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by
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**Contents**

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by

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Abstract:
Several researchers looking at the development of international export specialisation patterns have shown that there is a general tendency for OECD countries to de-specialise. This finding is in contrast to findings made by other authors, working on technological specialisation. These authors 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 did in general de-specialise in terms of export specialisation. 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 increase in terms of the level of specialisation, while the other half tend to engage in de-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 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 patters are more stable than are technological specialisation patterns.

*Keywords:* trade specialisation, technological specialisation, structural change

*JEL classification:* C23, F14, O31, O57

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## 1. Introduction

In previous research (Dalum *et al.*, forthcoming) it was shown that there has been a general tendency for 20 OECD countries to de-specialise in the period from 1965 to 1992 for what concerns export specialisation. This finding is in contrast to findings made by other authors working on technological specialisation (Cantwell, 1989; Cantwell, 1991; Archibugi and Pianta, 1992; Archibugi and Pianta, 1994), 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, using the same methodology. The second aim is to analyse the extent to which countries and sectors display stable specialisation patterns over time, also both in terms of export and technology.

One of the contributions made by Dalum *et al.* (forthcoming), was the distinction made between specialisation (or de-specialisation) in trade patterns on the one hand, and divergence (or on the contrary convergence) on the other. A specialisation process refers to a process in which specialisation *intra-country* becomes more dispersed (and counter-wise for de-specialisation). In contrast, 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). However the estimations made by Dalum *et al.* (forthcoming), were made making 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 one single model.

The paper is structured as follows. Section 2 contains a short theoretical discussion on 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 briefly outline some theoretical considerations in relation to the issues considered in this paper (for a more comprehensive treatment of the topic, see Dalum *et al.*, forthcoming).

In the evolutionary literature 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). 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.

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 the pattern in.

When it comes to structural change among catching-up countries, Beelen and Verspagen (1994) provides an argument stating 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 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 worlds 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.

# 3. Empirical analysis

## 3.1 The data

The export data are taken from the OECD STAN database (1995 edition), in which data is available from 1970 and onwards. The patent data are taken from the U.S. patent office, and concerns patent grants, dated by the year of grant. The attribution of patents to countries and industrial sectors is done by the patent office. Whenever a patent is attributed to more than one, say *m* sectors, the patent is counted as 1/*m* in each of these. It was chosen to work with U.S. patents because, rather than patent statistics from each of the national patent offices, US patents are subject to a common institutional system (novelty requirements etc.), and moreover, the U.S., for most of the period under consideration, constituted the largest ‘technology market’ in the world.

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

$$RCA_{ij} = \frac{X_{ij} / \sum_i X_{ij}}{\sum_j X_{ij} / \sum_i \sum_j X_{ij}}. \tag{1}$$

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 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. However, since the RCA turns out to produce data that does not conform to a normal distribution, the index is made symmetric, obtained as *(RCA-1)/(RCA+1)*; this measure ranges from -1 to +1. The measure is labelled 'Revealed Symmetric Comparative Advantage' (*RSCA*). The calculation of technological specialisation (US patents) is analogues, and hence termed 'Revealed Symmetric Technological Advantage' (*RSTA*).

In order to avoid small numbers problems, the patent data was aggregated together 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 is the sum of the patents 1971-1973, while the corresponding export figures are taken from 1972. The second set of observations in terms of patents is the sum of US patents 1974-1975, corresponding to export figures from 1975, and so on.

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

In order to test for 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):

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

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 $t_1$. $\alpha$ and $\beta$ are standard linear regression parameters and $\epsilon$ 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.

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 RSCAs increase over time while sectors with initial high RSCAs decrease their values. The magnitude of $(1-\beta)$ 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 $\beta<0$ 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.

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:

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

Thus,

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

It follows that 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 as *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 to our mind an empirical question. However, the outcome have 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 further apart, quite possibly to the extent that the ranking of sectors change. 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-$\beta$) suggest 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.

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 $\chi^2$ measure of specialisation (in Tables 2 & 3). The $\chi^2$ 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:

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

If a country has an export structure exactly similar to the OECD, the value of the indicator will be zero. The size of $\chi^2$ 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.

However, first we present the extent to which countries are specialised, as measured by the standard deviation 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 for each country ($\sigma$=0.67 and significant at the 1 per cent level). The table also confirm 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.* (forthcoming), showing that the OECD countries did in general de-specialise in terms of export specialisation, over the

**Table 1:** The standard deviation for export and trade 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 2.

period.[1] This conclusion stands, both when the $\chi^2$ 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 tend to increase in terms of the level of specialisation (for the two sub-periods), while the other half tend to engage in de-specialisation. In each of the two sub periods 11 out of 19 countries (7173-8082) and 10 out of 19 (8082-8991) countries, tend to increase the level of specialisation (measured as $\hat{\beta}/\hat{R}$) . Over the full period only 6 out of 19 countries tend 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 $\chi^2$ measure.

1 This finding is consistent with e.g. Proudman, J. and S. Redding (1997), who found that Germany and Great Britain showed no sign of increased export specialisation over a period from 1970 to 1993.

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

| | 7173-8991 | | | 7173-8082 | | | 8082-8991 | | |
|---|---|---|---|---|---|---|---|---|---|
| | $\hat{\beta}$ | $\hat{\beta}/\hat{R}$ | $\chi^2_{t2}/\chi^2_{t1}$ | $\hat{\beta}$ | $\hat{\beta}/\hat{R}$ | $\chi^2_{t2}/\chi^2_{t1}$ | $\hat{\beta}$ | $\hat{\beta}/\hat{R}$ | $\chi^2_{t2}/\chi^2_{t1}$ |
| 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.

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

| | 7173-8991 | | | 7173-8082 | | | 8082-8990 | | |
|---|---|---|---|---|---|---|---|---|---|
| | $\hat{\beta}$ | $\hat{\beta}/\hat{R}$ | $\chi^2_{t2}/\chi^2_{t1}$ | $\hat{\beta}$ | $\hat{\beta}/\hat{R}$ | $\chi^2_{t2}/\chi^2_{t1}$ | $\hat{\beta}$ | $\hat{\beta}/\hat{R}$ | $\chi^2_{t2}/\chi^2_{t1}$ |
| 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.

The findings appear 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 1963-1969 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 from 1975-81 to 1982-1988.

There can be several explanations for the difference. Firstly, Cantwell did not adjust the RTA measure, in order to make it symmetric. As the use of the 'pure' RTA gives too much weight to values above one, not adjusting for symmetry can produce biassed results. If for instance, some RTA values above unity increases over time and some values below unity also increases, the conclusion by using the pure RTA might be that the level of specialisation has increased while in fact, it remained neutral.[2] 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. Finally, the choice of time-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.[3]

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 (in 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 briefly going to discuss the stability characteristics, as measured by $\hat{\beta}$ in Tables 2 & 3. It should be pointed out however, that while the model estimated in Section 3.3 (Tables 4 & 5), below is based on data pooled over seven time periods, the results from Table 2 & 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 &3 are compared, it can be seen that trade specialisation patterns appear to more stable than technological specialisation patterns. Not surprisingly, as trade specialisation is to

2 For further discussion of this topic, see Laursen (1998).

3 The sensitivity to the time periods chosen, were not only tested using the two sub-periods, shown in Tables 2 & 3, but also on six sub-periods, not explicitly documented for reasons of space.

some extent bound to natural endowments; constraints not imposed on technological specialisation.

In the shorter run (the two sub-periods 7173-8082 and 8082-8991) 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 7 out of 38 pairs. Nevertheless, in the longer term (7173-8991) the relationships is only present in case of 10 out of 19 countries, showing that cumulativeness fades away over longer time periods. It can be also be seen that 5[4] (Finland, Greece, New Zealand, Portugal, Spain) out of the 9 countries, for which no relationship could be detected in the longer run, are in fact OECD 'catching-up' countries. For 6 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.

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 Spain and Portugal do have the lowest $\hat{\beta}$'s), and high-income countries on the other. Especially the low $\hat{\beta}$ for Germany is striking. However, as argued by Dalum *et al.*(forthcoming), 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 strong (but remains strong in these areas), while Germany 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, in one single model, this paper applies a regression model, developed by Magnier and Toujas-Bernate (1995), but also applied by Amable and Verspagen (1995). The specification is as follows:

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4 In fact all OECD 'catch-up' countries in our sample.

$$RSCA_{ij}^{t} \;=\; \alpha_{ij} \;+\; (\beta_{\mu} + \beta_{i} + \beta_{j}) RSCA_{ij}^{t-1} \;+\; \epsilon_{ij},\; with \; \sum_{i} \beta_{i} = \sum_{j} \beta_{j} = 0. \qquad (5)$$

Each coefficient is the sum of an average coefficient ($\beta_\mu$), an industry-specific coefficient ($\beta_i$), and a country-specific coefficient ($\beta_j$). The (relatively strong) restrictions allow for estimating both industry- and country-specific coefficients in the same model. The interpretation of the β's are the same as in Equation 2. As mentioned in the previous section, the data has been pooled together over seven time periods[5] in this section, so that we get 2166 observations in total, for all sectors and countries.

The estimations, using Equation 5, can be found in Tables 4 & 5. From these tables 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 patters are more stable than are technological specialisation patterns. Of the sectors, the low-tech areas of activity; food, drink & tobacco; rubber and plastics; non-ferrous metals; shipbuilding; and other transport display a relative low stability across countries and time for both types of specialisation. Industrial chemicals; pharmaceuticals; and non-electrical machinery, on the other hand, are stable to the extent that the hypothesis of an unchanged specialisation pattern cannot be rejected, in the case of both types of specialisation. Among the countries, Denmark; West Germany; Portugal; Spain; and United Kingdom display the highest degree of turbulence in the specialisation patterns, across sectors and time. In contrast, the specialisation pattern for countries such as Australia; Belgium; Italy; Japan; and Norway are path-dependent to the extent that the hypothesis of an unchanged specialisation pattern cannot be rejected, also both for what concerns technological and export specialisation. 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 the structural change took place in the 1960s, in the case of Japan (see Dalum *et al.*, forthcoming, Appendix Table A2).

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, New Zealand, Spain, and Portugal) we do find that the specialisation patterns of these countries (Spain and Portugal in particular) belong to the group

5 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 of in terms of beta convergence (or divergence) over the period 1971-1991 (n=2166).

| | | | $R^2$=0.93 | |
|---|---|---|---|---|
| | | Estimate | *p*-value ($H_0$: β=1) | *p*-value ($H_0$: β=av. effect) |
| Average coefficient | | 0.931 | 0.0001 | |
| Coeff. per sector* | Food, drink and tobacco | 0.972 | 0.0004 | 0.1002 |
| | Textiles, footwear and leather | 0.950 | 0.0866 | 0.4395 |
| | Industrial chemicals | 0.936 | 0.1988 | 0.8932 |
| | Pharmaceuticals | 0.938 | 0.0628 | 0.7987 |
| | Petroleum refineries (oil) | 0.909 | 0.1526 | 0.4033 |
| | Rubber and plastics | 0.919 | 0.0015 | 0.7336 |
| | Stone, clay and glass | 0.986 | 0.0259 | 0.0488 |
| | Ferrous metals | 0.889 | 0.0030 | 0.1631 |
| | Non-ferrous metals | 0.941 | 0.0052 | 0.6943 |
| | Fabricated metal products | 0.904 | 0.0396 | 0.5791 |
| | Non-electrical machinery | 0.951 | 0.5442 | 0.5120 |
| | Office machines and computers | 0.932 | 0.0010 | 0.9586 |
| | Electrical machinery | 0.901 | 0.1826 | 0.4347 |
| | Communication eq. and semiconductors | 0.948 | 0.0953 | 0.5553 |
| | Shipbuilding | 0.909 | 0.0001 | 0.2807 |
| | Other transport | 0.879 | 0.0001 | 0.0315 |
| | Motor vehicles | 0.962 | 0.0513 | 0.1877 |
| | Aerospace | 0.916 | 0.9181 | 0.5246 |
| | Instruments | 0.941 | 0.5560 | 0.7083 |
| Coeff. per country** | Australia | 0.920 | 0.2720 | 0.6162 |
| | Austria | 0.954 | 0.0434 | 0.3679 |
| | Belgium | 0.963 | 0.1240 | 0.2425 |
| | Canada | 0.945 | 0.0385 | 0.6242 |
| | Denmark | 0.963 | 0.0006 | 0.1927 |
| | Finland | 0.924 | 0.0242 | 0.7822 |
| | France | 0.850 | 0.6434 | 0.2081 |
| | Germany (West) | 0.845 | 0.0003 | 0.0872 |
| | Greece | 0.947 | 0.0268 | 0.4073 |
| | Italy | 0.921 | 0.0611 | 0.7948 |
| | Japan | 1.014 | 0.1442 | 0.0003 |
| | The Netherlands | 0.893 | 0.0132 | 0.2303 |
| | New Zealand | 0.970 | 0.0151 | 0.0729 |
| | Norway | 0.962 | 0.0827 | 0.1497 |
| | Portugal | 0.858 | 0.0001 | 0.0094 |
| | Spain | 0.846 | 0.0001 | 0.0034 |
| | Sweden | 0.937 | 0.1312 | 0.8431 |
| | United Kingdom | 0.994 | 0.0004 | 0.2413 |
| | United States | 0.978 | 0.0517 | 0.2069 |

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

Note: All coefficients are different from zero at the one per cent level.

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

| | | Estimate | $R^2$=0.44 *p*-value ($H_0$: β=1) | *p*-value ($H_0$: β=av. effect) |
|---|---|---|---|---|
| Average coefficient | | 0.643 | 0.0001 | |
| Coeff. per sector* | Food, drink and tobacco | 0.824 | 0.0001 | 0.0046 |
| | Textiles, footwear and leather | 0.493 | 0.0041 | 0.0227 |
| | Industrial chemicals | 1.173 | 0.0003 | 0.0001 |
| | Pharmaceuticals | 0.635 | 0.2862 | 0.9094 |
| | Petroleum refineries (oil) | 0.542 | 0.0001 | 0.1263 |
| | Rubber and plastics | 0.504 | 0.0001 | 0.1754 |
| | Stone, clay and glass | 0.595 | 0.0057 | 0.5604 |
| | Ferrous metals | 0.574 | 0.0762 | 0.2402 |
| | Non-ferrous metals | 0.546 | 0.0001 | 0.1022 |
| | Fabricated metal products | 0.769 | 0.0019 | 0.2155 |
| | Non-electrical machinery | 0.593 | 0.9311 | 0.7603 |
| | Office machines and computers | 0.584 | 0.2359 | 0.4587 |
| | Electrical machinery | 0.573 | 0.0001 | 0.5467 |
| | Communication eq. and semiconductors | 0.830 | 0.0001 | 0.0498 |
| | Shipbuilding | 0.599 | 0.0001 | 0.3867 |
| | Other transport | 0.382 | 0.0001 | 0.0001 |
| | Motor vehicles | 0.645 | 0.0056 | 0.9780 |
| | Aerospace | 0.694 | 0.0592 | 0.4563 |
| | Instruments | 0.658 | 0.3356 | 0.8798 |
| Coeff. per country** | Australia | 0.600 | 0.0121 | 0.6733 |
| | Austria | 0.767 | 0.0001 | 0.1313 |
| | Belgium | 0.716 | 0.1367 | 0.3560 |
| | Canada | 0.845 | 0.0001 | 0.1500 |
| | Denmark | 0.598 | 0.0001 | 0.5362 |
| | Finland | 0.653 | 0.0001 | 0.8876 |
| | France | 0.473 | 0.0001 | 0.3535 |
| | Germany (West) | 0.740 | 0.0001 | 0.4929 |
| | Greece | 0.141 | 0.0001 | 0.0001 |
| | Italy | 0.592 | 0.0355 | 0.6910 |
| | Japan | 0.988 | 0.0191 | 0.0096 |
| | The Netherlands | 0.870 | 0.0001 | 0.0387 |
| | New Zealand | 0.128 | 0.0007 | 0.0001 |
| | Norway | 0.531 | 0.0972 | 0.1254 |
| | Portugal | 0.280 | 0.0001 | 0.0001 |
| | Spain | 0.493 | 0.0001 | 0.0262 |
| | Sweden | 0.722 | 0.0001 | 0.4262 |
| | United Kingdom | 0.631 | 0.0001 | 0.9490 |
| | United States | 1.445 | 0.0024 | 0.0684 |

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

Note: All coefficients are different from zero at the one per cent level.

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 high degree of turbulence in the case of technological specialisation. In terms of trade specialisation, the hypothesis of no structural change for Greece only holds at a 3 per cent level, showing that the pattern of specialisation is very sticky for this country. 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, using the same methodology, and level of aggregation. 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 paper confirmed that the OECD countries did in general de-specialise in terms of export specialisation. The evidence was 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. In terms of country and sectoral stability of specialisation patterns, 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 patters were more stable than are technological specialisation patterns. Of the sectors, food, drink & tobacco; rubber and plastics; non-ferrous metals; shipbuilding; and other transport displayed a relative low stability across countries and time, for both types of specialisation. Industrial chemicals; pharmaceuticals; and non-electrical machinery, 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. Among the countries, Denmark; West Germany; Portugal; Spain; and United Kingdom displayed the highest degree of turbulence in the specialisation patterns, across sectors and time. In contrast, the specialisation pattern for countries such as Australia; Belgium; Italy; Japan; and Norway were path-dependent to the extent that the hypothesis of an unchanged specialisation pattern could not be rejected, also both for what concerns technological and export specialisation.

Concerning the hypothesis of OECD catching up countries experiencing the highest degree of turbulence in the specialisation patterns, the results were not as clear-cut, as they were in Dalum *et al.* (forthcoming), since only Portugal and Spain were consistently among the countries experiencing the highest degree of turbulence (although Greece, Finland and Italy were also among the countries experiencing the highest degree of turbulence for what concerns technological specialisation). The explanation has to do with the time periods considered, as Dalum *et al.* (forthcoming) considered a period starting in 1965, while this paper started in 1971. In this way it appeared that countries such as Austria and Japan encountered a high degree of structural in the 1960s, while this process stopped from the 1970s onwards.

A conclusion coming out this paper is that, while European integration has been on-going throughout the period, there has been a tendency for European countries to de-specialise in terms of trade specialisation, while technological specialisation has not taken a particular direction. Standard trade theory (Hechscher-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 occur surprising. However, it appears to be a fact that intra-industry trade grows in a period of economic integration.

On the basis of these findings, one can speculate that countries instead specialise increasingly according to consumer preferences (within the same industries), rather than specialising increasingly in different industries. Hence, the findings are more in line with theoretical models allowing for increasing returns and (vertically or horizontally) differentiated products (see e.g. Grossman and Helpman, 1989; 1991, for a theoretical treatment).

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# Danish Research Unit for Industrial Dynamics

*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
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