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Do export and technological specialisation patterns co-evolve in terms of convergence or divergence? Evidence from 19 OECD countries, 1971–1991

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Abstract. Several researchers looking at the development of international export specialisation patterns have shown that there is a weak tendency for OECD countries to exhibit decreased levels of specialisation. This finding is in contrast to findings made by other authors, who found *increasing* technological specialisation. The first aim of this paper is to investigate whether these contradictory findings are due to a 'real world' phenomenon, or whether the explanation is purely technical, by comparing the development of export specialisation to specialisation in terms of US patents, using the same methodology and level of aggregation. The second aim is to analyse the extent to which countries and sectors display stable specialisation patterns over time, also both in terms of exports and in terms of technology. The paper confirms that the OECD countries tend in general to become less specialised in terms of exports. The evidence is less conclusive with regard to technological specialisation, as the results are mixed in the sense that just about half of the countries tend to exhibit increased levels of specialisation, while the other half tend to exhibit lower levels of specialisation. In terms of country and sectoral stability of specialisation patterns, it can be concluded that both trade specialisation and technological specialisation patterns are path-dependent. In comparison, however, trade specialisation patterns are more stable than are technological specialisation patterns.

Key words: Trade specialisation – Technological specialisation – Structural change

JEL-classification: C23, F14, O31, O57

1 Introduction

The issue of whether countries tend to become more or less similar over time, in terms of specialisation patterns is an important one, since the *assumption* of increased sectoral specialisation, has been the rationale underlying most of the thinking on international free trade (also in organisations such as the World Trade Organisation and in the World Bank). The present paper examines this assumption.

In previous research (Dalum, Laursen and Villumsen, 1998), it was shown that in the period from 1965 to 1992 there were a general tendency for 20 OECD countries to de-specialise (refers to a process in which the sectoral distribution for each country becomes less dispersed) as concerns international export specialisation. This finding is in contrast to other findings, such as Archibugi and Pianta (1994). Archibugi and Pianta (1992, 1994), as well as Cantwell (1989, 1991), who found increasing technological specialisation from the late 1970s to the early 1980s, measured as specialisation in US patents. The first aim of this paper is to investigate whether these seemingly contradictory findings are due to a ‘real world’ phenomenon, or whether the explanation is purely technical, by comparing the development of export specialisation to specialisation in terms of US patents[1]. The second aim of the paper is to analyse the extent to which countries and sectors display stable specialisation patterns over time, both in terms of exports and technology.

One of the contributions made by Dalum et al. (1998), was the distinction between specialisation (or de-specialisation) in trade patterns, on the one hand, and divergence (or convergence) on the other. A specialisation process refers to a process in which specialisation *intra-country* becomes more dispersed (and conversely for de-specialisation). In other words, the concepts of specialisation/de-specialisation refer to the sectoral distribution of a country. By contrast, a divergence process refers to a process in which countries become more different in terms of specialisation in a particular sector (and conversely for convergence). However, the estimations made by Dalum et al. (1998) were made with separate estimations for countries and sectors, respectively. In this paper, the stability characteristics of both trade and technological specialisation patterns will (respectively) be estimated for both countries and sectors in a single model.

The paper is structured as follows. Section 2 contains a theoretical discussion of the issues involved, while Section 3 contains the empirical analysis. The conclusion of the paper can be found in Section 4.

2 Theoretical discussion

This section will outline some theoretical considerations in relation to the issues considered in the paper. First, we will discuss the common forces that might change or preserve technological and trade specialisation over time (Section 2.1). Second, a discussion of mechanisms that can lead to a divergence between technological and trade specialisation patterns, can be found in Section 2.2. The propositions developed will be tested in the empirical part of the paper.

[1] By a ‘real world phenomenon’ we mean that there is some economic explanation underlying the observed differences, while a ‘technical explanation’ refers to differences in ways of measuring specialisation

2.1 Structural change and patterns of specialisation

2.1.1 Persistence in specialisation patterns

In the evolutionary literature, it is recognised that important aspects of technology are mainly specific and tacit in nature, to a large extent embodied in persons and in institutions, in addition to being cumulative over time (Dosi, Pavitt and Soete, 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, enabling them to build on their 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. Thus, given that firms make up most of the exports (and technology) of a country, one should expect that specialisation patterns remain stable over long time periods.

Furthermore and from a neoclassical point of view, Krugman (1987) presents 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 in the pattern.

2.1.2 Structural change and patterns of specialisation

Beelen and Verspagen (1994) argue that, one should expect the highest degree of structural change in specialisation patterns among catching-up countries, as opposed to high income countries and poor slow-growing countries. Beelen and Verspagen reverse the arguments of Pasinetti (1981), who maintained that the extent to which the specialisation structure of a country is similar to that of the leading countries - the countries operating at the world's 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 better able to adopt 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 becomes 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.

From the supply-side, and based on the Dixit and Stiglitz (1977) model of monopolistic competition and expanding product variety, Krugman (1989) presents a neoclassical model portraying the role of structural change in growth processes. The idea is that countries expand their product variety as they grow, and thus face favourable income elasticities at the aggregate level. Hence, again we should expect the fastest degree of structural change among catching-up countries.

Concerning the relationship between structural change and the types of products/technologies, it can be argued that more sophisticated products are more difficult to transfer across borders, as production techniques for these products are complex and hence hard to codify (Dosi et al., 1990). Therefore, we would expect high-tech products to be more stable across national borders, when compared to other more low-tech products. This idea is consistent with the so-called product-life-cycle theories (Vernon, 1966; Grossman and Helpman, 1991), in which high-tech products are developed in the home country, while more mature products spread out to be produced abroad (in less sophisticated countries).

The Heckscher-Ohlin-Samuelson (HOS) model states that comparative advantage is determined by the interaction between nations' resources (the relative abundance of factors of production) and the technology of production (which influences the relative intensity with which different factors of production are used in the production of different products). Hence, the prediction is that a country will export those goods which use most intensively the country's more abundant factors of production. However, the model has implications also in the context of this paper, as the model predicts increasing specialisation - all other things being equal - if trade barriers are reduced, given different factor endowments[2].

Nevertheless, countries might not only specialise inter-industry, they might also specialise intra-industry, due to product differentiation. In this context, a distinction between horizontal and vertical product differentiation can been made. Horizontal product differentiation occurs when imports and exports between two countries involves basically the same products of similar quality, but with different characteristics, while vertical product differentiation refers to two-way trade in similar products of varying quality. The theoretical basis for the former type of product differentiation was developed by Lancaster (1980), Krugman (1981) and Helpman (1981), and more recently by Bergstrand (1990). These models suggest that the more similar countries are in terms of their endowments and incomes, the greater the share of horizontal intra-industry trade.

Theoretical models of the latter type of product differentiation were developed by Falvey (1981) and by Flam and Helpman (1987). In the Flam and Helpman model, the share of bilateral intra-industry trade between the North and the South

[2] In this context it can be noted that European integration has been on-going throughout the period in question (for documentation of growing intra EU trade, see Ben-David, 1991). It should be stressed that the prediction is the same from more recent models of 'dynamic' comparative advantage (e.g., Grossman, 1992)

is systematically related to differences in product quality. The North is assumed to export higher quality products, while the South produces lower quality products. Two-way trade occurs when the quality range being produced does not exactly match the product versions being demanded.

The discussion in this subsection lead to a number of propositions: (a) patterns of specialisation will display persistence over long time periods; (b) catching up countries will experience the fastest rate of change in the patterns of specialisation; (c) low-tech products will be more footloose than high-tech products; and finally (d) when economic integration is a central feature of development, specialisation patterns of countries will diverge (or put differently, the level of specialisation will increase).

2.2 The relationship between trade and technological specialisation

The previous section discussed the relationship between growth processes, on the one hand, and the change in specialisation patterns, on the other. This section will discuss the mechanisms which might make technological specialisation and trade specialisation patterns move in the same direction, or make them move in different directions. The discussion will be carried out in terms of *technology as a determinant of trade*, (natural resource) *endowments*, the role and properties of *knowledge* in relation to the localisation of business activities, and finally in terms of *measurement* problems.

Technology as a determinant of trade. Under the label of ‘technology gap theory’, Posner (1961) introduced the idea that temporary monopoly profits can be appropriated, based on a technological lead, in an international trade context. Given the assumption that technology is not a free and universally available good, Posner argued that, while technology might be important for trade in some sectors, and not in others, innovations made in one country would benefit that country as long as the lead could be kept. That is, a country will have ample first-mover advantages in a given sector, until other countries have imitated the innovation. From an empirical point of view, the technology gap theory has gained support from Soete (1981) and from Dosi et al. (1990). Based on cross-country regression analysis, for a single year, these two studies showed that among 40 sectors, about half were found to be influenced by technological specialisation (measured as US patents) in the same sector. From a panel data perspective, in a dynamic setting - in an aggregate country perspective - Amendola, Dosi and Papagni (1993) found convincing support for the hypothesis as well. Also applying panel data - and from a sectoral as well as a country-wise perspective - Amable and Verspagen (1995) showed that competitiveness in trade was significantly influenced by technological capabilities (US patenting) in eleven out of the eighteen sectors in question, when using a dynamic specification of the model.

Endowments. Although the Heckscher-Ohlin-Samuelson (HOS) model has been unable to explain the pattern of trade in general (Bowen, Leamer and Sveikauskas, 1987; Krugman, 1996), there are a number of commodities for which the model does work. For instance, it is clear that natural resource based commodities are in general exported from countries endowed with the relevant natural resources (e.g., agricultural products are exported from countries with abundant arable land). Given that some commodities are ‘bound’ to their natural resource endowment-base, we should expect that physical commodities are going to be more ‘sticky’ in relation to transfer of production across national borders, when compared to the corresponding technology class.

Knowledge and localisation. The general framework now used in the standard textbook for the analysis of the multinational enterprise (MNE) is due to Dunning (see e.g., Dunning, 1988), and offers a three part explanation of the existence of multinationals (known as the *OLI* paradigm). Multinationals can be explained by the *ownership* advantages enjoyed by the firm, the *location* advantages of foreign operation, and the *internalisation* advantages of keeping kinds of transactions within the firm. Foreign direct investment by, say, Nissan in the UK might be explained by the attraction of European consumers to particular qualities of Nissan’s cars, the need to produce some of these products in Europe to avoid protectionist barriers to imports from Japan, or to encourage quicker corporate responses to local market needs. Formal models with the aim of incorporating some of these insights into trade theory have been developed by, e.g., Markusen (1984) and Ethier (1986). These models allow the spatial separation of ‘headquarter services’ in terms of management and R&D on the one side, and production on the other. Given that a spatial separation (over national borders) between production and R&D exist, we cannot expect the evolution of technological specialisation and trade specialisation to be perfectly congruent.

Measurement. One possible cause of divergence between the development of technological and trade specialisation patterns is that trade specialisation might be determined by factors other than technology. In this way, Posner (1961) argued that technology is an important determinant of trade in some sectors, but not in others. One of the reasons for technology not being so important for trade in some sectors might be that production technology flows more easily across national borders in these sectors. Another potential measurement problem has to do with so-called ‘multi-technological’ characteristics of products. Granstrand and Sjölander (1990) point out that the product-technology relationship in firms is not of a one-to-one kind. Given the complexity of products, firms are often characterised as ‘multi-technological’: the development, production and use of a product usually involve more than one technology, and each component can be applied in more than one product. As a consequence, firms require the ability to orchestrate several technologies. A somewhat extreme case in this context is the evidence provided by Patel and Pavitt (1994). They show that among 440 of the world’s largest firms, companies situated in the industry ‘motor vehicles’ only take out 28.8 per cent of their patents in the technology class ‘transport’. Given that one of the ingredients in gaining competitiveness in automobiles is the application of electronics, it is not surprising that 20.7 per cent of the patents taken out in the US by companies in ‘motor vehicles’, were situated in the patents class ‘electrical equipment’ (including electronics). However, this line of argument should not be stressed too far, since the evidence provided by Patel and Pavitt also displays a broad concordance between the firms’ principal product group. The problem should be kept in mind, but as we are applying a data set in this paper at a relatively high level of aggregation, the problem is to some extent alleviated.

The discussion in this subsection leads to two propositions: (e) technological specialisation is less ‘sticky’ than is trade specialisation; and, (f) although several mechanisms, leading trade and technological specialisation to diverge, can be identified, trade and technological specialisation will tend to co-evolve.

3 Empirical analysis

3.1 The data

The export data used here are taken from the OECD STAN database (1995 edition), in which data are available from 1970 onwards. The patent data are taken from the US Patent Office. The attribution of patents to countries and industrial sectors is done by the patent office. In this context, it should be pointed out that such an attribution of technical patents to economic sectors necessarily involves some degree of approximation. However, the measure does correlate with other measures of technology at the sectoral level, such as R&D statistics (a technology input measure). Furthermore, we argue that patent data are the best available measure of technology output, partly because the data are available on a yearly basis, over a long time span. Whenever a patent is attributed to more than one, say m sectors, the patent is counted as $1/m$ in each of these. Hence we follow Verspagen (1997) and argue that the secondary assignments of patents contain useful knowledge, relevant for economic activity (in many studies of technological development, only the first reference on the patent is used, e.g., in Patel and Pavitt, 1994, 1997). In the previous section it was pointed out that the product-technology relationship is not always one-to-one. When a patent contains more than one reference to a product class, this can be said to reflect the fact that technologies can be applied to several products, and by assigning patents to all relevant product classes we further alleviate the potential ‘multi-technology’ problem. It was decided to work with US patents, rather than patent statistics from each of the national patent offices, because US patents are subject to a common institutional system (novelty requirements etc.), and, moreover, the US, for most of the period under consideration, constituted the largest ‘technology market’ in the world.

The variable chosen for measuring specialisation is Revealed Comparative Advantage (Balassa, 1965):

$$RCA_{ij} = \frac{X_{ij} / \sum_i X_{ij}}{\sum_j X_{ij} / \sum_i \sum_j X_{ij}}. \qquad (1)$$

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_{ij} index, thus, contains a comparison of national export structure with the OECD export structure. When RCA_{ij} equals one, for a given sector in a given country, the percentage share of that sector is identical with the OECD average (all export data are in current prices and are converted into US dollars). Where RCA_{ij} is above one the country is said to be specialised in that sector. However, since the RCA_{ij} turns out to produce data that do not conform to a normal distribution, the index is made symmetric, as $(RCA_{ij} - 1)/(RCA_{ij} + 1)$; this measure ranges from -1 to +1, and is labelled 'Revealed Symmetric Comparative Advantage' ($RSCA_{ij}$). The calculation of technological specialisation (US patents) is analogous, and hence termed 'Revealed Symmetric Technological Advantage' ($RSTA_{ij}$)[3].

In order to avoid problems of small numbers, the patent data were aggregated over three years, so that the midyear for the patents corresponds to the year chosen for exports. In this way, the patents in the first set of observations are the sum of the patents 1971-73, while the corresponding export figures are taken from 1972. The second set of observations in terms of patents is the sum of US patents 1974-76, corresponding to export figures from 1975, and so on.

3.2 Are countries becoming more or less specialised in trade and technology?

3.2.1 Methodology: presentation and discussion

In order to test whether countries are stable across sectors and whether they tend to become more or less specialised intra-country, we are going to employ a method first used in the context of specialisation by John Cantwell (1989). His basic source of inspiration was a 'Galtonian' regression model presented by Hart and Prais (1956). Stability (and specialisation trends) is tested by means of the following regression equation (country by country):

$$RSCA_{ij}^{t_2} = \alpha_i + \beta_i RSCA_{ij}^{t_1} + \varepsilon_{ij} \ . \qquad (2)$$

The superscripts t_1 and t_2 refer to the initial year and the final year, respectively. The dependent variable, $RSCA_{ij}$ at time t_2 for sector i, is tested against the independent variable, which is the value of the $RSCA_{ij}$ in the previous year t_1. α and β are standard linear regression parameters, and ε_{ij} is a residual term. It should be pointed out that the method is one of comparing two cross-sections at two points in time; i.e. there is no element of time in the observations.

[3] The $RSCA_{ij}$ has, e.g., been applied by Laursen (1996) and by Dalum et al. (1998). Another and very similar measure to the $RSCA_{ij}$ has been applied by Hariolf Grupp in various publications (see, e.g., Grupp, 1994; Grupp, 1998). The so-called RPA can be defined as:

$$RPA_{ij} = (RTA_{ij}^2 - 1)/(RTA_{ij}^2 + 1) * 100$$

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 tends to become more specialised in sectors where it is already specialised, and less specialised where initial specialisation is low - i.e. the existing pattern of specialisation is strengthened. If one makes an analogy to the convergence literature, $\beta > 1$ might be termed *β-specialisation*. Similarly, $0 < \beta < 1$ can be termed *β-de-specialisation*, i.e.,*on average* sectors with initial low *RSCA*s increase over time, while sectors with initial high *RSCA*s decrease their values. The magnitude of $(1 - \beta)$ therefore measures the size of what has been termed the ‘regression effect’, and this is the interpretation placed on the estimated coefficient of β in the present paper. In the special case where $\beta < 0$, the ranking of sectors has been reversed. Those *RSCA*s initially below the country average are in the final year above average, and vica 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.

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 $\beta > 1$ is not a necessary condition for an increase in the overall national specialisation pattern. With reference to Hart (1976) it can be shown that:

$$\sigma_i{}^{2t_2}/\sigma_i{}^{2t_1} = \beta_i^2/R_i^2, \tag{3a}$$

where σ^{2t_2} and σ^{2t_2} are the variances at time t_1 and t_2, respectively. R_i^2 is the coefficient of determination from the regression set up in Equation (2) above. From Equation (3a) it follows that:

$$\sigma_i^{t_2}/\sigma_i^{t_1} = |\beta_i/R_i| \ . \tag{3b}$$

Hence, the dispersion 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. Thus making the same kind of analogies as above, one might term this *σ-specialisation*. If $\beta < R$ (equivalent to a decrease in the dispersion) the degree of specialisation has decreased. Likewise, such a situation can be described as *σ-de-specialisation*. Whether countries tend to specialise or de-specialise is an empirical question. However, the outcome has important implications. We shall discuss these implications in the conclusion.

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 farther apart, quite possibly to the extent that the ranking of sectors changes. The value of (1-R) measures what has been described as the ‘mobility effect’. It may well be that, even where the 'regression effect' $(1-\beta)$ suggests a fall in the degree of specialisation due to a proportional change in sectors towards the average ($\beta < 1$), this is outweighed by the mobility effect, due to changes in the proportional position between sectors ($\beta > R$). Thus, we can 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 treated with care. In general, the R^2 is a decomposition of the variance (σ^2) of the dependent variable, $RSCA_{ij}$ 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 $RSCA_{ij}$ and the error term ε_{ij}. The combination of $\beta < 1$ and $\beta > R$, 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_{ij}. The mechanism causing increased standard deviation (dispersion) of the final *RSCA*s, in the case of $\beta < 1$, is the existence of a positive variance of the residual term - i.e. the increased standard deviation of the final *RSCA*s is partly caused by the residual and therefore not by a recognisable economic explanation (such as cumulativeness). 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).

In order to compare our results to, e.g., the results of Archibugi and Pianta (1992, 1994), and their studies of technological specialisation, we have included results, based on the χ^2 measure of specialisation (in Tables 2 and 3). The χ^2 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:

$$\chi^2 = \sum_i \left[\left[\left(X_{ij} \Big/ \sum_i X_{ij} \right) - \left(\sum_j X_{ij} \Big/ \sum_i \sum_j X_{ij} \right) \right]^2 \Big/ \left(\sum_j X_{ij} / \sum_i \sum_j X_{ij} \right) \right] . \tag{4}$$

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 an 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 $|\hat{\beta}/\hat{R}|$, i.e. to measure the changes in dispersion.

3.2.2 Estimation results

First we present the extent to which countries are specialised, as measured by the standard deviation[4] of the specialisation pattern for each of the 19 OECD countries. The standard deviations are given in Table 1. From the table it can be seen that the level of specialisation is quite similar for export and patents

[4] An alternative could be to use the coefficient of variation. However, there will only be differences between the standard deviation and the coefficient of variation if very large differences in sector or country sizes exist. In this particular case, it does not matter which measure is used

Table 1. The standard deviation for export and technological specialisation patterns 1971–73 for 19 OECD countries in descending order (n = 19 sectors)

Country	Exports	Patents
Greece	0.52	0.65
Norway	0.49	0.44
Australia	0.45	0.30
Finland	0.45	0.42
Japan	0.44	0.20
New Zealand	0.42	0.55
Denmark	0.40	0.46
Portugal	0.40	0.69
Spain	0.39	0.44
Austria	0.38	0.30
Canada	0.37	0.19
Belgium	0.33	0.36
The Netherlands	0.32	0.29
Sweden	0.32	0.31
United States	0.26	0.04
Italy	0.26	0.19
Germany (West)	0.25	0.21
France	0.16	0.22
United Kingdom	0.15	0.13

Note: For a description of the 19 sectors, see Table 4.

for each country (ρ=0.67 and significant at the 1 per cent level). The table also confirms the findings of Balassa (1965) and Dosi et al. (1990), for both exports and technology, showing that small countries are more specialised than large countries. Given the country size, countries less developed in 1972 (Greece, Spain, Portugal) were more specialised, compared to the other countries.

The results displayed in Table 2 confirm the findings of Dalum et al. (1998), showing that the OECD countries did in general *tend to* de-specialise in terms of export specialisation, over the period.[5] This conclusion stands, both when the χ^2 measure is used, and when the $|\hat{\beta}/\hat{R}|$ is applied. The evidence is less conclusive with regard to technological specialisation (Table 3), as the results are mixed in the sense that just about half of the countries tended to increase in terms of the level of specialisation (for the two sub-periods), while the other half tended to engage in de-specialisation. In each of the two sub-periods, 11 out of 19 countries (1971-73 to 1980-82) and 10 out of 19 (1980-82 to 1989-91) countries tended to increase the level of specialisation (measured as $|\hat{\beta}/\hat{R}|$). Over the full period, only 6 out of 19 countries tended to increase in terms of specialisation. This finding is, however, not robust to the measure used, as 11 out of 19 countries tend to increase their level of specialisation over the full period, when using the χ^2 measure. However it should be pointed out that only in a few cases are the $|\hat{\beta}/\hat{R}|$ significantly different from one (Germany for trade and France and the US for technology). Hence it can be concluded that while σ-de-specialisation is not a strong trend, we are certainly not experiencing σ-specialisation.

[5] This finding is consistent with, e.g., Proudman, and Redding (1997), who found that Germany and Great Britain showed no sign of increased export specialisation from 1970 to 1993

Table 2. The development of trade specialisation patterns 1971–1991 for 19 OECD countries (n = 19 sectors)

	1971–73 to 1989–91			1971–73 to 1980–82			1980–82 to 1989–91		
	$\hat{\beta}$	$\hat{\beta}/\hat{R}$	χ^2_{t2}/χ^2_{t1}	$\hat{\beta}$	$\hat{\beta}/\hat{R}$	χ^2_{t2}/χ^2_{t1}	$\hat{\beta}$	$\hat{\beta}/\hat{R}$	χ^2_{t2}/χ^2_{t1}
Australia	0.83*#	0.97	0.77	0.87*	0.98	0.94	0.96*	0.98	0.81
Austria	0.87*	0.95	0.63	0.96*	1.05	1.01	0.87*#	0.91	0.62
Belgium	0.99*	1.06	1.20	1.03*	1.10	1.12	0.93*	0.97	1.08
Canada	0.80*#	0.98	0.67	0.78*#	0.89	0.68	1.01*	1.10	0.98
Denmark	0.89*	0.94	0.89	0.96*	0.98	1.08	0.93*	0.96	0.83
Finland	0.74*#	0.91	0.63	0.93*	0.99	0.69	0.72*	0.92	0.91
France	0.63*#	0.94	0.95	0.76*#	0.88	0.76	0.83*	1.06	1.24
Germany (West)	0.43*#	0.67+	0.60	0.45*#	0.65+	0.51	0.93*	1.04	1.18
Greece	0.94*	1.04	1.59	0.95*	1.04	1.05	0.97*	1.00	1.51
Italy	0.72*#	0.93	1.46	0.88*	0.99	1.16	0.86*	0.94	1.26
Japan	0.94*	1.01	0.93	1.06*#	1.09	1.15	0.89*#	0.93	0.81
The Netherlands	0.68*#	0.81	0.88	0.91*	0.95	1.52	0.79*#	0.85	0.58
New Zealand	1.08*	1.20	0.65	1.03*	1.12	0.69	0.99*	1.07	0.94
Norway	0.83*#	0.94	1.18	0.89*#	0.95	0.72	0.94*	0.99	1.64
Portugal	0.60*#	0.87	1.65	0.87*	0.95	1.28	0.71*#	0.92	1.29
Spain	0.51*#	0.76	0.48	0.63*#	0.81	0.52	0.78*#	0.94	0.91
Sweden	0.65*#	0.85	0.76	0.98*	1.05	0.92	0.71*#	0.81	0.83
United Kingdom	1.02*	1.35	1.03	1.16*	1.27	0.88	0.93*	1.07	1.18
United States	0.81*#	0.87	0.70	1.03*	1.05	0.84	0.75*#	0.83	0.83
	0.79	0.95	0.93	0.90	0.99	0.92	0.87	0.96	1.02

Note: For a description of the 19 sectors, see Table 4.
* denotes significantly different from zero at the 10% level;
# denotes significantly different from unity at the 10% level (t-statistics calculated on the basis of White's heteroscedasticity consistent standard errors).
+ denotes that the hypothesis of equal variances, across the two points in time, can be rejected at the 10% level.

This finding appears to be in contrast to the results obtained by Cantwell (1991), and by Archibugi and Pianta (1992; 1994). Cantwell, using a classification encompassing 27 sectors, found that 11 out of 19 countries experienced an increase in specialisation from 1963-69 to 1977-1983. Archibugi and Pianta (1992) found that 11 out of 16 countries (across 41 patent classes) tended to increase the level of specialisation over the period 1975-81 to 1982-88. There can be several explanations for the difference. Firstly, Cantwell did not adjust the RTA_{ij} measure, in order to make it symmetric. As the use of the 'pure' RTA_{ij} gives too much weight to values above one, not adjusting for symmetry can produce biased results. If, for instance, some RTA_{ij} values above unity increase over time and some values below unity also increase, the conclusion by using the pure RTA_{ij} might be that the level of specialisation has increased, while in fact it remained neutral[6]. Secondly, the chi square measure tends to produce more extreme values as the difference between the export structure of the country in question and the export structure of the OECD is squared. Hence, the measure is more erratic over time, as compared to the $RSTA_{ij}$. Finally, the choice of time-

[6] For further discussion of this topic, see Laursen (2000, Chapter 3)

Table 3. The development of technological specialisation patterns 1971–1991 for 19 OECD countries (n = 19 sectors)

	1971–73 to 1989–91			1971–73 to 1980–82			1980–82 to 1989–91		
	$\hat{\beta}$	$\hat{\beta}/\hat{R}$	χ^2_{t2}/χ^2_{t1}	$\hat{\beta}$	$\hat{\beta}/\hat{R}$	χ^2_{t2}/χ^2_{t1}	$\hat{\beta}$	$\hat{\beta}/\hat{R}$	χ^2_{t2}/χ^2_{t1}
Australia	0.39#	0.78	1.11	0.76*	0.93	1.22	0.60*#	0.85	0.91
Austria	0.75*	1.10	1.01	0.65*	1.14	1.04	0.76*	0.97	0.98
Belgium	0.60*#	0.98	1.08	0.55*	1.04	0.77	0.77*	0.94	1.40
Canada	0.77*	0.99	0.93	0.96*	1.05	1.07	0.76*	0.93	0.87
Denmark	0.62*#	0.88	1.98	0.42*#	0.81	0.89	0.87*	1.09	2.22
Finland	0.25#	0.89	0.70	0.55*#	0.88	0.69	0.05#	1.00	1.02
France	0.10#	0.49+	0.96	0.21*#	0.47+	0.66	0.66*#	1.03	1.45
Germany (West)	0.77*	0.95	1.67	0.74*#	0.78	0.91	1.09*	1.23	1.83
Greece	0.18#	0.89	0.46	0.10#	1.11	1.94	0.11#	0.80	0.24
Italy	0.44#	1.14	1.40	0.88*	1.07	0.92	0.69*	1.07	1.53
Japan	0.89*	1.11	1.35	0.93*	1.06	0.91	0.99*	1.04	1.49
The Netherlands	0.73*	1.00	1.17	0.85*	0.97	0.99	0.71*	1.03	1.18
New Zealand	−0.19#	0.89	1.31	0.41*#	0.87	0.50	0.28#	1.03	2.60
Norway	0.29#	0.82	0.82	0.38#	1.02	1.49	0.34#	0.80	0.55
Portugal	0.12#	0.93	0.92	0.42#	1.02	1.43	0.15#	0.91	0.64
Spain	0.18#	0.79	0.92	−0.07#	1.16	1.29	0.53*#	0.68	0.71
Sweden	0.45*#	0.69	1.05	0.71*	0.89	1.61	0.61*#	0.78	0.65
United Kingdom	0.10#	1.19	3.03	0.68*	1.08	1.85	0.60*	1.10	1.64
United States	1.35*	2.18+	5.48	1.28*#	1.39+	2.08	1.08*	1.57+	2.63
	0.48	0.98	1.44	0.61	0.99	1.17	0.61	0.99	1.29

Note: For a description of the 19 sectors, see Table 4.
* denotes significantly different from zero at the 10% level;
# denotes significantly different from unity at the 10% level (t-statistics calculated on the basis of White's heteroscedasticity consistent standard errors).
+ denotes that the hypothesis of equal variances, across the two points in time, can be rejected at the 10% level.

periods might influence the results, as well as the level of aggregation applied. It should be pointed out, however, that our results appear not to be sensitive to the period applied in as far as the conclusion is that the there seems to be no particular increase or decrease in terms of the level of technological specialisation over the 1970s and the 1980s[7]. It should also be pointed out that neither Cantwell nor Archibugi and Pianta tested for the statistical significance of the increased level of specialisation.

As explained previously in this section, the size of $\hat{\beta}$ measures the degree of turbulence (or alternatively stability) of a specialisation pattern between two periods. However, as we are going to estimate a fuller model (Section 3.3, below), in a single estimation looking both at β-specialisation/de-specialisation (country-wise, across sectors), as well as β-divergence/ convergence (sector-wise, across countries), we are only going to discuss the stability characteristics briefly, as measured by $\hat{\beta}$ in Tables 2 and 3. It should be pointed out, however, that while the model estimated in Section 3.3 (Tables 4 and 5) below is based on data

[7] The sensitivity to the time periods chosen, was tested not only using the two sub-periods, shown in Tables 2 and 3, but also on six sub-periods, not explicitly documented for reasons of space

pooled over seven time periods, the results from Tables 2 and 3 are based on comparing end-points. Hence, the results discussed in this section is of a longer term nature, as compared to the model estimated in the section below.

If Tables 2 and 3 are compared, it can be seen that trade specialisation patterns appear to be more stable than technological specialisation patterns. This is not surprising, as trade specialisation is to some extent bound to natural endowments (as argued in the previous section); constraints which are not imposed on technological specialisation. In the shorter run (the two sub-periods 1971-73 to 1980-82 and 1980-82 to 1989-91), technological specialisation is cumulative (Table 3), as there is a significant and positive relationship between the specialisation pattern in the previous period, and the most recent period for 29 out of 38 pairs. Nevertheless, in the longer term (1971-73 to 1989-91), the relationship is only present in 9 out of 19 countries, showing that cumulativeness fades away over longer time periods. It can also be seen that all five OECD 'catch-up' countries in our sample (Finland, Greece, New Zealand, Portugal, Spain), out of the total of nine countries, for which no relationship could be detected in the longer run, are in fact OECD 'catching-up' countries. For six high-income countries (Austria, Canada, Germany, Japan, The Netherlands, and the United States), technological specialisation patterns are so stable, in the longer run, that the hypothesis of the specialisations patterns remaining unchanged between the two periods cannot be rejected. A large value of $\hat{\beta}$ can be noted for the US. Since $\hat{\beta}$ is larger than unity (although not statistically different from unity), this means that the US has increasingly specialised in areas where already strong, and de-specialised in areas of activity where already weak. If one makes a closer inspection of the US pattern of technological specialisation, it can be seen that a dramatic increase in specialisation in food, drink and tobacco has taken place (from $RSCA_{ij}$=0.06 in 1971-73 to $RSCA_{ij}$=0.21 in 1989-91). Also a strong decrease in motor vehicles can be detected (from $RSCA_{ij}$=-0.02 in 1971-73 to $RSCA_{ij}$=-0.17 in 1989-91). It can be seen that random elements have played a role for the US as well, as the level of σ-specialisation (2.18) is even higher and significant.

For what concerns trade specialisation (Table 2), the picture is less clear-cut, as there appear to be no clear distinction between catch-up countries on the one hand (although Finland, Italy, Spain and Portugal do have $\hat{\beta}$'s, significantly different from unity), and high-income countries on the other. Especially the low $\hat{\beta}$ for Germany is striking. However, as argued by Dalum et al. (1998), the change in the German specialisation pattern has not been characterised by radical change. Rather, closer inspection of the specialisation pattern of Germany reveals that the country has been in a process of de-specialisation, meaning that Germany has become (slightly) weaker in nearly all areas where it has been strong (but remains strong in these areas), while it has become stronger in areas of under-specialisation (but remains weak in these areas).

3.3 The stability characteristics of specialisation patterns across sectors and countries

In order to investigate the degree to which both countries and sectors are stable in their specialisation patterns over time, this paper applies a regression model, used in a dynamic setting by Magnier and Toujas-Bernate (1994), but also applied by Amable and Verspagen (1995). The specification is as follows:

$$RSCA_{ij}^{t} = \alpha_{ij} + (\beta_{\mu} + \beta_i + \beta_j)RSCA_{ij}^{t-1} + \varepsilon_{ij}\, , with \sum_i \beta_i = \sum_j \beta_j = 0\ . \qquad (5)$$

Each coefficient is the sum of an average coefficient (β_{μ}), a sector-specific coefficient (β_i), and a country-specific coefficient (β_j). One reason for applying this model is that it allows for direct comparison between the development of trade and trade specialisation patterns, as the size of the average coefficient, using export and patent data respectively, can be compared directly. If we wish to estimate a model with an average coefficient and variable slopes for each sector and country, such a model cannot be estimated, as it is not of full rank. However, the restrictions allow for estimating both sector- and country-specific coefficients in the same model. The basic procedure is to estimate the largest possible model of full rank, and then subsequently to estimate the remaining variables as a linear combination of the coefficients from the first step, while imposing the constraints (see Johnston, 1991, pp. 241-245). An alternative procedure (in order to make the model of full rank) would be to drop the average coefficient, and one other coefficient (e.g., a sector slope) and make the interpretation in one dimension (e.g., in the sectoral dimension) relative to a benchmark (a sector). Nevertheless, in the model used in this paper, the *levels* of the coefficients can be compared directly. The interpretation of the β's in Equation 5 is the same as in Equation 2. As mentioned in the previous section, the data has been pooled together over seven time periods[8], so that we get 2166 observations in total, for all sectors and countries.

The estimations, using Equation 5, can be found in Tables 4 and 5. It can be noted that the results have been found to be time invariant, for both trade and technology, using a Chow test for poolability over time. The F-statistics for the models in Tables 4 and 5 are 0.012 and 0.091 for trade and technology, respectively. Hence, the hypothesis of no structural change cannot be rejected at any reasonable level (p-values of 1.000 in both cases). From Tables 4 and 5 it can be concluded that both trade specialisation and technological specialisation patterns are path-dependent in the sense that all country and sectoral patterns are correlated between seven three-year intervals, within the period in question. In comparison, however, trade specialisation patterns are more stable than are technological specialisation patterns, as the average coefficient for trade is 0.93, while the coefficient is 0.64 for technology. Most of the sectors (textiles, footwear and leather; pharmaceuticals; petroleum refineries; rubber and plastics;

[8] The observations are: 1971-73, 1974-76, 1977-79, 1980-82, 1983-85, 1986-88, and 1989-91

Table 4. The development of trade specialisation patterns in terms of beta convergence (or divergence) over the period 1971–1991 (n = 2166)

		$R^2 = 0.93$		
	Estimate	p-value ($H_0 : \beta = 1$)	p-value ($H_0 : \beta$ =av. effect)	p-value ($H_0 : \beta = 0$)
Average coefficient	0.931	0.0000		0.0000
Coeff. per sector*				
Food, drink and tobacco	0.972	0.1219	0.0201	0.0000
Textiles, footwear and leather	0.950	0.0175	0.3659	0.0000
Industrial chemicals	0.936	0.0642	0.8767	0.0000
Pharmaceuticals	0.938	0.0064	0.7430	0.0000
Petroleum refineries (oil)	0.909	0.0320	0.6100	0.0000
Rubber and plastics	0.919	0.0030	0.6704	0.0000
Stone, clay and glass	0.986	0.5821	0.0232	0.0000
Ferrous metals	0.889	0.0006	0.1983	0.0000
Non-ferrous metals	0.941	0.0246	0.6922	0.0000
Fabricated metal products	0.904	0.0163	0.5007	0.0000
Non-electrical machinery	0.951	0.0285	0.3533	0.0000
Office machines and computers	0.932	0.0010	0.9531	0.0000
Electrical machinery	0.901	0.0078	0.4203	0.0000
Communication eq. and semiconductors	0.948	0.0242	0.4716	0.0000
Shipbuilding	0.909	0.0010	0.4247	0.0000
Other transport	0.879	0.0003	0.1182	0.0000
Motor vehicles	0.962	0.0418	0.0896	0.0000
Aerospace	0.916	0.0010	0.5630	0.0000
Instruments	0.941	0.0024	0.5775	0.0000
Coeff. per country**				
Australia	0.920	0.0040	0.6876	0.0000
Austria	0.954	0.1486	0.4565	0.0000
Belgium	0.963	0.2128	0.2760	0.0000
Canada	0.945	0.0186	0.5417	0.0000
Denmark	0.963	0.1281	0.1784	0.0000
Finland	0.924	0.0228	0.8458	0.0000
France	0.850	0.0050	0.1320	0.0000
Germany (West)	0.845	0.0022	0.0899	0.0000
Greece	0.947	0.0063	0.4196	0.0000
Italy	0.921	0.0031	0.7219	0.0000
Japan	1.014	0.3525	0.0000	0.0000
The Netherlands	0.893	0.0025	0.2880	0.0000
New Zealand	0.970	0.1504	0.0587	0.0000
Norway	0.962	0.0551	0.1060	0.0000
Portugal	0.858	0.0002	0.0561	0.0000
Spain	0.846	0.0000	0.0041	0.0000
Sweden	0.937	0.0206	0.8224	0.0000
United Kingdom	0.994	0.9039	0.1917	0.0000
United States	0.978	0.6133	0.2870	0.0000

*/** Sum of the average coefficient and the sector specific coefficients; and the sum of the average coefficient and the country specific coefficients, respectively.
Notes: Standard errors heteroscedasticity consistent, using White's method, corrected for d.f. Sector and country specific constants not reported for reasons of space.

Table 5. The development of technological specialisation patterns in terms of beta convergence (or divergence) over the period 1971–1991 (n = 2166)

		$R^2 = 0.44$		
	Estimate	p-value ($H_0 : \beta = 1$)	p-value ($H_0 : \beta$ =av. effect)	p-value ($H_0 : \beta = 0$)
Average coefficient	0.643	0.0000		0.0000
Coeff. per sector*				
Food, drink and tobacco	0.824	0.0609	0.0549	0.0000
Textiles, footwear and leather	0.493	0.0000	0.1980	0.0000
Industrial chemicals	1.173	0.0606	0.0000	0.0000
Pharmaceuticals	0.635	0.0147	0.9575	0.0000
Petroleum refineries (oil)	0.542	0.0000	0.2988	0.0000
Rubber and plastics	0.504	0.0101	0.4705	0.0091
Stone, clay and glass	0.595	0.0174	0.7777	0.0005
Ferrous metals	0.574	0.0002	0.5544	0.0000
Non-ferrous metals	0.546	0.0000	0.3394	0.0000
Fabricated metal products	0.769	0.1194	0.3938	0.0000
Non-electrical machinery	0.593	0.0247	0.7839	0.0011
Office machines and computers	0.584	0.0016	0.6574	0.0000
Electrical machinery	0.573	0.0200	0.7036	0.0018
Communication eq. and semiconductors	0.830	0.0562	0.0360	0.0000
Shipbuilding	0.599	0.0001	0.6581	0.0000
Other transport	0.382	0.0000	0.0387	0.0025
Motor vehicles	0.645	0.0007	0.9828	0.0000
Aerospace	0.694	0.0029	0.6142	0.0000
Instruments	0.658	0.0050	0.8991	0.0000
Coeff. per country**				
Australia	0.600	0.0000	0.5252	0.0000
Austria	0.767	0.0024	0.1053	0.0000
Belgium	0.716	0.0003	0.3437	0.0000
Canada	0.845	0.0420	0.0079	0.0000
Denmark	0.598	0.0000	0.5498	0.0000
Finland	0.653	0.0000	0.8898	0.0000
France	0.473	0.0000	0.0209	0.0000
Germany (West)	0.740	0.0000	0.1274	0.0000
Greece	0.141	0.0000	0.0000	0.1431
Italy	0.592	0.0000	0.5180	0.0000
Japan	0.988	0.8766	0.0000	0.0000
The Netherlands	0.870	0.0905	0.0032	0.0000
New Zealand	0.128	0.0000	0.0000	0.2119
Norway	0.531	0.0000	0.2125	0.0000
Portugal	0.280	0.0000	0.0001	0.0019
Spain	0.493	0.0000	0.0840	0.0000
Sweden	0.722	0.0000	0.1307	0.0000
United Kingdom	0.631	0.0001	0.9002	0.0000
United States	1.445	0.0623	0.0008	0.0000

*/** Sum of the average coefficient and the sector specific coefficients; and the sum of the average coefficient and the country specific coefficients, respectively.

Notes: Standard errors heteroscedasticity consistent, using White's method, corrected for d.f. Sector and country specific constants not reported for reasons of space.

ferrous metals; non-ferrous metals; non-electrical machinery; office machines and computers; electrical machinery; shipbuilding; other transport; motor vehicles; aerospace; and instruments) are turbulent to the extent that the hypothesis of an unchanged pattern of specialisation can be rejected at the 5 per cent level, for both trade and technological specialisation. Only for food, drink and tobacco, and industrial chemicals can the hypothesis of an unchanged pattern not be rejected for both types of specialisation. It can be seen from Tables 4 and 5 that textiles, footwear and leather is one of the sectors with the strongest difference between the development in trade and technological specialisation. The relatively low parameter value for this sector in Table 5 indicates that technology is more fluid in this sector, while the production (exports) is found to be relatively more stable. In the case of office machines and computers the opposite pattern can be observed. In this case, one interpretation could be that firms spread out their production (exports) facilities, while this is not the case when it comes to the production of technology. A similar (but stronger) conclusion can be made for what concerns fabricated metal products. The latter two cases are consistent with the models allowing for spatial separation of headquarter services (R&D and management) from production facilities, presented in Section 2.

Among the countries analysed, Australia, Finland, France, West Germany, Greece, Italy, Portugal, Spain, Sweden, and the United Kingdom display the highest degree of turbulence in specialisation patterns, across sectors and time. Again, the criterion is whether or not the hypothesis of an unchanged pattern can be rejected for both types of specialisation. By contrast, the specialisation patterns for Japan and for the US are path-dependent, to the extent that the hypothesis of an unchanged specialisation pattern cannot be rejected. The case of Japan is worth noting, as it is confirmed that the specialisation of that country remained very stable over the 1970s and the 1980s, while structural change took place in the 1960s (see Dalum et al., 1998, Appendix Table A2). It can be seen from Tables 4 and 5 that Denmark is one of the countries with the strongest difference between the development in trade and technological specialisation (there is also a striking difference for New Zealand). The trade specialisation pattern is very stable for Denmark, as the hypothesis of no change in the pattern of specialisation cannot be rejected. By contrast, this hypothesis is strongly rejected for technology. In terms of technological specialisation, Denmark has increased specialisation rather strongly in pharmaceuticals, but also to some extent in industrial chemicals. At the same time patenting activity has increased in almost all transport sectors, but starting from a very low level (Denmark remains under-specialised in these sectors).

As stated in the theoretical section, we expect catching-up countries to experience the highest degree of turbulence in the specialisation patterns over time. For the OECD ‘catch-up countries’ in this sample (Finland, Greece, Italy, Spain, and Portugal), we do find that the specialisation patterns of these countries (Spain and Portugal in particular, given the low coefficients) belong to the group of countries experiencing the highest degree of turbulence, both in terms of trade and technology. It should be pointed out that Greece (the slowest growing of these countries) only display a very high degree of turbulence in the case of technological specialisation. In terms of trade specialisation, the hypothesis of no structural change for Greece can be rejected, but the parameter is around the size of the average coefficient. But as compared to high-income countries, Greece is (and remains) specialised in low-tech sectors, and has nearly no activity in other sectors.

4 Conclusions

The first aim of this paper was to investigate whether the seemingly contradictory findings in the empirical literature on the development of technological specialisation and on export specialisation patterns, respectively, are due to a 'real world' phenomenon, or whether the explanation is purely technical, by comparing the development of export specialisation to specialisation in terms of US patents. The second aim was to analyse the extent to which countries and sectors display stable specialisation patterns over time, also both in terms of exports and in terms of technology. The conclusions will be drawn by making reference to the propositions set up in Section 2.

The paper confirms that the OECD countries did in general *tend to* de-specialise in terms of export specialisation. The evidence was (even) less conclusive with regard to technological specialisation, as the results were mixed in the sense that just about half of the countries tended to increase in terms of the level of specialisation, while the other half tended to engage in de-specialisation. However, it should be pointed out that the tendency towards de-specialisation is very weak, as it was statistically significant in a few cases only. Based on the discussion of the weaknesses of the alternative analyses (in particular, the bias due to the unadjusted RCA_{ij} and the bias due to the heavy weight attributed to extreme values when using the chi-square measure), and based on the results found in this paper, it can be concluded that the contradictory findings are to a large extent due to differences in the applied methodology, rather than being due to 'real world' differences between the two measures.

In terms of country and sectoral stability of specialisation patterns [proposition (a)], it was concluded that both trade specialisation and technological specialisation patterns are path-dependent in the sense that all country and sectoral patterns were correlated between seven three- year intervals, within the period in question. In comparison, however, trade specialisation patterns were more stable than were technological specialisation patterns [proposition (e)]. Among the countries, Australia, Finland, France, West Germany, Greece, Italy, Portugal, Spain, Sweden, and the United Kingdom displayed the highest degree of turbulence in the specialisation patterns, across sectors and time. By contrast, the specialisation patterns for Japan and for the US were path-dependent, to the extent that the hypothesis of an unchanged specialisation pattern could not be rejected, also for what concerns both technological and export specialisation. Concerning the hypothesis of OECD catching-up countries experiencing the highest degree of turbulence [proposition (b)] in the specialisation patterns, the results were not as clear-cut as they were in Dalum et al. (1998), since only Finland, Greece, Italy, Spain, and Portugal were consistently among the countries experiencing the highest degree of turbulence. The explanation has to do with the time periods considered, as Dalum et al. (1998) considered a period starting in 1965, while this paper started in 1971. In this way it appears as though Japan encountered a high degree of structural change in the 1960s, while this process stopped from the 1970s onwards. Fourteen sectors displayed structural change across countries and time, for both types of specialisation. Food, drink and tobacco, and industrial chemicals, on the other hand, were stable to the extent that the hypothesis of an unchanged specialisation pattern could not be rejected, in the case of both types of specialisation. Hence, in general, proposition (c), stating that ‘low-tech’ sectors are more footloose than ‘high-tech’ sectors, could not be confirmed, either in the case of exports, or in the case of technology.

Concerning proposition (f), stating that trade and technological specialisation will in general tend to co-evolve in terms of divergence or convergence, some support can be said to be given for this proposition as the parameters for structural adjustment were in general high (or low) for the same countries and sectors for the two types of specialisation, as the 38 parameters for export and technology correlate, although the relation is not extremely strong (ρ=0.29). However, we have also seen in this paper that there are a number of cases, where there is no co-evolution between the two types of specialisation.

A conclusion is that, while European integration has been on-going throughout the period, there has been no tendency for European countries to specialise in terms of trade specialisation [in contrast to what was stated in proposition (d)], or in terms of technological specialisation. Standard trade theory (Heckscher-Ohlin) would predict increasing specialisation - all other things being equal - if trade barriers are being reduced, given different factor endowments in various countries. Seen in that light, our findings may appear surprising. However, it is a ‘stylised fact’ that intra-industry trade has grown in a period of economic integration. On the basis of these findings, one can speculate that countries increasingly specialise according to consumer preferences (within the same industries), rather than specialising in different industries. Hence, the findings are more in line with theoretical models allowing for increasing returns and (vertically or horizontally) differentiated products, presented in the theoretical section of this paper. Such a finding has important policy implications, in particular with respect to catching-up countries, since the growth opportunities of these countries appear not to lie in (static) gains from deepening the already existing pattern of specialisation. Instead, such opportunities can be realised in a process of structural change in the patterns of specialisation.

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