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Abstract

The aim of the present paper is twofold. We want to present and test a methodology capable to deal more satisfactorily with the question of stability of international export specialisation patterns and, secondly, we want to relate this issue to the convergence-divergence debate in growth theory and the rapidly increasing strand of literature on national systems of innovation.

We conclude that the relative export structures are moving together in the long term. However, the speed of convergence is fairly slow, indicating that national export specialisation patterns are quite stubborn or 'sticky'. These findings are complementary to the new knowledge generated wit convergence-divergence debate in growth theory and the rapidly increasing strand of literature on natonal systems of innovation.

Keywords

Specialisation, International Trade Patterns, Growth and Trade

JEL Classification

F14, O33, O57

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1. The aim of the paper[1]

The paper takes as one of its points of departure the growing literature on national systems of innovation (Freeman 1988, Lundvall 1992, Nelson 1993 and Freeman 1995). The relative importance of nation-specific inducement mechanisms, such as factor supply (abundance or serious lacks), institutional structure and user-producer relations, versus industry and/or technology specific mechanisms, independent of any national context, is a major theme in that line of research. We are going to examine one issues related to this discussion of national specificity - whether the group of OECD countries are characterised by a high degree of stability of their export specialisation patterns at the country level or not. The countries to be examined are 21 OECD countries during a period of three decades from 1961 to1992.

In previous, more descriptive, work (Dalum 1992) it was found that only 4 out of 21 OECD countries experienced radical change in export specialisation patterns during the quarter-century from the early 1960s to the mid-1980s; and in two of these cases, Norway and the UK, the oil and gas sector apparently was the major single explanation. In that study the emphasis was put on qualitative stability of the specialisation patterns at a fairly aggregate level. The findings were based on 'impressionistic' inspections of the data and not on a more rigourous testing procedure.

The aim of the present paper is twofold. We want to present and test a methodology capable to deal more satisfactorily with the question of stability of international export specialisation patterns and, secondly, we want to relate this issue to the convergence-divergence debate in growth theory and the rapidly increasing strand of literature on national systems of innovation.

Concerning the latter aim, the main conclusion of the literature on convergence-divergence of growth patterns is that convergence has been the dominant feature among the OECD countries in the postwar period. Does this feature undermine the increasing interest among innovation researchers and economists in developing the concept of national systems of innovation as a vehicle for strengthening the analytical foundations of the study of long term development of nations and related policy measures in the science and technology (S&T) field? Is the combined effect of convergence in growth patterns and increasing internationalisation, if not globalisation, synonymous with decreasing importance of distinct national patterns in economic analysis? As will be shown below, we do not see any inconsistency between convergence of some of the main macroeconomic indicators between members of the rich club of OECD countries on the one hand, and even persistent differences in international specialisation in S&T indicators and exports on the other.

Some central features of the convergence-divergence debate are stated in the following section, while section 3 deals with the methodological technicalities involved in measuring stability of specialisation patterns. Section 4 contains a survey of some of the most central studies of science

[1] The present version has benefitted especially from comments by Bart Verspagen, Steve Dowrick and Keld Laursen. The usual disclaimer applies.

and technology specialisation patterns, while section 5 contains the core empirical part of the paper in terms of our stability tests of export specialisation. Section 6 contains the conclusions, including a discussion of some implications for the national systems of innovation literature.

2. Convergence or divergence of patterns of economic growth

In the last ten years or so the literature on economic growth has been much concerned about the issue of convergence versus divergence in living standards as measured by GDP per capita - i.e. whether growth patterns have led countries nearer to each other in economic terms or apart. The main conclusion appears to be that convergence has been the dominant feature among the OECD countries in the postwar period. However, when the sample of countries is enlarged to include less developed countries, divergence rather than convergence appears to have characterised international economic development patterns. The lack of global convergence of per capita GDP has been a major challenge for the established mainstream neoclassical growth theory, as represented by the Solow model (1956). The implication of Solow's model was global convergence of per capita incomes, but this is now clearly contradictory to empirical findings. The model was based, however, on very crude and simplifying assumptions: perfect competition was assumed to prevail and technology was assumed to be a public good, change in which was determined exogenously ('Manna from Heaven').

Fagerberg's survey (1994a) of links between technology and differences in growth rates reflects the widespread view that technological development may be a major factor in explaining growth differentials and/or the lack of global convergence of income levels. Applied neoclassical analyses have tried for decades to cope with 'why growth rates differ' by means of so-called growth accounting (e.g. Dennison 1967). This strand of research has tried to reduce the 'productivity residual', assigned originally by Solow (1957) himself as technical change, by ad hoc addition of numerous explanatory variables to the mere quantitative growth of labour and capital input. However, most of these added factors have been those assumed exogenous in the basic growth model; what is supposed to determine the growth patterns empirically is, thus, neglected in the basic theory.

The inconsistencies between the basic growth model and the growth accounting exercises on the one hand and the arbitrary character of the addition of productivity residual 'squeezing' variables (Nelson 1981) on the other, did finally lead to the advent of an innovation of mainstream economics, the so-called 'new growth theory'. Technological change has been assigned the role of an endogenous variable in the various model specifications. Fagerberg (1994a) distinguishes between a first generation of models (e.g. Romer 1986 and Lucas 1988) where investment in physical and human capital can lead to technological change through 'learning by doing'. By assuming technological change through positive externalities at the industry level, and not at the firm level, perfect competition still prevailed in the model specifications. These models resulted in the possibility of the rich countries getting even richer in comparison with the poor countries. The second generation of models - of which Romer (1990) and Grosmann and Helpman (1991) are the most prominent examples - has introduced a technology sector where technological change

is the outcome of deliberate actions taken by entrepreneurs leading to temporary monopoly power for the innovators, allowing for the integration of several new methods of modelling imperfect competition from the discipline of industrial economics. Both generations of models are characterised by emphasising a certain amount of cumulativeness in economic development - the stronger may even get stronger, and the weaker may get weaker. The importance of cumulativeness in technical change, stressed for long by researchers in innovation theory, was already introduced to mainstream international economics by Krugman in 1987.[2]

These model building efforts have, however, been characterised by very long time lags vis-à-vis other less mathematically oriented parts of the economics profession. Nelson and Winter (1982) distinguish between 'formal' and 'appreciative' theorising (for a recent account see also Nelson 1994). Fagerberg (1994a) categorises a wide array of empirically based 'appreciative' investigations by economic historians, innovation researchers and economists under the broad heading of the technology gap approach to economic growth. Abramovitz (1986) focuses on the hypothesis that growth rates in per capita income tend to vary inversely with their initial levels. The main conclusions of a more recent study (Abramovitz 1994, pp. 21-22) are that for the group of presently advanced countries:

> -From around 1800 to 1860 divergence characterised their income per levels.
> -Between 1870 and World War II there was group convergence (measured by decreasing coefficients of variation), but there was no catch-up. The US per capita income lead was increased (the US 'forged ahead').
> -The quarter of a century 1948-73 was characterised by a historically exceptional combination of fast catch-up and convergence.
> -After 1973 convergence slowed down and nearly stopped.

For the present group of less developed countries divergence has been the dominant feature. Although a few East Asian countries (the 'Tigers') have developed very rapidly since the late 1960s, they are still the exception from the main rule.

Abramovitz has put forward an important distinction between the potential for catch-up and convergence and the actual realisation of this potential. Two kinds of constraints are set up: lack of technological congruence and lack of social capability. The first refers to e.g. the capital-using and scale-intensive bias of the American manufacturing industry in the late 19th century and the first half of this century. The combination of abundance of raw materials and land and the large scale and unified character of the US market led to this bias. All sorts of barriers in Europe and lack of cheap raw materials (coal, iron, etc.) represented a lack of congruence to this US context. The concept of social capability refers to a broad set of factors, such as the general level of education, the quality of the vocational, managerial and engineering training, the institutional

[2] See also Drud Hansen (1995).

structure in a broad sense, the functioning of capital markets, etc - all of which may have retarded growth, if they did not function well.[3]

Outside the mainstream of neoclassicals, economists of a more heterodox background have tried to build and test models combining the potential of catching-up of technology gaps with the actual efforts to realise these potentials. With roots back to Schumpeter and Keynes, Cornwall (1977) presented and tested a model that was able to explain the quarter-century postwar growth boom of the OECD countries, as well as the deceleration of growth rates in the late 1960s and early 1970s. Other early attempts, inspired by Kaldor (1957, 1961), focused on balance of payments constraints, such as Dixon and Thirlwall (1975) and Thirlwall (1979, 1986).[4] Structural characteristics of the manufacturing sector may exert a major influence on growth rates of productivity via world income elasticities of demand for exportables from a given country. A given specialisation pattern in production and/or exports can, thus, be deepened through cumulative processes, such as learning by doing. Countries specialised in the sectors of growing or potentially growing world demand may experience more favourable growth prospects than those more focused on low growth areas.

This approach has been developed further by economists by assigning endogenous technological development an important role in the growth equations. Various related models, such as those of Soete and Pavitt (1982), Fagerberg (1987, 1988a) and Verspagen (1993), have as independent variables combined per capita GDP (the technology-gap proxy inversely related to productivity growth) with especially investment and R&D/patenting indicators. In other models of the same family the focus has been on the combined process of productivity growth and international competitiveness, as measured by changes in export market shares (Fagerberg 1988b; Dosi, Pavitt and Soete 1990).

These kinds of models have been very much inspired by firm- and industry-based case studies of innovation processes, now 'embodied' in the discipline of the economics of industrial innovation or 'innovation theory'. This fairly new branch of economics owes is mains credentials to Freeman (1974). Other major contributions are Pavitt (1984), Dosi (1988), Dosi et al. eds. (1988), Dosi, Freeman and Fabiani 1994) and Freeman's recent survey of the state of the art (Freeman 1994). Among the most salient micro foundations of this discipline is the cumulative and path dependent character of technological change and the importance of tacit (i.e. non-codified) as well as codified knowledge. The term 'evolutionary' theory has to an increasing degree been used as a common denominator of this line of research, as originally put forward by Nelson and Winter (1982) and recently surveyed by Nelson (1995).

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[3] Abramovitz himself is quite aware of the lack of rigour of the social capability concept. However, his application of it in broad historical analyses appears none the less highly convincing.

[4] For more details, see the introductory chapter in Fagerberg, Verspagen and von Tunzelmann eds. (1994).

In recent years a dialogue has developed between at least some protagonists of the 'new growth' school and those of the 'evolutionary' macro modelling efforts mentioned above. Romer himself (1993) recognises the value of the appreciative work of the 'dissident' economists (more or less identifiable with the evolutionary school mentioned above) and urges this camp to try and embody their rich empirical insights in more rigorous models. He also urges mainstream model builders to integrate this body of research more in their future modelling efforts. In this spirit, so to speak, two volumes of papers have actually been published from conferences where the different schools of research have been confronted, see Solow and Pasinetti eds. (1994) and Silverberg and Soete eds. (1994).

Of special interest for the convergence-divergence discussion in an open economy context one of these papers (Soete and Verspagen 1994) has analysed the relationship between technological change - in terms of innovation versus imitation - and growth. As an analytical device the distinction between innovation and imitation leads as a first approximation to divergence versus convergence: they interpret the long term history of the market economies as a series of periods of alternating divergence and convergence. The net outcome is the result of the relative strength of the two forces. As far as the OECD countries are concerned, their 'condivergence' indicator points towards an end of the postwar convergence period in the early 1980s. In their interpretation of the South East Asian pattern they find a clear evidence of 'local convergence' of the 'Tiger' countries vis-à-vis Japan from the late 1960s until the mid-1980s where convergence levelled off. They further suggest that this pattern may be switched to divergence in the not too distant future:

> "In other words, the process of imovation (i.e. the strategy to build up own innovative capacities based on previously imitated accumulated knowledge) does not lead to further convergence but to a process of increased international trade specialization and in all likelihood a future process of growth divergence." (Soete and Verspagen 1994, p. 295).

3. Stability of specialisation patterns: methodological issues

Most empirical studies of international specialisation patterns use as a central indicator Balassa's so-called Revealed Comparative Advantage index (Balassa 1965), originally developed for analysis of specialisation in international trade but later also used in studies of specialisation in S&T, based on R&D, bibliometric data or patents. In a trade context the algebra can be set up as follows:

$$RCA = \frac{\frac{X_{ij}}{\Sigma_i X_{ij}}}{\frac{\Sigma_j X_{ij}}{\Sigma_{ij} X_{ij}}}$$

The numerator represents the percentage share of a given product in national exports - X_{ij} are exports of product i from country j. The denominator represents the percentage share of a given

product in OECD exports. The RCA index, thus, contains a comparison of national export structure (the numerator) with the OECD export structure (the denominator). When RCA equals 1 for a given product in a given country, the percentage share of that product is identical with the OECD average. Where RCA is above 1 the country is said to be specialised in that product and vice versa where RCA is below 1. The weighted average of the RCAs of a country should by definition add up to 1. From a methodological point of view, the RCA index is devised to compare relative specialisation in different products nation-wise that is, to allow comparison of the dominance of different products of a given nation with the pattern seen among a larger group of countries, such as the OECD.

Following exactly the same line of argument, it can also be shown that countries specialise in the kind of science and technological development they undertake. From a 'technical' point of view, the X in the expression above just need to be substituted by a S&T indicator, such as patents. If we call the latter T, an equivalent measure, RTA, can be set up showing international technological specialisation.This methodology was first developed by Soete (1980, 1987) and later further developed and/or extensively used by e.g. Pavitt (1988/89), Cantwell (1989), Dosi, Pavitt and Soete (1990), Patel and Pavitt (1994) and Archibugi and Pianta (1992, 1994). The latter also contains a comprehensive analysis of specialisation in technology vis-à-vis science. If the X in Balassa's expression above is substituted by S in terms of e.g. R&D expenditure, the amount of published scientific papers or citations of these, so-called RSAs can be calculated and international specialisation patterns in science can be compared.

From a methodological point of view, it should be kept in mind that these indices (RCA, RTA and RSA) are indicators of relative structures. If we look at, say, exports, the RCA index is a measure of relative export structure while market shares - measured as exports from a given country to, say, the OECD countries divided by OECD imports from the entire world - is an indicator of export performance (or 'international competitiveness').

In the present paper we are going to present a statistical test of the stability of the national export specialisation patterns. For testing purposes the Balassa measure has, however, the disadvantage of an inherent risk of lack of normality because it takes values between zero and infinity with a (weighted) average of 1.0.[5] A substantial amount of existing empirical studies of specialisation patterns has neglected this problem entirely.

Some procedures to alleviate the skewness problems have, however, been proposed, of which the logarithmic transformation of the the Balassa measure is the most common, see e.g. Soete and Verspagen (1994). A methodological problem arises when e.g. ln(RCA) is used as basis for statistical tests - small RCA values are transformed to high negative ln(RCA) values. A change in a RCA from say 0.01 to 0.02 or visa versa has the same impact as a change from 50 to 100. To

[5] Cantwell (1989, pp. 31-32) solved this this problem rather pragmatically by testing for skewness and kurtosis of his data sample. He found the distribution of the dataset used to be approximately normal.

avoid this problem it has been suggested to add a small value to the RCA (Fagerberg 1994b). How much to be added is somehow arbitrary; Fagerberg added 0.1. According to our tests of normality, the ln (RCA+0.1) operation alleviates the lack of normality somehow, but it still has the drawback of assigning high (negative) values to very small RCAs. Another variant, presented by Münt (1994), is the tangens hyperbolicus transformation of the RCAs which then will fall between +1.0 and -1.0.[6] A slightly simpler variant of the latter is (RCA-1/RCA+1), presented by Laursen and Engedal (1994, p. 98) under the lable 'Revealed Symmetric Comparative Advantage', RSCA, has been chosen in the present paper. The RSCAs also fall between +1.0 and -1.0 and avoid the problem with zero values which occur in the logarithmic transformation (when an arbitrary constant is not added to the RCA).

Pavitt's (1998/89) work on international comparisons of technological specialisation patterns has been a common point of departure for most of the subsequent research in this field. He developed a formal test of the stability of specialisation patterns, country by country, by correlating the RTA distributions in the final year of his sample with the initial year. This procedure was further refined by Cantwell (1989), also for analysis of technological specialisation patterns (RTA).[7] Cantwell's basic source of inspiration was a 'Galtonian' regression model presented by Hart and Prais (1956) and Hart (1974) and discussed further in the context of convergence of productivity in Hart (1994). Stability is tested by means of the following regression equation (country by country), bearing in mind that nothing can be said on these grounds about the determinants of the initial export specialisation pattern:[8]

$$RCA_{it_2} = \alpha + \beta RCA_{it_1} + \epsilon_{it_2}$$

The subscripts t_1 and t_2 refer to the initial year and the final year, respectively. The dependent variable, RCA at time t_2 for product i, is tested against the independent variable which is the value of the RCA in the previous year t_1. α and β are standard linear regression parameters. and ϵ is an error term.
The idea behind the regression is that $\beta=1$ corresponds to an unchanged pattern from t_1 to t_2. If $\beta>1$ the country tend to become more specialised in products where it already is specialised and less specialised where initial specialisation is low - i.e. the existing pattern of specialisation is

[6] This procedure has been extensively used by researchers at Fraunhofer Institute for Systems and Innovation Research (FhG-ISI) in Karlsruhe.

[7] Cantwell has used this methodology in several subsequent papers, such as Cantwell (1991) and Cantwell (1993).

[8] For a discussion of the importance of domestic demand as an inducement mechanism in creating competitive advantage see Andersen, Dalum and Villumsen (1981) and Fagerberg (1992, 1995).

strengthened. If $0<\beta<1$ the existing specialisation pattern moves toward the OECD average i.e., *on average* products with initial low RCAs increase over time while products with initial high RCAs decrease their values. However, the ranking of the products could change substantially depending of the size of R. If R=1 the ranking of the products remains unchanged. But if R is low (little correlation between initial and final values of RCAs) there is a considerable mobility of RCAs up and down the distribution. In the special case where $\beta<0$ the ranking has changed fundamentally. Those RCAs initially below the OECD average are in the final year above average and visa versa.

However, following Cantwell (1989, pp. 31-32) it can be deduced that $\beta>1$ is not a necessary condition for further strengthening of the specialisation pattern. With reference to Hart (1974) it can be shown that

$$\sigma_{t_2}^2/\sigma_{t_1}^2=\beta^2/R^2$$

which is equivalent to

$$\sigma_{t_2}/\sigma_{t_1}=\beta/R$$

From the latter it follows that the dispersion (= standard deviation or σ) of a given distribution is unchanged when $\beta=R$. If $\beta>R$ (equivalent to an increase in the dispersion) the degree of specialisation has increased. If $\beta<R$ (equivalent to a decrease in the dispersion) the degree of specialisation has decreased. Following Cantwell's vocabulary we can also characterise an increase in the dispersion as a change towards a more 'narrow' specialisation pattern; and a decrease in the dispersion as a change towards a more 'broad' pattern. According to Cantwell's interpretation, it is thus possible to characterise the combination of $\beta<1$ and $\beta>R$ as increased specialisation which again is *caused* by the independent variable (whether RTA or RCA at time t_1) - i.e. cumulativeness is the driving force.

The latter interpretation should, however, be taken with care. In general, the R^2 is a decomposition of the variance (σ^2) of the dependent variable, RCA/RTA in the final year t_2, into the sum of the variance of the independent variables - i.e. the sum of the variance of the initial RCA/RTA and the error term ϵ. The combination of $\beta<1$ and $\beta>R$, which is identical to an increased variance of the RCAs/RTAs over time, is thus to some extent caused by the variance of the error term. The mechanism causing increased standard deviation (dispersion) or the final RCAs/RTAs, in the case of $\beta<1$, is the existence of a positive variance of the error term - i.e. the increased standard deviation of the final RCAs/RTAs is partly caused by the stochatic error term and therefore not by a recognisable economic explanation (such as cumulativeness).[9] These problems of interpretation have their parallel in the discussion in 'new growth' analysis of β- versus σ-

[9] We are grateful to Bart Verspagen who pointed this out.

convergence as introduced by Barro and Sala-i-Martin (1991). According to this analogy, Cantwell's interpretation of the combination of $\beta<1$ and $\beta>R$ (equal to increased standard deviation) as increased specialisation is parallel to concommittant β-convergence and σ-divergence which, logically, is fully possible. In the empirical analysis of the RCA patterns below we have adhered to the more restrictive version of requiring $\beta>1$ as a necessary (and sufficient) condition for "increased" specialisation.

The 'dual' existence of the concepts of β- and σ-convergence (or divergence) is clarified further in the more technical note by Hart (1994), referred to above, and in Dowrick and Quiggen (1994). Hart shows that the change in dispersion of, in his paper, productivity growth (σ-convergence) can be decomposed into a 'regression' effect (β-convergence) and a 'size mobility' effect. He also claims that having this relation between concepts in mind there is no 'Galtonian fallacy' problem as argued by Friedman (1992) and Quah (1993). Drawing a parallel to the trade analysis in section 5 below, we could state that the advantage of Cantwell's method, when sufficient care is taken in the interpretation of the causal relationsships behind changes in the dispersion of the specialisation varibles, to e.g. Dollar and Wolff's (1993) more simple comparisons of changes in coefficients of variation over time is that it allows us to decompose the changes in dispersion in: 1) a *'regression' effect*, where a low β implies a 'high' regression effect, and 2) a *'mobility' effect*, where a low R, or a high (1-R), implies a 'high' mobility effect. A low value of R, thus, indicates a high degree of structural change and vice versa. In section 5 below we use the test procedure developed by Cantwell, but we will use the the RSCA variant of RCA as our the export specialisation indicator in order to solve the problems of (potential) lack of normality.

4. Science and technology specialisation: increasing or decreasing?

While the main driving force behind developing the 'new growth' theories has been the obvious inconsistency between the inherent convergence and equilibrium bias of mainstream neoclassical growth theory and the (often widening) income disparities between the rich and the poor world, our focus is on (the potential) unequal development between members of the club of rich countries. There is, according to our point of departure, no automatic guarantee for permanent membership of this club. Unequal development and divergence are very much at the core of the worries of policy makers. The field of economic analysis where these features have been most clearly analysed has, according to our perspective, been in the empirical studies of long term specialisation of the science and technology (S&T) system of these countries and the efforts to develop and operationalise the concept of national systems of innovation.

In their comprehensive study of international specialisation in S&T among the advanced countries, Archibugi and Pianta (1992, 1994) found convergence in aggregate (national-level) S&T indicators such as R&D intensity (R&D as a percentage of GDP), patent intensity (external patenting per US$ of exports) and in bibliometric indicators (such as published articles and citations). However, at the sectoral level they found increasing technological specialisation - i.e. growing divergence between the countries:

> "Such striking diversity of national profiles in science and technology was not an obvious outcome. Several case studies on technological change in individual countries have shown that most countries devote a growing share of their resources to selected new technologies, suggesting a common shift towards 'advanced' sectors. Our findings suggest, however, that within such a common technological transition, the relative position of countries in disaggregated fields is still marked by growing divergence and specialisation.....In other words, the 'catching up' process has not driven the European countries and Japan to follow and replicate the US pattern of sectoral technological strengths. On the contrary, each country has developed a distinct model of specialisation, concentrating its efforts in particular fields where world class capacities have often been developed." (Archibugi and Pianta 1992, p. 148).

Dosi, Pavitt and Soete (1990, p. 102) in their comprehensive study of technology, productivity growth and trade summarise a set of characteristics of technological specialisation. They show that:

-Technological specialisation patterns are *distinctly different* from country to country.
-Technological specialisation patterns of each country are *fairly stable over time*.
- Small countries are more technologically specialised than large countries
-Relatively few (large) firms have a considerable impact on country patterns, most visibly so in the case of small countries.

The dichotomy between the harmonising and differentiating forces of increased internationalisation is discussed on a more fundamental theoretical basis by Dosi, Pavitt and Soete, than most other contributions to this line of research. The harmonising mechanisms are related to the common characteristics of the main technologies on the one hand (across countries and across firms) and 'strategies, context conditions and history' on the other (vary with companies and countries but across technologies). The national context has, in their view, a significant role to play in determining long term growth patterns:

> "Once the cumulative and firm-specific nature of technology is recognized, its development over time ceases to be random but is likely to be constrained to zones that are closely related technologically to existing activities. If those zones can be identified, measured and explained, it is possible in principle to predict likely future patterns of innovative activities in firms and countries." (p. 85).

The work of Pavitt (1988/1989) paved the way for studying for empirical studies of the stability characteristics of technological specialisation patterns at the country level. He found positive and significant correlations between the RTA distributions, country by country, in nine out of ten OECD countries -i.e. relative stability of the RTA patterns. Patel and Pavitt (1994) further confirmed the original results, now with an enlarged sample of countries. Most OECD countries show statistically significant degrees of stability over time, measured country by country by

correlating the RTAs in the 1960s with those of the 1980s.[10] This kind of stability is interpreted as the statistical reflection of the cumulative and path dependent character of technological change at the micro level. When firms have gained some kind of competitive advantage in one field they tend to strengthen that advantage further (or go bankrupt). For the same reasons diversification often occurs only in fields which are close to the core competence of firms.

Before digging into the question of stability of the RCA patterns in the following section, let us consider an important 'gateway' through which the economic impact of the S&T specialisation often is considered to materialise most directly so - i.e. in the structure of international trade.

Presently, there are only a few studies of the determinants of long term development of export specialisation patterns are available. Soete and Verspagen (1994) use a cross-country intra-industry analysis of manufacturing exports from the OECD countries 1970-90 to analyse the international trade specialisation of industries across countries. An implication of this methodology is that they look for regularities at the industry level across countries; country patterns are *not* at the focal point of the analysis. Their results further corroborate the close correlations found by Soete (1987) between RCAs and RTAs for a certain amount of the industries, which they label 'technology industries'. Export specialisation, RCA, is treated as the dependent variable to be explained by technological specialisation, RTA. For another group of industries investment is found to be the explanatory variable and, finally, wage rates are found to be able to explain trade specialisation for a third group of industries.

A universal explanation of export specialisation by technological specialisation was, thus, not found, although it was found to be strong for a fairly large share of the industries. The strong correlations between RCAs and RTAs for the 'technology industries' were only found for 'static' comparisons of the RCAs and RTAs for the same year. When the RCAs were correlated with previous RTAs , say RCA_{1990} correlated with RTA_{1980}, the close correlations level off, indicating that firms in the original innovator countries may have been imitated by firms in other countries.

According to these results there is, thus, no simple correlation between technological and trade specialisation over time; the technology factor is no doubt of major importance but the transmission mechanisms to economict impact are more subtle. It is especially important to have in mind that the 'blurred' long term correlations between technological and trade specialisation in the 'technology industries', as found by Soete and Verspagen, at the one side are indications of the ongoing dynamics of structural change in these industries. At the other these features coexist with apparently rather stable technological specialisation patterns, country by country, over time. This apparent contradiction does, however, represent the very core of the dynamics of national systems of innovation analysis. The *converging* mechanisms may most clearly be represented by international diffusion/imitation of technology, although divergence may result in periods

[10] Cantwell (1989) also confirmed the main conclusions on stability from Pavitt's seminal paper. While Cantwell, as mentioned above, checked for normality of the distribution of the RTAs, Pavitt and Patel neglect this potential problem.

dominated by forging-ahead by the leader countries instead of catching-up by the follower countries to use Abramovitz's vocabulary. The *diverging* mechanisms may most clearly be represented by 'context conditions and history' (Dosi, Pavitt and Soete) and various degrees of 'social capability' (Abramovitz). It is the relative strength of these forces that determine the final outcome. When considered as a current dialectical interplay between forces working in opposite directions, the apparent contradictions in the observed patterns may be solved.

5. Are the OECD export specialisation patterns 'sticky'?

Before answering the main question of *country-by-country* stability of the specialisation patterns - what we call the degree of 'stickyness' - some overall observations of whether some groups of OECD countries show *bilateral* similarities or not will be discussed briefly.

5.1 Some 'stylised' features of bilateral similarity patterns

The results of pair-wise country comparisons are shown at the detailed level in Table 1. We have correlated RSCAs for 60 product groups and for 21 countries in 1961, 1973 and 1992 (further details are described in the Appendix). When comparing RCAs/RSCAs for a given product/sector in different countries, the nature of the measure should be kept in mind. By construction, if the RCA/RSCA is high in one country it has to be low somewhere else. At the limit we will in a simple two country-two commodity case, by definition, find a negative correlation in the bilateral comparison of the two specialisation patterns. But in a sample of 21 countries nothing prevents two or more countries having similar RCA/RSCA distributions - i.e. to have a high degree of similarity.[11]

The pattern observed for the 21 countries is fairly complex. However, some 'stylised' features can be noted. First, most of the positive correlations are either between smaller countries or between larger countries. At the other side of the coin, most of the negative correlations are between a large and a small country.

[11] We do, however, not make any overall conclusion on the similarity/dissimilarity patterns over time based on counts of the amount of significant positive and/or negative bilateral correlations, as done by Patel and Pavitt (1994) in their study of country dissimilarity of technological specialisation. The problem by this kind of counting is that experiments with stochastic datasets of the same magnitude on average point towards sligthly more than 50% negative bilateral correlations. It is not evident what kind of empirical evidence that is required to prove either growing similarity of dissimilarity in that setting.

Table 1
Correlations among countries 1961, 1973 and 1992
RSCA

1961

	Be	Ca	De	Fi	Fr	Ge	Gr	Ic	Ir	It	Ja	Ne	No	Au	Po	Sz	Sp	Sw	Tu	UK
Belgium-Lux																				
Canada	-0,063																			
Denmark	-0,202	-0,076																		
Finland	-0,031	0,215	0,141																	
France	0,287 **	0,023	-0,098	-0,070																
Germany	0,144	-0,607	-0,108	-0,208	-0,231															
Greece	0,191	0,178	0,021	0,065	0,250	-0,430 ¤														
Iceland	0,068	0,271 **	0,379 *	-0,019	0,026	-0,229	0,168													
Ireland	0,214	0,120	0,333 **	0,101	0,262 **	-0,503 ¤	0,460 *	0,485 *												
Italy	0,251	-0,375 ¤	-0,067	-0,180	0,460 ¤¤	0,235	0,053	-0,227	0,104											
Japan	0,415 *	-0,364 ¤	-0,211	-0,086	-0,037	0,226	-0,234	0,044	-0,066	0,238										
Netherlands	0,154	-0,027	0,423 *	-0,074	0,102	-0,172	0,116	0,222	0,352 *	0,187	-0,001									
Norway	0,293 **	0,497 *	0,051	0,377 *	0,039	-0,178	0,073	0,460 *	0,125	-0,208	0,025	0,114								
Austria	0,240	-0,190	0,049	0,278 **	-0,025	0,237	-0,152	-0,133	0,011	-0,128	0,173	-0,132	-0,084							
Portugal	0,217	0,348 *	0,214	0,182	0,227	-0,481 ¤	0,422 *	0,328 **	0,401 *	0,066	0,148	0,307 **	0,296 **	-0,086						
Switzerland	-0,035	-0,566 ¤	0,025	-0,122	0,039	0,439 *	-0,133	-0,258 ¤¤	-0,116	0,261 **	0,150	-0,130	-0,340 ¤¤	0,227	-0,275 ¤¤					
Spain	0,232	0,439 *	-0,032	0,027	0,291 **	-0,463 ¤	0,525 *	0,190	0,321 **	0,168	-0,002	0,165	0,352 *	-0,269 ¤¤	0,626 *	-0,343 ¤				
Sweden	-0,232	0,005	0,013	0,539 *	-0,001	0,181	-0,217	-0,166	-0,292 ¤¤	0,010	-0,025	-0,360 ¤	0,161	0,234	-0,208	0,037	-0,223			
Turkey	0,048	0,403 *	0,294 **	0,014	0,131	-0,598 ¤	0,702 *	0,482 *	0,575 *	-0,125	-0,274 ¤¤	0,290 **	0,161	-0,298 ¤¤	0,470 *	-0,398 ¤	0,529 *	-0,327 ¤¤		
United Kingdom	0,063	-0,581 ¤	-0,141	-0,240	0,050	0,576 *	-0,127	-0,313 ¤¤	-0,217	0,283 **	0,113	-0,174	-0,367 ¤	0,160	-0,387 ¤	0,469 *	-0,418 ¤	0,068	-0,422 ¤	
United States	-0,369 ¤¤	-0,122	-0,159	-0,371 ¤	-0,180	0,101	0,011	-0,197	-0,170	-0,125	-0,404 ¤	-0,198	-0,479 ¤	-0,183	-0,414 ¤	0,049	-0,306 ¤¤	-0,253 ¤¤	0,006	0,224

1973

	Be	Ca	De	Fi	Fr	Ge	Gr	Ic	Ir	It	Ja	Ne	No	Au	Po	Sz	Sp	Sw	Tu	Uk
Belgium-Lux																				
Canada	-0,130																			
Denmark	-0,044	-0,231																		
Finland	0,274 **	0,003	0,176																	
France	0,232	-0,122	0,021	-0,041																
Germany	0,161	-0,568 ¤	0,066	0,095	0,028															
Greece	0,403 *	0,190	-0,002	0,049	0,188	-0,333 ¤¤														
Iceland	0,070 *	0,194	0,311 **	0,019	-0,025	-0,191	0,394 *													
Ireland	0,216	-0,206	0,348 **	0,100	0,292 **	-0,074	0,203	0,354 *												
Italy	0,294 **	-0,398 ¤	0,142	0,079	0,318 **	0,405 *	0,181	-0,284 ¤¤	0,019											
Japan	0,061	-0,366 ¤	-0,209	0,006	-0,057	0,449 *	-0,268 ¤¤	-0,202	-0,123	0,281 **										
Netherlands	0,348 *	-0,113	0,426 *	-0,006	0,141	-0,112	0,384 *	0,199	0,240	0,092	-0,278 ¤¤									
Norway	0,130	0,386 *	0,084	0,388 *	-0,321 ¤¤	-0,138	0,283 **	0,453 *	-0,070	-0,235	0,005	0,085								
Austria	0,310 **	-0,308 ¤¤	0,091	0,531 *	0,144	0,460 *	-0,123	-0,100	0,121	0,369 *	0,222	-0,131	0,000							
Portugal	0,199	0,012	-0,000	0,173	0,142	-0,235	0,358 *	0,061	0,348 *	0,190	0,153	0,093	0,006	0,109						
Switzerland	0,029	-0,589 ¤	0,168	0,070	0,100	0,633 *	-0,233	-0,194	0,161	0,268 **	0,125	-0,047	-0,312 ¤¤	0,429 *	-0,061					
Spain	0,044	0,059	0,124	0,037	0,150	-0,212	0,415 *	0,054	0,113	0,336 *	0,026	0,097	0,209	-0,058	0,466 *	-0,216				
Sweden	-0,156	0,102	-0,020	0,460 *	-0,159	0,247	-0,365 ¤	-0,237	-0,272 ¤¤	0,072	0,244	-0,495 ¤	0,291 **	0,372 *	-0,176	0,060	-0,068			
Turkey	0,159	0,180	0,189	-0,077	0,165	-0,502 ¤	0,771 *	0,444 *	0,254	0,003	-0,432 ¤	0,336 **	0,064	-0,203	0,304 **	-0,333 ¤	0,370 *	-0,488 ¤¤		
United Kingdom	0,129	-0,394 ¤	-0,015	-0,084	0,221	0,504 *	-0,077	-0,162	0,213	0,457 *	0,261	-0,172	-0,317 ¤¤	0,289 **	0,005	0,581 *	-0,101	-0,008	-0,213	
United States	-0,357 ¤	0,129	-0,200	-0,383 ¤	0,019	-0,006	-0,116	-0,073	-0,113	-0,182	-0,142	-0,175	-0,319 ¤¤	-0,257 ¤¤	-0,109	-0,043	-0,247	-0,213	0,016	0,098

1992

	Be	Ca	De	Fi	Fr	Ge	Gr	Ic	Ir	It	Ja	Ne	No	Au	Po	Sc	Sp	Sv	Tu	UK
Belgium-Lux																				
Canada	0,095																			
Denmark	0,087	-0,188																		
Finland	0,113	0,112	-0,080																	
France	0,345 *	-0,061	0,216	-0,149																
Germany	0,171	-0,481 ¤	-0,048	0,269 **	0,221															
Greece	0,466 *	0,253	0,088	0,095	0,293 **	-0,223														
Iceland	0,009	0,186	0,315 **	-0,097	0,027	-0,197	0,375 *													
Ireland	0,197	-0,213	0,266 **	-0,149	0,302 **	-0,114	0,155	0,083												
Italy	0,156	-0,372 ¤	0,261 **	0,036	0,157	0,558 *	0,078	-0,031	-0,001											
Japan	-0,270 ¤¤	-0,445 ¤	-0,347 ¤	0,164	-0,233	0,394 *	-0,485 ¤	-0,243	-0,215	0,073										
Netherlands	0,438 *	-0,043	0,473 *	-0,139	0,221	-0,182	0,352 *	0,245	0,451 *	-0,109	-0,394 ¤									
Norway	0,006	0,570 *	-0,017	0,395 *	-0,320 ¤¤	-0,302 ¤¤	0,258 **	0,422 *	-0,213	-0,327 ¤¤	-0,199	0,051								
Austria	0,258 **	-0,051	-0,129	0,512 *	0,090	0,537 *	-0,014	-0,094	-0,115	0,467 *	0,211	-0,306 ¤¤	-0,097							
Portugal	0,242	0,037	0,171	0,258 **	0,049	-0,171	0,472 *	0,119	0,124	0,236	-0,124	0,046	0,090	0,279						
Switzerland	0,089	-0,520 ¤	-0,007	0,125	-0,035	0,635 *	-0,253 ¤¤	-0,157	0,105	0,433 *	0,236	-0,148	-0,277 ¤¤	0,428 *	-0,101					
Spain	0,272 **	0,183	0,012	0,156	0,127	-0,052	0,475 *	0,103	-0,094	0,227	-0,113	-0,034	0,257 **	0,135	0,398 *	-0,207				
Sweden	-0,277 ¤¤	0,150	-0,145	0,464 *	-0,355 ¤	0,107	-0,383 ¤	-0,176	-0,239	0,063	0,135	-0,427 ¤	0,319 **	0,291 **	-0,131	0,281 **	-0,009			
Turkey	0,436 *	0,107	0,076	0,008	0,358 *	-0,149	0,767 *	0,150	0,092	0,151	-0,265 ¤¤	0,258 **	0,009	0,121	0,465 *	-0,307 ¤¤	0,542 *	-0,379 ¤¤		
United Kingdom	0,081	-0,331 ¤¤	-0,158	0,052	0,231	0,243	-0,014	-0,026	0,356 *	0,035	0,271 **	0,066	-0,181	0,087	0,008	0,337 *	-0,146	-0,106	-0,103	
United States	-0,278 ¤¤	0,293	-0,125	-0,134	0,058	-0,197	0,000	0,099	0,134	-0,223	-0,168	0,006	-0,043	-0,220	-0,206	-0,183	-0,281 ¤¤	-0,056	-0,121	0,090

* and ¤ indicate positive and negative correlation and 1 percent significance level
* * and ¤¤ indicate positive and negative correlation and 5 percent significance level

To go a bit further, we find that the evidence allows us to subdivide the positive correlations between the small countries in three different groups. There is a group of Mediterranean low income countries (Portugal, Spain, Greece and Turkey) which are pair-wise positively correlated, illustrating the comparative advantage in parts of agricultural products and textiles and disadvantages in machinery and electronics. Further, the group of small European high income countries can be divided into one group where forrestry/wood is important, historically and at present, and another where agriculture/food is an important part of the economy. Sweden, Finland, Norway (and Canada) forms a group of countries which show bilateral similarities in export specialization 'revealing', the importance of wood based products. Denmark, the Netherlands and Ireland show similarities their agriculture based export specialisation. It is noteworthy that the similarities for those groups of countries not only are limited to the 1960s but persist during the entire period where all the countries went through a rapid a process of structural change with shifts from primary to secondary and tertiary production.

Secondly, concerning the larger countries (US, Japan, Germany, UK, France and Italy) we find from Table 1 that similarity is the typical pattern and in several cases the correlation are significant at the 5 percent level. The large European economies are for all three years positively correlated - in several occasions even significantly so. The US and Japan are negatively correlated and both countries are dissimilar to some of the larger European countries. It is, however, only in the case of US-Japan in 1961 we have found a significant negative correlation; This difference persists during the following decades, although at a lower level of significance.

Thirdly, most of the negative correlations are between a large and a small country. This is somehow contradictory to the findings in most studies of technological specialisation. Archibugi and Pianta find that smaller countries typically are specialised in different technological areas and tend to be closer to a larger country with similar specialisation.

> "The ability of large countries to cover most technology fields with their innovative activity means that the size (i.e. the aggregate volume of their resources devoted to innovation) is an important factor in the measure of similarity. This lead to a picture of a core made of the major countries, which are fairly close to one another, while smaller ones appear scattered around them, closer to one of the larger countries and highly different from most of the other smaller ones." (Archibugi and Pianti 1994, p. 29).

Switzerland is similar to Germany and Italy during the entire period, especially caused by specialisation in chemicals and machinery; and from 1973 also Austria became similar to Italy and Germany. Ireland and Belgium-Luxembourg (just outside the significance level in 1973) were similar to France; and Belgium-Luxembourg was in 1961 positive and significantly correlated with Japan, caused by high specialisation in textiles and clothing, minerals, manufactured fertilizers, consumer electronics and manufactures of metals. In 1992 similarities between large and small countries also emerged for other pairs: Germany-Finland, Denmark-Italy and France vis-à-vis some of the other Mediterranian countries.

These features may be *summarised* as a tendency towards (i) small countries to show similar specialisation patterns compared to other small countries with historically similar resource base and (ii) large European countries to be similar with each other. (iii) The US and Japan are basically characterised by mutual dissimilarities while (iv) small countries typically show different patterns compared to large countries. Concerning the latter, there is, however, a weak tendency towards more small countries achieving specialisation patterns similar to a larger country.

5.2 The stability of the country-wise specialisation patterns

When we proceed to analyse the development over time of the RCAs/RSCAs, the few studies available are either organised 1) *industry-wise* and cross-country (in order to study industry patterns across countries) or 2) *country-wise* but across industries in order to study national specificities in international specialisation.

The empirical results reported in the literature of the first category of studies (industry-wise) do point in different directions. Soete and Verspagen (1994) analysed a sample of manufacturing industries across countries and conclude that convergence was predominant in most industries. They set up and test following kind of relation in various specifications:

$$\ln(RCA_{jt_2}) = \beta \ln(RCA_{jt_1}) + \epsilon_{jt_2}$$

where *i* refer to sector, *j* to country, *t* to time. In their vocabulary, if $\beta > 1$ specialisation is increased or 'divergence' prevails in the export specialisation patterns; if $\beta < 1$ 'convergence' prevails. They concluded that convergence was predominant in every sector, except food (non-significant convergence) and textiles (significant divergence). On this background, Soete and Verspagen draw the following, quite strong, conclusion:

> "This means that in general, over the 1970-90 period, *specialization* patterns in OECD markets for manufactured products have been converging." (Soete and Verspagen 1994, p. 289).

Their theoretical discussion of the relations between technology, growth and trade is based on the combination of Schumpeterian, Kaldorian and, generally, evolutionary open economy perspective as is most comprehensively expressed by Dosi, Pavitt and Soete (1990).

This approach is further developed by Beelen and Verspagen (1994). They concentrate on the period after 1970 when productivity convergence has levelled off inside the OECD. Their regression model is a slight modification of the model shown above. They found significantly negative coefficients on most of the initial RCAs in the, industry-wise, published results A country-wise constant is included in the regressions, devised to be positive if a given country might show a country-determined trend towards increasing export specialisation, and negative if there are

country-specific forces moving towards decreasing specialisation.[12] They only found three countries with significant constants leading to the conclusion that there did not seem to be country-specific tendencies to specialise or despecialise. The predominant convergence features depend on more general mechanisms - ie. imitation of technology. In discussing the relation between convergence of productivity and trade patterns, Beelen and Verspagen are inclined to conclude that these processes at some stages might be developed fairly independent of each other.[13] Trade has, according to this view, a more 'calibrating' role with inherent convergence mechanisms, at least when the samples of study are limited to a group of similar countries.

Dollar and Wolff (1993, chapter 7) report, however, that the trade specialisation patterns of 11 OECD countries 1970-86 did not become more similar also based on an industry-wise approach. They use a slightly simpler methodology based on comparing coefficients of variation (standard deviations divided by means) of the RCAs over time; six sectors show increasing dispersion and the other six show a decrease. But this study, however, use the non-modified RCAs and does not take the problems of normality into account.

In the second category of studies of export specialisation (country-wise) we are only aware of the study by Amendola, Guerrieri and Padoan (1992). They follow Cantwell's methodology and compare the development of RCAs and RTAs for three periods. In slightly more than 50% of their estimated equations the hypothesis of constant specialisation ($\beta=1$) could not be rejected and the R^2s are generally high. On this basis they conclude that both trade and technological specialisation patterns have been remarkably stable in the medium term, although to a decreasing degree in the long term. The normality problem with the RCAs as well as the RTAs are, however, neglected.

When Cantwell's methodology, as desribed in section 2 above, is applied on the dataset described in the Appendix, Table 2 shows the values for β, R and β/R for the thirty year period 1961-92 ('long' term) and for two subperiods 1961-73 and 1973-92 (both 'medium' term). In addition the table contains the standard deviation for 1961, 1973 and 1992 for each country. The specialisation indicator is (RCA-1)/(RCA+1), the socalled RSCA.

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[12] In our interpretation the country constant appears to be a dummy variable added to the still basically *industry-wise* regression model.

[13] In a more speculative discussion, they suggest that the divergence pattern for technological specialisation at the sector level, reported by Archibugi and Pianta (1992), might indicate a process of (renewed) divergence, which, later on, might be followed by convergence facilitated by international trade.

Table 2
Beta , R and Beta/R. Long term and medium term Regression models based on RCA-1/RCA + 1

	1961 - 1992				1961 - 1973				1973 - 1992			
	Beta	**R**	**Beta/R**	**STD(t)** **STD(t-1)**	**Beta**	**R**	**Beta/R**	**STD(t)** **STD(t-1)**	**Beta**	**R**	**Beta/R**	**STD(t)** **STD(t-1)**
Belgium-Lux	0,55	0,59	0,93	0,348 0,374	0,68	0,74	0,91	0,342 0,374	0,87	0,86	1,02	0,348 0,342
Canada	0,70	0,77	0,91	0,444 0,490	0,77	0,83	0,94	0,459 0,490	0,86	0,89	0,97	0,444 0,459
Denmark	0,73	0,83	0,88	0,439 0,502	0,90	0,91	0,98	0,493 0,502	0,81	0,91	0,89	0,439 0,493
Finland	0,56	0,57	0,98	0,436 0,445	0,77	0,74	1,04	0,462 0,445	0,73	0,77	0,94	0,436 0,462
France	0,31	0,35	0,89	0,214 0,241	0,61	0,66	0,92	0,221 0,241	0,66	0,68	0,97	0,214 0,221
Germany	0,38	0,63	0,61	0,246 0,405	0,69	0,90	0,77	0,312 0,405	0,64	0,81	0,79	0,246 0,312
Greece	0,50	0,46	1,08	0,558 0,516	0,69	0,61	1,12	0,580 0,516	0,78	0,81	0,96	0,558 0,580
Iceland	0,80	0,71	1,12	0,480 0,427	0,90	0,78	1,14	0,488 0,427	0,87	0,88	0,98	0,480 0,488
Ireland	0,44	0,45	0,98	0,491 0,498	0,53	0,57	0,93	0,462 0,498	0,77	0,73	1,06	0,491 0,462
Italy	0,42	0,45	0,92	0,350 0,378	0,73	0,79	0,92	0,347 0,378	0,68	0,68	1,01	0,350 0,347
Japan	0,46	0,46	1,00	0,468 0,469	0,73	0,77	0,95	0,446 0,469	0,87	0,83	1,05	0,468 0,446
Netherlands	0,59	0,66	0,89	0,363 0,406	0,77	0,84	0,92	0,373 0,406	0,82	0,84	0,97	0,363 0,373
Norway	0,75	0,80	0,93	0,485 0,519	0,85	0,89	0,96	0,496 0,519	0,82	0,84	0,98	0,485 0,496
Austria	0,66	0,73	0,91	0,403 0,444	0,84	0,87	0,96	0,427 0,444	0,80	0,85	0,94	0,403 0,427
Portugal	0,47	0,54	0,86	0,446 0,516	0,63	0,62	1,01	0,520 0,516	0,54	0,64	0,86	0,446 0,520
Switzerland	0,70	0,76	0,92	0,482 0,523	0,85	0,85	1,00	0,523 0,523	0,86	0,93	0,92	0,482 0,523
Spain	0,25	0,48	0,51	0,268 0,530	0,49	0,62	0,78	0,416 0,530	0,44	0,69	0,65	0,268 0,416
Sweden	0,65	0,73	0,90	0,408 0,455	0,88	0,94	0,94	0,428 0,455	0,78	0,82	0,95	0,408 0,428
Turkey	0,33	0,38	0,86	0,510 0,592	0,82	0,81	1,01	0,596 0,592	0,57	0,67	0,85	0,510 0,596
United Kingdom	0,49	0,61	0,80	0,283 0,354	0,78	0,83	0,93	0,330 0,354	0,69	0,80	0,86	0,283 0,330
United States	0,55	0,55	1,00	0,263 0,263	0,90	0,73	1,23	0,324 0,263	0,69	0,85	0,81	0,263 0,324
Mean(unweighted)	0,54	0,60	0,90		0,75	0,78	0,97		0,74	0,80	0,93	

In the 'long' term perspective (1961-92) the results show a general decrease in the dispersion of export specialisation, implying a trend towards a decrease in specialisation. The exceptions are Greece and Iceland who become more specialised. However, the decrease in dispersion is rather weak. The unweighted mean for β/R is 0.90 and most of the countries fall inside this 10 percent decrease in dispersion. The decomposition of the dispersion in a 'regression' effect, β, and a 'mobility' effect, R, reveals two interesting features. On the one side, the β-values are significantly different from 0 at the 1 per cent level for all the 21 countries, implying stability in trade specialisation. Trade patterns do not change 'overnight' and do not change fundamentally even over three decades. On the other side, 20 countries are significantly different from 1.0 at the one per cent level. (Iceland, the only exception, matches a 5 per cent level). This points to a general tendency to increases in industries where countries have been relatively less specialised and a decreases in industries where they have been highly specialised.

The 'long' term analysis thus shows that σ-convergence prevails, although to a fairly moderate degree, as indicated by the high values of β/R.The moderate decrease in the dispersion of the RSCAs can, however, not be explained entirely as a result of cumulative mechanisms. The β-convergence phenomenon, which in our setting is a measure of the capability of previous specialisation patterns to determine those of the future, is more outspoken, as indicated by the unweighted β-value of 0.54.

Concerning the 'medium' term of 1961-73 and 1973-92, it should be noted that the the two periods are of different length, thirteen and twenty years respectively. The unweighted mean of the dispersions decrease only slightly, with β/R equal to 0.97 1961-73 and 0.93 1973-92, indicating indeed a very small degree of σ-convergence. During 1961-73 σ-divergence can be found in five countries while that was the case in four countries 1973-92. The unweighted β-convergence measure was 0.75 and 0.74, respectively - indicating a lower degree of ('explained') β-convergence compared to the 'long' term period 1961-92. The 'regression' effects (1-β) as well as the 'mobility' effects (1-R) are, thus, generally lower (equivalent to larger values of β and R) for the two medium term subperiods implying the long term changes have evolved gradually.

This picture of gradual, path dependent, change - or evolutionary change - is further underlined by the data for the seven 'short' term periods presented in Table A2 in the Appendix. Compared with the medium term periods, the short term β- and R-values are generally found to be at a higher level. From Table A2 it can be found that in 12-15 out of the sample of 21 OECD countries the values of β could not be distinguished from unity at the 5% level of significance, except the 1984-88 period with only nine countries. But it was only in the case of the US in 1969-73 that significant β-divergence could be registered.

Finally, a few 'stylised' features in the specialisation patterns between various groups of countries should be noted. The less developed OECD countries generally show high regression effects (low β) and high mobility effects (low R) whereas most of the small high-income countries show low regression effects (high β) and low mobility effects (high R). The large countries usually show higher regression effects (lower β-values) implying a stronger tendency towards decrease in

initially advantaged industries and increase in disadvantaged industries. However, there are important differences in the nature of these changes. An example may be illustrative. A comparison of Japan and Germany shows that both countries have high regression effects, but Japan clearly has a higher mobility effect. In fact, the mobility effect has outweighted the regression effect in the Japanese case - in 1992 the dispersion of export specialisation was unchanged compared to 1961. A high mobility in relation to an unchanged or even an increased dispersion indicates a shift in the pattern of export specialisation. In 1961 Japan was highly specialised in fish, textile fabrics, clothing, consumer electronics and ships. In 1992 the highly specialised industries were consumer electronics, semiconductors, telecommunications equipment, ships and photographical and optical good and watches. Thus, an important change in the ranking has taken place without changing the dispersion of the RSCAs.

The Japanese case illustrates that causal inferences about cumulativeness as an important micro-foundation behind the development of specialisation patterns can only be made on the basis of the β-values in our setting. A high β-value (ie. close to unity from below) indicates a high degree of stability or 'stickyness' of the relative export structure and the cause is, at the same token, shown to be the influence of the existing structure. The degree of β-convergence is, thus, the decisive test of stability or 'stickyness' of the exports specialisation pattern at the national level - not the degree of σ-convergence.

6. Conclusions: implications for the national systems of innovation approach

In terms of the *stability* of each of the national export specialisation patterns, the long term perspective of 1961-92 shows a general trend towards β-convergence of the export specialisation patterns, as indicated by the unweighted average β-value of 0.54 in Table 2. The relative export structures are in that sense moving together in the long term. The medium and short term results, however, show that the speed of convergence is fairly low. In our view these results leave no doubt that the national export specialisation patterns are quite stubborn or 'sticky'. National patterns set their quite visible finger-prints on the probable future development paths, as also has been the result of the country-by-country studies of technological specialisation referred to in the paper.

However, as made possible to analyse by the Cantwell-methodology and further clarified by the distinction between the two concepts of β- versus σ-convergence as introduced by Barro and Sala-i-Martin, the decrease in the dispersion of the specialisation indicator is rather weak even in the long term perspective. The unweighted mean for β/R 1961-92 is 0.90 and most of the countries fall inside this 10 percent decrease in dispersion. β-convergence has apparently more outspoken than σ-convergence. In terms of the dispersion of the specialisation indicator the move towards convergence is, indeed, very low.

Are these findings, then, contradictory to the results reported by Soete & Verspagen (1994) and Beelen & Verspagen (1994)? In our opinion that is not the case; the two kinds of studies have a different perspective and are complementary. The latter studies have related developments in trade

patterns to the convergence-divergence debate by means of the *industry-wise* export specialisation patterns only. The hints in those studies to the role of international trade as a mainly equilibrating mechanism facilitating convergence in productivity patterns, country by country, may be somehow preliminary. The results of the present paper may be interpreted as evidence pointing to also the differentiating mechanisms of international trade; virtuous circles of economic development may be strengthened by international trade, and countries locked-in in a vicious circle of international specialisation, may be confronted with even harder problems caused by further increases in the degree of internationalisation.

There is, however, no simple answer to the question of what is the 'right' versus the ' wrong' export specialisation pattern. In the technological specialisation field Archibugi and Pianta (1992) reported that the fields in which most EU countries were specialised were the slow-growing or even falling patenting classes, measured by growth rates of the amounts of patents granted in the US to all countries. Japan was the only country among the OECD members showing the 'right' specialisation in fast-growing patent classes. These classes, however, tend to be small and narrow, and are focused on the technological frontier, while the bulk of industrial activity takes place in more mature sectors. Archibugi and Pianta, thus, found that any high degree of technological specialisation rather than none was associated with better economic performance, measured by growth of patenting as well as industrial production:

> "There seems to be a specific advantage in a higher degree of specialisation in technological fields, associated with the economies of scale and scope made possible at the national level. This advantage emerges regardless of the particular sectors in which individual countries concentrate their efforts; *in other words, for advanced countries being specialised appears to be even more important than choosing the 'right' fields*." (Archibugi and Pianta 1992, p. 150. Italics added).

A simple mechanistic panacea of 'Paradise on Earth' in terms of specialisation in high tech sectors and/or high growth sectors may often be beside the point. Further research along this track seems important analytically as well as from a normative point of view. The national system of innovation approach has a role to play in delivering a common framework this kind of work. The common point of departure is that nations still matter - a lot!

APPENDIX: The IKE trade database

The trade data are based on the taped version OECD's *Trade by Commodities, Series C,* which has been published annually since 1961. The data consist of trade by 'visible' goods in current US $. Trade in services ('invisibles') are not included. The OECD tapes consist of exports from and imports to 23 OECD countries. The data are delivered at their most detailed level according to the Standard International Trade Classification (SITC).

The IKE trade database at the Department of Business Studies, Aalborg University was initiated in the early 1980s for studies of long term structural features of OECD trade. Construction of comparable time series data has from the beginning the major analytical aim. The database contains a selection of years 1961-92. As far as possible, the selection criterion has been 'peak years' in world trade/'average' OECD business cycles. The following years have been used in the present paper 1961, 1965, 1969, 1973, 1979, 1984, 1988 and 1992.

Given the long term focus mentioned, all data have been converted from the two more recent versions of the SITC to SITC, Revision 1. In 1961-77 the OECD reported the data in Revision 1. But in 1978-87 the data have published according to SITC, Revision 2. The latter has been converted to the previous classification in order to construct comparable time series. From 1988 the data are published according to SITC, Revision 3.

The first step of handling the data consists of aggregating the 'raw' tapes to country matrices with 625 rows (the number of commodity groups at the 4-digit SITC, Revision 1 level) and 33 columns (23 OECD countries, the World, OECD, the Nordic countries and 7 groups of non-OECD countries, including e.g. the former Soviet Union, the OPEC countries, a group of Newly Industrdialised Countries). Then several steps of checking for confidentiality clauses in the tapes, whether at the commodity or the country level. The tapes, thus, contain a large amount of so-called alphanumeric codes (instead of the usual numeric SITC codes) for which the trade information is omitted *at the given level of disaggregation*. This information is, however, included in the SITC codes at a more aggregate level.

The data have then been aggregated to 60 commodity groups and then further to 5 main sectors as shown in Table A.1 of this Appendix.

The data for Japan and Finland for 1961 are not available in the OECD tapes and have been reconstructed from national statistical sources - with some approximation for Finland, but rather precise for Japan.

Appendix Table A1 *(SITC, Revision 1)*

Products based on natural resources

1.	Meat & meat preparations		00, 01, 091.3, 411.3
2.	Dairy products		02
3.	Fish & fish preparations		03, 411.1
4.	Cereals & cereal preparations		04
5.	Feeding-stuff for animals		08
6.	Other food products		05, 06, 07, 091.4, 099
7.	Beverages & tobacco		11, 12
8.	Animal & vegetable oil & fats		22, 42, 43
9.	Cut flowers, bulbs, & oth. plants		292.1-4, 292.6-9
10.	Seeds & spores for planting		292.5
11.	Skins & leather manufactures		21, 61, 291
12.	Wood & wood manufactures		24, 63
13.	Pulp & paper		25, 64
14.	Textile fibres		26
15.	Textile yearn, fabrics, etc.		65
16.	Iron ore		281
17.	Iron, steel & ferro-alloys		67
18.	Aluminium	684	
19.	Non-ferrous ores & metals		282-86, 681-83, 685-89
20.	Crude fertilizers, crude minerals & coal	27, 32	
21.	Non-metallic minerals (cement, bricks, ceramics, glass, etc.)		66
22.	Rest: rubber; electr. energy		23, 62, 35

Oil and gas

23.	Oil & gas		33, 34

Chemicals

24.	Organic chemicals		512
25.	Inorganic chemicals		513, 514
26.	Dyestuffs, colouring materials		53
27.	Pharmaceuticals		54
28.	Fertilizers, manufactured		56
29	Plastic materials		581.1, 581.2
30.	Other chemicals		515, 52, 55, 57, 581.3, 581.9, 59

Engineering, electronics and transport equipm.

31.	Agricul. & food proces. mach.	712, 718.3
32.	Textile & sewing machines	717.1, 717,3
33.	Paper & pulp machinery	718.1
34.	Machinery for other special industries or processes	717.2, 718.2, 718.4-5, 719.3, 719.5, 719.8
35.	Heating & cooling equipment	719.1
36.	Metalworking machinery	715
37.	Power generating machinery	711
38.	Pumps & centrifuges	719.2
39.	Typewriters & office mach.	714.1, 714.9
40.	Computers & peripherals	714.2, 714.3
41.	Semiconductors	729.3
42.	Telecommunications equipment	724.9
43.	Machinery for production & distribution of electricity	722, 723
44.	Consumer electronics	724.1, 724.2, 891.1
45.	Domestic electrical equipment	725
46.	Electromedical equipment	726
47.	Non-elec. medical equipment	861.7
48.	Measuring & control. instrum.	729.5
49.	Photograhic & optical goods, watches	861.1-6, 861.8-9, 862, 864
50.	Railway vehicles	731
51.	Road motor vehicles	732
52.	Aircraft	734
53.	Ships and boats (& oilrigs)	735
54.	Other non-electrical equipm.	719.6-7, 719.9, 733
55.	Other electrical equipment	729.1-2, 729.4, 729.6-7, 729.9

Other industrial products ('traditional industries')

56.	Manufactures of metal	69, 719.4, 812.1, 812.3
57.	Furniture	82
58.	Clothing	84
59.	Orthopaed. eq. & hearing aids	899.6
60.	Industrial products, n.e.s.	812.2, 812.4, 83, 85, 863, 891.2-9, 892-97, 899.1-5, 899.9, 9

Appendix Table A2
Beta, R and B/R
Seven sub periods

Country	61 to 65			65 to 69			69 to 73			73 to 79			79 to 84			84 to 88			88 to 92		
	Beta	*R*	*B/R*	*Beta*	*R*	*B/R*	*Beta*	*R*	*B/R*	*Beta*	*R*	*B/R*	*Beta*	*R*	*B/R*	*Beta*	*R*	*B/R*	*Beta*	*R*	*B/R*
Belgium-Lux	**0,87**	0,90	0,97	0,92	0,93	0,99	**0,88**	0,93	0,95	**0,87**	0,92	0,94	1,01	0,92	1,10	0,94	0,96	0,98	0,99	0,98	1,00
Canada	0,92	0,92	1,00	**0,90**	0,94	0,95	0,95	0,97	0,98	0,90	0,92	0,98	**0,89**	0,95	0,94	0,98	0,93	1,05	0,98	0,97	1,00
Denmark	0,95	0,96	0,99	0,95	0,97	0,98	0,99	0,97	1,01	**0,91**	0,97	0,95	0,95	0,96	0,99	**0,94**	0,98	0,96	0,96	0,97	0,99
Finland	1,02	0,94	1,08	**0,91**	0,93	0,97	0,91	0,92	0,99	0,97	0,95	1,01	0,93	0,96	0,97	0,94	0,91	1,03	**0,82**	0,88	0,94
France	0,90	0,91	0,99	0,90	0,89	1,01	**0,83**	0,90	0,92	0,89	0,88	1,01	0,99	0,91	1,09	**0,86**	0,91	0,95	**0,88**	0,95	0,93
Germany	**0,85**	0,97	0,88	**0,88**	0,97	0,90	0,94	0,97	0,97	**0,85**	0,94	0,90	**0,91**	0,94	0,97	0,95	0,97	0,98	**0,88**	0,95	0,93
Greece	0,90	0,93	0,97	0,93	0,82	1,14	0,91	0,90	1,02	**0,84**	0,87	0,97	1,00	0,97	1,03	**0,90**	0,93	0,97	0,94	0,94	1,00
Iceland	0,94	0,97	0,97	1,01	0,85	1,19	0,96	0,97	0,99	1,00	0,98	1,02	0,99	0,95	1,04	**0,90**	0,94	0,96	**0,86**	0,89	0,97
Ireland	0,90	0,87	1,03	0,92	0,87	1,05	**0,62**	0,72	0,85	0,94	0,90	1,04	**0,86**	0,88	0,98	0,91	0,93	0,98	0,97	0,91	1,06
Italy	**0,82**	0,92	0,89	0,96	0,94	1,02	0,98	0,96	1,02	0,92	0,92	1,00	0,95	0,92	1,03	**0,87**	0,95	0,92	0,96	0,91	1,06
Japan	**0,86**	0,91	0,94	**0,87**	0,94	0,93	1,02	0,93	1,09	0,97	0,95	1,03	1,02	0,97	1,05	0,96	0,98	0,98	0,97	0,98	0,99
Netherlands	0,92	0,96	0,95	0,95	0,96	0,99	0,92	0,95	0,97	0,96	0,93	1,03	0,94	0,91	1,03	**0,89**	0,96	0,92	0,98	0,98	1,00
Norway	0,95	0,97	0,98	0,97	0,98	0,99	0,95	0,97	0,98	0,90	0,92	0,98	**0,94**	0,98	0,96	0,98	0,98	1,00	1,01	0,98	1,03
Austria	0,98	0,96	1,02	**0,91**	0,96	0,95	0,94	0,95	0,99	**0,79**	0,83	0,96	0,96	0,95	1,01	**0,84**	0,87	0,97	0,95	0,94	1,01
Portugal	0,95	0,93	1,02	**0,89**	0,92	0,98	0,92	0,91	1,01	**0,86**	0,89	0,96	**0,81**	0,85	0,95	**0,81**	0,86	0,94	0,93	0,93	1,00
Switzerland	**0,87**	0,89	0,97	0,97	0,99	0,99	1,02	0,97	1,05	0,94	0,96	0,98	0,99	0,98	1,00	**0,96**	0,99	0,97	**0,96**	0,99	0,97
Spain	**0,77**	0,85	0,91	**0,88**	0,91	0,97	**0,77**	0,87	0,89	**0,76**	0,85	0,89	**0,79**	0,78	1,01	**0,70**	0,84	0,83	**0,77**	0,89	0,87
Sweden	0,96	0,99	0,98	0,96	0,99	0,97	0,96	0,97	0,99	0,91	0,94	0,98	**0,90**	0,96	0,93	0,97	0,95	1,02	1,00	0,97	1,03
Turkey	0,98	0,95	1,03	0,99	0,97	1,01	**0,87**	0,90	0,97	0,89	0,88	1,01	**0,73**	0,82	0,90	**0,84**	0,85	0,99	**0,82**	0,85	0,96
UK	0,93	0,92	1,01	0,99	0,98	1,01	**0,86**	0,95	0,91	**0,84**	0,93	0,91	0,94	0,93	1,01	**0,89**	0,90	0,99	**0,80**	0,84	0,94
US	0,88	0,89	0,99	0,99	0,94	1,06	**1,12**	0,95	1,17	0,91	0,93	0,98	0,97	0,97	1,00	0,92	0,95	0,97	**0,82**	0,96	0,85
Mean (unweigted)	0,91	0,93	0,98	0,94	0,94	1,00	0,92	0,93	0,99	0,90	0,92	0,98	0,93	0,93	1,00	0,90	0,93	0,97	0,92	0,94	0,98

Bold types indicate beta significantly different from unity at a 5 percent level

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