer goods. The marked differences in the development of intra-industry trade between sectors may be interpreted in support of a perspective which allows for sector- and product-specific explanations.

Table 2 and 3 report specialization indices (S) and intra-industry trade indices (I) for the Nordic countries' trade with the OECD area between 1961 and 1983 for the 41 products covered by the investigation.

In the early 1960s, the Nordic countries were export- specialized in a few products only(table 2). These products stemmed from traditional sectors such as agriculture, fishing, the forest industry (furniture included) and ores and metals. The Nordic countries were import-specialized in all other products except two machinery products where trade was approximately balanced. As a consequence of this pattern of specialization, intra-industry trade was at a rather low level.

As shown in chapter 5, the Nordic countries' structure of production and trade underwent radical changes between the early 1960s and the early 1980s. What happened was that the Nordic countries managed to catch up in a number of sectors, partly by diversifying from natural resources to products using these natural resources, and partly by importing technology from the more advanced countries of the OECD area. Examples of diversification on the basis of initial competitive advantage in natural resources may be found in a.o. the forest industry (from wood to furniture), the metal industry (from ores (and hydroelectric energy) to steel, aluminum and metal products), and in the chemical industry (from hydroelectric energy and other natural resources to a.o fertilizers and plastics). In many cases, the process of diversification on the basis of initial competitive advantage and import of technology went hand in hand, as, for instance, in the case of plastics. The impact of this process of diversification on intra-industry trade depends on whether export-specialization increases or import-specialization decreases, but since the latter has been more frequent than the former, the overall consequence has been increased levels of measured intra-industry trade.

The process of structural change was not limited to diversification on the basis of initial competitive advantage. On the contrary, the Nordic countries caught up and reduced import dependency in a whole range of chemical and machinery products, some of them typical research- and development-intensive products as, for instance, pharmaceuticals and telecommunications. In most cases, import dependency as measured by the specialization rate declined and intra-industry trade increased throughout the period. Even if some of these products, such as vehicles, are sold mostly to consumers, the majority of them are capital goods, which indicates that the sources of intra-industry trade specialization have to be found between capital-goods users and capital-goods producers, rather than in consumer-demand diversity.

However, there is also a group of products, mostly directed for private consumption, which does not conform to this picture. What these products have in common is that the import dependency decreased in the 1960s, reached a minimum in 1973, and increased thereafter. As a consequence, the level of intra-industry trade follows a "hat-shaped" curve with a peak in 1973. Typical examples are consumer electronics, domestic electrical equipment, manufactures of metals and clothing, products which, all other differences notwithstanding, have in common that they in the 1970s were approaching the "mature" phase. Other products that at least partly conform to this pattern are telecommunications and pumps. As shown in the preceding chapter, the Nordic countries lost market shares on the OECD market after 1973 for these products and these losses were matched by increased market shares for Non-OECD countries on the same market. Thus, the evidence seem to suggest that these products are typical Vernon cases.

TABLE 2. SPECIALIZATION-INDICES, NORDIC COUNTRIES vs. THE OECD MARKET

	NUMBER	I961	I965	I969	I973	I979	I983
ANIMALS	1	96.71	96.82	96.17	95.35	95.84	95.99
DAIRY	2	95.64	94.85	90.71	86.26	83.29	79.80
FISH	3	82.38	85.75	82.20	78.51	83.82	87.79
CEREALS	4	-34.99	-38.38	-3.15	-41.03	-22.19	-2.14
FEEDING	5	-11.95	3.92	20.11	17.19	-15.50	-31.11
LEATHER	6	29.75	46.38	46.14	46.69	53.59	60.46
WOODMANU	7	90.72	84.83	80.44	79.79	81.02	78.01
PULPPAPER	8	93.48	91.92	89.58	88.67	85.43	83.76
TEXTILES	9	-85.63	-80.90	-75.35	-66.73	-59.75	-51.30
IRONORE	10	99.74	83.63	90.97	82.33	98.51	99.95
STEEL	11	-38.24	-25.49	-12.84	-17.19	3.75	4.73
ALUMINUM	12	30.06	39.98	59.81	56.68	50.35	54.52
OTHERNAT	13	-49.60	-47.14	-40.56	-34.60	-36.17	-30.19
OILGAS	14	-99.13	-96.79	-90.39	-83.99	-.94	39.13
ORGANIC	15	-53.12	-45.13	-21.45	-45.93	-31.59	-19.30
INORGANIC	16	-68.13	-57.85	-50.75	-41.23	-45.83	-24.25
DYESTUFF	17	-76.76	-73.39	-56.33	-55.33	-41.56	-54.52
PHARMAC	18	-55.29	-59.35	-53.68	-48.06	-26.29	-11.88
FERTILIZ	19	-72.75	-72.13	-63.86	-43.33	-55.62	-22.30
PLASTIC	20	-71.09	-72.22	-74.95	-69.90	-55.49	-46.53
OTHERCHE	21	-62.04	-55.36	-55.68	-52.94	-49.65	-49.29
POWERMAC	22	-56.61	-52.88	-46.29	-35.86	-29.36	-21.34
SPECINDU	23	-49.59	-38.69	-25.77	-18.83	-14.56	-17.20
HEATCOOL	24	7.43	9.89	15.96	14.80	8.81	13.34
PUMPS	25	-23.49	-23.84	-17.95	-17.40	-22.68	-26.34
TYPEWRITER	26	-49.87	-52.05	-38.32	-30.79	-32.77	-34.24
COMPUTER	27	5.27	-4.05	-16.72	-37.36	-42.72	-45.93
SEMICOND	28	-95.11	-94.45	-93.66	-95.25	-88.75	-84.98
TELECOM	29	-50.79	-53.80	-32.36	.72	-3.83	-3.41
ELPROD	30	-68.43	-59.70	-57.99	-54.24	-53.77	-46.20
CONSELEC	31	-79.14	-58.67	-66.28	-26.44	-39.15	-40.35
DOMELEQ	32	-63.66	-43.04	-8.25	-2.05	-13.43	-9.15
INSTRUMENTS	33	-69.44	-67.86	-59.43	-48.46	-41.10	-35.83
VEHICLES	34	-75.29	-72.37	-53.84	-31.55	-24.26	-14.17
AIRCRAFT	35	-68.00	-87.33	-92.72	-95.23	-80.64	-81.68
SHIPS	36	-44.73	-36.27	7.65	-9.58	10.04	20.96
OTHERENG	37	-54.88	-54.21	-49.85	-44.67	-38.07	-42.14
MANMETAL	38	-37.49	-28.51	-21.12	-13.49	-21.28	-28.72
FURNITURE	39	69.38	64.97	51.12	59.84	44.55	55.20
CLOTHING	40	-65.06	-63.81	-56.04	-33.06	-52.84	-50.98
NEC	41	-51.38	-47.51	-52.28	-31.48	-36.39	-38.41

TABLE 3. INTRA-INDUSTRY TRADE-INDICES, NORDIC COUNTRIES vs. THE OECD MARKET

	NUMBER	I961	I965	I969	I973	I979	I983
ANIMALS	1	3.29	3.18	3.83	4.65	4.16	4.01
DAIRY	2	4.36	5.15	9.29	13.74	16.71	20.20
FISH	3	17.62	14.25	17.80	21.49	16.18	12.21
CEREALS	4	65.01	61.62	96.85	58.97	77.81	97.86
FEEDING	5	88.05	96.08	79.89	82.81	84.50	68.89
LEATHER	6	70.25	53.62	53.86	53.31	46.41	39.54
WOODMANU	7	9.28	15.17	19.56	20.21	18.98	21.99
PULPPAPER	8	6.52	8.08	10.42	11.33	14.57	16.24
TEXTILES	9	14.37	19.10	24.65	33.27	40.25	48.70
IRONORE	10	.26	16.37	9.03	17.67	1.49	.05
STEEL	11	61.76	74.51	87.16	82.81	96.25	95.27
ALUMINUM	12	69.94	60.02	40.19	43.32	49.65	45.48
OTHERNAT	13	50.40	52.86	59.44	65.40	63.83	69.81
OILGAS	14	.87	3.21	9.61	16.01	99.06	60.87
ORGANIC	15	46.88	54.87	78.55	54.07	68.41	80.70
INORGANIC	16	31.87	42.15	49.25	58.77	54.17	75.75
DYESTUFF	17	23.24	26.61	43.67	44.67	58.44	45.48
PHARMAC	18	44.71	40.65	46.32	51.94	73.71	88.12
FERTILIZ	19	27.25	27.87	36.14	56.67	44.38	77.70
PLASTIC	20	28.91	27.78	25.05	30.10	44.51	53.47
OTHERCHE	21	37.96	44.64	44.32	47.06	50.35	50.71
POWERMAC	22	43.39	47.12	53.71	64.14	70.64	78.66
SPECINDU	23	50.41	61.31	74.23	81.17	85.44	82.80
HEATCOOL	24	92.57	90.11	84.04	85.20	91.19	86.66
PUMPS	25	76.51	76.16	82.05	82.60	77.32	73.66
TYPEWRITER	26	50.13	47.95	61.68	69.21	67.23	65.76
COMPUTER	27	94.73	95.95	83.28	62.64	57.28	54.07
SEMICOND	28	4.89	5.55	6.34	4.75	11.25	15.02
TELECOM	29	49.21	46.20	67.64	99.28	96.17	96.59
ELPROD	30	31.57	40.30	42.01	45.76	46.23	53.80
CONSELEC	31	20.86	41.33	33.72	73.56	60.85	59.65
DOMELEQ	32	36.34	56.96	91.75	97.95	86.57	90.85
INSTRUMENTS	33	30.56	32.14	40.57	51.54	58.90	64.17
VEHICLES	34	24.71	27.63	46.16	68.45	75.74	85.83
AIRCRAFT	35	32.00	12.67	7.28	4.77	19.36	18.32
SHIPS	36	55.27	63.73	92.35	90.42	89.96	79.04
OTHERENG	37	45.12	45.79	50.15	55.33	61.93	57.86
MANMETAL	38	62.51	71.49	78.88	86.51	78.72	71.28
FURNITURE	39	30.62	35.03	48.88	40.16	55.45	44.80
CLOTHING	40	34.94	36.19	43.96	66.94	47.16	49.02
NEC	41	48.62	52.49	47.72	68.52	63.61	61.59

Finally, there are two very research- and development-intensive and closely related products where the Nordic countries do not seem to succeed: semiconductors and computers. Both products are characterized by a high rate of innovation and substantial static and dynamic economies of scale. Thus, it may be taken as examples of a Van Duijn-like type of diffusion pattern. In semiconductors, import dependency remains very high and intra-industry trade very low, while in computers import dependency increases and intra-industry trade decreases throughout the period. As noted in chapter 5 this reflects that Nordic producers did not manage to keep competitive when micro-electronic technology substituted a whole range of traditional electronic, electromechanical and mechanical technologies in the late 1960s.

The Nordic countries' trade with the Non-OECD area

Table 4 reports weighted, non-adjusted indices of intra-industry trade between the Nordic countries and the Non-OECD area for selected years 1965-1983[8]. The Non-OECD area consists of all Non-

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[8] The results for 1961 did not conform well to the results for 1965 and 1969. We have no good explanation for this, but since we cannot exclude the possibility that this is caused by bad statistics, we decided not to present the results for 1961. Finland was not a member of the OECD in 1961 and we therefore had to supplement the OECD data by other sources. For the trade between Finland and the OECD area, OECD's import from Finland were used together with national sources and published data from the UN. For Finland's trade with the Non-OECD area and the socialist countries, we had to rely on national sources and published data from the UN only, and since the commodity and country breakdown of these data did not conform to the one used here, we had to make a number of assumptions, which, eventually, may prove to be wrong. But even so, this is probably not enough to explain the discrepancies between the recorded levels of intra-industry trade in 1961 and 1965.

OECD countries except the Soviet Union and the socialist countries in Europe. Thus, this group of countries may alternatively be labeled "developing countries".

TABLE 4. INTRA INDUSTRY TRADE, NORDIC COUNTRIES VS. THE NON OECD AREA

	1965	1969	1973	1979	1983
ALL	12.12	13.61	17.70	19.30	25.91
NATUR.RES	16.32	20.69	27.03	31.69	35.00
CHEMICALS	25.99	22.22	24.32	18.24	19.63
MACHINERY	2.21	5.78	11.52	10.35	17.96
OTHER	28.09	28.91	26.53	42.66	43.62

When compared to the trade between the Nordic countries and the Non-OECD countries, a number of interesting differences emerge. First, the levels of intra-industry trade between the Nordic countries and the Non-OECD countries were much lower in all sectors than between the Nordic countries and the OECD countries, as should be expected from the type of models discussed in the second section of this chapter. Second, while the overall level of intra-industry trade between the Nordic countries and the OECD area declined after 1979, it increased very fast between the Nordic countries and the Non-OECD area. Third, while chemicals were the sector where intra-industry trade grew fastest in the Nordic countries' trade with the OECD area, intra-industry trade actually declined in this sector in the trade between the Nordic countries and the Non-OECD countries. And fourth, while intra-industry trade in machinery stagnated between the Nordic countries and the OECD area after the early 1970s, intra-industry trade in this sector increased very fast between the Nordic countries and the Non-OECD countries after 1979. Thus, with a possible exception for products based on natural resources, the tendencies differ very much from those discussed in the previous section, both on the aggregate and the sector level.

To understand what happened, it is necessary to turn to the development of the Nordic countries' pattern of specialization in relation to the Non-OECD countries (table 5). But in doing this, one has to bear in mind that the Nordic countries' trade with the Non-OECD countries is much less developed and less regular than with the OECD countries, and that stochastic year-to-year variations should be expected to be more frequent. This is also the case, as can be seen form a brief inspection of table 5, especially within products based on natural resources.

Even so, it is possible to detect a broad tendency within products based on natural resources in the direction of decreased import dependency, a tendency which is reflected in increased levels of measured intra-industry trade. Throughout the 1960s, the Nordic countries were import-specialized in 6 out of 13 products based on natural resources, in 1979 they remained so in 4, and in 1983 in 3 products, only. Furthermore, even in these three products, the measured level of import specialization declined markedly and intra-industry trade increased, throughout the period. It should be noticed, however, that this tendency was counteracted by a tendency towards increasing export specialization and decreasing intra-industry trade in a number of products.

The general trend in chemicals was not very different from the trend in products based on natural resources, but the point of departure was different in the sense that the Nordic countries in the 1960s were export-specialized in 6 out of 7 chemical products. This pattern of specialization was stable throughout the period, but the level of export-specialization increased , especially in dyestuffs, fertilizers and other chemical products. As a consequence, intra-industry trade decreased.

TABLE 5. SPECIALIZATION INDICES, NORDIC COUNTRIES vs. THE NON-OECD MARKET

	NUMBER	1965	1969	1973	1979	1983
ANIMALS	1	57.18	66.86	40.05	38.79	71.75
DAIRY	2	99.98	98.91	94.30	99.28	98.93
FISH	3	80.13	81.26	73.86	25.35	13.81
CEREALS	4	-62.82	-18.76	15.00	26.55	67.23
FEEDING	5	-97.61	-98.44	-86.34	-82.22	-70.89
LEATHER	6	-73.43	-76.25	-93.89	-74.75	14.15
WOODMANU	7	-28.29	-21.26	-28.49	50.79	70.17
PULPPAPER	8	99.89	99.89	91.75	92.96	94.83
TEXTILES	9	-67.28	-56.25	-51.19	-44.35	-46.84
IRONORE	10	-100.00	-98.27	-100.00	94.73	99.40
STEEL	11	74.43	60.57	55.84	62.33	65.94
ALUMINUM	12	62.74	25.75	55.97	78.52	51.46
OTHERNAT	13	-87.46	-83.72	-75.60	-68.51	-57.36
OILGAS	14	-99.75	-99.77	-99.85	-96.62	-91.89
ORGANIC	15	55.20	85.29	65.19	67.39	61.13
INORGANIC	16	-81.06	-80.57	-70.45	-76.04	-74.82
DYESTUFF	17	47.46	80.56	81.29	87.64	89.14
PHARMAC	18	86.07	74.96	86.12	87.95	83.87
FERTILIZ	19	71.80	48.61	73.02	82.99	93.48
PLASTIC	20	95.62	91.11	97.17	93.65	91.26
OTHERCHE	21	64.01	72.63	79.08	90.24	87.20
POWERMAC	22	96.56	94.69	94.91	95.07	98.30
SPECINDU	23	99.45	99.15	98.03	96.79	95.66
HEATCOOL	24	99.89	99.77	99.08	99.47	99.42
PUMPS	25	98.70	98.88	93.68	95.21	94.18
TYPEWRITER	26	98.23	97.90	77.32	94.17	54.83
COMPUTER	27	81.02	96.97	85.39	64.73	41.39
SEMICOND	28	65.85	86.87	-70.38	-72.04	-73.43
TELECOM	29	99.66	99.82	98.02	94.73	94.04
ELPROD	30	98.02	97.22	90.80	92.64	87.05
CONSELEC	31	91.26	71.40	-14.23	-49.98	-55.47
DOMELEQ	32	99.61	98.28	84.70	77.43	56.14
INSTRUMENTS	33	86.81	80.93	74.69	59.70	65.41
VEHICLES	34	96.95	98.12	97.21	95.42	92.12
AIRCRAFT	35	99.65	93.70	84.34	21.36	91.19
SHIPS	36	99.22	89.94	82.92	86.73	68.44
OTHERENG	37	95.04	90.75	84.81	86.28	83.60
MANMETAL	38	93.09	89.75	76.33	73.71	69.46
FURNITURE	39	79.11	42.57	57.88	50.90	50.90
CLOTHING	40	-96.46	-97.15	-97.82	-93.62	-93.10
NEC	41	11.85	-15.16	-28.74	-8.09	-11.50

TABLE 6. INTRA-INDUSTRY TRADE INDICES, NORDIC COUNTRIES vs. NON-OECD MARKET

	NUMBER	1965	1969	1973	1979	1983
ANIMALS	1	42.82	33.14	59.95	61.21	28.25
DAIRY	2	.02	1.09	5.70	.72	1.07
FISH	3	19.87	18.74	26.14	74.65	86.19
CEREALS	4	37.18	81.24	85.00	73.45	32.77
FEEDING	5	2.39	1.56	13.66	17.78	29.11
LEATHER	6	26.57	23.75	6.11	25.25	85.85
WOODMANU	7	71.71	78.74	71.51	49.21	29.83
PULPPAPER	8	.11	.11	8.25	7.04	5.17
TEXTILES	9	32.72	43.75	48.81	55.65	53.16
IRONORE	10	0	1.73	0	5.27	.60
STEEL	11	25.57	39.43	44.16	37.67	34.06
ALUMINUM	12	37.26	74.25	44.03	21.48	48.54
OTHERNAT	13	12.54	16.28	24.40	31.49	42.64
OILGAS	14	.25	.23	.15	3.38	8.11
ORGANIC	15	44.80	14.71	34.81	32.61	38.87
INORGANIC	16	18.94	19.43	29.55	23.96	25.18
DYESTUFF	17	52.54	19.44	18.71	12.36	10.86
PHARMAC	18	13.93	25.04	13.88	12.05	16.13
FERTILIZ	19	28.20	51.39	26.98	17.01	6.52
PLASTIC	20	4.38	8.89	2.83	6.35	8.74
OTHERCHE	21	35.99	27.37	20.92	9.76	12.80
POWERMAC	22	3.44	5.31	5.09	4.93	1.70
SPECINDU	23	.55	.85	1.97	3.21	4.34
HEATCOOL	24	.11	.23	.92	.53	.58
PUMPS	25	1.30	1.12	6.32	4.79	5.82
TYPEWRITER	26	1.77	2.10	22.68	5.83	45.17
COMPUTER	27	18.98	3.03	14.61	35.27	58.61
SEMICOND	28	34.15	13.13	29.62	27.96	26.57
TELECOM	29	.34	.18	1.98	5.27	5.96
ELPROD	30	1.98	2.78	9.20	7.36	12.95
CONSELEC	31	8.74	28.60	85.77	50.02	44.53
DOMELEQ	32	.39	1.72	15.30	22.57	43.86
INSTRUMENTS	33	13.19	19.07	25.31	40.30	34.59
VEHICLES	34	3.05	1.88	2.79	4.58	7.88
AIRCRAFT	35	.35	6.30	15.66	78.64	8.81
SHIPS	36	.78	10.06	17.08	13.27	31.56
OTHERENG	37	4.96	9.25	15.19	13.72	16.40
MANMETAL	38	6.91	10.25	23.67	26.29	30.54
FURNITURE	39	20.89	57.43	42.12	49.10	49.10
CLOTHING	40	3.54	2.85	2.18	6.38	6.90
NEC	41	88.15	84.84	71.26	91.91	88.50

In the 1960s, the Nordic countries' degree of export specialization in machinery was close to one hundred(complete export-specialization), and intra-industry trade close to zero. For the majority of machinery products, this pattern of specialization remained stable throughout the period, but there were notable exceptions: Typewriters, computers and peripherals, consumer electronics, domestic electrical equipment, instruments and ships.[9] For these six products, the Nordic countries' degree of export specialization declined from the 1960s onwards, even if the Nordic countries remained export-specialized in all but one (consumer electronics). As a consequence, intra-industry trade in these six products, and in machinery as a whole, increased throughout the 1970s and early 1980s. A similar explanation may be found for the growth of intra-industry trade in traditional industrial products during the same period: Intra-industry trade increased, because the Nordic countries' export specialization in metal products decreased.

Summing up: The case of the Nordic countries

In the early-mid 1960s, the Nordic countries were in a typical "middle" position in the international division of labour. In

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[9] Also semiconductors were an exception, but since the level of trade between the Nordic countries and the Non-OECD area was almost negligible in this category, we will not draw any conclusions from this.

relation to the OECD countries, the Nordic countries' pattern of specialization was rather "peripheral" : A high degree of export specialization in a number of products based on natural resources, and a high degree of import specialization in most other products, especially the technologically more advanced ones. But in relation to the Non-OECD countries, the Nordic countries' pattern of specialization was more "developed" : Import-specialized in a number of products based on natural resources and clothing, export-specialized in all other products, especially the technologically more advanced ones.

As shown in chapter 5, what happened during the 1960s was that the Nordic countries in relation to the rest of the OECD "traded up the development ladder". Gradually, the Nordic countries became more competitive and increased production capacity within a whole range of industries, partly by diversifying from natural resources to industries using natural resources, partly by imitation and technology import. As a consequence, import dependency was reduced and intra-industry trade increased in a number of products, most markedly within the machinery sector.

In relation to the Non-OECD countries, the Nordic countries' pattern of specialization remained relatively unchanged during the 1960s. But by the early 1970s it became clear that many developing countries were trading up the development ladder, too. Gradually, they became more competitive and increased production capacity within a range of maturing products, i.e. products where technology is well known and transferable and cost competitiveness is decisive. As a consequence, the export specialization of the Nordic countries in their trade with the Non-OECD countries decreased throughout the 1970s and early 1980s in a number of maturing products, resulting in increasing intra-industry trade.

Thus, what happened during the 1970s was a gradual shift in comparative advantage in favour of less developed, low-cost countries, as they managed to cope with the technology necessary for exploiting their potential cost advantages. As a consequence, high-cost Nordic producers gradually lost ground in a number of maturing products, not only in Third World markets, but in the OECD market as well. In their trade with the OECD-countries, the Nordic countries became gradually more import specialized in such products throughout the 1970s and early 1980s, and as a consequence intra-industry trade decreased. It is worthwhile noticing, that the same factor which caused intra-industry trade between the Nordic countries and the OECD countries to <u>decrease</u>, caused the intra-industry trade between the Nordic countries and the Non-OECD countries to <u>increase</u>.

However, there is one sector where the Nordic countries seem to develop a new comparative advantage: Chemicals. In the trade with the OECD countries, where the Nordic countries initially were import-specialized, the increasing competitiveness of Nordic producers in this sector caused import specialization to decrease and intra-industry to <u>increase</u> throughout the period. But in their trade with the Non-OECD countries, the increased competitiveness of the Nordic countries within this sector caused intra-industry trade to decrease, because in this case increasing competitiveness caused export specialization to increase.

6.6 CONCLUDING REMARKS

Recently, several writers have developed models which show that intra-industry trade is what should be expected in a world where imperfect competition and economies of scale prevail. However, these models are all essentially static. Very little research has been done, both theoretical and applied, on the dynamics of intra-industry trade.

The approach of this study differs from the one referred to above by focusing on trade as a medium for diffusion of technology, sector- and product-specific conditions for diffusion, and shifts in comparative advantages across countries. However, it should be stressed that the approach of this chapter complements rather than contradicts other types of explanation of intra-industry trade. In sectors or products where the structure of comparative advantage across countries does not change much over time, it is quite probable that the most important source of intra-industry trade is to be found in the link between economies of scale and the market structure. But where sector- or product-specific conditions of diffusion cause the structure of comparative advantage across countries to change radically, as they often do, this is a source of intra-industry trade of its own. The empirical evidence considered by this chapter suggests that the latter type of diffusion pattern has had strong influence o measured levels of intra-industry trade for the countries an time spans under consideration.

CHAPTER 7

CONCLUSION

The basic questions addressed by this study have been why some countries grow faster than others, what determines trade performance (competitiveness/specialization) and how trade and growth interact.

These questions are by no means new. On the contrary, they belong to the core of international economics. It is fair to say, however, that the theory of international economics for some time has been in a state of flux. Beginning with Ricardo, and continuing with Ohlin, Samuelson and others, the theory of international trade has gradually developed into an applied version of general equilibrium theory. The same holds for growth theory (Solow and others). In both cases, much effort has been devoted to establishing the properties of optimal equilibrium solutions and discussing the implications for economic policy. However, these conclusions rest on very restrictive assumptions on technology and economic behaviour. Unless these assumptions- including that of general equilibrium - are shown to hold, at least in an approximate sense, there is no reason to expect that the actual international economy should share the properties predicted by the theory. Nevertheless, this is what many researchers, until recently at least, seem to have been expecting. However, as shown in chapter 1, applied research has in many cases revealed that the actual international economy does not possess the properties that the neoclassical theories "predict". These findings have launched a still ongoing search for new ways to explain international economic phenomena.

As pointed out in chapter 1, many of these attempts came to adopt Schumpeterian perspectives on the working of the economy. This is certainly no coincidence. In contrast to the neoclassicals, Schumpeter strongly emphasized that the actual economy would never be in a state of equilibrium, and that the study of actual economic developments has to be based on an understanding of disequilibrium dynamics. According to Schumpeter, economic development should be analysed as the interplay of two conflicting forces: innovations which create disequilibria, and diffusion or imitation which tends to reduce them. Since this is a continuous process, the economy will never settle down on a (moving) equilibrium. Indeed, Schumpeter points out, even "to speak of "moving equilibria" may prove misleading, in the face of the fact that what really happens is destruction of equilibria in the received meaning of the term" (Schumpeter, 1928, p.369). Thus, without explicitly denouncing equilibrium theory as such, he laid the foundations for a qualitatively different approach to the study of economic development, including international economics, than that of general equilibrium theory.

Take, for instance, the question of "why growth rates differ" between countries (chapter 2 of this study). The neoclassical theory of growth predicts that economic growth is a linear function of the growth in the factors of production (capital and labour) and exogenous technical progress ("manna from heaven").[1] However, when this model is applied to the actual differences in growth between countries on different levels of economic and technological development, a large part of the differences in growth continues to be unaccounted for. In applied work, therefore, the above factors are often supplemented by "the scope for imitation", measured as the distance between the productivity level of the country in question and world productivity frontier, or other factors related to disequilibria that exist within and between countries. But in the long run these disequilibrium factors are assumed to vanish and all countries converge towards the world productivity frontier. Thus, even when disequilibrium assumptions are introduced into the equilibrium framework, important phenomena such as changes of technological leadership and the existence of laggards continue to be unexplained. The main reason for this, the presents study argues, is the assumption that when differences in the scope for imitation are adjusted for, all countries should be expected to gain equally from technological progress.

[1] According to the neoclassical theory of growth, when time grows towards indefinitely, the capital-term will vanish and economic growth become a function of growth in labour supply and exogenous technical progress alone. However, in applied studies, the growth of capital (or the saving rate) is always included, e.g. it is implicitly assumed the economy is not in a state of long run equilibrium.

In contrast to the neoclassical view, where growth in knowledge is treated as "manna from heaven", Schumpeterian (or neo-Schumpeterian) analyses treat growth of knowledge as the outcome of technological activities, e.g. innovative efforts of firms, research and development efforts in the public sector and interaction processes (learning) between firms and their environments. According to this view knowledge is both <u>specific</u>, in the sense that in most cases advances in knowledge cannot be automatically transferred from one environment (firm, sector, industry or country) to another, and <u>cumulative</u>, in the sense that advances in knowledge in one area tend to lead to further advances within the same or related areas. This implies that imitation in many cases is difficult and costly to undertake, especially in the early phases of the life cycle. Thus, even though diffusion to other countries will take place, this takes time, and in the meantime the economic benefits accrue solely to the innovating country. It follows, other factors left apart, that if the national technological activities of one country continue to grow faster than that of another country, the former, more "dynamic" country should be expected to have a higher rate of technical progress and, hence, growth than the latter. If the more dynamic country is a leader country, this will help it to keep its lead, if it is a follower country, this will help it to catch up and, eventually, surpass the (former) leader (change of leadership). The findings of this study (chapter 2) support the view that differences in the growth of national technological activities, together with differences in the scope for imitation and efforts related to the economic exploitation of innovation and diffusion, contribute significantly to differences in growth performance between countries.

However, the model of economic growth set out in chapter 2 abstracts from trade, which is, of course, a major shortcoming, since trade is often assumed to play a crucial role in the distribution of the economic benefits that come out of the international process of innovation and diffusion. To take trade into account, however, we have to be more specific on how domestic and international markets work. Here the traditional neoclassical models with their sole emphasis on price competition are of little help since, as every manager knows, the outcomes of competitive processes depend as much on technology as on price. To Schumpeter this was so obvious that he, too optimistically it seems, took it for granted that economists would take this into account in their future analyses:

> "Economists are at long last emerging from the stage in which price competition was all they saw. As soon as quality competition and sales effort are admitted into the sacred precincts of theory, the price variable is ousted from its dominant position. However, it is still competition within a rigid pattern of invariant conditions, methods of production and forms of industrial organization in particular, that practically monopolizes attention. But in capitalist reality as distinguished from its textbook picture, it is not that kind of competition which counts, but the competition from the new commodity, the new technology, the new source of supply, the new type of organization (the largest-scale unit of control for instance) - competition which commands a decisive cost or quality advantage and which strikes not at the margins of the profits and the outputs of the existing firms, but at their foundations and their very lives. This kind of competition is as much more effective than the other as a bombardment in comparison with forcing a door, and so much more important that it becomes a matter of comparative indifference whether competition in the ordinary sense functions more or less promptly; the powerful lever that in the long run expands output and brings down prices is in any case made of other stuff." (Schumpeter, 1947, pp. 84-85).

Following this view, chapter 3 developed an open economy model where the growth in a country's market share, domestically as well as abroad, was assumed to depend on the ability to compete in technology, the ability to compete in price and the ability to compete in delivery (capacity). By definition, the growth in a country's market shares (domestically and abroad), the growth in terms of trade and the growth in world demand add up to "the balance-of-payments equilibrium growth rate"[2], to which the actual growth rate was assumed to adjust. In addition, demand was assumed to feed back on competitiveness by affecting the ability to deliver and stimulating investments in productive capacity. Prices and, hence, terms of trade were assumed to depend (mark-up pricing) on unit wage costs (assumed to be exogenously determined). Thus, the model combines the Schumpeterian emphasis on innovation (technological competition) with Keynesian (or post-Keynesian) features such as mark-up pricing and an accelerator-based investment function. However, since differences in investments across countries also depend on differences in institutional and economic structures, these were also taken into account when testing the model.

The findings of chapter 3 suggest that in the long run the growth of market shares is determined mainly by technological factors, e.g. the scope for imitation, the growth in national technological activity (or technological competitiveness) and efforts related to the economic exploitation of innovation and diffusion

[2] This is the growth rate which secures that the current account, if initially balanced, continues to be in balance.

(investments), while differences in the growth of unit labour costs were found to be of minor importance. These results are consistent with the finding by Thirlwall (1979), that growth in the long run can be explained without reference to relative prices or costs, by the relation between income elasticities for exports and imports. The explanation proposed here is simply that the estimated differences in income elasticities of demand for exports and imports reflect different degrees of technological competitiveness.[3] The findings of chapter 3 were also shown to be consistent with the observations by Kaldor(1979) and others that market shares for exports and unit labour costs often move together instead of in opposite directions as many other models suggest. The explanation in this case is, as suggested by Schumpeter, that differences in technological competitiveness more than outweigh differences in price or cost competitiveness.

The model presented in chapter 3, though relatively elaborated compared to the model presented in chapter 2 and most other approaches to the subject, has one major shortcoming when related to the Schumpeterian perspective adopted in this study: the one-sector framework. According to the perspective outlined in chap-

[3] If one country, say, Japan, continuously increases its level of technological competitiveness relative to other countries and gains market shares domestically as well as abroad, this should, given the models and methods normally applied in estimating income elasticities of demand for total exports and imports, be reflected in a relatively high income elasticity for exports and a relatively low income elasticity for imports. However, these estimates may also reflect the level of technological activity, since countries that produce new advanced goods, for which demand is above average, in most cases also have a high level of technological activity and vice versa. This case is discussed in more detail below.

ter 1, world demand should be expected to grow faster for new, advanced products, originating from R&D-intensive industries and firms, than for more mature products. Since the character of the goods that a country produces is closely related to its level of national technological activity, it follows that the growth of world demand will affect countries differently depending on their levels of technological activity. For instance, a country that has a higher level of technological activity or a higher share of new, advanced products in production than the average, will normally face an above average growth in the demand for its exports. Similarly, a country that has a lower level of technological activity or a higher share of mature goods in production than the average, will normally face a below-average growth in the demand for its products. Thus the level of technological activity and the composition of production and trade enter as important factors determining the competitiveness of a country. In principle, this could be taken into account by developing a multi-sector version of the model presented in chapter 3, but in this study (chapter 4) we have adopted a simpler approach.

Chapter 4 presents evidence on the relation between the international process of innovation-diffusion, the changing composition of world trade and the export performance of countries with different sets of characteristics. Between 1961 and 1983 the composition of world trade changed quite radically. The main source of these changes was found to be the creation and subsequent diffusion of new products and technologies originating in R&D-intensive industries, especially the electronics and chemical industries. In general, these changes were shown to be most favourable for countries with a high level of technological activity and a relatively large domestic market. According to chapter 4 the group of countries most favourably affected includes the United States, Japan, Germany (BRD), the United Kingdom, Italy and Switzerland.[4] However, in some cases (the United States and the United Kingdom in particular), favourable demand effects were outweighed by declining market shares within individual commodity groups and a lack of ability to adjust the production structure in pace with the changing structure of world demand. Even if one should be extremely cautious in interpreting results obtained from pooled regressions on data for individual countries, it is worth noticing that the analysis of chapter 3 suggests that this may be part of the price paid by these countries for their participation in the Cold War.[3]

As noted, with one exception (Switzerland), the countries most favourably affected by the structural changes in the composition of world demand in the period covered by this study were all relatively large countries. This raises the important issue of

[4] These countries are mentioned because the commodity composition effects were positive in both periods. Other countries that share some of the same characteristics are France and Sweden, but for these two countries a positive commodity composition effect in the first period turned to a negative effect in the second period (though close to zero).

[3] Compared to other countries, the United States and the United Kingdom have devoted a much higher share of national resources to military expenditures, and a much lower share of national resources to investments. According to the calculations (table 4, chapter 3) this explains most of the losses in market shares by these countries throughout this period.

whether there exist significant small country disadvantages (economies of scale) in new, advanced products and technologies. The data on revealed comparative advantage (export specialization) reported in chapter 5 seem to support this view. On average, large developed countries have a much higher degree of specialization in high-technology products than the small developed ones. Indeed, with the exception of Switzerland, all small developed countries turned out to be specialized in low-technology products.[4] However, though they exist, small-country disadvantages differ substantially between and within different "high-tech" industries. As suggested by Walsh (1987) these disadvantages may in many cases be overcome through the adoption of relevant strategies, such as supporting domestic user-producer interaction in areas where domestic competence is strong or through cooperation (including trade) between small countries. The findings of chapter 5 showed that intra-regional trade between a group of small countries (the Nordic ones) may function as an important stimulus to the growth of new, relatively advanced lines of production based on diffusion of technology from abroad and indigenous development efforts. However, as the Nordic countries approached the frontier countries in terms of income per capita, they become more vulnerable to increased price-competition from the newly industrialized countries (see below) in a number of areas, and, at the same time, less inclined to develop their mutual trade and cooperation further. One possible interpretation of the latter, which - however - will not be discussed here, is that these

[4] Note, however, that Sweden is export specialized in both medium-technology and low-technology products.

countries have substituted a regional-integration strategy for a global-internationalization strategy, with a stronger emphasis on supporting "national" MNE's (Walsh, 1987).[5]

While favouring countries with a high level of national technological activity and sophisticated production structure, the growing international trade in the Post-War period did at the same time allow countries on a lower level of economic development to catch up and increase market shares through imitation and exploitation of cost advantages. In fact, in the early Post-War period, when the United States enjoyed a large technological lead, most European countries (and, of course, Japan) followed this route. In later years a number of other countries from different parts of the world (the NIC's) have embarked on the same route and, as this study shows[6], with some success in terms of market shares for exports on the world market. However, the increasing price competition (and the strong emphasis on low wage costs) that characterizes the drive towards maturity, makes this a questionable strategy to follow in the long run. The results of this study suggest that to catch up in terms of income per capita, the NIC's have to combine imitation and exploitation of cost advantages with a strengthening of their indigenous technological base and a transformation of their production structure. This, it may be noted, is exactly what Japan did a few decades ago, and

[5] This seems more likely in the Swedish and Finnish cases, where national MNE's such as Ericsson and Nokia have received relatively large support (see Dalum et al.,1988), than in the Norwegian and Danish cases.

[6] See tables 5 and 6, chapter 4 and table 8, chapter 5.

what the Asian NIC's attempt to do today. The Republic of Korea, for instance, is now reported to have a share of R&D expenditures in GDP comparable to that of many developed countries.

The continuous transformation of industrial structures and trade patterns that follows in the wake of the international process of innovation and diffusion has important implications for the development of export specialization and, hence, intra-industry trade. According to the traditional neoclassical theory of international trade, the growing intra-industry trade that has been observed in the Post-War period is difficult to account for because it contradicts the assumption of increasing specialization on the basis of differences in factor endowments.[7] However, the growth of intra-industry trade is difficult to explain only as long as the world economy is assumed to approach a state of general equilibrium. As soon as it is recognized that innovation causes the products and technologies of the centre countries (as well as other countries) to change, and that these innovations thereafter (at different degrees and paces) diffuse to the international economic environment, a continuous change in specialization patterns is what should be expected. As shown in chapter 6

[7] As pointed out in chapter 6, there have been many attempts to make the existence of intra-industry trade consistent with neoclassical theory, for instance by introducing assumptions of imperfect competition. However, while useful, these explanations do not explain the growth of intra-industry trade. Alternatively, it is sometimes suggested that increasing intra-industry trade reflects the increasing importance of intra-MNE trade. While possible for large, developed countries such as,for instance, the United States, this is probably not an important factor for the group of small, developed countries covered in chapter 6.

this process is likely to lead to a large amount of intra-industry trade.

The starting point for this study was the observation that many cases of applied research have provided evidence that has proven difficult to reconcile with the neoclassical theories of growth and trade. This is, as noted, no proof that it cannot be done, and there are, indeed, many attempts to do so. However, this is not what concerns us here. The purpose of this study has been a different one, to apply the basic Schumpeterian model of innovation-diffusion to the problem of how technology, growth and trade interact, and to confront this with empirical evidence from the Post-War period. In general, the Schumpeterian perspective outlined here was found to be consistent with the empirical evidence considered by the study. However, a few qualifications seem to be in order.

Firstly, the basic Schumpeterian hypothesis of a causation running from innovation to growth has been assumed to be true. No attempt has been made to test for the direction of causation, or, more generally, to test alternative models. Thus, what is presented here is one story, hopefully a convincing one, which is shown to be consistent with the data. Others may construct other stories, convincing or not, which may fit the data equally well or even better, but this task is left to them. Secondly, the focus of this study has been on the consequences of innovation processes for growth and trade, and on how growth and trade interact. No attempt has been made to explain innovation processes.

Thirdly, and related to the previous point, the level of the analysis has been that of the world economy, not that of individual countries. In general, data from individual countries are used to analyse the working of the world economy, not the other way around. What we can hope for is that this throws some light on why the performance of groups of countries with certain common characteristics differs. To analyse the performance of individual countries, a more elaborated framework, which takes differences in institutional setting and economic structure more explicitly into account, would be required.

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