Does Specialization Matter for Growth?*

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1. Introduction

The question as to what extent the growth performance of an economy if determined by its external relations is a controversial one. Krugman (1994) has forcefully argued that the issue of competitiveness, which underlies a the idea that growth is determined by the performance in international product markets, does not make sense from a theoretical point of view. Underlying his view, as well as the point of view expressed in most mainstream work based on a ‘Solow-type theory’ approach, is that growth is determined by supply-side factors, which are basically determined by domestic factors, such as the growth rate of the population or the labour force, factor prices, the savings rate, and, in more recent ‘new growth’ models, the generation of technology. In this approach, the impact of trade is not so much on economic growth, but instead on welfare, and works through the allocation of production factors, and factor prices.

Outside the mainstream, there are several approaches which stress the interaction between international factors and domestic growth performance. In the Keynesian tradition, Kaldor (1966, 1970) and Thirlwall (1979) have argued that exports and trade performance are the main determinants of growth (see also Boggio, 1996). Their approaches, which characterize growth as ‘export-led’, or as ‘balance of payments restricted’, stress the impact of demand on growth. The recent ‘evolutionary’ literature on economic growth (see Silverberg and Verspagen, 1995, for an overview), takes technical change as the main determinant of growth, but reserves an important role for demand in the form of exports and imports. Finally, models of open economies in the so-called ‘new growth theory’ argue that trade matters for growth.

This paper takes different elements from these hybrid theoretical approaches, and combines them into a framework that stresses the importance of specialization for economic growth. This framework, and the literature it is founded in, will be discussed in Section 2 of the paper. The main aim of the work is to test the hypotheses developed in Section 2 by using an elaborate dataset on growth and trade performance in manufacturing sector in the OECD area over the period 1965-1988. This empirical work will be presented in Section 3 of the paper. Some of the implications of the analysis will be discussed in Section 4.

2. Trade, specialization and growth

Most growth models in the ‘Solow-tradition’, including the so-called ‘new growth’ models, take a production function as the main determinant of economic growth. Because of the (implicit) assumption of full utilization of factors such as labour and capital, and given the functional form of the production function, growth of production is simply the result of the growth rate of inputs (labour and capital) and their productivity increases. This rather straightforward explanation of economic growth is best illustrated by the ‘art’ of growth accounting, as pioneered by Tinbergen (1943).

Obviously, the supply of production factors such as labour and capital mostly results from domestic sources. Factors related to the supply of foreign labour, such as migration, often do not have a straightforward economic interpretation, although there is a theory on the relation between economic growth and migration (e.g., Blanchard and Katz, 1992). International capital flows, for example in the form of foreign direct investment (FDI), do have an obvious economic interpretation, but the (neoclassical) theory on the impact of FDI on growth is still ill-developed. Under the ‘normal’ assumption of homegeneity of domestically produced goods and imports, trade, in the form of imports of capital and intermediate goods is also not related to any of the traditional production factors, and, therefore, does not enter the neoclassical growth models directly.

As summarized in Dowrick (1997), the impact of trade in the traditional models is thus mainly an indirect one, related to the issues of allocation and factor prices. The idea here is that an economy that is opened up to international trade, can benefit from a more efficient allocation of its production factors (along the lines of the HOS theory), and the resulting lower consumer prices. Thus, welfare is higher in an open economy as compared to a situation where domestic markets are protected by tariffs or quota. However, typically, so-called CGE models indicate that these welfare effects are relatively small (Dowrick, 1997).[1]

Within the more recent so-called new growth theory, Dowrick (1997) distinguishes between two approaches: the Smithian approach and the Ricardian approach. The Smithian approach, with authors such as Rivera-Batiz and Romer (1991) and Rivera-Batiz and Xie (1993), stresses the importance of 'learning-by-doing' or increasing returns to scale. Opening up to trade enables individual countries to specialize in a narrow range of goods, and thus exploit these increasing returns. The difference relative to the traditional CGE-type models discussed above is that, due to the endogenous growth nature of the models in the Smithian tradition, there will be a long-run effect on growth, rather than just a level effect in terms of welfare.

In the Ricardian type models, different activities are characterized by different rates of growth of productivity, e.g., due to differences in technological opportunities. Thus, countries specializing in activities with higher rates of productivity growth are in a better position to achieve fast overall growth. Grossman and Helpman (1991) is an example of such a model. Note, however, that, as in the Grossman and Helpman model, it is not obvious that a higher rate of productivity growth also implies a higher growth rate of real consumption. However, especially in situations where knowledge does not spill over national borders, there is opportunity for national governments to change the specialization pattern of its economy, and hence the growth path.

As acknowledged by Dowrick (1997), the dynamic analysis of Keynesian models, long before new growth theory, established the idea that trade matters for growth. As in the recent neo-classical models discussed above, the argument comes in two flavours here (see, e.g., McCombie and Thirlwall, 1995). First, there is the export-led growth theory, which, following Kaldor (1966, 1970), argues that the economy is not constrained by supply-side factors, because the main production factor, capital, must be seen as an endogenous factor. Should capital constrain economic growth in the short run, so it is argued, increased profits will solve this constraint in the medium- to long-run. Thus, only natural resources (which are indeed exogenous) are accepted as a possible supply-side factor constraining economic growth (McCombie and Thirlwall, 1995, p. 392).[2] Seen in this way, the only truly exogenous factor to the domestic economy is foreign demand (domestic demand is endogenous to the extent that it is determined by savings behaviour and wages).

Kaldor (1970) argued that dynamic increasing returns to scale play an important role in the process of economic growth. The argument goes back at least to Young (1928), and says that

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[1] The welfare gains are generally larger in situations where increasing returns to scale characterize the production process, possibly in combination with product differentiation.

[2] Kaldor (1966) also forcefully argued that labour must be seen as an endogenous factor, due to labour reserves contained in the primary sector of the economy, which, by the nature of industrialization, is contracting, and therefore 'hides' labour available for industry.

when production expands, new ways of doing things (*learning-by-doing*) are discovered, which makes productivity increase. The functional form Kaldor used to illustrate his argument is the so-called Verdoorn-law, which argues that production growth causes productivity growth. Naturally, increased productivity may, on its turn, lead to increased growth (as Kaldor argued, by means of increasing exports), which opens up possibilities for self-reinforcing mechanisms. Cumulative causation and virtuous growth cycles thus play an important role in the Kaldorian export-led growth theory. Dixon and Thirlwall (1975) have expressed the Kaldor-Verdoorn theory in a dynamic model of export-led growth, and present conclusions with regard to under which conditions growth rate differentials between regions or nations will converge to a stable value.

The second variety of the post-Keynesian theory on trade and growth is mainly due to Thirlwall. Thirlwall (1979), although operating in the same post-Keynesian theoretical framework as Kaldor, argued that the 'simple' export-led growth theory does not take into account the role of the balance of payments. For example, in the model by Dixon and Thirlwall (1975), export growth, and thus output growth, is not constrained at all, even if the balance of payments, which is not explicitly modeled, grows without bounds. Viewed from the balance of payments point of view, demand elements (domestic demand for imports as a fraction of domestic GDP, and domestic exports as a function of foreign GDP) are again the main determinants of growth. McCombie and Thirlwall (1995, pp. 234-237) set out the 'model' of balance of payments restricted growth as follows. Denote the respective price changes of imports and exports (both in domestic currency, so the price of imports includes the exchange rate as well as foreign prices) by p_m and p_x. The price and income elasticities of imports are denoted e_{pm} and e_{ym} (both negative), respectively, and accordingly define e_{px} and e_{yx} (both positive). For balance of payments equilibrium to hold, nominal exports must grow at a rate equal to nominal imports, or

$$p_m + e_{pm}(p_m - p_x) + e_{ym}y = p_x - e_{px}(p_m - p_x) + e_{yx}y^*, \quad \textbf{(1)}$$

where y and y^* are the growth rates of real GDP of the domestic and foreign economies, respectively. The above equation can easily be rearranged to yield

$$y = \frac{(1 + e_{pm} + e_{px})(p_x - p_m) + e_{yx}y^*}{e_{ym}}. \quad \textbf{(2)}$$

This implies that a non-zero growth rate differential between the domestic economy and the rest of the world may arise as a result long-run differences in the rate of inflation, as well as differences in the income elasticities of demand. The proposition made by Thirlwall (1979) is that the long-run effect of differences in inflation is small (in other words, that $p_x = p_m$ in the long run), so that differences in the income elasticities of demand are the main reason for growth rate differentials.

As was argued by Fagerberg (1988), the main problem with Thirlwall's theory is that he does not provide an endogenous explanation of the differences between the two income elasticities. Fagerberg argued that one might explain these differences by factors such as product quality and R&D efforts. He thus builds a bridge between the post-Keynesian literature and 'evolutionary' inspired theories of growth. In the 'evolutionary' literature on economic growth, (stochastic) technological change plays an important role. For example, in the model by Verspagen (1993), (technological) competitiveness of a country determines the growth of its export market shares. Differential rates of growth of the total market size in different sectors, under the influence of income elasticities, as in Pasinetti (1981), imply that different sectors grow at different rates, such that specialization matters for growth. A similar model is presented by Dosi *et al.* (1994).

Boggio (1996) rightfully argues that the evolutionary models, in many important respects, resemble the early and later post-Keynesian models that were discussed above. He argues, however, against a strict interpretation of the concept of balance of payments constrained growth, and shows that in models of national growth partly based on ‘evolutionary notions’, trade balance disequilibrium may indeed be related to fast growth in a Kaldor-Verdoorn framework. One important difference between the ‘evolutionary’ growth model by Verspagen (1993) and the work in the post-Keynesian tradition outlined in this section, however, is that the latter does not attach much importance to the issue of specialization. In the export-led growth theory, specialization does not play a large role, as is illustrated, for example, by Dixon and Thirlwall (1975), who present a one-sector model, which by definition excludes specialization from the analysis. In the balance of payments constrained growth literature, specialization patterns may be seen as entering the growth equation indirectly, through the elasticities of imports and exports. But this is at best only one of the many interpretations that can be given to the differences in elasticities, and a more elaborate empirical analysis, as done by Fagerberg (1988) with respect to product quality and technological factors, is necessary to establish the empirical importance of this argument.

How does all this relate to the question as to what is the relationship between economic growth and specialization? The common conclusion from the literature discussed in this Section seems to be that there is indeed such a relationship, although it may take different forms. Basically, the distinction between demand and supply-side mechanisms applies. As is argued by both the new growth theorists (‘Smithians’) and the Kaldorian export-led theory, specialization, by opening up possibilities for increased specialization, leads to higher productivity growth in the form of learning, which is essentially a supply-side argument. The extent to which different sectors or activities are characterized by different learning opportunities provides an extra dimension to these perspectives (the ‘Ricardian’ variety of new growth theory), but this is usually taken as exogenous to the economic analysis. In the neo-classical (or new growth) version of this argument, an additional complication is formed by the interrelatedness of the economy in the form of general equilibrium. An exact modelling of the result of specialization on growth thus not only requires the modelling of learning, but also of the evolution of factor prices and the resulting allocation. From the demand side, specialization may have an impact on growth through ‘Engel’s law’, or the idea that markets for some goods grow more rapidly than others, thus providing more opportunities for growth.

The empirical analysis in this paper thus starts from the assumption that the structure of an economy matters for economic growth, and that the most important way in which the production structure has an impact on international growth rate differentials is through international trade. This approach is thus based on a combination of certain elements of all theoretical frameworks discussed above. However, as will become evident when the empirical approach is described in detail, the empirical analysis in the rest of this paper cannot be seen as a test of either of these different theoretical frameworks, because we do not want to commit ourselves to any of the specific modeling environments proposed by the theories (such as general equilibrium in the new growth theory, balance of payments restrictions or export-led growth in the post-Keynesian theory). The empirical model we adopt must therefore be seen as a test of the basic ideas that underlie all of these theories about trade, specialization and growth. Only when discussing the outcomes of the analysis in the final Section, will we be able to relate back to some of the mechanisms proposed by the different theories.

3. Empirical analysis

3.1. A description of the data

This paper applies a dataset on growth and trade in 11 manufacturing sectors, for the period 1965-1988, for the OECD area. We apply data on labour input (employees), gross investment in fixed capital (current prices), value added and gross production (fixed prices and current prices), the number of patents taken in the US per sector (by date of grant), and export values (in US dollars) for 75 product categories, each of which can be assigned to a single of the 11 manufacturing sectors. The trade data are taken from the IKE trade database (main source: OECD), the patent data from the US Patent Office, and all other data from UNIDO (Industrial Statistics Database).

The main novelty in our database is the assignment of the 75 products in the trade data to the 11 industrial sectors. Traditionally, the combination of trade and industrial data has been accomplished by aggregating detailed SITC trade data into more aggregated industrial sectors, without making a distinction into different product categories per sector (e.g., Verspagen, 1993). Rather than just looking at aggregate exports per sectors, we are thus able to calculate within-sector specialization, or study the relations between specialization indices of different product categories within the same sector.

In setting up the 75 product groups, our aim was to establish relatively homogenous groups. Thus, in cases where we get a relatively little number of products in a single industrial sector (like in the case of 'wood and product', where we have only three products, the sector can be characterized as relatively homogenous. In case of a more heterogenous sector we define a larger number of products, like in the case of 'transport equipment', where we have 11 products within one sector.

Because of the novelty of the data, a first exploration of the data will be presented in this Section. The aim of this analysis is to investigate whether or not specialization indices for each of the 11 'sector-groups' are correlated. In other words, we ask the question whether, given that a country is specialized in a product that belongs to a certain industrial sector, there is an increased probability this country is also specialized in other products within the same sector. To the extent that our sectoral classification groups together products with similar underlying technological and economic characteristics, one would expect to find evidence of such relations. Note that in case one would find a 'near-perfect' correlation, this would indeed confirm that the traditional procedure of grouping together all intra-sectoral products under aggregate exports would be a useful procedure.

To this end, we calculate the well-known RCA-index, which is defined as follows:

$$RCA_{ij} = \frac{X_{ij}/X_j}{X_i/X}, \qquad \textbf{(3)}$$

where X is exports, the subscripts i and j indicate a country and a product group, respectively, and the absence of either i or j indicates aggregation over that particular dimension. Thus, the RCA index for country *i* and sector *j* is defined as *i*'s share in total exports of *j* divided through by i's share in total exports. Because the RCA-index is not symmetric (values for negative specialization are squeezed into the interval [0,1⟩, while values for positive specialization are in ⟨1,∞]), we apply the transformation RCA* = (RCA-1)/(RCA+1). This yields values in [-1,0⟩ for negative specialization, and values in ⟨0,1] for positive specialization. Neutral specialization corresponds to a zero value.

For each of the 75 product groups and the 20 countries[3] in our sample, we calculate the value of RCA*. For each of the years for which we have export data, this gives, for each of the 75 product groups, 20 observations. Within each sector, these observations are used to calculate correlation coefficients between the product groups. The number of correlation coefficients obtained in this way is n^2-n, where n is the number of product groups within the sector. Figure 1 gives, for each of the 11 sectors, the fraction of those correlations that is significant at the 5% level for the years 1965 and 1992. The sectors in the figure are ordered in increasing order of the 1992 significant fraction.

There are five sectors for which the 1992 value is higher than the 1965 value, five sectors for which the reverse is true, and one sector for which the two fractions are identical. The overall picture is one in which the sectors with high values in 1965 tend to have lower values in 1992 (electrical products, metal products, transport equipment, machines, instruments), and the sectors with low values in 1965 tend to have higher values in 1992 (food, textiles and chemical).

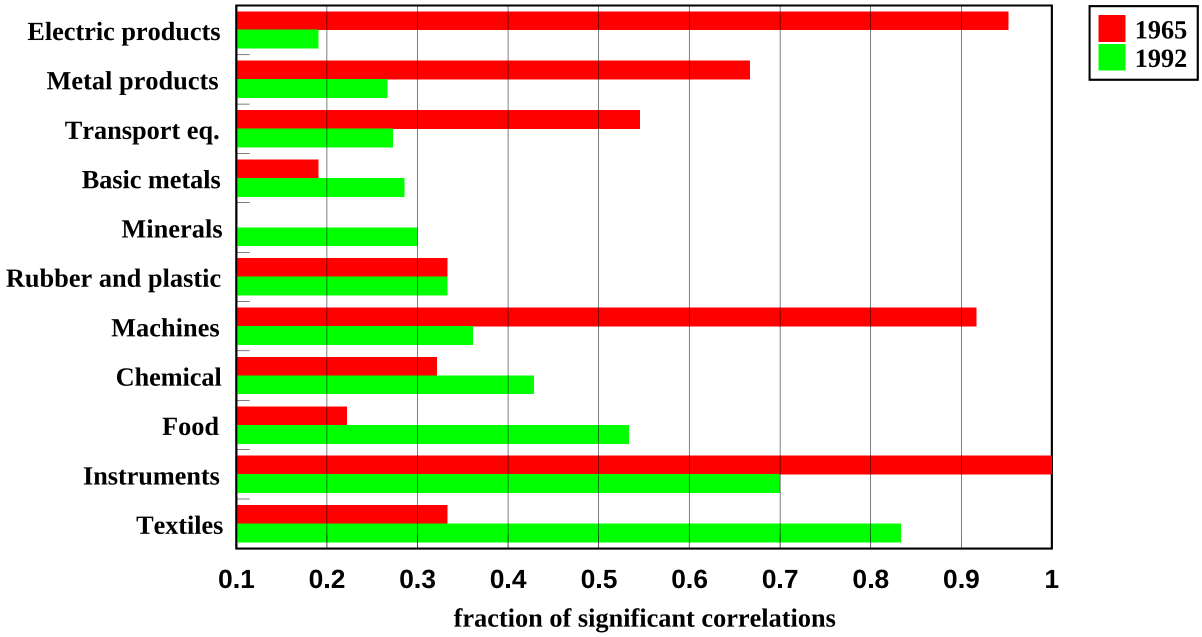

Figure 1. Significant correlations between within-sector product-group specialization indices, 1965 and 1992

Figure 1 thus clearly indicates the differential dynamics of specialization between broad industrial sectors. From the point of view of the product life cycle, these differences seem to have

[3] Austria, Belgium, Canada, The Netherlands, Portugal, Spain, France, Germany (West), Switzerland, Denmark, Sweden, Norway, Finland, Japan, United Kingdom, United States, Greece, Turkey, Ireland, Italy.

a useful interpretation. Sectors for which one could argue that products have been in the expansion phase of the product life cycle over the last decades, for example high-tech products such as electrical products, machines, instruments and transport equipment, are characterized by specialization patterns which are becoming less homogenous, in line with rapid technological development and product differentiation. Other sectors for which one may argue that their products have been in a declining phase over the past decades, low-tech sectors such as food and textiles, but also chemicals, display specialization patterns that have become more and more homogenous. Metal products seems to be one sector in which the observed specialization dynamics are not so well explained from the product life cycle point of view.

Overall, Figure 1 shows that the expected relevance of distinguishing sectoral exports into different product groups differs between sectors and over time. One would expect that in instruments in 1965, it would not add very much to our understanding to distinguish between the five product groups in the sector, because specialization patterns in all possible combinations of these product groups are strongly correlated. However, in electrical products in 1992, the other extreme, this seems to be essential, because less than one fifth of all possible correlations between the seven product groups in this sector are significant.

The RCA* indices used so far are all defined as 'overall specialization' indices, i.e., they measure a country's export share relative to the country's total export share. From the point of view of the argument on the relation between growth and trade put forward in Section 2, it also makes sense to calculate 'within-sector' RCA-indices, which can be defined as

$$RCA_{ip}^{j} = \frac{X_{ip}/X_{p}}{X_{ij}/X_{j}}, \qquad \textbf{(4)}$$

where the superscript j indicates within-sector j RCA, and the subscript p is a product group belonging to sector j (I, as before, indicates a country). This index measures specialization in product group p relative to the total sector to which p belongs, rather than total exports. The same transformation $RCA^{j}* = (RCA^{j}-1)/(RCA^{j}+1)$ is applied to achieve symmetry.

In order to make the dataset more comprehensive, principal components analysis was applied to the data for $RCA^{j}*$ for four key years: 1965, 1973, 1979 and 1988. These years all (roughly) correspond to peaks in the business and trade cycles, to that our data are not too much influenced by cyclical variations in export market shares or exchange rates. For each sector and per year, we estimate principal components for the within-sector specialization indices for the n product groups. By studying the changes in factor loadings, one may get an impression of the major changes in specialization patterns over time.[4]

[4] The principal components technique, a form of factor analysis, estimates linear combinations of the underlying variables, in this case the specialization indices, that 'explain' the highest possible fraction of the remaining variance in the dataset. Thus, the first principal component is estimated to explain the highest possible fraction of the total variance, the second principal component the highest possible fraction of the variance not explained by the first principal component, etc. By maximizing the 'explained residual variance' in each round, the first m ($< n$) principal components will explain a relatively large proportion of the total variance, which is why the technique is used for data-reduction. This will be the main application of the technique in the next sub-section.

Table 1. Factor loadings, principal components analysis of within-sector specialization patterns of export-values, 1965-1979*

	Principal Component 1			Principal Component 2			Principal Component 3		
	1979	1973	1965	1979	1973	1965	1979	1973	1965
1. Food, beverages and tobacco									
1 Meat	0.85	0.78	0.55	0.21	0.04	0.21	0.22	0.45	0.71
2 Fish	-0.54	-0.51	-0.52	0.37	0.16	-0.10	-0.50	-0.19	-0.31
3 Cereals	-0.00	0.50	0.52	-0.86	-0.06	0.17	-0.23	-0.63	-0.61
4 Vegetables	-0.58	-0.48	-0.17	-0.63	-0.34	-0.38	0.19	-0.42	-0.59
5 Animal-food	0.39	0.06	-0.21	0.02	0.82	0.70	-0.66	0.04	-0.12
6 Oils	-0.51	-0.47	-0.42	-0.18	0.54	0.65	-0.69	-0.55	-0.55
7 Non-alco	0.51	0.67	0.80	-0.71	-0.44	-0.23	-0.04	-0.48	-0.25
8 Alco	-0.19	-0.12	0.33	-0.15	-0.78	-0.77	0.68	0.11	-0.28
9 Tobacco	0.74	0.77	0.74	0.02	0.28	0.43	-0.21	0.02	-0.21
10 Other	0.78	0.84	0.84	-0.17	0.12	0.27	-0.18	-0.33	-0.16
2. Textiles, clothes and leather									
11 Raw	0.69	0.64	0.26	0.06	0.41	0.87	0.72	0.65	0.41
12 Yarn	0.92	0.91	-0.92	0.03	-0.21	0.27	-0.27	-0.24	-0.16
13 Leather	-0.81	-0.65	0.92	-0.46	0.72	-0.27	0.25	-0.12	-0.14
14 Clothing	-0.55	-0.69	-0.31	0.82	-0.58	-0.86	0.10	0.40	0.41
3.Wood and wooden products									
15 Products	0.35	0.67	0.74	0.93	0.72	0.66	0.09	0.14	0.12
16 Raw	-0.97	-0.97	-0.97	-0.02	0.03	0.06	0.22	0.26	0.25
17 Furniture**	0.90	0.79	0.84	-0.39	-0.58	-0.51	0.21	0.19	0.18
4. Chemicals									
20 Plastic**	0.32	0.13	0.35	0.02	0.90	0.83	0.82	0.14	0.10
21 Organic	-0.54	-0.52	-0.05	0.48	0.30	0.44	0.54	0.41	0.86
22 Inorganic	0.80	0.91	0.80	-0.42	-0.09	-0.25	-0.19	0.04	0.23
23 Other	-0.14	-0.24	-0.21	0.80	0.23	0.45	-0.36	-0.88	-0.72
24 Dyeing	-0.80	-0.69	-0.54	0.25	0.20	0.61	-0.19	-0.24	0.08
25 Fertilizers	0.64	0.70	0.25	0.41	-0.29	0.22	-0.45	-0.23	0.08
26 Drugs	-0.82	-0.87	-0.94	-0.32	-0.32	0.02	-0.21	0.02	0.15
27 Oils	-0.57	-0.40	-0.57	-0.64	-0.61	-0.57	-0.16	0.09	0.27
5. Rubber and plastic products									
28 Other	0.19	0.09	0.69	0.98	0.99	0.73	0.02	0.04	0.03
29 Rubber	-0.96	0.97	0.90	0.13	0.04	-0.31	-0.24	-0.23	0.29
30 Plastic	0.97	-0.96	-0.92	-0.07	0.14	0.24	-0.24	-0.23	0.31
6. Glass, clay, etc.									
31 Pottery	0.30	0.38	0.05	0.85	0.81	0.77	0.03	0.36	0.54
32 Sanitary	0.48	0.60	-0.57	-0.71	-0.16	0.68	0.23	0.53	0.04
33 Glass	0.78	0.70	-0.93	-0.12	-0.57	-0.23	-0.57	0.06	0.03
34 Building	-0.95	-0.95	0.87	-0.08	-0.05	0.19	0.10	0.08	-0.02
35 Other	0.74	0.60	-0.06	0.14	0.24	0.53	0.57	-0.69	-0.82
7. Basic metals									
36 Steel	0.90	0.88	0.91	0.23	0.16	0.09	0.01	0.15	0.29

37 Wires	0.23	0.34	0.58	0.69	-0.73	-0.02	0.16	0.14	-0.31
38 Aluminum	-0.55	-0.54	-0.49	-0.66	0.68	0.67	0.37	-0.21	0.27
39 Uranium	-0.08	-0.19	0.46	0.47	0.36	0.07	0.83	0.78	-0.57
40 Silver	-0.73	-0.48	-0.04	0.29	-0.17	0.64	0.07	0.62	-0.53
41 Copper	-0.48	-0.70	-0.49	0.74	-0.57	-0.56	-0.34	-0.06	-0.60
42 Other	-0.72	-0.86	-0.03	0.17	-0.08	0.76	-0.16	-0.12	-0.22
8. Simple metal products									
43 Structural	0.07	0.31	0.31	0.38	0.49	0.61	0.48	0.05	0.57
44 Wires, screws	0.44	-0.88	0.44	-0.54	-0.06	0.74	-0.53	-0.15	-0.14
45 Hand tools	0.06	-0.45	0.64	0.76	-0.76	-0.51	-0.52	-0.14	-0.28
46 Stoves	-0.85	0.92	0.66	-0.37	-0.17	-0.41	0.21	-0.08	0.31
47 Furniture	-0.57	0.07	0.66	0.56	-0.42	0.44	-0.19	0.89	-0.48
48 Scrap	0.70	-0.55	-0.88	0.25	0.65	0.24	0.43	0.34	-0.20
9. Machines									
49 Agriculture	0.55	0.11	0.58	0.02	0.77	0.48	0.40	0.46	0.24
50 Turbines	0.70	-0.38	0.65	0.35	0.59	0.23	0.32	0.17	-0.43
51 Computers	0.51	-0.62	0.71	0.65	0.63	0.48	-0.44	-0.17	-0.15
52 Office	-0.04	-0.69	0.69	0.76	0.19	-0.28	0.04	-0.38	-0.12
53 Metal working	-0.39	-0.72	0.79	0.43	-0.05	-0.48	0.73	0.42	-0.02
54 Textile	-0.62	-0.52	0.47	0.44	-0.71	-0.74	0.55	-0.04	-0.05
55 Specialized	0.52	0.69	0.12	-0.46	0.18	0.38	0.61	0.37	-0.76
56 Other	-0.13	0.85	-0.82	-0.67	0.08	0.09	0.21	-0.30	-0.22
57 Firearms	-0.68	-0.11	0.42	-0.04	-0.55	0.42	-0.18	0.60	0.68
10. Electrical goods, excl. computers									
58 TV etc	0.72	0.63	0.49	0.18	0.04	0.06	0.29	0.08	0.80
59 Generating	0.29	0.03	0.33	-0.23	0.71	-0.45	-0.87	0.50	-0.04
60 Telecom	-0.59	0.18	0.24	-0.38	-0.89	0.73	0.24	0.16	-0.52
61 White goods	-0.74	-0.88	0.78	0.09	0.05	-0.34	0.26	0.23	-0.23
62 Medical	0.07	0.34	0.86	-0.85	-0.21	0.17	0.31	0.85	-0.16
63 Other	0.40	0.42	-0.88	-0.70	0.30	0.19	-0.00	-0.01	0.05
64 Semiconductors	0.71	0.67	0.33	0.16	0.16	0.71	0.49	-0.27	0.35
11. Transport equipment									
65 Aero engines	0.53	0.69	0.55	0.56	0.39	0.73	0.38	0.36	0.12
66 Auto engines	0.44	0.50	0.71	0.51	0.04	-0.25	-0.27	0.41	0.51
67 Non-motor	0.06	-0.10	0.27	0.75	-0.38	-0.67	0.01	0.80	0.56
68 Locomotives	0.74	0.39	0.54	-0.37	-0.66	-0.24	-0.05	-0.18	-0.21
69 Oth. railway	0.61	0.36	0.58	-0.27	-0.75	-0.74	-0.42	0.23	0.03
70 Cars	0.52	0.54	0.53	-0.45	0.03	-0.02	0.28	-0.64	-0.47
71 Trucks	-0.28	0.22	0.76	-0.58	-0.12	-0.19	-0.34	-0.03	-0.36
72 Auto parts	0.83	0.87	0.84	0.01	0.04	0.31	0.06	-0.31	-0.10
73 Motorcycles	0.03	-0.03	0.32	0.11	-0.82	-0.79	-0.89	-0.20	-0.25
74 Aircraft	0.77	0.78	0.69	0.27	0.21	0.53	-0.22	0.29	0.23
75 Ships	-0.50	-0.87	-0.86	0.56	0.03	-0.35	-0.23	0.02	-0.05
12. Instruments									
76 Measuring	0.89	0.86	0.77	0.27	0.25	0.43	0.11	0.06	0.27
77 Medical	0.04	0.66	-0.73	-0.84	-0.45	0.28	-0.33	-0.16	-0.11
78 Optical	-0.62	-0.23	0.39	0.51	-0.53	-0.17	0.28	0.81	-0.89

79 Photo	-0.57	-0.11	0.79	-0.46	0.82	-0.11	0.57	0.39	0.08
80 Clocks	-0.59	-0.89	-0.02	0.27	-0.06	-0.93	-0.69	-0.32	0.24
13. Other manufacturing									
81 Pearls	0.87	0.93	0.92	0.34	0.24	0.28	0.05	0.03	0.16
82 Music	-0.31	-0.29	-0.53	0.87	0.95	0.71	-0.37	-0.12	-0.46
83 Toys, sports	-0.74	-0.84	-0.63	0.48	-0.14	0.40	0.46	-0.48	0.66
84 Other	-0.84	-0.79	-0.87	-0.39	0.07	-0.43	-0.22	0.59	-0.03

* Factor loadings with absolute values above 0.5 are indicated against a grey background.
** We have two more products groups for the sector 'printing and publishing', however, for two product groups it does not make sense to calculate principal components, so the numbering in the table is non-consecutive.

Table 2. Cumulative R^2 values for subsequent principal components

	Sector	1979			1973			1965		
		F1	F2	F3	F1	F2	F3	F1	F2	F3
1	Food etc.	0.32	0.51	0.70	0.33	0.53	0.68	0.31	0.52	0.70
2	Textiles, etc.	0.57	0.79	0.96	0.53	0.80	0.96	0.46	0.87	0.96
3	Wood, etc.	0.63	0.97	1.00	0.67	0.96	1.00	0.73	0.96	1.00
4	Chemicals	0.39	0.61	0.79	0.38	0.58	0.71	0.30	0.53	0.71
5	Rubber and plastic	0.63	0.96	1.00	0.63	0.96	1.00	0.71	0.94	1.00
6	Glass, etc.	0.48	0.73	0.87	0.45	0.67	0.85	0.39	0.67	0.87
7	Basic metal	0.35	0.61	0.75	0.38	0.60	0.75	0.27	0.52	0.70
8	Simple metal	0.29	0.55	0.72	0.37	0.61	0.77	0.39	0.65	0.79
9	Machines	0.26	0.50	0.69	0.34	0.58	0.71	0.38	0.57	0.72
10	Electrical	0.31	0.52	0.71	0.28	0.48	0.65	0.38	0.58	0.74
11	Transport	0.30	0.51	0.64	0.32	0.50	0.65	0.40	0.65	0.75
12	Instruments	0.37	0.63	0.83	0.41	0.65	0.84	0.38	0.62	0.81
13	Other	0.53	0.84	0.94	0.57	0.82	0.96	0.57	0.81	0.97

Overall, specialization patterns appear to be quite stable, as indicated by the many 'similar factor loadings' for the different years. For example, within the first sector (food, beverages and tobacco), the product groups meat, non-alcoholic beverages, tobacco and other all have relatively high and positive factor loadings for all three years, while fish and oils have large negative values (grey cells indicate factor loadings with an absolute value larger than 0.5, as a rough measure of 'large' values). The other product groups have values which are relatively small in absolute value (with the exception of vegetables in 1973 and 1979). An economic interpretation of this result is that the 'typical' within-sector specialization pattern in this sector is one in which the above mentioned product groups play a major role. Countries tend to be positively (negatively) specialized in meat, non-alcoholic beverages, tobacco and other, and, at the same time, negatively (positively) in fish and oils. Note that the sign of the factor loadings in itself does not have a direct meaning.[5] Countries might either be positively or negatively specialized in the product groups (in fact, because of the mere concept of specialization, we cannot expect all countries to have similar signs in the same product groups). What is important is that product groups with a identical signs (and fairly large absolute values) of the factor loadings tend to be enter the 'typical specialization patterns' of our individual countries with the same sign.

Although there appears to be some stability of the factor loadings over the years, there are also cases when the signs and values change quite drastically, indicating that there are indeed changes in within-sector specialization patterns. For example, for the first principal component in machines, there does not seem to any stable relationship over the years. In transport equipment, on the other hand, stability is very high. It also seems to be the case that there are somewhat more 'breaks' between 1965 and 1973 than there are between 1973 and 1979.

Although factor loadings themselves are interesting from the point of view of descriptive statistics, we will not pursue their discussion here. The main interest of this paper is in the relation between specialization and growth, and the next section will show how the principal components from Table 1 can be used for that purpose. Before we explain that analysis, however, we will briefly discuss the explanatory power of the principal components analysis, documented in Table 2.

This table gives the cumulative R^2 for the first three principal components. Note that, by definition, the cumulative explanatory power for the first *n* components, where *n* is the number of product groups, is equal to unity. Thus, for the sectors for which we have only three product groups (wood; rubber and plastic) we find a value of one for the last principal component. Similarly, the smaller the number of product groups in a sector, the higher one would, *a priori*, expect the cumulative explanatory power for the *i*th principal component to be.

Keeping this in mind, what stands out from the table is that in virtually all cases, 3 principal components is enough to explain, roughly two-thirds of the total variance in the specialization data. In 1973 and 1979, the lowest cumulative R^2 value is 0.65 and 0.64, respectively (both times in transport equipment, which has 11 product groups), while in 1965 the lowest value is 0.70 (in food, beverages and tobacco, which has 10 product groups). Thus, even in the sectors where we have a relatively large number of product groups, three principal components are enough to explain a reasonable fraction of the total variance in our specialization data. In many sectors, especially the ones where we have only a limited number of product groups, one or two principal components seem to be adequate.

3.2. Growth and Specialization: Regression Analysis

The way in which the relationship between growth and specialization will be tested is by running a regression with the sectoral growth of value added (in fixed prices) as the dependent variable, and several variables, including some measuring specialization as well as other factors, as the

[5] This property of the factor loadings will be exploited in the regressions carried out in the next section.

independent variables. We have data for 20 countries and three time periods[6], which means that the number of variables in the regression cannot be so large. Given these limitations of the data, we set up a regression framework in which we estimate separate equations for three periods: 1965-1973, 1973-1979 and 1979-1988. All our variables, except the ones related to specialization and catch-up (see below), are simple means over the complete period, with growth rates defined as annual compound rates. Besides the specialization variables, we include four other variables: the growth rate of employment (*GL*, measured in persons, rather than hours), the investment-output ratio (*I*, as a proxy for the growth rate of the capital stock), the number of patents granted in the U.S. per employee (*P*) as an indicator of technical change, and the ratio of value added per employee in the country/sector relative to the maximum value for the sector in the 20 countries sample (*CU*).

The latter variable is included in the equation to pick up effects related to *catch-up*: countries with an initially backward position may be expected to grow relatively fast (see, e.g., Fagerberg 1994, for an overview of theories on catch-up). This variable is measured for the initial year of the period for which growth rates are measured. Given the interpretation of this variable as a catch-up variable, we would expect a negative sign for it in the regressions. The signs for the other non-specialization variables are all expected to be positive.

The patent data we use is 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*, sector, the patent is counted as 1/*m* in each of these. We choose to work with U.S. patents because, rather than patent statistics from each of the national patent offices, these 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. Because we would expect U.S. firms to have relatively much patents due to a 'home-market' effect, we include a dummy for the U.S. in the regressions (DUSA).

The data for the growth rates of value added, *CU*, *GL*, *I* and the employees data used in *P* is taken from the UNIDO Industrial Statistics Database. For each of the independent variables mentioned so far, one might expect that the elasticities to be estimated would differ between sectors, and possibly countries. In the sectoral dimension, much of the variance of the elasticities might be related to technological differences between sectors. Given the limited number of observations within each sector, however, we choose to pool our data in the cross-section dimension, allowing for two broad classes of sectors: so-called *high-tech* sectors (defined as chemicals, machines, electrical goods, transport equipment, and instruments), and *low-tech* sectors (all other sectors). This broad classification has proven to be useful in estimating production structures and the impact of R&D on productivity in an earlier paper by one of us (Verspagen, 1995).

The resulting dataset is one in which we have 11 sectors (no patent data is available for two of the 13 sectors in Table 1: wood; other manufacturing), and 20 countries, leading, in principle, to 220 data points for each period. Due to missing values in some of the data, however, we have significantly less points in each case. For the first period, this problem is worst, with only 98 data

[6] We have time series for 1965-1988 for most of our variables, except for RCA, for which the data is available for 6 years in the period 1965-1988 only. Moreover, visual inspection of our time series confirms our expectation that the annual time series data is affected by business and trade cycles.

points available. We estimate the impact of the variables *I*, *GL*, *CU* and *P* separately for the two groups of sectors, and denote this by the variable symbol together with '-high' or '-low'.

The specialization indices are defined meaningfully only at the sectoral level, so we estimate their impact for each sector separately. Although it would in principle be possible to include the individual RCA-indices for each of the sector's product groups into the regression, this would soon lead to difficulties in case of sectors with a large number of product groups, due to our limited number of observations. We therefore choose to use the data-reduction possibilities of the principal components analysis presented in the previous section. We included up to three of the principal components in the final estimates presented below, although we experimented with more in some sectors. The resulting setup is one in which the principal components included in the regression pick up at least 60% of the total variance of the specialization data. Including the fourth, sometimes, fifth principal component did not change the results in a major way. We denote the principal components by Fi-sA, where A is the number of the sector from Tables 1 and 2, and i is the i-th principal component

Because we would expect that the impact of specialization on the growth performance of large countries may be smaller than in the case of small countries, an additional variable is included for all of the three principal components included in the regressions, defined as Fi-sA*DL, where DL is a dummy variable set to one for large countries.[7] Note that this variable, because it is entered in the equation in an additive manner, is only meaningful if the sectoral specialization variables all enter the regression equation with the same sign. However, because of the way the specialization variables are constructed, the sign with which it enters the regression is not theoretically meaningful. In order to assure the meaningfulness of the large countries specialization variable, we started with an initial regression including all specialization variables with their original sign. In a next step, we multiplied all specialization variables with a negative sign in the regression by -1, thus expecting that they would turn up with a positive sign.[8] This yields a regression in which we would expect the large country specialization variable to turn up with a negative sign. However, in order to allow for a direct comparison between Tables 3 and 1, e.g., by combining factor loadings and regression results to arrive at the predicted impact of specialization in individual products, Table 3 presents those factors which were multiplied by -1 with a negative sign.

Table 3 documents the regression outcomes for the three periods. We discuss the outcomes for the non-specialization variables first. The growth rate of labour input is highly significant and positive in all cases. The values of the coefficients for this variable differ between periods and sectors, with the highest value found in low-tech sectors during the period 1965-1973 (this value is indeed quite high if one would reason in a neoclassical framework). In the period 1973-1979, the value for these coefficients are relatively low.

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[7] France, Germany, Japan, United Kingdom, United States, Italy are defined as large countries.

[8] In no cases did this procedure change conclusions about the significance levels of any of the variables in the regressions.

Table 3. Regression results for the Specialization-Growth relationship*

	1965-1973		1973-1979		1979-1988	
R2-adj	0.67		0.47		0.22	
N	98		158		164	
Variable	estimate	*t*-value	estimate	*t*-value	estimate	*t*-value
GL-low	1.269	6.73	0.587	7.14	0.764	5.85
GL-high	0.532	5.95	0.583	3.29	0.817	3.51
I-low	0.215	2.73	-0.012	-0.32	0.072	1.63
I-high	0.388	6.29	0.248	3.52	0.223	2.92
DUSA	-0.025	-1.83	0.022	2.58	0.018	1.91
Pat-low	-5.179	-0.83	-4.704	-1.10	-13.157	-1.84
Pat-high	6.482	3.83	2.446	1.80	4.643	1.23
CU-low	-1.990	-5.00	-0.632	-3.40	-0.092	-0.41
CU-high	-2.780	-8.18	-1.596	-4.47	-0.566	-1.53
F1-s1	-0.011	1.89	-0.002	0.30	0.006	0.68
F1-s2	0.004	0.53	0.001	0.22	0.004	0.96
F1-s4	0.029	1.91	-0.023	2.16	-0.007	1.07
F1-s5	-0.008	1.19	0.000	0.09	-0.007	1.58
F1-s6	0.008	2.74	0.000	0.19	-0.003	0.90
F1-s7	-0.006	0.67	0.007	1.17	-0.004	0.53
F1-s8	-0.017	2.51	0.008	3.25	-0.001	0.08
F1-s9	-0.007	1.05	0.024	3.53	-0.009	0.95
F1-s10	-0.007	0.79	-0.006	1.46	-0.013	1.62
F1-s11	-0.014	3.16	-0.001	0.08	-0.005	0.61
F1-s12	0.011	1.74	0.013	1.55	0.012	1.12
F1-large	-0.007	-1.28	-0.016	-3.41	-0.009	-1.21
F2-s1	-0.015	1.98	-0.001	0.16	0.013	1.81
F2-s2	-0.003	0.57	-0.005	1.31	-0.002	0.45
F2-s4	-0.022	4.68	-0.027	4.40	-0.008	1.21
F2-s5	-0.002	0.14	-0.010	1.60	-0.010	1.85
F2-s6	-0.010	3.17	-0.010	2.63	-0.013	2.63
F2-s7	-0.005	0.53	-0.008	1.38	-0.006	1.14
F2-s8	-0.001	0.21	-0.002	0.49	-0.010	2.02
F2-s9	0.016	1.54	-0.007	0.58	-0.017	1.34
F2-s10	-0.001	0.18	0.003	0.44	-0.006	0.74
F2-s11	0.010	2.60	-0.014	1.28	0.012	1.62
F2-s12	0.026	5.03	-0.023	1.83	-0.024	2.52
F2-large	-0.003	-0.46	0.002	0.34	0.009	1.22
F3-s1	-0.006	1.10	0.002	0.31	0.012	2.34
F3-s4	-0.022	3.51	0.028	3.88	0.002	0.69
F3-s7	0.005	0.78	-0.001	0.07	-0.005	0.71
F3-s8	0.011	1.31	0.009	1.60	-0.002	0.22
F3-s9	-0.001	0.27	-0.028	2.67	0.005	0.74
F3-s10	-0.018	1.84	-0.006	1.02	0.000	0.04
F3-s11	-0.015	4.23	0.022	2.37	-0.006	0.56
F3-large	0.005	1.02	0.004	0.76	-0.004	-0.93
C	0.066	7.47	0.030	4.44	0.025	2.37

*Cells with coefficients significant at a level >10% in a 2-tailed *t*-test are printed in bold.

The coefficients for the investment-output ratio are significant in all but one cases. The one exception is low-tech industries during the period 1973-1979. For all three periods, the value of this coefficient is higher for the high-tech sectors, while the value of the coefficients tends to fall over time. The patents variable is significant and positive, as expected, in only two cases, high tech industries during 1965-1973 and 1973-1979. For low-tech industries, this variable is always negative, during the last period even significantly so, a result which is hard to explain. The U.S. dummy is negative during the first period, in line with our expectations about the 'home market' effect for U.S. firms in the patents variable, but it is perfectly conceivable that this variable also picks up other influences specific to the U.S.[9] For the other two periods, the U.S. dummy is positive and significant.

Overall, the regressions tend to explain a decreasing fraction of the total variance as time increases. The adjusted R^2 falls from roughly two-thirds in the first period to slightly less than one half in the second, to barely one fifth of the total variance in the last period.

With regard to the specialization variables, which are the crucial part of our argument, we do indeed find many significant variables. Only in textiles (2) and basic metals (7), none of the specialization variables is significant. For the other nine sectors, there is at least one, but often more, principal component for one time period that is significant. In the first period, roughly all of the specializtion variables are significant (14 out of 29), for the second period this is slightly less (11 out of 29), and for the last period, it is even less (8 out of 29). We thus conclude that there is indeed some evidence that sectoral growth rates of production are to some extent related to within-sector specialization patterns of international trade, although the impact seems to become weaker over time.

We can only speculate as to why the specialization variables are becoming less important over time as a factor explaining growth. It might be related to the fact that we our sample is not a balanced one (some observations in the sample for the last period are not present in the early period), thus reducing the phenomenon at least partly to a technical one. It might also be the case that 'real' phenomena, such as trade liberalization, the increased importance of FDI, or technological developments underlying the production structure, have a role in this. For the time being, we will not discuss this part of our findingsfrom a statistical point of view, but instead focus on a more 'qualitative' interpretation of our regression results in the next Section.

4. Interpretations, conclusions and policy issues

The regression results presented in the previous Section seem to indicate that specialization does indeed matter for economic growth. The theoretical frameworks that were discussed in Section 2, suggest that there are various factors that may account for these results. On the supply-side, there are factors such as the learning opportunities offered by various activities or products, while from the demand side, income elasticities are important.

The result that the variables such as technology (as measured by patents), specialization and catching-up potential all show a weaker impact on growth during the 1980s, suggests that there might be an interaction between them. In other words, while catching-up in the 1960s and 1970s

[9] We have also experimented with dummy variables for other countries, but in no cases did these prove to influence the results in the table in an important way, even if some of the country dummies were statistically significant for some periods.

was mainly due to a non-activity-specific rapid learning of relatively backward economies, in the 1980s, it became an activity specific phenomena. Some activities provided 'windows of opportunity', while others, e.g. due to their relatively cumulative technological nature, provide more opportunities for relativelty advanced countries. It has to be stressed, however, that such an interpretation is rather speculative, and more research would be necessary to substantiate these ideas.

In order to obtain a more precise notion of which activities have had a 'positive' impact on growth, the methodology can be taken one step further. If the factor loadings from Table 1 (numerically above 0.5, admittedly an arbitrary value) are combined with the regression results in Table 3, it is possible to analyse the impact of intra-sectoral specialization patterns on sectoral growth, i.e., to obtain a positive or negative impact on growth. It should, however, be kept in mind that the data reduction, itself a central aim of the principal components methodology, by definition leaves out some of the underlying information. Therefore such specific conclusions at the product level should be interpreted with caution. It should also be stressed that the specialization patterns referred to are calculated at the intra-sectoral level - the weighted average of the specialization indicator sums to 0 for each of the sectors.

Applying this procedure, yields a number of products which have a 'significant' impact on sectoral growth in each of the three periods. Such a list (not explicitly documented), shows that the interpretation of our regression results is indeed one which involves a rather complex set of interacting supply and demand side factors. In e.g. the electrical goods sector, specialization in semiconductors in 1979 turns out to have had a negative impact on real growth in value added (of the electrical goods sector) 1979-88, in spite of high growth of the value of international trade in semiconductors over that period. Inspection of underlying data shows that only a few countries are specialized in semiconductors, including 'established' technology leaders such as Japan, the US and The Netherlands (Philips), as well as less advanced countries such as Austria (where Philips has many of its production facilities) and Portugal (which has a relatively low export volume in electrical goods). Although these countries (perhaps with the exception of Portugal) have seen the volume of their semiconductors exports increase significantly over the period, they have also experienced increasing competition by catching-up nations, which have been growing rapidly, but only in selected product-segments, like telecommunication equipment. Thus, our interpretation of the negative impact of semiconductors specialization on growth in electrical goods production, is that in the semiconductors segment, the 'technology leaders' are in the best position, due to for example the short product life cycle and high investments. Other segments in the electrical goods industry, however, seem to provide a 'window of opportunity' for catching-up for relatively backward nations, which implies that catching-up related rapid growth is correlated with negative specialization in semiconductors.

This example (others could be mentioned) indeed brings out the complicated nature of the causal relationship between specialization and growth. Demand related mechanisms (e.g., the high income elasticities of semiconductors) may not always work in the same direction as supply side effects (e.g., the little opportunity for catching-up in semiconductors), and the net result is rather unpredictable from the theories that we have discussed in Section 2.

Perhaps more interesting is the mixed pattern that emerges when we compare the impact of one product group across periods. In 29 cases, a single product group appears with a similar impact (negative or positive) for different periods. However, in 35 cases, the same product group appears with different impacts for different periods.[10] This seems to indicate that the stickiness with regard to the sign of the impact of specialization on growth is not very large.

Where does this leave policy makers who want to 'steer' the economy into a high-growth specialization path? First, it has to be noted that the opportunities for such policies are probably low. Dalum and Villumsen (1996) find that, within the group of OECD countries, specialization patterns tend to be sticky over the 1961-1992 period, although their conclusion is not for intra-sectoral specialization as in the present analysis. On the other hand, in terms of the 5-10 year periods that we have considered in the analysis, changes with regard to the sign of the impact of specialization on growth are quite common. Thus, the relative stability of the factor loadings in Table 1 and other efforts to measure long term change of export specialisation patterns imply some degree of tension: the 'reaction speed' of specialization patterns might simply be too low to allow for an active policy. Moreover, our finding that both supply- and demand-side factors matter, calls for a cautious mix of different policies: e.g., technology policy aimed at increasing the rate of innovation and learning, industrial policies aimed at changing the specialization patterns of the economy, and, within international rules, trade policies aimed at stimulating exports. It is obvious that if policies aimed at stimulating growth by specializaing in the 'right' kind activities are to be succesful, policy makers must be prepared to aim at a high degree of interaction between their various instruments, as well as be willing to risk unsuccesful measures, and admit these in an early enough stage. Enhancing growth by steering specialization patterns seems a quite riskful 'art' rather than a well-established 'science' without major uncertainty.

[10] These numbers are 'double-counted', i.e. if a product group appears twice with the same impact, we counted it twice.

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