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The Long Term Development of OECD Export Specialisation Patterns: De-specialisation and "Stickiness"

by

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Abstract

The paper examines an issue related to the 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. During a period of nearly three decades from 1965 to 1992, 20 OECD countries are examined. In addition we test whether the countries, have become more or less specialised in terms of trade specialisation in the period in question. In order to fulfill these aims we examine the sensitivity for, firstly; the level of aggregation, and secondly; the kind of statistical methodology applied. In this context we distinguish between specialisation (or de-specialisation) in trade patterns on the one hand, and divergence (or on the contrary convergence) in trade patterns on the other. A specialisation process refers to a process in which specialisation *intra-country* becomes more dispersed (and counter-wise for de-specialisation). On the contrary, a divergence process refers to a process in which countries become more different in terms of specialisation in a particular sector, *across countries* (and counter-wise for convergence).

The results show that elements of ‘stickiness’ and incremental change are combined for what concerns the *intra-country* analysis. In addition there is a (however slow) tendency for countries to de-specialise in terms of exports. The *sector-wise results* display convergence both in terms of β- and σ-convergence.

Keywords

Technological change, cumulativeness, international export specialisation patterns, national systems of innovation

JEL Classification

C13, F14, O31, O57

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1. The aim of the paper[1]

One of the main conclusions 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. An important question which arises from this observation concerns whether this feature undermines the increasing interest among innovation researchers and economists in developing the concept of national systems of innovation (Freeman, 1988; Freeman, 1995; Lundvall, 1992; Nelson, 1993) 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 the erosion of distinct national patterns in economic analysis?

In their comprehensive study of international specialisation in *S&T* among the advanced countries, Archibugi and Pianta (1992) and Archibugi (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. Also Cantwell (1989; 1991) generally found increasing technological specialisation patterns among most of the countries examined.

We are going to examine one issue 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 20 OECD countries during a period of nearly three decades from 1965 to 1992.

In previous, more descriptive, work by one of us (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 (5 sectors). However, the findings were based on 'impressionistic' inspections of the data and

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1 The present version has benefited especially from comments by Bart Verspagen, Steve Dowrick, John Cantwell, Daniele Archibugi, Mario Pianta, Paulo Guerrieri & Giovanni Dosi. The usual disclaimer applies.

not on a more rigorous testing procedure. In addition we want to test whether 20 relatively advanced countries (20 OECD countries), have become more or less specialised in terms of trade specialisation in the period in question. In order to fulfill these aims we will examine the sensitivity for, firstly; the level of aggregation, and secondly; the kind of statistical methodology applied.

In this context we will distinguish between specialisation (or de-specialisation) in trade patterns on the one hand, and divergence (or on the contrary convergence) in trade patterns on the other. A specialisation process refers to a process in which specialisation *intra-country* becomes more dispersed (and counter-wise for de-specialisation). On the contrary, a divergence process refers to a process in which countries become more different in terms of specialisation in a particular sector, *across countries* (and counter-wise for convergence). This distinction is an important one, since the two kinds of processes might not in all cases move in the same direction, and is probably going to take place at different speeds. Thus we will discuss these differences further - in the empirical section - and empirically test for the rate and direction of both kinds of processes.

Some theoretical considerations are presented in the following section, while section 3 deals with the statistical methodology involved in measuring stability of specialisation patterns and whether these tend to become more or less dispersed over time. Section 4 contains the core empirical part of the paper in terms of our stability tests of export specialisation and section 5 contains the conclusions, including a discussion of some implications for the national systems of innovation literature.

2. Theoretical considerations

The paper takes as one of its points of departure the growing literature on national systems of innovation. The relative importance of nation-specific institutional structure on the one hand and nation-specific inducement mechanisms on the other, such as factor supply (abundance or serious lacks), innovative vertical linkages (user-producer interaction) and cumulative mastery of core technologies, is a major theme in that line of research.

This line of thinking has 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 its mains credentials to Freeman (1974). Other major contributions are Nelson and Winter (1982), Pavitt (1984), Dosi (1988), Dosi *et al.* (1988), Dosi, Freeman and Fabiani (1994) and Freeman’s recent survey of the state of the art (1994). The term ‘evolutionary’ theory has to an increasing degree been used as a common denominator of this line of research.

The dichotomy between the harmonising and differentiating forces of increased internationalisation is discussed on a more fundamental theoretical basis in the evolutionary literature by Dosi, Pavitt and Soete (1990), 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) while ‘strategies, context conditions and history’ on the other hand are related to differentiating forces (vary with companies and countries but across technologies).

As outlined in section 1, this paper has made a distinction between an analysis conducted country-wise across sectors, and an analysis conducted sector-wise, across countries. Since these two types of analysis have got more or less different theoretical contexts and implications, we will discuss theoretical considerations with respect to the two kinds of analysis separately. Thus, section 2.1 is most closely related to the country-wise analysis, while section 2.2 is more closely related to the sector-wise analysis.

2.1 The stability of trade patterns

In evolutionary economics it is recognised that important aspects of technology are mainly specific and tacit in nature, since it is - to a large extent - embodied in persons and in institutions, in addition to being cumulative over time. Given such a set of assumptions, firms produce things that are technically different from what other firms produce, on the basis of in-house technology, but with some contributions from other firms and from public institutions and public knowledge (Dosi *et al.*, 1990 , p. 8). In this model, firms are not likely to improve their technology, by making a survey of the complete stock of knowledge, before making technical choices. Rather, given the differentiated nature of technology, firms will try to improve and diversify their technology, by searching in zones that enable them to build on the firms existing technology base. Thus, technological and organisational change is a cumulative process, constraining firms in the possibilities of what they can do, by what they have done in the past (i.e.

path dependency). When such a perception of technology is recognised, its development, over time, ceases to be random, but is constrained by the set of existing activities (ibid).

However, not only firms but also 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).

More generally, evolutionary economics (cf. Nelson and Winter, 1982) consider three basic mechanisms, namely mechanisms of transmission (in terms of routine behaviour); search (in terms of search for new routines or technologies); and selection (in terms of market selection or 'Schumpetarian competition'). Thus, an evolutionary interpretation is that (firms of) countries competes (the selection mechanism) in a struggle for market shares, where they learn (the mechanism of search) and gain or loose depending on their relative (technological) competitiveness (or 'fitness'). In addition, what firms (and countries) can do in period t is dependent on what have been done in period $t-1$ (the mechanism of transmission).

Thus, if trade specialisation is closely related to technological specialisation at the level of the country (Soete, 1981) one should expect that specialisation patterns remain stable at the national level over long time periods. In addition to the inherent characteristics of technology, described above, vertical innovative linkages (or user-producer relationships) are likely to influence specialisation patterns to be stable as well, given that such relationships are usually durable (Lundvall, 1988). Supporting institutions are likewise likely to affect specialisation patterns in a preserving way, since institutions change only gradually (Johnson, 1992). On the other hand, a country's specialisation pattern might change incrementally due to technology based diversification (Teece, 1988), or due to the creation of new 'backward and forward linkages', possible to the extent of the creation of new 'development blocks' (Dahmén, 1988).

From a neoclassical point of view Krugman (1987) has made a model, which predicts stability in the specialisation pattern of countries, given the presence of economies of scale. In the model the productivity of resources in each sector, in each country, depends on an index of cumulative experience ('learning-by-doing'), creating economies of scale at the level of the industry. Thus, once a pattern of specialisation is established (e.g. by chance) in the model, it remains unchanged, with changes in relative productivity acting to further lock the pattern in.

2.2 Overall growth performance and divergence/convergence in trade specialisation patterns.

If cumulativeness in technological progress is not only present at the company level, but also at the level of the country, virtuous and vicious circles might arise in the pattern of international advantages and disadvantages in trade, which in turn might affect national economic performance. According to Dosi *et al.* (1990) cumulative processes have at least three dimensions; a technological one (the nature of technological trajectories); an economic one (the profitability signals which stem from technological asymmetries between firms, sectors and countries); and a behavioural one (the different search and learning, different efficiency and different incentives of firms placed in different positions in relation to the technological frontier).

However, despite the forces in international trade which tend to reinforce strength and weaknesses in terms of growth and trade performance, there are forces enabling backward countries to catch up. According to Dosi *et al.* (1990, p. 129) the following channels of technology transfer tend to induce convergence and the international diffusion of technology:

a. the 'free' international diffusion of codified knowledge (e.g. patents and publications)
b. processes of technological imitation (e.g. reverse engineering) by late-coming companies and countries.
c. traded transfers of technology (licensing, transfer of know-how etc.)
d. foreign direct investment in late-coming countries, by companies which own - among their company-specific advantages - differential technological capabilities.
e. international trade in capital goods and intermediate components.

However, while these are all channels of knowledge and rent spill-overs, which might assist in explaining catching up, the catching up has not been unconditional, since also an absorptive capacity is required. Such a capacity has been termed 'social capability' by Abramowitz (1986), and can be described as the level of education and institutions created for the purpose of absorbing knowledge diffused internationally. Thus rather than automatically capturing technology spill-overs, countries have to invest in the capacity to do so.

Even though the positive feedbacks involved in virtuous circles imply that ‘success breeds success’, it can also be said that the past success constrain the future, since past technological success is also embodied in the stock of existing capital equipment, the structure of skills and the existing behavioural pattern of firms. Under these circumstances a national technological leadership in an old paradigm may be an obstacle (but not always) to the diffusion of a new technological paradigm in that country (Freeman and Perez, 1988).

To a large extent following the assumptions just presented, Beelen and Verspagen (1994) suggest that the catching up process involves (at least) two different, but complementary, modes. The first is by means of the mechanism of knowledge spill-overs, while the other is by means of structural change. While the first mechanism is pretty straight forward, the latter deserves further description. The latter mechanism reverses the arguments of Pasinetti (1981), who argued that the extent to which the specialisation structure of a country is similar to that of the leading countries - the countries operating at the words technological frontier - determines the degree to which this country can catch up. The reverse argument states that in order to catch up, a country must change its production structure in order to become more adapted to catch technology spill-overs. Furthermore, high-tech industries (or alternatively the areas of specialisation of the leading countries) generally seem to yield higher value added per unit of production. Thus, there is an incentive for followers to develop activities in high-tech sectors. From the demand-side Pasinetti shows that the emergence of a fundamental structural change is unavoidable for an economy with increasing per capita income, since income elasticities change with the value of per capita income itself. With the level of per capita income growing, the importance of luxury goods become higher and higher, and thus there will be an incentive for the firms of countries catching up, to produce these goods domestically, rather than importing them.

Thus, in relation to this paper one would expect trade specialisation patterns to converge in the OECD countries, given that convergence in per capita income has been a dominant feature in the postwar period. However, since 1973 convergence has slowed down and has now nearly stopped. Nevertheless, Beelen and Verspagen (1994) argue that convergence in trade patterns will not slow down as fast as levels of per capita income, since the two modes of catching up are not likely to be synchronised in time. Accordingly the following country must first catch up in competitiveness before convergence in patterns of specialisation can take place. Therefore, the authors argue that technology spill-overs are likely to be most important initially. Once the catching up process has gained momentum, a convergence trend with regard to specialisation structures sets in.

3. Stability and development 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 (the latter also known as RTA; relative technological advantage). In a trade context the algebra can be set up as follows:

$$RCA_{ij} = \frac{X_{ij} / \sum_i X_{ij}}{\sum_j X_{ij} / \sum_i \sum_j X_{ij}}$$

The numerator represents the percentage share of a given sector in national exports - X_{ij} are exports of sector *i* from country *j*. The denominator represents the percentage share of a given sector 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 sector in a given country, the percentage share of that sector is identical with the OECD average. Where RCA is above 1 the country is said to be specialised in that sector 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 was originally devised to compare relative specialisation in different sectors nation-wise that is, to allow comparison of the dominance of different sectors of a given nation with the pattern seen among a larger group of countries, such as the OECD.

It should be kept in mind that these indices (RCA, RTA etc.) 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').

The work of Pavitt (1989) paved the way 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. Such 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.

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. Cantwell (1989, pp. 31-32) solved this problem rather pragmatically by testing for skewness and kurtosis of his data sample. He found the distribution of the data set used to be approximately normal. However, it does not hold for the export data sets presented in this paper. Using the Shapiro-Wilks statistics only data for one country (Germany) seems to follow a normal distribution and the test reveals very large values for skewness and kurtosis. This holds both for RCAs calculated for the whole economy and for RCAs solely based on manufacturing.

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 avoid the problem it has been suggested to add a small value to the RCA (Fagerberg, 1994). 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. A different method (RCA-1/RCA+1), presented by Laursen and Engedal (1995) under the label 'Revealed Symmetric Comparative Advantage', RSCA, has been chosen in the present paper. The RSCAs 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). The method has got the economic advantage of attributing *changes* below unity (zero in this case) the same weight as changes above unity. Further, the measure is the best of the alternatives discussed with respect to normality. Data sets for more than half of the countries are normally distributed according to the Shapiro-Wilks-test.

The methodology for testing whether countries are stable across sectors and whether they tend to become more or less specialised intra-country *and* the test of whether countries tend to converge within the same sector are analogous. However, we will start off by describing the methodology to be used for the intra-country, cross sectoral analyses.

The testing procedure presented in Pavitt's (1989) seminal work on international comparisons of technological specialisation patterns was further refined by Cantwell (1989). His 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 (and specialisation trends) 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:[2]

$$RSCA_{ij}^{t_2} = \alpha_i + \beta_i RSCA_{ij}^{t_1} + \epsilon_{ij}^{t_2}$$

The superscripts t_1 and t_2 refer to the initial year and the final year, respectively. The dependent variable, RSCA at time t_2 for sector i, is tested against the independent variable which is the value of the RSCA in the previous year t_1. α and β are standard linear regression parameters and ϵ is a residual term.

The idea behind the regression is that β=1 corresponds to an unchanged pattern from t_1 to t_2. If β>1 the country tends to become more specialised in sectors where it already is specialised and less specialised where initial specialisation is low - i.e. the existing pattern of specialisation is

2 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 one makes an analogy to the convergence literature[3], β>1 might be termed *β-specialisation*. If 0<β<1 the existing specialisation pattern changes incrementally i.e., *on average* sectors with initial low RSCAs increase over time while sectors with initial high RSCAs decrease their values. Similarly, 0<β<1 can be termed *β-de-specialisation.* The magnitude of (1-β) therefore measures the size of what has been termed as the 'regression effect', and this is the interpretation placed on the estimated coefficient of β in the empirical section of the present paper. In the special case where β<0 the ranking of sectors has been reversed. Those RSCAs initially below the country average are in the final year above average and visa versa.

Given the above listed line of reasoning, the test of cumulativeness (or 'stickiness') is whether $\hat{\beta}$ is significantly greater than zero. If $\hat{\beta} \leq 0$, it cannot be rejected that the development of the trade specialisation pattern of a country is either reversed or random, contrary to the hypothesis of cumulativeness. However, as argued in the theoretical section, the evolutionary approach not only predicts stickiness, but also predicts that trade specialisation patterns might undergo incremental change. The condition under which stickiness outweighs incremental change is that $\hat{\beta} \geq 1$. Where $\hat{\beta}$ is significantly higher than zero and significantly less than one, cumulativeness and incremental change are combined.

Another feature emerging from the regression analysis is a test of whether the degree of specialisation changes. Following Cantwell (1989, pp. 31-32) it can be deduced that β>1 is not a necessary condition for an increase in the overall national specialisation pattern. With reference to Hart (1974) it can be shown that:

$$\sigma_i^{2\,t_2} / \sigma_i^{2\,t_1} = \beta_i^2 / R_i^2$$

Thus,

$$\sigma_i^{t_2} / \sigma_i^{t_1} = |\beta_i| / |R_i|$$

3 The 'dual' existence of the concepts of β- and σ-convergence (or divergence) in the growth literature is clarified by Hart (1994) and by 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 argues that having the relation between the concepts in mind there is no 'Galtonian fallacy' problem as argued by Friedman (1992) and Quah (1993).

From the latter it follows that the dispersion (= standard deviation or σ) of a given distribution is unchanged when β=R. If β>R (equivalent to an increase in the dispersion) the degree of specialisation has increased. Thus making the same kind of analogies as above, one might term this as *σ-specialisation*. If β<R (equivalent to a decrease in the dispersion) the degree of specialisation has decreased. Likewise, such a situation can be described as *σ-de-specialisation*.

The estimated Pearson correlation coefficient is a measure of the mobility of sectors up and down the RSCA distribution. A high level of the coefficient indicates that the relative position of sectors is little changed, while a low value indicates that some sectors are moving closer together and others further apart, quite possibly to the extent that the ranking of sectors change. The value of (1-R) measures thus, what has been described as the 'mobility effect'. It may well be that, even where the 'regression effect' suggest a fall in the degree of specialisation due to a proportional change in sectors towards the average (β<1), this is outweighed by the mobility effect, due to changes in the proportional position between sectors (β>R). 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.

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, RSCA 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 RSCA and the error term ϵ. The combination of β<1 and β>R, which is identical to an increased variance of the RSCAs over time, is thus to some extent caused by the variance of the residual term ϵ. The mechanism causing increased standard deviation (dispersion) of the final RSCAs, in the case of β<1, is the existence of a positive variance of the residual term - i.e. the increased standard deviation of the final RSCAs is partly caused by the residual and therefore not by a recognisable economic explanation (such as cumulativeness).[4] These problems of interpretation have their parallel in the discussion in 'new growth' analysis of β- versus σ-convergence of per capita incomes as introduced by Barro and Sala-i-Martin (1991).

We will now turn to the sector-wise methodology, which is used to test whether specialisation patterns tend to *converge* across countries, within the same sector:

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4 We are grateful to Bart Verspagen who pointed this out.

$$RSCA_{ij}^{t_2} = \alpha_j + \beta_j RSCA_{ij}^{t_1} + \epsilon_{ij}^{t_2}$$

Like in the case of the country-wise analysis, the idea behind the regression is that $\beta=1$ corresponds to an unchanged pattern from t_1 to t_2. If $\beta>1$ the countries which are (heavily) specialised in the sector in question tend to become increasingly specialised in this sector while countries which are under-specialised in the sector in question tend to become even less specialised in this sector. Such a movement can be termed *β-divergence* in trade patterns. If $0<\beta<1$ the existing specialisation pattern changes (incrementally) i.e., *on average* countries with initial low RSCAs increase over time, while countries with initial high RSCAs decrease their values. Similarly, $0<\beta<1$ can be termed *β-convergence*. In the special case where $\beta<0$ the ranking of countries has changed fundamentally, so that those RSCAs initially below the OECD average are in the final year above average and visa versa.

Like in the case of specialisation/de-specialisation it can be shown for divergence/convergence that:

$$\sigma_j^{t_2} / \sigma_j^{t_1} = |\beta_j| / |R_j|$$

From above 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 divergence has increased. Thus, one can term this situation as *σ-divergence*. If $\beta<R$ (equivalent to a decrease in the dispersion) the countries have converged in their trade patterns, which in turn can be described as *σ-convergence*.

4. Development and stability characteristics of OECD export specialisation patterns

4.1 The country-wise specialisation patterns

In the country-wise category of studies of stability of export specialisation we are only aware of the study by Amendola, Guerrieri and Padoan (1992) and the study by Papagni (1992). Amendola *et al.* 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 is, however, neglected.

The Papagni study confirms the stability of trade specialisation patterns for high-technology goods, using three-mode principal components analysis. However, the study only consider seven individual countries and a rather limited time-period (1981-1987), and contains no analysis of the development of the specialisation patterns.

Our analysis is conducted across 60 sectors (described in Appendix Table A1) for 20 OECD countries. More detailed characteristics of the data set used, are documented in the Appendix. The results of our tests are summarised in Table 1. The Table shows the values for $\hat{\beta}$, $\hat{R}$ and $\hat{\beta}/\hat{R}$ for the period 1965-92 ('long' term) and for two sub-periods 1965-79 and 1979-92 (both 'medium' term). In addition Table 1 also contains the chi square value for 1965, 1979 and 1992 for each country. Such an indicator has been used by Archibugi and Pianta (1992) in their comprehensive study of technological specialisation. The latter measures the sum of the squared difference between the export distribution of a given country and the total OECD divided by the OECD export distribution. The formula is:

$$\chi^2 = \sum_i [[(X_{ij}/\sum_i X_{ij}) - (\sum_j X_{ij}/\sum_i\sum_j X_{ij})]^2/(\sum_j X_{ij}/\sum_i\sum_j X_{ij})]$$

If a country has an export structure exactly similar to the OECD, the value of the indicator will be zero. The size of χ^2 is, according to Archibugi and Pianta and indication of how strongly each country is specialised. The more a country differs from OECD the greater the value. Over time it indicates changes in the degree of specialisation for each country. Although different in construction, the aim of this measure is the same as $\hat{\beta}/\hat{R}$ (which is equal to $\hat{\sigma}^{t2}/\hat{\sigma}^{t1}$), i.e., to measure the changes in dispersion.

In the 'long' term perspective (1965-92) the results show a general decrease in the dispersion of export specialisation, implying a trend towards a decrease in specialisation (so-called σ-de-specialisation). The exceptions are Greece, Italy, Japan and US, which become more specialised. However, the decrease in dispersion is rather weak. The unweighted mean for $\hat{\beta}/\hat{R}$

Table 1: Country-wise stability and development of OECD export specialisation patterns in the long term (1965-1992)

	1965 -1992				1965 -1979				1979-1992			
Country	$\hat{\beta}$	$\hat{R}$	$\hat{\beta}/\hat{R}$	χ^2_{t2}/χ^2_{t1}	$\hat{\beta}$	$\hat{R}$	$\hat{\beta}/\hat{R}$	χ^2_{t2}/χ^2_{t1}	$\hat{\beta}$	$\hat{R}$	$\hat{\beta}/\hat{R}$	χ^2_{t2}/χ^2_{t1}
United States	0.75	0.74	1.01	0.88	0.97	0.80	1.21	1.62	0.79	0.94	0.84	0.54
Japan	0.62	0.58	1.07	0.62	0.77	0.74	1.04	0.81	0.95	0.93	1.03	0.76
Germany	0.52	0.73	0.70	0.37	0.67	0.85	0.79	0.55	0.77	0.86	0.89	0.66
France	0.37	0.40	0.94	1.27	0.60	0.63	0.94	0.80	0.78	0.78	1.00	1.59
Italy	0.59	0.55	1.06	1.11	0.87	0.84	1.04	0.97	0.78	0.76	1.02	1.15
United Kingdom	0.57	0.71	0.80	0.65	0.72	0.87	0.84	1.11	0.76	0.80	0.95	0.59
Belgium-Lux	0.66	0.69	0.96	0.79	0.68	0.76	0.89	0.58	0.97	0.91	1.07	1.37
Canada	0.72	0.82	0.88	0.60	0.77	0.84	0.92	0.71	0.83	0.87	0.96	0.84
Denmark	0.78	0.88	0.88	0.32	0.89	0.95	0.93	0.42	0.86	0.91	0.94	0.75
Finland	0.61	0.68	0.90	0.42	0.79	0.82	0.97	0.56	0.78	0.84	0.93	0.75
Netherlands	0.61	0.64	0.94	0.92	0.79	0.79	0.99	1.08	0.84	0.89	0.94	0.86
Norway	0.74	0.80	0.92	2.70	0.85	0.89	0.95	1.19	0.91	0.94	0.97	2.26
Austria	0.67	0.76	0.89	0.57	0.69	0.77	0.90	0.73	0.79	0.81	0.98	0.78
Switzerland	0.86	0.90	0.96	0.50	0.96	0.95	1.01	0.59	0.92	0.97	0.95	0.85
Sweden	0.70	0.76	0.91	0.52	0.84	0.90	0.94	0.55	0.89	0.91	0.97	0.95
Greece	0.63	0.58	1.10	0.40	0.71	0.63	1.12	0.23	0.87	0.89	0.98	1.72
Ireland	0.37	0.39	0.95	0.20	0.46	0.50	0.93	0.30	0.85	0.84	1.02	0.66
Portugal	0.54	0.64	0.84	0.85	0.69	0.73	0.94	0.92	0.64	0.72	0.89	0.93
Spain	0.29	0.51	0.57	0.11	0.52	0.68	0.77	0.19	0.59	0.79	0.74	0.58
Turkey	0.36	0.43	0.83	0.57	0.72	0.73	0.99	0.89	0.64	0.76	0.84	0.64
Mean (unweighted)	0.60	0.66	0.91	0.72	0.75	0.78	0.96	0.74	0.81	0.86	0.95	0.96

is 0.91 and most of the countries fall inside the 10 percent decrease in dispersion. Only Spain (and to a lesser extent Germany) show significant decreases in dispersion, indicating that the speed in broadening of their exports have been higher than in other OECD countries.

The decomposition of the dispersion in a 'regression' effect (1-β), and a 'mobility' effect (1-R), reveals two features. On the one side, the $\hat{\beta}$-values are significantly different from zero and significantly below unity at the one per cent level for all the 20 countries, meaning that the hypothesis of a reverse or random patterns can be rejected. Since the $\hat{\beta}$-values are significantly smaller than one, the elements of stickiness and incremental change are combined. Trade patterns do not change 'overnight' and do not change fundamentally even over three decades. Put differently, this feature 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.

On the other side, the 'long' term analysis shows that σ-de-specialisation prevails, although to a fairly moderate degree, as indicated by the high values of $\hat{\beta}/\hat{R}$. On average there is no strong tendency towards de-specialisation (decline in $\hat{\beta}/\hat{R}$). The moderate decrease in the dispersion of the RSCAs can, however, not be explained entirely as a result of cumulative mechanisms. The β-de-specialisation mechanism, 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 $\hat{\beta}$-value of 0.60 (vis-á-vis the $\hat{\beta}/\hat{R}$ of 0.91).

The χ^2-values confirms the impression of de-specialisation in international trade. Of 20 countries only three have an increase in specialisation and for two of these (France and Italy) the changes are very limited. Only Norway, explained by its rapid increase in oil and gas exports, has an significant increase. The conclusion is, that both measures (changes in dispersion σ or $\hat{\beta}/\hat{R}$ as well as changes in χ^2) overall indicate a development towards less specialised export structures in OECD countries.

Concerning the 'medium' term of 1965-79 and 1979-92, it should be noted that the unweighted mean of the dispersions increase slightly, with $\hat{\beta}/\hat{R}$ equal to 0.91 1965-79 and 0.96 1979-92, indicating a stronger σ-de-specialisation in the first period. During 1965-79 σ-specialisation can be found in five countries - the same as in 1979-92. The unweighted β-de-specialisation measure was 0.75 and 0.74, respectively - indicating a lower degree of ('explained') β-de-specialisation compared to the 'long' term period 1961-92. The estimated 'regression' effects (1-$\hat{\beta}$) as well as the 'mobility' effects (1-$\hat{R}$) are, thus, generally lower (equivalent to larger values of $\hat{\beta}$ and $\hat{R}$) for the two medium term sub-periods implying the long term changes have evolved gradually.

How sensible are the data with respect to the level and kind of aggregation? And do the inclusion of primary goods influence the results? In order to answer these questions we did a similar analysis based on the categorical aggregation - at the 2-digit and 3-digit SITC levels, respectively. However, the levels of aggregation do not seem to affect our conclusion based on the 60-sectors aggregation. On average, both for 2 and 3-digit SITC the same kind of slow trend towards de-specialisation appear. Only three countries show $\hat{\beta}/\hat{R}$-values above unity.

Secondly, concerning the scope of the analysis it could be argued, that inclusion of primary goods automatically would produce lower $\hat{\beta}/\hat{R}$-values since the process of industrialisation is followed by a broadening in the production and export structure. In fact our conclusions would not change if we limit the analysis to manufacturing. In this case only five countries (compared to four for the whole economy) seem to become more specialised (Italy, Switzerland, Japan, UK and US). And the unweighted mean for $\hat{\beta}/\hat{R}$ 1965-92 is slightly smaller (0.89 vs. 0.91).

The picture of gradual, path-dependent, change - or evolutionary change - is further underlined by the data for the six 'short' term periods presented in Appendix Table A2. Compared with the medium term periods, the short term $\hat{\beta}$- and $\hat{R}$-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 20 OECD countries the values of $\hat{\beta}$ 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 statistically significant β-specialisation 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 $\hat{\beta}$) and high mobility effects (low $\hat{R}$) whereas most of the small high-income countries show low regression effects (high $\hat{\beta}$) and low mobility effects (high $\hat{R}$). The large countries usually show higher regression effects (lower $\hat{\beta}$-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 outweighed the regression effect in the Japanese case - in 1992 the dispersion of export specialisation was slightly higher compared to 1965. A high mobility in relation to an unchanged or even an increased dispersion indicates a shift in the pattern of export specialisation. In 1965 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 $\hat{\beta}$-values in our setting. A high $\hat{\beta}$ (ie. close to unity from below) indicates a high degree of stability or stickiness of the relative export structure and the cause is, at the same token, shown to be the influence of the existing structure.

4.2 The sector-wise specialisation patterns

The empirical results reported in the literature of the sector-wise category of studies point in different directions. Soete and Verspagen (1994) analysed a sample of 22 manufacturing industries across countries in the period 1970-1990. The specification was similar to our sector-wise specification (β-convergence), the only difference being that they estimated a restricted model, in assuming a zero intercept. Soete and Verspagen concluded that convergence was predominant in every sector, except food (non-significant convergence) and textiles (significant divergence). Based on these observations, 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. (p. 289).

The approach is further developed by Beelen and Verspagen (1994) as mentioned in section 2. 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 Soete-Verspagen model. They found significantly negative coefficients on most of the initial RCAs (expressed in logarithms) in the, sector-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.[5] They only found three countries with significant constants leading to

5 The country constant is a dummy variable added to the still basically *sector-wise* regression model.

the conclusion that there did not seem to be country-specific tendencies to specialise or de-specialise.

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 sector-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 the study however, uses the non-modified RCAs and does not take the problems of normality into account.

The general results from Table 2 have much in common with the country-wise findings of Table 1. For all sectors we find β-convergence and in all cases $\hat{\beta}$ is significantly below unity (and above 0). Further, we find σ-convergence for all sectors except five; i.e. the dispersion of specialisation in almost all sectors has decreased. Put differently, the countries which have been under-specialised in given sectors tend to increase specialisation in these sectors and/or countries which are specialised in given sectors tend to decrease specialisation in these sectors. This β-convergence appears marginally stronger compared to the country-wise σ-de-specialisation when the level of disaggregation shown in Appendix Table A1 is used.

While section 4.1 above showed that the overall de-specialisation trends were not sensitive to the different levels of disaggregation tested, the interpretation of the detailed sector-wise results of Table 2 demands some further comments on the specific kind of disaggregation used. Besides the inherent problems of missing values in foreign trade data, mainly at the 4 and 5 digit SITC levels, the basic idea behind the chosen list of 60 sectors - aggregated to 5 main sectors - is to get a slightly more richly faceted division than the standard two main sectors of manufacturing versus ‘raw materials’. The first main sector (so-called natural resource based products) consists of raw materials and highly resource based semi-manufactures. Oil & gas is treated as a main sector of its own, while chemicals is identical to SITC 5. The main sector of ‘other industrial products’ (or ‘traditional industries’) contains the more labour intensive (and low skilled) parts of manufacturing, while the fourth main sector contains engineering, electronics & transport equipment. In a non-rigorously defined sense the natural resource based main sector, and of course also oil & gas, to a certain extent reflect the natural endowments of a country. On the other hand the ‘traditional industries’ appears to be pretty well characterised as labour intensive (low skilled) sectors. Chemicals and engineering, electronics & transport equipment contain the more R&D and/or capital intensive areas.

Table 2: Sector-wise stability and development of OECD export specialisation patterns in the long term (1965-1992)

No.	Sector	1965-1992 $\hat{\beta}$	$\hat{R}$	$\hat{\beta}/\hat{R}$	No.	Sector	1965-1992 $\hat{\beta}$	$\hat{R}$	$\hat{\beta}/\hat{R}$
1	Meat & meat preparations	0.82	0.85	0.96	31	Agricul. & food proces. mach.	0.57	0.69	0.83
2	Dairy products	0.70	0.75	0.94	32	Textile & sewing machines	0.83	0.88	0.94
3	Fish & fish preparations	0.65	0.79	0.82	33	Paper & pulp machinery	0.87	0.94	0.93
4	Cereals & cereal preparations	0.65	0.62	1.04	34	Mach. for other spec. industries/processes	0.81	0.83	0.99
5	Feeding-stuff for animals	0.35	0.45	0.77	35	Heating & cooling equipment	0.45	0.68	0.67
6	Other food products	0.72	0.88	0.83	36	Metalworking machinery	0.77	0.87	0.89
7	Beverages & tobacco	0.70	0.90	0.79	37	Power generating machinery	0.58	0.69	0.85
8	Animal & vegetable oil & fats	0.84	0.76	1.10	38	Pumps & centrifuges	0.63	0.85	0.74
9	Cut flowers, bulbs, & oth. plants	0.62	0.73	0.86	39	Typewriters & office mach.	0.57	0.55	1.04
10	Seeds & spores for planting	0.73	0.83	0.89	40	Computers & peripherals	0.20	0.23	0.87
11	Skins & leather manufactures	0.51	0.53	0.97	41	Semiconductors	0.54	0.64	0.84
12	Wood & wood manufactures	0.76	0.84	0.91	42	Telecommunications equipment	0.40	0.53	0.76
13	Pulp & paper	0.69	0.90	0.77	43	Mach. for prod. & dist. of electricity	0.24	0.39	0.60
14	Textile fibres	0.58	0.74	0.79	44	Consumer electronics	0.39	0.41	0.96
15	Textile yearn, fabrics, etc.	0.48	0.56	0.87	45	Domestic electrical equipment	0.36	0.48	0.75
16	Iron ore	0.82	0.90	0.91	46	Electromedical equipment	0.58	0.65	0.89
17	Iron, steel & ferro-alloys	0.33	0.44	0.76	47	Non-elec. medical equipment	0.54	0.61	0.89
18	Aluminium	0.48	0.62	0.77	48	Measuring & control. instrum.	0.60	0.78	0.77
19	Non-ferrous ores & metals	0.58	0.76	0.77	49	Photograhic & optical goods, watches	0.73	0.90	0.81
20	Crude fertilizers, crude minerals & coal	0.63	0.78	0.80	50	Railway vehicles	0.53	0.60	0.88
21	Non-metallic minerals	0.40	0.50	0.81	51	Road motor vehicles	0.69	0.73	0.95
22	Rest: rubber; electr. energy	0.37	0.50	0.75	52	Aircraft	0.67	0.70	0.95
23	Oil & gas	0.32	0.30	1.10	53	Ships and boats (& oilrigs)	0.60	0.72	0.84
24	Organic chemicals	0.46	0.58	0.80	54	Other non-electrical equipm.	0.72	0.90	0.80
25	Inorganic chemicals	0.22	0.33	0.65	55	Other electrical equipment	0.73	0.90	0.81
26	Dyestuffs, colouring materials	0.57	0.75	0.76	56	Manufactures of metal	0.37	0.57	0.66
27	Pharmaceuticals	0.69	0.73	0.94	57	Furniture	0.52	0.62	0.83
28	Fertilizers, manufactured	0.20	0.28	0.69	58	Clothing	0.05	0.04	1.18
29	Plastic materials	0.34	0.59	0.57	59	Orthopaed. eq. & hearing aids	0.60	0.68	0.88
30	Other chemicals	0.42	0.56	0.76	60	Industrial products, n.e.s.	0.63	0.78	0.81
	Mean (unweighted)						0.56	0.66	0.85

Sectors with low $\hat{\beta}$s usually reveals a high mobility effect (1-$\hat{R}$) indicating major shift in the ranking of the country specialisation in the specific sector. However, Table 2 points at important differences in the level of $\hat{\beta}$ (and $\hat{R}$) across sectors. As should be somehow expected the components of the natural resource based main sector (sectors 1-22) have generally high $\hat{\beta}$s and low mobility.[6] The 'traditional industries' show high β-convergence and high mobility consistent with a conception of these areas as characterized by the importance of relative factor intensities, more in line with the standard Hechscher-Ohlin type of explanation.

Within chemicals as well as engineering, electronics & transport equipment there are quite evident differences in the degree of β-convergence. The machinery oriented sectors (no. 31-38 like agricultural and food processing machinery, textile and sewing machines, paper and pulp machinery, metalworking machinery, machinery for other special industries and processes, power generating machinery and pumps & centrifuges) all display mobility below the average (the unweighted mean). On the other hand, sectors like computers, consumer electronics, telecommunications equipment and domestic electrical equipment show much stronger β-convergence and a much higher mobility. These sectors may be argued to a certain degree to de dominated by multinational companies capable to exploit economies of scale and scope world-wide in their production and foreign trade pattern (but not necessarily so in their technological development patterns). Other parts of electronics, such as semiconductors, electro medical equipment and measuring and control instruments display lower than average β-convergence, indicating that these fields are less 'footloose' in their foreign trade pattern.

These more intuitive and preliminary indications of potentially systematic sector specificities in the stability characteristics of international specialisation may act as a complement to the more widespread analyses of country-wise patterns (see also Yeats, 1985). The country-wise and sector-wise results are more or less by definition two sides of the same coin. Countries with relative high $\hat{\beta}$s in their country-wise specialisation patterns tend to be specialised in those sectors that display a fairly low degree of β-convergence (high $\hat{\beta}$s) in their sector-wise patterns.

6 The low $\hat{\beta}$ and low mobility for oil & gas may be a reflection of the geographical division between oil drilling and oil refinery which may cross national borders.

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

In the present paper we have made a distinction between the two concepts of β- and σ-specialisation on the one hand and β- and σ-convergence/divergence on the other; the latter introduced to the growth literature by Barro and Sala-i-Martin (1991). We shall deal with the analysis of the results using these concepts in turn.

In terms of the *stability* of each of the national export specialisation patterns, the long term perspective of 1965-92 shows that the hypothesis of a reverse or random patterns can be rejected. Since the $\hat{\beta}$-values are significantly smaller than one (and significantly greater than zero), the elements of stickiness and incremental change are combined (in other words the development can be characterised as β-de-specialisation). In our view these results leave, though, 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. Thus, these findings are in line with the evolutionary theorising presented in section 2.1, as well as the neoclassical model by Krugman (1987). However, it should be mentioned that Krugman's model cannot account for the observed incremental changes of the specialisation pattern.

In terms of the process of *specialisation versus de-specialisation* (measured by σ-specialisation) the results display a process of de-specialisation. However, as made possible to analyse by the Cantwell-methodology, the decrease in the dispersion of the specialisation indicator is rather weak even in the long term perspective. The unweighted mean for $\hat{\beta}/\hat{R}$ 1965-92 is 0.91 (0.90 1961-92) and most of the countries fall inside the 10 percent decrease in dispersion. β-de-specialisation has apparently been more outspoken than σ-de-specialisation.

It should be noted that the results were not *in general* sensitive to the level of aggregation used, or to the statistical method applied, even though there appear to be some fluctuation for what concerns *the degree* of the stability of the individual countries.

The sector-wise results presented in this paper are similar to the results reported by Soete & Verspagen (1994) and Beelen & Verspagen(1994). However, the findings of these studies have 1988 as the most recent year, whereas the present study includes 1992. The 'appreciative theorising' by Beelen & Verspagen, suggested (as described in section 2) that convergence in specialisation patterns would level off (however with some lag), as the convergence in per capita income has more or less come to an end. However, the average σ-convergence has been very stable if one split the long-run period into six sub-periods (Appendix Table A3). But maybe the recent minor (and very fragile indeed) drop in the β-convergence of the trade patterns indicates that such a process of divergence is beginning to take place.

An interesting feature of comparing the country-wise and the sector-wise results to each other is that σ-convergence appear to be stronger than σ-de-specialisation (about 7 per cent difference), over the full period. Such an observation might be interpreted as a consequence of backward countries catching up (implies convergence at a sectoral level, across countries), while the most advanced countries tend to neither engage in a process trade specialisation, nor de-specialisation.[7]

The studies of Soete & Verspagen (1994) and Beelen & Verspagen (1994) have related developments in trade patterns to the convergence-divergence debate by means of the *sector-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.

Apparently it is a stylized fact that international trade specialisation in the OECD countries have decreased slightly in the near 30 year period 1965-92 as opposed to the general findings concerning technological specialisation. Among the tentative explanations could be that patents do only represent potential economic assets - not necessarily realised assets. According to e.g. Patel and Pavitt (1991) patenting activity of the large multinationals is still heavily concentrated in their perceived home countries. But production and hence exports may very well be more ‘foot-loose’ and less nationally embedded than the capability to develop new patents. The internationalisation of production may thus have taken place at a higher speed than the internationalisation of the capability of developing new technology.

7 One can imagine a scenario, in which there is a tendency (on average) towards convergence, while at the same time countries tend to specialise (on average).

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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 been the major analytical aim from the beginning. 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 Industrialised 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 Appendix Table A1.

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 A2: Country-wise stability and development of OECD export specialisation patterns for six sub-periods 1965-1992

	1965-1969				1969-1973				1973-1979				1979-1984				1984-1988				1988-1992			
	β	R	β/R	χ^2_{t2}/χ^2_{t1}	β	R	β/R	χ^2_{t2}/χ^2_{t1}	β	R	β/R	χ^2_{t2}/χ^2_{t1}	β	R	β/R	χ^2_{t2}/χ^2_{t1}	β	R	β/R	χ^2_{t2}/χ^2_{t1}	β	R	β/R	χ^2_{t2}/χ^2_{t1}
United States	0.90	0.91	0.98	1.02	**1.12**	0.95	1.17	1.82	0.91	0.93	0.98	0.87	0.97	0.97	1.00	0.84	0.92	0.95	0.97	0.91	**0.82**	0.96	0.86	0.71
Japan	**0.87**	0.93	0.94	0.88	1.02	0.93	1.09	1.02	0.97	0.95	1.03	0.91	1.02	0.97	1.05	1.05	0.96	0.98	0.98	0.79	0.98	0.98	1.00	0.92
Germany	**0.89**	0.94	0.94	0.70	0.94	0.97	0.97	1.05	**0.85**	0.94	0.90	0.75	**0.91**	0.94	0.97	0.94	0.95	0.97	0.98	0.86	**0.90**	0.96	0.94	0.82
France	0.90	0.91	0.99	1.40	**0.83**	0.90	0.92	0.84	0.89	0.88	1.01	0.68	0.99	0.91	1.09	1.62	**0.86**	0.91	0.95	1.07	0.92	0.95	0.97	0.92
Italy	0.91	0.92	1.00	1.06	0.98	0.96	1.02	0.88	0.92	0.92	1.00	1.04	0.95	0.92	1.03	1.22	**0.87**	0.95	0.92	0.87	0.98	0.91	1.08	1.08
United Kingdom	0.98	0.97	1.01	0.95	**0.86**	0.95	0.91	1.32	**0.84**	0.93	0.91	0.89	0.94	0.93	1.01	1.67	**0.89**	0.90	0.99	0.55	**0.81**	0.85	0.95	0.63
Belgium-Lux	0.92	0.94	0.98	0.90	**0.88**	0.93	0.95	0.84	**0.87**	0.92	0.94	0.76	1.01	0.92	1.10	1.32	0.94	0.96	0.98	1.07	0.98	0.99	0.99	0.97
Canada	**0.91**	0.95	0.96	0.74	0.95	0.97	0.98	1.01	0.90	0.92	0.98	0.95	**0.89**	0.95	0.94	0.74	0.98	0.93	1.05	1.14	0.95	0.97	0.98	1.00
Denmark	0.95	0.93	1.02	0.70	0.99	0.97	1.01	0.70	**0.91**	0.97	0.95	0.86	0.95	0.96	0.99	0.95	0.94	0.98	0.96	0.88	0.96	0.97	0.99	0.89
Finland	**0.85**	0.85	1.00	0.78	0.91	0.92	0.99	0.89	0.97	0.95	1.01	0.80	0.93	0.96	0.97	0.90	0.94	0.91	1.03	0.99	**0.82**	0.88	0.93	0.84
Netherlands	**0.91**	0.94	0.97	0.99	0.92	0.95	0.97	1.08	0.96	0.93	1.03	1.02	0.94	0.91	1.03	1.07	**0.89**	0.96	0.92	0.82	0.98	0.98	1.00	0.97
Norway	0.93	0.94	0.99	1.24	0.95	0.97	0.98	0.89	0.90	0.92	0.98	1.08	**0.94**	0.98	0.96	1.17	0.98	0.98	1.00	1.29	0.98	0.98	1.00	1.50
Austria	0.97	0.97	1.01	0.90	0.94	0.95	0.99	1.01	**0.79**	0.83	0.96	0.81	0.96	0.95	1.01	0.95	**0.84**	0.87	0.97	0.87	0.96	0.95	1.01	0.95
Switzerland	0.97	0.97	0.99	0.82	1.02	0.97	1.05	1.02	0.94	0.96	0.98	0.70	0.99	0.98	1.00	1.04	**0.96**	0.99	0.97	0.86	**0.96**	0.99	0.97	0.95
Sweden	0.92	0.92	0.99	0.80	0.96	0.97	0.99	0.90	0.91	0.94	0.98	0.75	**0.90**	0.96	0.93	0.91	0.97	0.95	1.02	0.97	1.00	0.97	1.02	1.08
Greece	0.94	0.88	1.07	0.52	0.91	0.90	1.02	0.58	**0.84**	0.87	0.97	0.77	1.00	0.97	1.03	1.07	**0.90**	0.93	0.97	1.66	0.92	0.94	0.99	0.97
Ireland	**0.91**	0.87	1.04	0.83	**0.62**	0.72	0.85	0.49	0.94	0.90	1.04	0.74	**0.86**	0.88	0.98	0.77	**0.91**	0.93	0.98	0.85	0.96	0.91	1.06	1.01
Portugal	0.93	0.93	0.99	0.77	0.92	0.91	1.01	0.97	**0.86**	0.89	0.96	1.24	**0.81**	0.85	0.95	0.87	**0.81**	0.86	0.94	1.25	0.93	0.93	1.00	0.85
Spain	0.84	0.85	0.98	0.45	**0.77**	0.87	0.89	0.75	**0.76**	0.85	0.89	0.56	**0.79**	0.78	1.01	0.70	**0.70**	0.84	0.83	0.95	**0.78**	0.89	0.88	0.88
Turkey	0.96	0.94	1.02	1.31	0.87	0.90	0.97	0.61	0.89	0.88	1.01	1.12	**0.73**	0.82	0.90	0.52	**0.84**	0.85	0.99	0.95	**0.80**	0.85	0.94	1.29
Mean (unweighted)	0.92	0.92	0.99	0.89	0.92	0.93	0.99	0.93	0.89	0.91	0.98	0.86	0.92	0.93	1.00	1.02	0.90	0.93	0.97	0.98	0.92	0.94	0.98	0.96

Bold types indicate β-values significantly different from unity at the 5 per cent level.

Appendix Table A3: Sector-wise stability and development of OECD export specialisation patterns for six sub-periods 1965-1992

	1965-1969		1969-1973		1973-1979		1979-1984		1984-1988		1988-1992	
	β	β/R	β	β/R	β	β/R	β	β/R	β	β/R	β	β/R
Meat & meat preparations	0.97	1.01	0.97	0.99	1.00	1.01	0.98	1.01	0.96	0.99	0.93	0.96
Dairy products	0.96	0.99	1.00	1.05	0.97	0.98	0.86	0.94	0.84	0.93	1.03	1.04
Fish & fish preparations	0.96	0.97	0.94	0.95	0.94	0.96	0.93	0.93	0.96	0.99	1.00	1.01
Cereals & cereal preparations	0.87	1.00	0.79	0.97	0.87	1.08	0.94	0.99	0.89	1.03	0.94	0.97
Feeding-stuff for animals	0.93	0.97	0.93	0.98	0.69	0.93	0.70	0.94	0.69	0.85	1.02	1.09
Other food products	0.91	0.92	0.94	0.95	1.00	1.03	0.94	0.95	1.01	1.01	0.95	0.95
Beverages & tobacco	0.97	0.98	0.92	0.94	0.91	0.93	0.92	0.94	1.03	1.03	0.92	0.94
Animal & vegetable oil & fats	1.02	1.07	0.92	0.97	0.92	0.94	0.94	1.06	0.88	0.96	1.03	1.10
Cut flowers, bulbs, & oth. plants	0.99	1.00	0.85	0.89	0.96	1.01	0.93	0.99	0.98	1.01	0.94	0.96
Seeds & spores for planting	0.96	0.98	0.88	0.97	0.96	1.02	0.95	0.98	0.96	0.99	0.91	0.95
Skins & leather manufactures	0.96	0.98	0.86	0.91	0.95	1.05	0.97	1.03	0.93	0.99	0.96	1.02
Wood & wood manufactures	0.97	0.98	0.93	0.97	1.00	1.04	0.90	0.94	0.97	0.99	0.97	0.98
Pulp & paper	0.93	0.94	0.96	0.97	0.90	0.92	0.95	0.98	0.98	0.99	0.94	0.95
Textile fibres	0.98	1.00	0.97	1.00	0.83	0.88	0.95	1.01	0.88	0.90	0.87	0.98
Textile yearn, fabrics, etc.	0.85	0.89	0.89	0.99	1.02	1.07	1.06	1.08	0.92	0.93	0.91	0.92
Iron ore	1.02	1.03	0.89	0.92	0.98	1.00	0.94	0.94	1.01	1.09	0.87	0.93
Iron, steel & ferro-alloys	0.83	0.95	0.89	0.95	0.84	0.89	0.82	0.98	0.96	1.03	0.91	0.93
Aluminium	0.73	0.99	0.80	0.89	0.80	0.84	1.02	1.10	0.90	0.95	0.96	0.99
Non-ferrous ores & metals	0.84	1.00	0.96	1.02	0.73	0.77	0.97	1.04	0.87	0.98	0.87	0.97
Crude ferti., crude minerals & coal	0.94	0.98	0.88	0.93	1.00	1.08	0.90	0.94	0.93	0.99	0.85	0.88
Non-metallic minerals	0.94	0.97	0.75	0.84	0.84	1.06	0.99	1.02	0.90	0.92	0.97	1.00
Rest: rubber; electr. energy	0.79	0.91	0.93	1.06	0.87	0.94	0.73	0.87	0.83	0.89	0.96	1.07
Oil & gas	0.84	0.92	0.92	1.23	0.78	1.11	0.71	0.84	1.02	1.04	0.93	1.00
Organic chemicals	0.94	1.01	0.87	0.98	0.86	0.94	0.85	0.92	0.76	0.84	1.05	1.12
Inorganic chemicals	0.48	0.79	0.79	0.86	0.70	0.97	0.72	0.99	0.97	1.13	0.79	0.87
Dyestuffs, colouring materials	0.84	0.94	1.01	1.03	0.90	0.94	0.94	0.97	0.85	0.93	0.89	0.93
Pharmaceuticals	0.98	1.01	0.89	0.93	0.87	0.92	1.00	1.02	0.93	0.96	1.03	1.11
Fertilizers, manufactured	0.80	0.86	0.90	1.00	0.65	0.99	0.58	0.79	0.93	1.10	0.83	0.94
Plastic materials	0.90	0.95	0.89	0.94	0.90	0.96	0.81	0.89	0.67	0.77	0.87	0.97
Other chemicals	0.86	0.92	0.91	0.94	0.84	0.96	0.96	1.02	0.84	0.97	0.89	0.93
Agricul. & food proces. mach.	0.97	1.00	0.92	0.95	0.90	0.93	0.83	0.94	1.03	1.08	0.91	0.93
Textile & sewing machines	0.98	1.03	0.91	0.94	0.97	0.98	0.97	1.00	0.88	1.00	0.91	0.99
Paper & pulp machinery	0.95	0.98	0.81	0.93	0.95	1.02	0.98	1.02	0.95	0.99	0.98	0.99
Mach. for other spec. indu./proces.	0.98	1.00	0.92	0.93	1.00	1.04	1.00	1.02	0.98	0.99	0.99	1.01
Heating & cooling equipment	0.96	0.99	0.87	0.92	0.87	0.96	0.95	0.98	0.84	0.86	0.84	0.91
Metalworking machinery	1.00	1.01	0.96	0.97	0.96	0.99	0.94	0.96	0.94	0.96	0.97	0.99
Power generating machinery	1.03	1.07	0.96	0.98	0.93	0.95	0.70	0.87	0.90	0.98	0.97	1.01
Pumps & centrifuges	0.91	0.94	0.93	0.97	0.89	0.93	0.93	0.94	0.88	0.94	0.97	0.99
Typewriters & office mach.	0.91	0.96	0.79	0.92	0.82	1.11	0.70	1.00	0.78	0.95	0.92	1.12
Computers & peripherals	0.95	1.00	0.77	0.92	0.85	0.98	0.92	0.99	0.95	1.01	0.91	0.96
Semiconductors	0.71	1.00	0.84	0.94	0.93	1.02	0.95	0.99	0.87	0.92	0.91	0.97
Telecommunications equipment	0.75	0.81	0.83	0.91	0.93	1.02	0.87	1.01	0.99	1.07	0.90	0.94
Mach. for prod. & dist. of electricity	0.90	0.94	0.88	0.92	0.79	0.92	0.71	0.85	0.83	0.89	0.91	0.99
Consumer electronics	0.76	0.90	0.95	1.05	0.81	0.94	0.96	1.00	0.80	0.96	1.04	1.14
Domestic electrical equipment	0.90	1.01	0.88	0.95	0.87	0.93	0.90	0.97	0.82	0.86	0.92	1.01
Electromedical equipment	0.94	0.98	0.92	0.95	0.93	0.98	0.97	1.06	0.90	0.95	0.94	0.95
Non-elec. medical equipment	0.96	0.98	0.79	1.09	0.86	0.93	0.95	1.00	0.92	0.95	0.94	0.95
Measuring & control. instrum.	0.95	0.97	0.98	0.99	0.92	0.96	0.94	1.00	0.95	0.98	0.82	0.85
Photogr. & optical goods, watches	0.97	0.98	0.83	0.93	0.93	0.95	0.99	1.00	0.94	0.96	0.96	0.98
Railway vehicles	0.90	1.03	0.78	0.97	0.78	0.98	0.62	0.79	0.42	1.21	0.51	0.94
Road motor vehicles	0.98	1.04	0.96	0.99	0.90	0.93	1.00	1.01	0.97	0.99	0.98	0.99
Aircraft	0.91	0.96	0.95	0.98	0.95	1.02	0.92	1.02	0.87	0.96	0.99	1.01
Ships and boats (& oilrigs)	1.00	1.03	0.85	0.90	0.92	1.03	0.94	1.00	0.85	0.97	0.67	0.92
Other non-electrical equipm.	0.88	0.90	0.97	0.99	0.88	0.92	0.97	0.99	0.91	0.93	1.04	1.06
Other electrical equipment	0.88	0.90	0.98	1.03	0.99	1.01	0.91	0.94	0.89	0.92	0.98	1.01
Manufactures of metal	0.86	0.92	0.84	0.86	0.94	1.01	0.80	0.87	0.83	0.93	0.99	1.02
Furniture	0.92	0.96	1.08	1.12	0.84	0.89	0.84	0.94	0.91	0.99	0.90	0.93
Clothing	0.74	0.88	0.67	1.00	1.07	1.14	1.10	1.13	1.01	1.03	0.98	1.01
Orthopaed. eq. & hearing aids	0.90	0.94	0.81	0.94	1.04	1.18	0.86	0.93	0.90	0.92	0.91	0.99
Industrial products, n.e.s.	0.92	0.95	0.92	0.96	0.93	0.99	0.93	0.96	0.79	0.88	1.02	1.06
Mean (unweighted)	*0.91*	*0.97*	*0.89*	*0.96*	*0.90*	*0.98*	*0.90*	*0.97*	*0.90*	*0.97*	*0.93*	*0.98*

Danish **R**esearch **U**nit for **I**ndustrial **D**ynamics

The Research Programme

The DRUID-research programme is organised in 3 different research themes :

- The firm as a learning organisation

- Competence building and inter-firm dynamics

- The learning economy and the competitiveness of systems of innovation

In each of the three areas there is one strategic theoretical and one central empirical and policy oriented orientation.

Theme A: The firm as a learning organisation

The theoretical perspective confronts and combines the ressource-based view (Penrose, 1959) with recent approaches where the focus is on learning and the dynamic capabilities of the firm (Dosi, Teece and Winter, 1992). The aim of this theoretical work is to develop an analytical understanding of the firm as a learning organisation.

The empirical and policy issues relate to the nexus technology, productivity, organisational change and human ressources. More insight in the dynamic interplay between these factors at the level of the firm is crucial to understand international differences in performance at the macro level in terms of economic growth and employment.

Theme B: Competence building and inter-firm dynamics

The theoretical perspective relates to the dynamics of the inter-firm division of labour and the formation of network relationships between firms. An attempt will be made to develop evolutionary models with Schumpeterian innovations as the motor driving a Marshallian evolution of the division of labour.

The empirical and policy issues relate the formation of knowledge-intensive regional and sectoral networks of firms to competitiveness and structural change. Data on the structure of production will be combined with indicators of knowledge and learning. IO-matrixes which include flows of knowledge and new technologies will be developed and supplemented by data from case-studies and questionnaires.

Theme C: The learning economy and the competitiveness of systems of innovation.

The third theme aims at a stronger conceptual and theoretical base for new concepts such as 'systems of innovation' and 'the learning economy' and to link these concepts to the ecological dimension. The focus is on the interaction between institutional and technical change in a specified geographical space. An attempt will be made to synthesise theories of economic development emphasising the role of science based-sectors with those emphasising learning-by-producing and the growing knowledge-intensity of all economic activities.

The main empirical and policy issues are related to changes in the local dimensions of innovation and learning. What remains of the relative autonomy of national systems of innovation? Is there a tendency towards convergence or divergence in the specialisation in trade, production, innovation and in the knowledge base itself when we compare regions and nations?

The Ph.D.-programme

There are at present more than 10 Ph.D.-students working in close connection to the DRUID research programme. DRUID organises regularly specific Ph.D-activities such as workshops, seminars and courses, often in a co-operation with other Danish or international institutes. Also important is the role of DRUID as an environment which stimulates the Ph.D.-students to become creative and effective. This involves several elements:

- access to the international network in the form of visiting fellows and visits at the sister institutions
- participation in research projects
- access to supervision of theses
- access to databases

Each year DRUID welcomes a limited number of foreign Ph.D.-students who wants to work on subjects and project close to the core of the DRUID-research programme.

External projects

DRUID-members are involved in projects with external support. One major project which covers several of the elements of the research programme is DISKO; a comparative analysis of the Danish Innovation System; and there are several projects involving international co-operation within EU's 4th Framework Programme. DRUID is open to host other projects as far as they fall within its research profile. Special attention is given to the communication of research results from such projects to a wide set of social actors and policy makers.

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