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HIGH TECH EXPORTS AS A STRATEGIC FACTOR OF INTERNATIONAL COMPETITIVENESS

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Abstract

This paper explores the link between technology, investment, price factors and export performance in a set of 21 OECD countries and for 7 science based sectors over the period 1988-1996. The main argument in the paper is that each industry contains a segment in which competition is based on new products and one in which competition is based on costs. Which of these two segments is the larger will depend on the stage in the business cycle. The existence of a list of high tech product exports allowed us to distinguish between these two segments for seven industries. Consistent with the conceptual model, technology is found to have a direct and highly significant correlation with high tech exports, which in turn positively influence the non-high tech export part of the industry. Hence, the indirect influence of patents on non-high tech exports is much higher than the direct one (which points to the existence of process innovation). The relation between the price factors and the non-high tech part remains ambiguous and difficult to explain. We suggest that high costs of employment might be an indication of the use of highly skilled personnel, which in turn points to innovative capacity as a basis for competition. The paper shows paradoxically that the linear view seems to be still valuable, but for reasons that can only be explained by the systemic approach.

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1. Introduction

In this paper, we introduce the export of high tech products as an additional factor which can shed further light on the current discussion between the importance of price and non-price factors to explain market shares of exports, a well-known indicator of competitiveness. Neo-classical economists have tried to explain the relative export performance of countries by their relative price levels. Kaldor (1978) was among the first to challenge this view by pointing out the important influence of so-called non-price factors. His arguments found support in the empirical observation that those countries in which prices were increasing were also the countries that experienced growth in their export market shares – the Kaldor Paradox. Ever since, non-price factors, and more specifically those variables that indicate the differences in technological capabilities have become a crucial element in this debate (Soete, 1981; Fagerberg, 1996).

Amable and Verspagen (1995) have recently argued that both price and non-price factors might explain different parts of the competitive export share. Depending on the 'technology intensity' of the sector, they suggest that either the non-price or the price factor will dominate. In a highly technology intensive industry such as pharmaceuticals, one finds the non-price factor as the dominating variable, whereas in the least technology oriented industries such as textiles, the costs of employment (i.e. the price factor) explain best the export market share. This paper extends this analysis from technology intensity differences between sectors towards differences within sectors. Even in sectors generally recognized as technology intensive, not all products are considered to be high tech. An extreme example of this is the chemical industry, which only consists of a very small percentage of high tech products.

The present paper presents a model which makes a distinction at the industry level between the share of exports that is related to high tech and that which is not, thus allowing us to enter into the complex relation between technology efforts and economic outputs. The main argument underlying the model is that technology efforts (non-price factors) have a direct impact on exports of high tech products, which in turn influence the non-high tech export shares of the sector. This means that the technology investments only have an indirect impact on the non-high tech export shares, namely through the realization of high tech exports. The intuition behind this is that investments in technological development first lead to pioneering positions in which the technology intensive countries dominate. Those that are able to reach competitive position on the market for high tech products are assumed to be better positioned to export the non-high tech products in the same sector. However, to explain the non-high tech exports, we hypothesize that price factors will also play a role and should be introduced as a competing variable in the model.

The paper is organized as follows. The next section presents a review of the related literature and positions the paper in relation to previous work in the field. Section 3 explains in detail the definition of hi-tech products and hi-tech industries used in this paper, and then section 4 goes on to look at recent trends in the European Union's trade in hi-tech products. Section 5 presents the specifications of the model itself and section 6 its main results. In the final section some overall conclusions are drawn.

2. Literature Overview

The interest in the study of exports as a factor which explains growth of an economy emerged from the Keynesian approach (Fagerberg, 1996). Whereas neo-classic economists generally have neglected international trade, Keynesian scholars introduced the demand for exports as an exogenous factor in the growth equation. Consistent with this, the economic community became interested in the study of the factors which determine exports.

In the early contributions, price differences were identified as the most important determinants of export performance. If a country can produce something cheaper in a certain sector, then its export will increase. In spite of their appealing, quite simple logic, the price models have difficulty to pass the test of reality. Low cost labor economies such as the Asian and more recently Eastern European examples have high difficulties in attracting foreign direct investment necessary to increase their exports. Kaldor formalized this observation in what is generally known as the 'Kaldor Paradox' (Kaldor, 1978): it is precisely those countries that have experienced the highest growth in labor costs which also show the largest increases in exports and GDP. Relative price differences thus cannot explain long-term export performance.

The post-Keynesian tradition was originated by Thirwall (1979) who argued that the growth of international trade depended on changes in relative prices (the Keynesian price factor) and on the ratio of income elasticity of demand for exports to that for imports. If world income is rising, then those countries that produce goods or services for which this ratio, better known as the Thirwall formula, is the highest, will experience the largest increases in their own export shares. The Thirwall formula is an indirect measure of all so-called non-price factors which are assumed to determine export shares. For instance, one could argue that if world income rises, the demand for goods or services of higher quality will rise more than the demand for less qualitative products. Another example is the demand for 'newer', for instance high tech, products which is supposed to increase more than the demand for low-tech products.

One can think of a whole set of 'non-price' factors such as the degree of innovation, quality, technical specification, design, advertising, marketing support, and value for money (Buxton et al (1994)). However, despite current efforts going on in Europe to measure some of these non-price factors through the Community Innovation Survey, direct measures of non-price factors at the level of the economy or of any sector are still very scarce. One very important factor suggested by Kaldor (1981) and elaborated by Soete (1981) is a country's technological capability. Thanks to the major efforts of the OECD and EUROSTAT, one can find proxies to measure the technological capability of a country, even desegregated at the sector level. Soete (1981) divided these measures into two categories: technology-input (e.g. R&D employment, R&D expenditures) and technology-output measures (patents, innovation counts).

Initial studies analyzed the impact of R&D on export performance at the country level, disregarding sectoral differences. More recent studies have analyzed the influence of technology on export performance at the sectoral level for single countries (Soete, 1981; Lacroix and Scheuer, 1979; Fagerberg, 1995). Others have pooled countries and industries using a time series model (Magnier and Toujas-Bernate, 1994; Amable and Verspagen, 1995; Carlin et al., 1998). In general, these studies find a positive impact of technology on export performance (see Table 1) for the majority of sectors and countries.

Table 1: Impact of technology and other factors on trade performance

	R&D intensity 1985	Technology			Technology		
		R&D			Patents		
		Lacroix and Scheuer 1976	Fagerberg 1995	Magnier and Toujas-Bernate 1994	Soete 1981	Fagerberg 1995	Amable and Verspagen 1995
Aerospace	20	-	-	X	X	-	-
Computers	10	X[e]	-	X	X	-	X
Electronics	8	X[e]	X	-	X		-
Instruments	6	X[e]	X	-	X	X	X
Electrical machinery	3	X[e]		-	X	X	-
Cars	3	X[f]	-	X	X	-	X
Drugs	9	X		-	X	X	X
Industrial chemicals	3	X	X[a]	X	X		X

Symbols: X = significant, correct sign; blank = not included.
Notes: [a] Organic chemicals, [e] Electrical machinery (broadly defined) and instruments, [f] Transport equipment excluding aerospace.
Source: based on Fagerberg (1996)

The study of Amable and Verspagen (1995) is noteworthy in this respect. Using the Pavitt taxonomy[1] (Pavitt, 1984), the authors hypothesize that in the lower technology intensive industries (i.e. the supplier dominated ones) price factors will determine export performance, while in the medium and higher technology intensive ones non-price factors will be the main determinants. In the scale intensive industries this non-price factor is basically related to gross fixed investment, while technology investment is most important in the science based industries. Their results are somewhat puzzling. In general, they find that both the price and

[1] Pavitt classified sectors according to the sources of innovation and the mode of competition. Five categories were distinguished: supplier dominated (eg textile industry) ; scale intensive (eg automobiles) ; science based (eg pharmaceuticals) ; information based (eg software) and specialized suppliers (instruments, machinery).

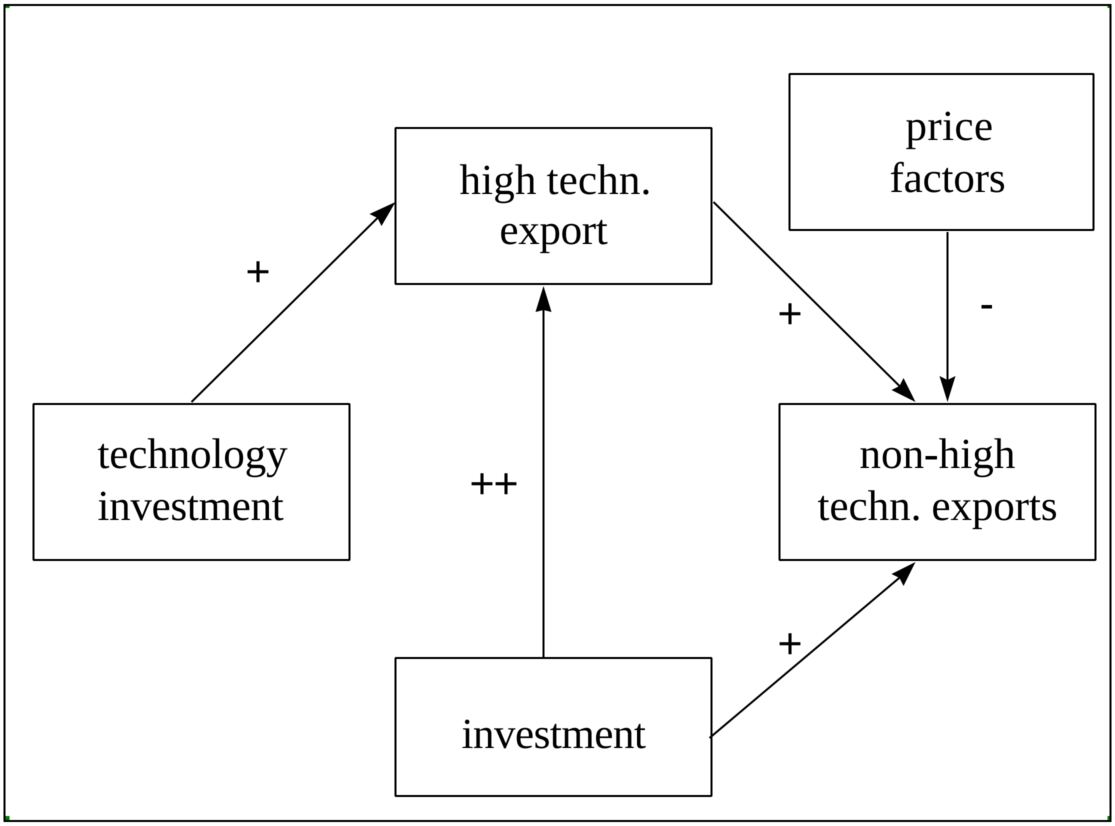
non-price (i.e. technology) factors explain export performance in *both* lower and higher tech sectors, which, they conclude, shows the limited use of the sectoral taxonomy outside the field of institutional economics.

Amable and Verspagen state that it is surprising to see in the science based sectors (aerospace, electronics, chemicals and electrical machinery) such an important influence of the price factor, while the supplier-dominated sectors such as textiles involve a highly significant technology variable. Part of the explanation might lie in the fact that both in high and low tech sectors, one finds 'innovative' and 'less innovative' companies. Clarysse et al. (1997) have shown that the percentage innovative enterprises in a low tech sector such as textiles does not significantly differ from a high tech sector such as chemicals. However, the basis for competition between both sectors differs. In the low tech sector, one finds innovative enterprises which introduce new products, basically using technologies generated in other sectors, while in the chemical industry, the most innovative enterprises generate their own technologies. The result is that, at the company level, both in the low and high tech sectors, new products/processes are the source of competitive advantage, but the extent to which the technology on which these products are based is generated in the sector itself differs considerably. In other words, once the sectoral effects are controlled for, one would expect that the technology variable, as measured by patents or R&D expenditures, to further distinguish between the better and less performing.

For the science based (and supplier specialized) industries, economists have a proxy to discriminate the 'newer high tech' from the more traditional 'low tech' products. As aforementioned, a list of high tech products is available which covers products in nine 'science based' industries. This paper incorporates the exports of high tech products as an intermediary to explain the link between technology and exports at the sectoral level.

Conceptually, one could argue that high tech products are the first to be produced along the business cycle. They reflect the results of research which find their industrial applications either within the sector which finances the research or in other sectors. Since this paper focuses on the science-based industry, we can assume that most of the technological inventions will be realized by the sector itself. Consequently, we expect a high, positive influence of a country's technological investments in any science based sector on its export performance in high tech products (see Figure 1).

Figure 1: Conceptual model



In turn, we have shown before that, to a varying degree, each science-based sector produces low-tech products as well. These low-tech products might come later along the business life cycle. According to the linear model of technological innovation (Soete and Arundel, 1993), one could argue that the extent to which countries excel in the export of high tech products will also influence their performance in the low tech part. Scholars like Lieberman (1991) have shown that enterprises which obtained a pioneering advantage through selling high tech products in certain industrial niches, usually succeeded in retaining a high market share when additional competitors enter this market and hence the technological content of the products decreases. The same argument can be taken to explain country (instead of company) level differences. In most cases, this pioneering advantage is not only related to technological knowledge, which can be imitated when the technology is no longer the key to competitive success, but also can reflect the learning experience which the country has built up in exporting this particular kind of product.

We further hypothesize that once we control for the impact of high tech exports on the non-high tech part of the industry, the influence of the technology investments on non-high tech basically falls down to zero (as is shown by the non-existent arrow between technology investment and non high tech export performance in Figure 1). At this stage, the price factors come into the picture, which together with investment in fixed capital are assumed to affect export performance.

Finally, we put forward that investment in fixed capital will influence a country's performance in both high tech and low-tech exports. Since investment in fixed capital also reflects the country's belief in its future competitive position in this industry (thus both in the high tech and non-high tech part), we assume that country's will only invest a lot if they believe in the high tech potential of their products. Therefore its impact will be higher on high tech exports than on the non-high tech exports since low-tech products are competing at a later stage in the business cycle where investment in fixed capital such as production has only a marginal effect on performance.

Figure 1 summarizes all the relations put forward under this point.

3. Definition of hi-tech products and technology-intensive sectors

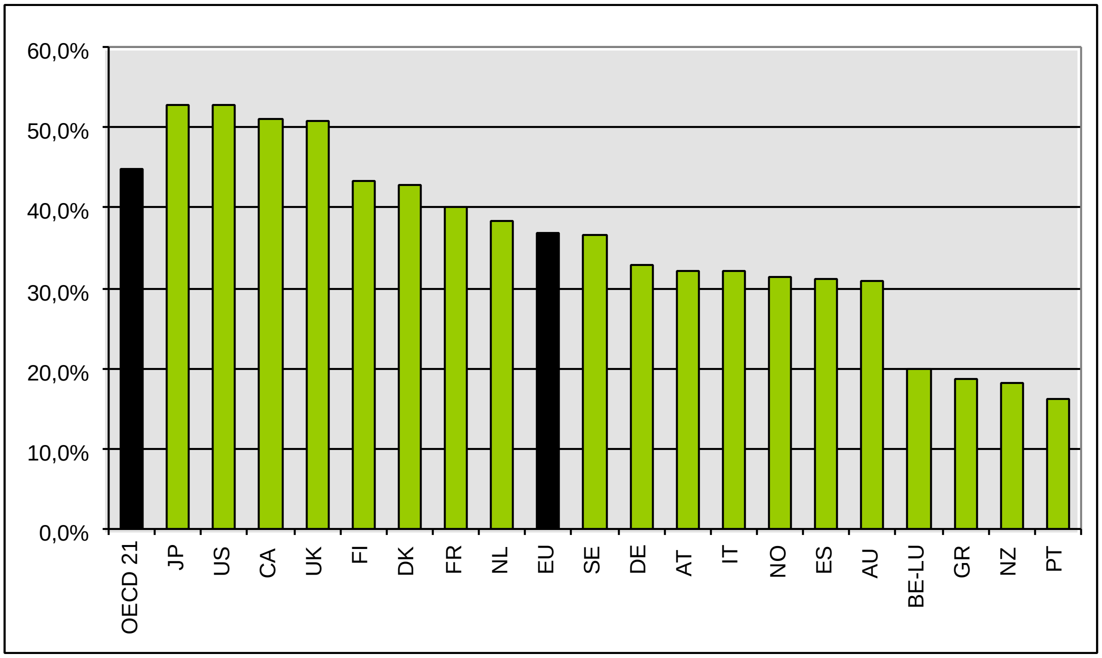
There has been considerable discussion in the literature about appropriate definitions of high-tech products and industries, and various studies have analyzed trade data using different approaches (Guerrieri and Milana (1995), Grupp (1995), Abbott (1991)). The present paper uses the revised definitions of high technology products and technology-intensive sectors recently developed by the OECD (OECD (1997)). These definitions have the advantage of being relatively fresh – which is important in the rapidly evolving field of advanced technologies – and of being internationally accepted, having been established with the collaboration of the OECD countries and of Eurostat (the Statistical Office of the European Communities).

The OECD classification of high technology sectors is based upon the R&D intensity of the 22 manufacturing industries analyzed in 10 OECD countries. Sectors are thus ranked according to their direct and indirect R&D intensity (indirect intensity takes account of technology incorporated in purchased intermediate or capital goods), and are divided in to 4 categories: high-technology, medium-high-technology, medium-low-technology and low-technology sectors. The seven sectors covered by the analysis in this paper – aerospace, computers and office machinery, electronics, pharmaceuticals, scientific instruments, electrical machinery and chemicals - correspond to those where most high-tech products can be found, and fall into the high- and medium-high technology sectors of the OECD. Hereafter we shall refer to them as the "seven technology-intensive sectors".

The high-tech product classification of the OECD is based upon an analysis of the technology intensity of products carried out at a very fine level of product detail (4 and 5 digit SITC codes). Where necessary, experts were also consulted to determine whether a particular product should be considered as high-tech. The resulting list covers approximately 130 products that are deemed to be of the highest technology intensity (see Appendix 1).

Figure 2 shows, for the 21 OECD countries considered in this paper, the share of high-technology products in the total exports of the seven technology-intensive sectors. For this group of 21 countries as a whole, hi-tech products account for 45% of all exports in these sectors. One sees that the US, Japan and Canada are relatively hi-tech rich in their export composition, whereas the average for the EU is considerably lower (37%).

Figure 2: **High-tech products as a % of total exports for the seven technology-intensive sectors [1] (1994, value in ecus)**



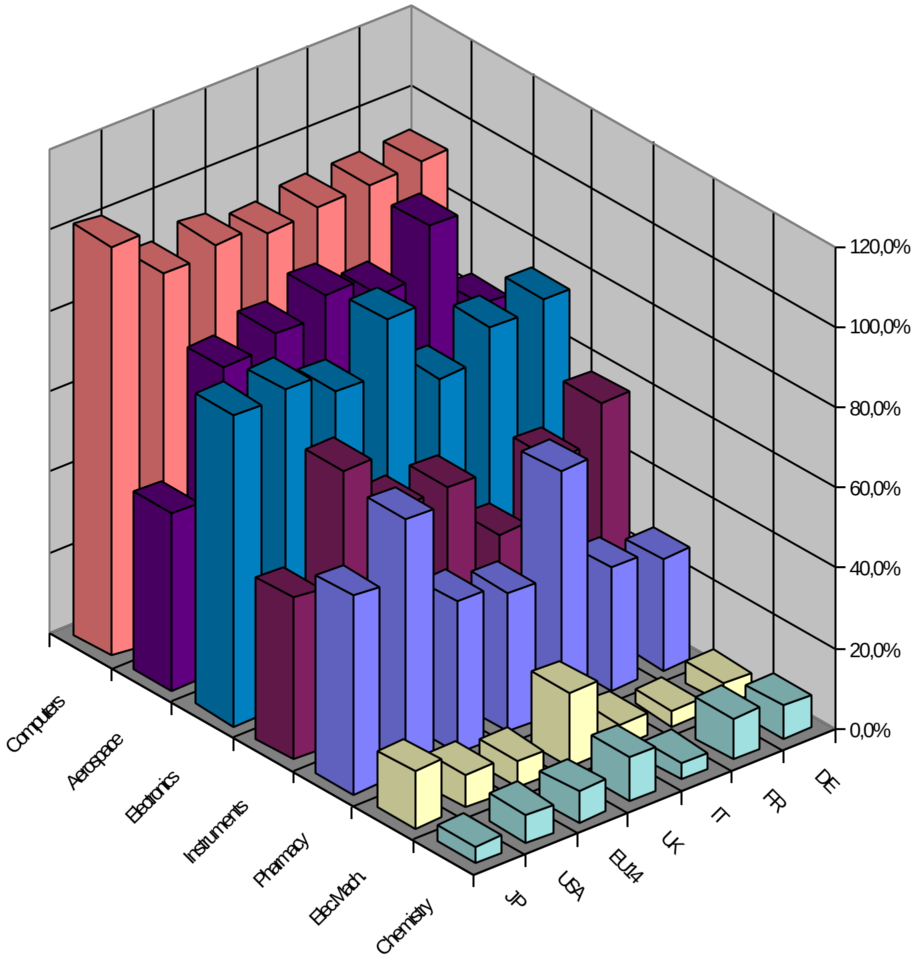
Source: COMTRADE, STAN (OECD)

Notes: (1) The seven sectors are: Aerospace, Computers and Office Machinery, Electronics, Pharmaceuticals, Scientific Instruments, Electrical Machinery and Chemicals.
(2) European Union exports include both intra- and extra-EU trade.

To some extent such variations can be explained by differences between countries in their sectoral specialization. In other words, those countries that have more production and exports in those sectors with a high proportion of hi-tech products will tend to export more hi-tech as a result. This effect can be seen in Figure 3 which presents the percentage of hi-tech products in the exports of each of the seven sectors. Computers, aerospace and electronics are clearly the sectors with the largest percentage of hi-tech products, while chemicals and electrical machinery are seen to be predominantly low- to medium-tech in their export structure.

It is also interesting to observe the differences between countries' exports in the same sector. For example, in instruments the US has significantly more hi-tech products in its exports (67%) than the EU (52%) and Japan (40%), whereas in chemicals the EU is clearly ahead with 8% hi-tech versus 7% for the US and 4% for Japan.

Figure 3: **Percentage of high-technology products in the total exports of technology-intensive sectors (1994, value in ecus)**



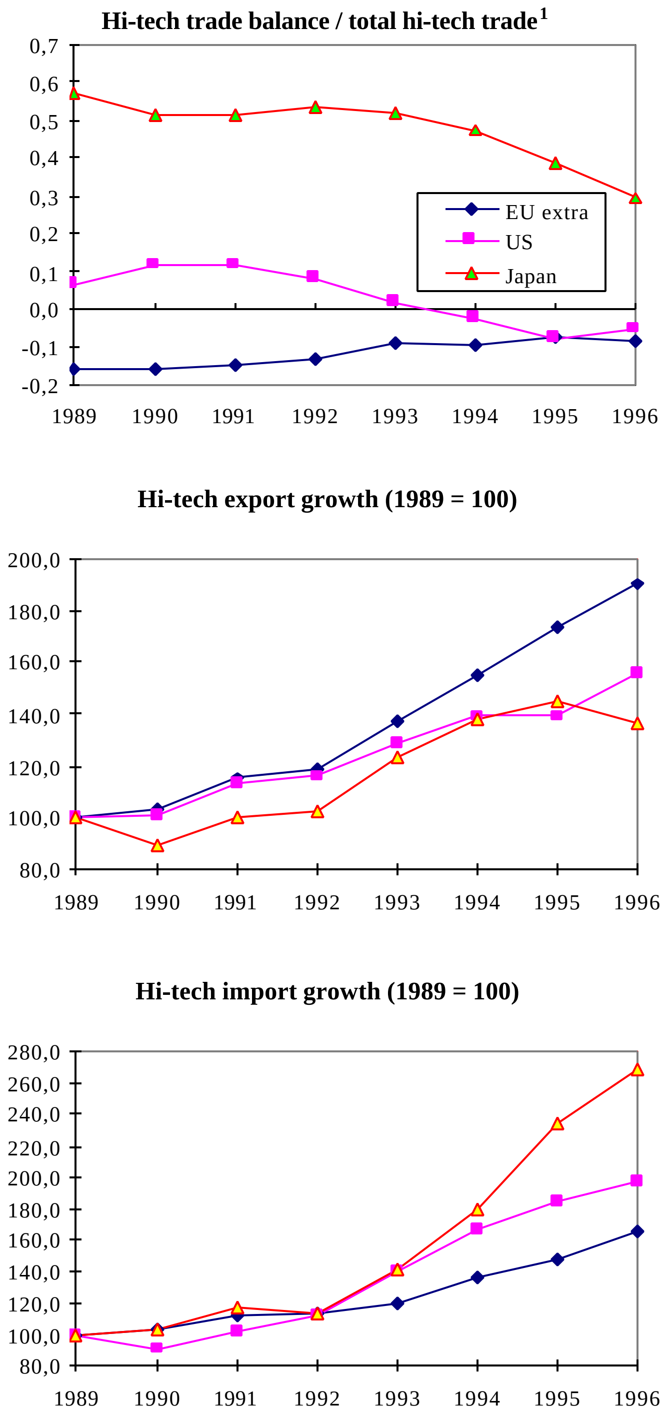
Source: COMTRADE, STAN (OECD)

In section 5 we shall go on to look at whether performance in hi-tech exports has any broader implications for total export market share within a sector, and to what extent the determinants of hi-tech and non-hi-tech exports may differ. Before that, however, we shall briefly sketch some of the general trends in hi-tech exports, including the dynamics of market shares and patterns of trade specialization.

4. Trade dynamics and specialization

Recent developments in hi-tech trade for the triad countries can be seen from Figure 4. The EU's balance of trade in hi-tech products remains negative. Although the deficit in relation to total trade (exports + imports) had shown signs of falling at the start of the 1990s, its has leveled out since 1993. However, EU exports of hi-tech

Figure 4: Trends in hi-tech trade (value in ecus)



Source: COMTRADE

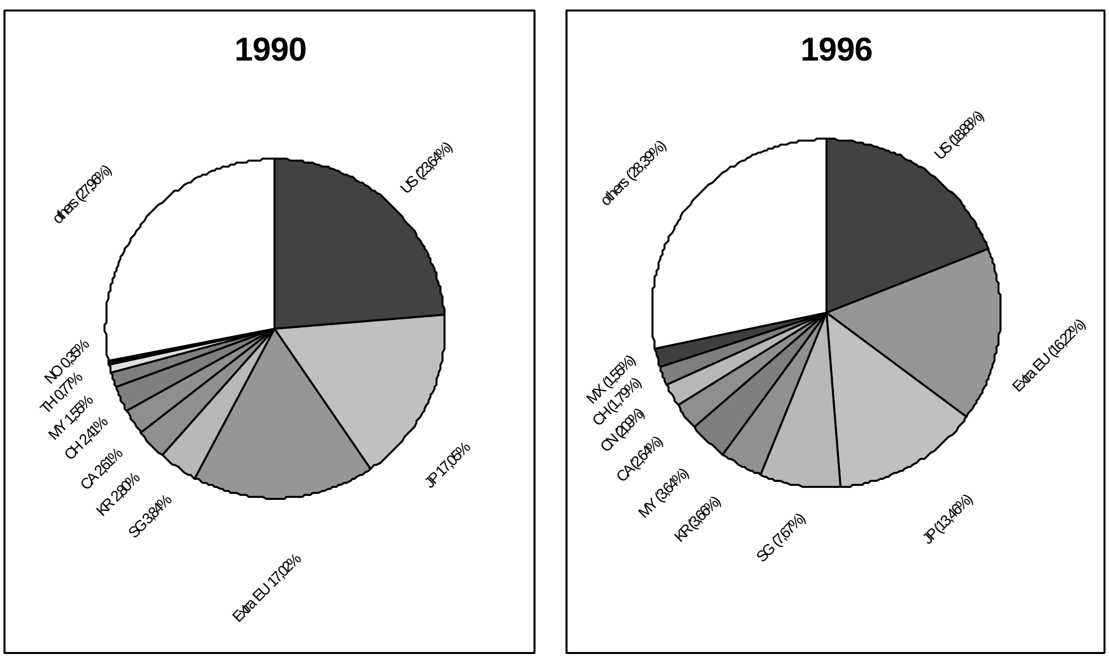
Note: (1) Total trade = exports + imports.

products have been growing at a faster rate than the other partners of the Triad (at an annual average of 10.4% for the period 1989-96 for the EU versus 6.7% for the USA and 6.2% for Japan), while its hi-tech imports have been growing almost as rapidly (9%), although less markedly than the USA (10.7%) and particularly Japan (16.6%)[2]. The consequence for the latter two countries has been a dramatic fall in their hi-tech balance (in the US since 1990 and in Japan since 1994).

The latest data, for 1996, indicate some slowing down in the EU's hi-tech export growth (8.1%), and a significant decline in Japanese exports (-6%). However, the US appears to have experienced an export surge, with 1996 growth registering 11.6%.

The classical analysis of competitive performance is based upon the dynamics of export market shares rather than on pure growth rates, where countries/firms compete to expand their share by increasing their exports more rapidly than their market rivals. While managing to increase their exports of high-tech products, the EU, US and Japan have seen their collective hi-tech market share fall from nearly 60% in 1990 to under 50% in 1996 (Figure 5), owing to the emergence of significant competition from the countries of South East Asia - Singapore, Malaysia and Korea - in the fields of computers and electronics.

Figure 5: Market shares of high-technology exports (value in ecus)



Source: COMTRADE

[2] For further explanation of these trends see The Second European Report on S&T Indicators (European Commission (1997)), pp. 190-200.

This analysis can be extended further by looking at the separate dynamics of exports of hi-tech products and exports of non-hi-tech products (Table 2). The 21 OECD countries in the table are those that will be used later in section 5 for the development of the model of export determinants. The table splits the exports of the seven technology-intensive sectors into two groups: hi-tech products and non-hi-tech products. As expected, the structure and dynamics of the two groups of exports are rather different. One sees that the EU (intra plus extra-EU trade) has a higher market share for its exports of non-hi-tech goods (62% in 1994) than for its exports of hi-tech products (44% in 1994), in notable contrast to the US, Japan and Canada, where hi-tech exports have the larger share. Within the EU, only UK and Finland (and one suspects, Ireland) have a bigger share of hi-tech than non-hi-tech.

Table 2: Market shares of exports of high-tech and non-high-tech products: aggregates for the seven technology-intensive sectors[1] (based on value in ecus)

	Exports of hi-tech products			*Exports of non-hi-tech products*		
	% Market share 1994	% Market share 1990	Av. Change in share % 90-94	% Market share 1994	% Market share 1990	Av. Change in share % 90-94
European Union	44,0	45,5	2,2	61,8	66,1	-1,6
Belgium-Luxembourg	1,7	1,4	6,8	5,7	5,5	1,2
Denmark	1,0	1,0	-1,0	1,1	1,1	0,1
Germany	11,2	12,6	-2,7	18,7	20,3	-1,9
Greece	0,0	0,0	8,0	0,1	0,1	5,2
Spain	1,1	0,8	8,8	2,0	1,9	0,9
France	8,0	8,2	-0,5	9,8	10,0	-0,4
Ireland	2,4	2,2	3,0	:	:	:
Italy	3,2	3,4	-1,9	5,5	5,9	-2,1
Netherlands	4,7	4,0	4,0	6,1	7,6	-5,2
Austria	0,9	0,8	3,0	1,6	1,9	-5,1
Portugal	0,1	0,2	-3,1	0,5	0,5	3,5
Finland	0,8	0,5	11,9	0,8	0,8	1,6
Sweden	1,5	1,8	-4,3	2,1	1,9	2,4
UK	9,8	10,7	-2,0	7,8	8,6	-2,2
US	26,9	27,8	-0,8	19,6	17,9	2,4
Japan	22,6	20,7	2,2	16,5	14,1	3,9
Canada	3,4	3,2	1,4	2,6	2,4	2,8
Norway	0,3	0,4	-6,5	0,5	0,6	-3,6
Australia	0,4	0,2	18,4	0,7	0,3	24,8
New Zealand	0,0	0,0	15,7	0,2	0,1	16,1

Source: COMTRADE, STAN (OECD)

Notes: (1) The seven sectors are: Aerospace, Computers and Office Machinery, Electronics, Pharmaceuticals, Scientific Instruments, Electrical Machinery and Chemicals.

(2) European Union exports include both intra- and extra-EU trade.

(3) Market shares are calculated in relation to the total exports of the 21 OECD countries in the table.

In terms of dynamics, the EU's share of both types of exports fell between 1990 and 1994 (although its hi-tech exports rose again in 1994, thus resulting in an overall average growth rate of 2.2% for 1990-94, and have continued to grow in 1995-96). The strong growth in the hi-tech shares of the Netherlands, Finland and Belgium stand out, as do those of Spain and Greece (albeit from a lower base). Meanwhile the US has seen an erosion of its hi-tech market share from 1990 to 1994, while Japan's share grew over the same period (but has since declined significantly in 1995 and 1996). The strong increase in share of both types of exports of Australia and New Zealand is also worth highlighting.

But what is the significance of these trends? Does it matter that the EU has a smaller market share in hi-tech exports than in non-hi-tech? Firstly, it is useful to analyze these two product groups separately because the factors explaining their trade dynamics may be different, with hi-tech being more strongly correlated with non-price factors, notably technology, and non-hi-tech exports more dependent on price-related factors. Moreover, one of the hypotheses to be explored in the next section, is that performance in hi-tech exports in a particular sector may itself have an influence in the course of time on non-hi-tech exports: obtaining a strong pioneering position in certain hi-tech markets of today may help a firm to develop the technological and market advantages which in turn lead to an improved position for exporting non-hi-tech products in the same sector.

So far we have looked at hi-tech exports aggregated over the seven technology intensive sectors. Clearly, some countries may be more specialized in certain sectors, and therefore in the export of certain groups of hi-tech products, and less specialized in others. Under a traditional "linear" model of innovation, one might expect to see a distinct relationship between a country's trade specialization and its patterns of investment in technology.

Table 3 presents such a comparison, in terms of relative specialization indices by sector for hi-tech exports, patents (EPO and US) and business R&D. The European Union's areas of specialization are aerospace, pharmaceuticals and chemicals for exports of hi-tech products, and its areas of weakness are computers and electronics. This pattern of specialization is mirrored in the RS indices for US patents (although not for European patents, which is to be expected since the EU figure relates to exports to the non-EU market). Japan's strength in exports of computers, electronics and instruments is also immediately apparent, and again this corresponds generally to a distinct technological specialization in these sectors. The US seems to have a very broad hi-tech trade specialization, which is also reflected in its patenting indices. As one might anticipate, the relationship between patterns of business R&D expenditure and hi-tech exports appears less clear than that between patents and hi-tech trade.

Such relationships are of course hard to discern in this manner, and necessitate a more rigorous analytical approach, which is developed in the following section. In particular, an econometric model is presented which sheds light on some of the issues alluded to in this brief descriptive overview, namely, the relation between technological investment and trade in hi-tech products, the relative importance of price versus non-price factors in determining exports of hi-tech and non-hi-tech

Table 3: Relative specialization indices for hi-tech trade, technology and R&D (averages 1992-1995)

	All hi-tech exports	AEROSPACE Hi-tech exports	AEROSPACE EPO patents	AEROSPACE US patents	AEROSPACE Business R&D exp.	COMPUTERS - OFFICE MACHINERY Hi-tech exports	COMPUTERS - OFFICE MACHINERY EPO patents	COMPUTERS - OFFICE MACHINERY US patents	COMPUTERS - OFFICE MACHINERY Business R&D exp.
European Union	1,00	1,94	1,15	1,43	0,93	0,49	0,49	0,50	0,50
Belgium-Luxembourg	0,35	0,12	0,10	0,20	:	0,23	0,36	0,33	:
Denmark	0,63	0,25	0,06	0,25	0,00	0,37	0,18	0,20	0,20
Germany	0,76	0,89	0,87	1,80	0,64	0,48	0,40	0,39	0,56
Greece	0,14	0,24	-	-	:	0,03	-	-	:
Spain	0,40	0,56	0,47	1,89	0,87	0,33	0,18	0,21	0,43
France	0,98	3,02	2,62	1,49	1,54	0,60	0,60	0,59	0,43
Ireland	2,07	0,19	0,00	0,95	0,02	4,20	1,24	1,76	0,93
Italy	0,49	0,55	0,58	0,70	0,97	0,46	0,40	0,33	0,69
Netherlands	0,95	0,78	0,15	0,36	0,19	1,40	1,11	0,72	0,57
Austria	0,54	0,07	0,47	0,84	:	0,24	0,21	0,34	:
Portugal	0,23	0,21	-	-	:	0,05	-	-	:
Finland	0,70	0,03	0,66	0,68	0,01	0,59	0,24	0,28	0,34
Sweden	0,81	0,86	0,60	1,30	0,48	0,26	0,28	0,47	0,34
UK	1,40	1,81	1,63	1,51	1,15	1,45	0,67	0,82	0,35
US	1,63	3,35	1,17	0,90	1,52	1,33	1,31	0,95	1,31
Japan	1,60	0,06	0,15	1,06	0,07	1,78	2,01	1,65	1,09
Canada	0,60	1,06	1,16	0,67	1,43	0,57	0,51	0,35	0,92
Norway	0,25	0,25	0,68	0,41	0,04	0,17	0,75	1,02	0,21
Australia	0,21	0,02	0,97	1,05	0,14	0,27	0,43	0,33	0,36
New Zealand	0,12	0,04	0,82	0,00	:	0,02	0,24	0,21	:

	ELECTRONICS Hi-tech exports	ELECTRONICS EPO patents	ELECTRONICS US patents	ELECTRONICS Business R&D exp.	PHARMACEUTICALS Hi-tech exports	PHARMACEUTICALS EPO patents	PHARMACEUTICALS US patents	PHARMACEUTICALS Business R&D exp.
European Union	0,81	0,78	0,70	1,14	1,88	0,85	1,39	1,20
Belgium-Luxembourg	0,29	0,67	0,61	:	1,98	0,88	1,76	:
Denmark	0,41	0,27	0,31	0,61	4,87	1,52	4,33	2,81
Germany	0,60	0,67	0,51	0,98	0,84	0,76	1,04	0,59
Greece	0,13	-	-	:	0,43	-	-	:
Spain	0,29	0,48	0,32	1,13	1,31	1,02	2,34	1,29
France	0,59	0,94	0,96	1,52	1,27	0,89	1,51	0,91
Ireland	1,90	0,69	1,31	0,28	2,44	0,68	1,99	1,77
Italy	0,32	0,59	0,52	1,28	1,55	0,89	1,76	1,49
Netherlands	0,66	1,25	1,50	0,88	0,96	0,68	1,03	0,92
Austria	0,60	0,40	0,36	:	2,81	0,55	0,98	:
Portugal	0,30	-	-	:	0,40	-	-	:
Finland	1,07	1,98	0,92	1,73	0,15	0,41	0,95	0,65
Sweden	1,12	0,84	0,69	1,71	1,15	0,52	1,11	1,58
UK	1,06	0,83	0,84	0,72	1,71	1,21	1,99	2,54
US	1,25	1,07	0,87	0,80	1,33	1,29	1,04	1,00
Japan	2,16	1,62	1,55	1,11	0,38	0,86	0,61	0,75
Canada	0,61	0,79	0,60	2,35	0,23	1,06	1,01	0,94
Norway	0,21	0,22	0,53	1,68	0,20	0,59	1,74	1,14
Australia	0,17	0,42	0,45	0,95	0,49	0,84	1,85	0,81
New Zealand	0,11	0,51	0,33	:	0,52	0,60	1,91	:

Sources: Hi-tech: COMTRADE database; EPO patents: European Patent Office; US patents: US Patent and Trademark Office; Business R&D expenditure: OECD ANBERD database.

	SCIENTIFIC INSTRUMENTS				ELECTRICAL MACHINERY			
	Hi-tech exports	EPO patents	US patents	Business R&D exp.	Hi-tech exports	EPO patents	US patents	Business R&D exp.
European Union	1,32	0,83	0,77	0,29	0,92	1,08	0,95	1,22
Belgium-Luxembourg	0,34	0,92	0,97	:	0,20	0,70	0,33	:
Denmark	1,17	0,77	0,98	1,39	0,49	0,58	0,68	0,45
Germany	1,42	0,74	0,74	0,28	0,87	1,14	1,02	1,74
Greece	0,07	-	-	:	0,03	-	-	:
Spain	0,46	0,76	0,68	0,34	0,21	1,12	0,51	0,70
France	0,82	0,92	0,71	0,16	0,51	1,33	1,11	0,62
Ireland	0,65	1,09	0,85	1,17	0,57	1,48	0,86	0,70
Italy	0,46	0,63	0,60	0,19	0,65	1,05	0,70	0,92
Netherlands	1,07	0,76	0,69	0,19	0,83	1,36	1,09	2,69
Austria	0,70	0,65	0,91	:	0,78	1,23	0,84	:
Portugal	0,31	-	-	:	0,59	-	-	:
Finland	1,01	0,83	0,69	0,75	0,42	0,66	1,32	1,23
Sweden	1,22	1,06	0,91	0,93	0,35	0,76	1,07	0,30
UK	1,41	1,07	0,95	0,16	1,79	0,80	0,74	1,30
US	2,02	1,24	1,03	1,74	1,08	0,84	0,98	0,47
Japan	1,60	1,03	1,15	0,58	2,70	1,09	1,10	1,82
Canada	0,40	0,91	0,85	0,29	0,39	0,85	0,93	0,26
Norway	0,46	0,83	0,67	0,48	0,29	0,56	0,92	0,65
Australia	0,28	0,87	0,90	0,47	0,26	0,74	0,79	0,58
New Zealand	0,19	0,56	0,57	:	0,41	1,37	1,59	:

	CHEMICALS			
	Hi-tech exports	EPO patents	US patents	Business R&D exp.
European Union	1,48	0,94	1,51	1,18
Belgium-Luxembourg	1,04	1,98	1,89	:
Denmark	0,64	0,76	1,74	0,44
Germany	1,49	1,12	1,63	1,46
Greece	0,50	-	-	:
Spain	0,52	0,55	1,32	0,70
France	2,02	0,65	1,48	1,04
Ireland	0,11	0,67	1,03	0,52
Italy	0,44	0,87	1,64	0,65
Netherlands	1,13	1,01	1,39	2,62
Austria	0,39	0,62	0,87	:
Portugal	0,16	-	-	:
Finland	0,19	0,59	0,82	0,89
Sweden	0,19	0,41	0,61	0,30
UK	1,95	0,99	1,54	1,26
US	1,07	1,10	0,94	0,86
Japan	0,49	1,05	0,84	1,09
Canada	0,63	0,96	0,70	0,43
Norway	0,55	0,67	0,69	1,07
Australia	0,35	0,70	0,63	0,48
New Zealand	0,34	0,49	0,60	:

Notes: (1) Relative specialization indices are calculated as the ratio of the market share of a country on the world market for a particular sector (product) to the market share of a country on the world market for all products (sectors). In the case of exports this reduces to the classical indicator of "Revealed Comparative Advantage".
(2) The relative specialization index for business R&D expenditure is calculated in relation to the total BERD of the 15 OECD countries above for which sectoral data are available.

(3) European Union aggregate for hi-tech exports relates to exports to non-EU countries. The individual EU member state data relate to all exports of that country (intra- and extra-EU).
- = too few patents to be statistically significant. : = not available

goods, and the inter-relationship between hi-tech trade performance and sales of total exports.

5. Model construction

The model uses an unbalanced panel of twenty countries for the period 1988-1996. An overview of variables, sectors, countries and years included in the panel is shown in Appendix 2. As was shown in Figure 1, we basically consider three factors to explain export performance: technology, price and investment. Technology is measured using the EPO and USPTO databases. The MERIT concordance scheme has been applied to the patent data to categorize patents into different sectors. The sectoral classification which appears on the USPTO is taken directly from the ISI database. As explained in the previous part of the paper, high tech exports have been collected by EUROSTAT. Further, the price factor is calculated as the cost of employment (current ECU) divided by the value added in constant 1990 ECU. Unfortunately, we had no price deflator available at the sectoral level so that the implicit GDP deflator was used. This can distort the results in some way in comparison with for instance the Amable and Verspagen paper. Finally, investment was measured by Gross Fixed Capital Formation at the sectoral level.

The data were gathered from a variety of sources, including the OECD STAN database (for data on investment and cost of employment), and the UNIDO and VISA databases (value added). Appendix 2 includes for each variable the original sources from which this variable is collated.

The general model was tested using a seemingly unrelated regression model of two cross-sectional time-series regressions. The cross sections reflect the different sectors since both the high tech export intensity (relative to the total exports) and technology investment have been shown above to vary considerably between industries. We would expect the influence of the high tech exports on the low-tech sectoral exports to be higher in those industries where the high tech part makes up a considerable share of total production. In the more mature sectors, such as chemicals, we would expect this influence to be lower. Otherwise, we would expect the technology influence to be higher in sectors where patenting is common such as instruments and chemicals and lower in those where patenting is marginal such as aerospace.

Although some variations between countries reflect differences in 'national innovation systems', no country effects were included in the model, since there would be insufficient degrees of freedom remaining to estimate a within regression on the 20 countries in the model.

The basic model used to determine the value of total exports by sector is the following:

$$X_{it} = k + aP_{it} + bI_{it} + cT_{it} + H*_{it} + v_i + e_{it} \quad (1)$$
$$H_{it} = k + aP_{it} + bI_{it} + cT_{it} + v*_i + e*_{it} \quad (2)$$

with X reflecting the export shares of the non-high tech (or low-tech part), and H reflecting the high tech part. H is identified as the share of high tech exports in the sectoral total. P, I and T are the three determining variables. P stands for the price factors (cost of employment divided by value added). I is an investment indicator measured by GFCF (Gross Fixed Capital Formation) as a percentage of value added; this variable captures part of the non-price factors in the sense that it measures the embodiment of innovation in new capital. As suggested by Amable and Fagerberg (1995) the investment factor measures the non-price factors that are not *directly* related to technology. T is then an indicator of technology (EPO and USPTO patents).

v_i is the sector specific residual. It differs between sectors, but for any particular sector, its value is constant. ε_{it} is the usual residual with the usual properties (mean 0, uncorrelated with itself, uncorrelated with P, I and T and homoscedastic).

A three year, bell-shaped lag is adopted:

$$A = (A(-1))^{0.3}(A(-2))^{0.4}(A(-3))^{0.3} \quad (3)$$

for A=I, T, P, H*. All the variables are transformed into logs. For the general fixed effect model, by definition, the difference with respect to the sample average for the years is considered. For the sector specific regression the standardized transformation of each variable is estimated.

6. Estimation Results

This section reports the results of the estimation of the model presented in Figure 1. As aforementioned, the general model that was estimated is a fixed effect model in which the sectors are held constant. The main hypothesis formulated in Figure 1 concerns the positive overall impact of a good performance in the high tech exports on a country's market share in the non-high tech part. We find this hypothesis supported in Table 4, when we look at the coefficient of the high tech export variable. Indeed, the high tech variable is highly significant in this general model. Its standardized coefficient is more than twice the level of the next coefficient in the significance ranking (the price factor). The first part of this model receives thus general support.

Much more difficult to explain is the general *positive* influence of the price factor on the non-high tech market shares. Whereas economic theory suggests that price factors negatively influence the export performance of a country, the general model delivers a paradoxical result. At this point of the analysis, we can only find an explanation in the fact that the ‘cost’ variable measures other things than a real relative price difference. This can be attributed to measurement problems of the deflator. On the other hand, we could also hypothesize that those countries that employ higher skilled personnel (and thus experience higher employment costs) also benefit from the productivity of these employees. Nevertheless, this remains a hypothesis which needs further analysis.

Table 4: ***Estimation Results: Fixed Effects Model***

Determinants regressed on ***Non-High Tech Exports***

Regression Statistics

obs= 284
n=7
R^2 within= 0.68
R^2 between=0.60
R^2 overall=0.60

Variable	**Coefficient (Standard Error)**	***p*-value**
Technology		
USPTO	0.06 (0.06)	0.32
EPO	0.14 (0.08)	0.09
High Tech Exports	0.57 (0.06)	0.00
Investment	0.00 (0.00)	0.41
Price Factor	0.25 (0.12)	0.03
Sector Effects F(6,272)	9.986	0.00

Determinants regressed on ***High Tech Exports***

Regression Statistics

obs= 297
n=7
R^2 within= 0.72
R^2 between=0.006
R^2 overall=0.70

Variable	**Coefficient (Standard Error)**	***p*-value**
Technology		
USPTO	0.01 (0.06)	0.85
EPO	0.73 (0.06)	0.00
Investment	0.54 (0.07)	0.00
Price Factor	0.05 (0.12)	0.69

Sector Effects F(6,286)	3.817	0.01

Further, we find that the technology variable has a small direct impact on a country's non-high tech export position. This can be explained by a technological evolution model such as the Utterback/Abernathy model, which points to the fact that in the beginning of the industry life cycle (Utterback & Abernathy, 1976), product innovation (as captured by the high tech product factor) is crucial. However, when an industry becomes more mature, process innovation prevails. Despite the fact that most patents are taken for product innovations, also a significant number covers process oriented innovations. Hence, this evolutionary model of innovation suggests exactly the small impact of (process oriented) technology investments which we find back in the general model.

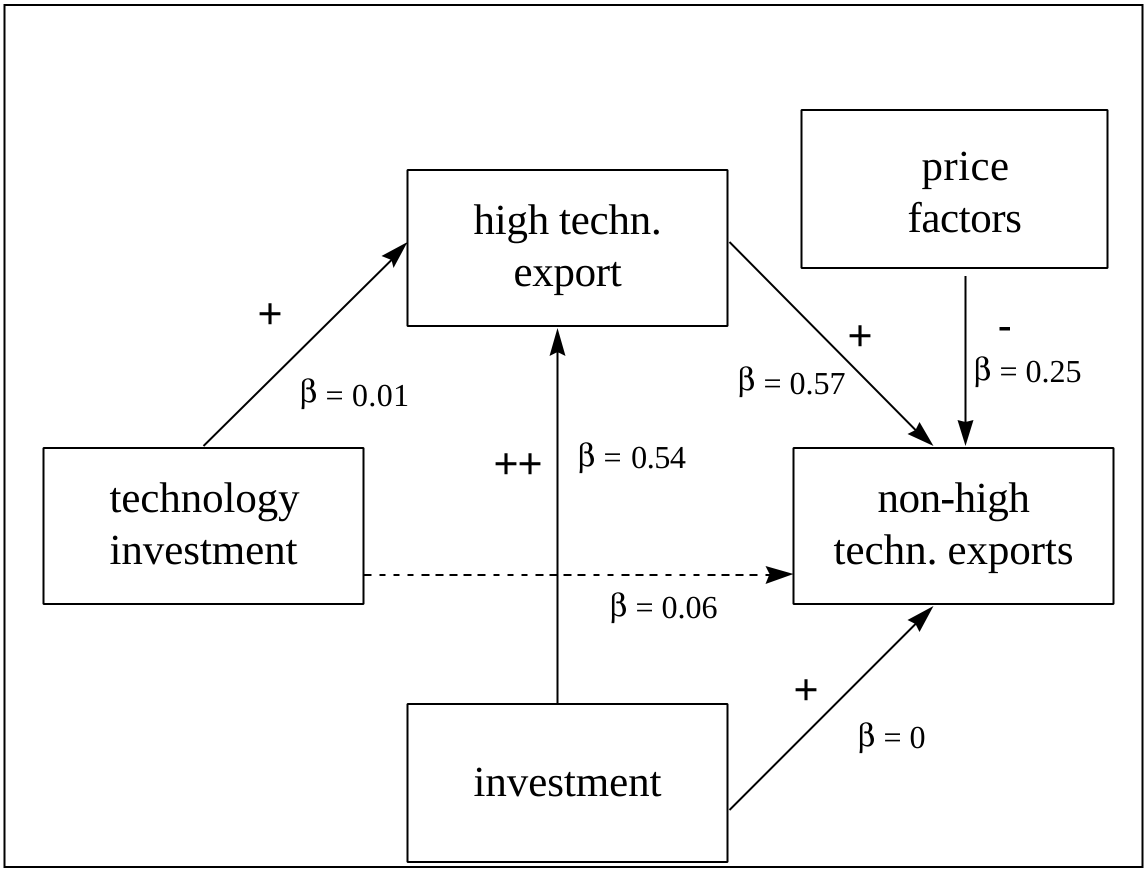
Contrary to our expectations, no link is found between the investment factor and non-high tech export performance. Probably, export market shares in mature industries no longer depend on new investment in capacity, but are based on existing industrial capacity. Finally, one should note the highly significant sectoral effects. This suggests that the non-high tech exports differ considerably between industries. In some industries these exports are quite concentrated in a small number of countries, while in others they remain dispersed. Also the coefficients of the determinants of these export shares are different between industries as is shown by the high R^2 of the between regression model.

The second part of Table 4 shows the results of the high tech export equation. In this model, most of our hypotheses are confirmed. First, the technology variable is highly correlated with the high tech export market share. Thus it explains quite well the differences in this market share. Further, the investment factor is also positive and significant. Again, this confirms our hypothesis that fixed investment explains well high tech exports. Since the very same investments are not significant in the previous model, the investment factor is indeed a better determinant of high tech exports than of low-tech exports.

One should also note the much lower F-statistic for the sectoral effects. The division of high tech export shares seems to be more similar across industries than the non-high tech exports, although it remains significantly different. This is not so for the coefficient of the determinants. The very low R^2 of the between regression suggests no differences between the coefficients. Finally, one should note the low USPTO impact, although this partly reflects the multicollinearity between the USPTO and the EPO data. Despite this problem, we have some evidence to argue that EPOs better explain high tech market shares than USPTOs. This is maybe not so surprising, given that the EU market is the largest export market for these products.

Concluding, we can state that the hypotheses related to the high tech export part in the model are confirmed, while the investment and technology variables only receive mixed support. For the technology impact on non-high tech export shares, the Utterback/Abernathy model provides a good explanation. More puzzling is the lack of relation between investment and non-high tech export shares, and it is very difficult to explain the positive and significant impact of the price factor on these non-high tech exports. Figure 6 shows the empirical relations between the different constructs of Figure 1.

Figure 6: Empirical relations between the model variables



To explore these results further, the two regression models explained above were re-estimated at the sectoral level. The results are displayed in Table 5.

In six of the seven sectors, we indeed find a large and significant impact of high tech exports on the non-high tech part. The standardized coefficients for this impact are by far the largest for the 'computer' and 'chemical' industries. Since these industries represent both the industry in which the high tech part is the largest (computers) and in which the high tech part is the lowest (chemicals) as a percentage of total exports, one can not hypothesize a decrease in explanatory power if an industry matures (and thus its high tech part decreases). One could perhaps suggest a curvilinear relation in the sense that high tech exports explain quite well the non-high tech part in the beginning of an industrial life cycle and at the end, but we have insufficient data to formally test this hypothesis. Intuition seems to support it, however: a country which invests in high tech might only gradually lose its market share to low tech producers, while once the low tech part makes up the bulk of the production, it is the same countries that produce the high tech that also produce the low tech.

Table 5. ***Estimation Results: Sector specific effects***

Determinants regressed on ***Non-High Tech Exports***

	obs	R^2	price factor β	*p*-val	technology epo β	*p*-val	technology uspto β	*p*-val	investment β	*p*-val	high tech exports β	*p*-val
Aerospace	30	0.90	**-0.33**	**0.00**	**0.29**	**0.05**	0.05	0.67	-0.15	0.26	**0.65**	**0.00**
Computers	34	0.91	**-0.10**	**0.05**	0.22	0.52	-0.15	0.58	-0.06	0.58	**0.88**	**0.00**
Chemicals	46	0.91	0.05	0.24	0.12	0.12	--	--	**0.08**	**0.07**	**0.82**	**0.00**
Instruments	54	0.89	0.04	0.47	**0.61**	**0.04**	-0.11	0.51	-0.00	0.87	**0.44**	**0.04**
Electrical machinery	35	0.87	**0.72**	**0.00**	**0.64**	**0.03**	--	--	0.03	0.72	0.13	0.69
pharmaceutical	49	0.90	-0.06	0.27	**1.88**	**0.00**	**-1.59**	**0.00**	**-0.13**	**0.01**	**0.51**	**0.00**
electronics	36	0.49	-0.17	0.73	--	--	--	--	**0.43**	**0.00**	**0.40**	**0.00**

Determinants regressed on ***High Tech Exports***

	obs	R^2	price factor β	*p*-val	technology epo β	*p*-val	technology uspto β	*p*-val	investment β	*p*-val
aerospace	30	0.56	-0.16	0.18	**0.68**	**0.02**	0.22	0.41	**1.10**	**0.00**
computers	34	0.90	-0.02	0.68	**1.23**	**0.00**	-0.32	0.68	**0.11**	**0.05**
chemicals	46	0.70	-0.03	0.76	**0.83**	**0.00**	--	--	**0.80**	**0.00**
instruments	54	0.89	**-0.14**	**0.00**	**1.08**	**0.00**	-0.09	0.43	**0.06**	**0.07**
electrical machinery	35	0.93	-0.09	0.06	**0.91**	**0.00**	--	--	**0.08**	**0.08**
pharmaceutical	49	0.44	0.15	0.29	**1.05**	**0.01**	-0.34	0.42	**1.15**	**0.00**
electronics	36	0.93	0.04	0.38	**0.98**	**0.00**	--	--	-0.19	0.68

Only in one industry, *electrical machinery*, does our hypothesis receive no support at all. The high tech standardized coefficient is low and insignificant. It is exactly in this very same sector that the price factor is positive and highly significant. Apparently, this positive price factor in the electrical machinery industry is the reason why the price factor turns out to be positive *and* significant in the general model. Probably the electrical machinery industry contains a large part of process innovation, not included in high tech products. For instance, the subsector which represents electrical parts for the car industry is under high pressure to deliver quality (but no really new technology-intensive products). This pressure might lead to a need for highly skilled, and thus costly, personnel. The countries that invest most in this type of process innovation also perform the best in the market for non-high tech exports.

Note also that electrical machinery, together with electronics (another sector in which the high tech export coefficient is less powerful, though still significant) is the sector in which Japan is leading in terms of high tech exports. The hypothesis of process innovation is also supported by the fact that the technology factor is highly significant and positive in the sector for electrical machinery.

In most other sectors, however, the price variable takes the expected sign and is even significant at the 5% level in aerospace and computers. In chemicals and instruments the coefficient is not significantly different from 0 and remains so low that no real conclusion can be drawn from it. One should also note that in those sectors where the technology coefficient is positive and significant, that for high tech exports is lowest (and in the case of electrical machinery thus even insignificant). Again, this points to the existence of process innovations as a main determinant of non-high tech exports.

To conclude this first model, we can state that in general the hypothesis that high tech exports influence non-high tech exports is robust between the different sectors. However, in certain more mature sectors such as instruments, pharmacy and electrical machinery, we find that process innovations might be the most important determinant of the non-high tech export shares. In electrical machinery, these process innovations might be closely correlated to the cost of employment, indicating a highly skilled labor force as a competitive factor.

As expected from the fixed effect model, the regression on high tech sectors by sector does not reveal drastically new insights. The technology and investment variables remain positive for most of the sectors. Only for *electronics*, is no relation found between fixed investment and the market share in high tech products. Interestingly, for the same sector, we found a positive *and* significant effect of investment on high tech export market shares. It is interesting to note that the price factor in this regression in five of the seven cases *has* the expected sign, including in the sector of electrical machinery. For instruments, the variable is even significantly different from 0.

Concluding, we can say that the second regression model holds across sectors, which confirms its internal validity. This brings us back to the point of departure of this paper: 'the Kaldor paradox'. This paradox is assumed to emerge from within-sector heterogeneity. Since technology is more important than prices in explaining high tech exports, we argued that it is normal to find high costs of labor in combination with a good export performance. Our Kaldor hypothesis receives mixed support in the sense that process innovations seem to be more important than labor price competition, even in the non-high tech part of the industry.

7. Conclusions

This paper has built on the work of the technology trade gap studies, arguing that technology is an important determinant of international competitiveness, measured in terms of a country's export performance. More recent research in this stream has put forward that technology investment probably plays a more important role in determining competitiveness in the so-called technology intensive sectors, while other factors such as cost of employment are more crucial in the low-tech sectors. Finally, investment plays a greater role in the scale-intensive industries. Each of these factors, namely investment, cost and technology, should be included to determine the international competitiveness of a country. However, their role is dependent on the key for competition which differs between sectors.

It is exactly this *between* sector argument which has been challenged in this paper. The empirical work of Amable and Verspagen had already shown that, quite surprisingly, technology played a very important role in determining the export market share in a sector such as textiles. Likewise, they found that the 'cost of employment' variable to a large extent determined the export performance in the highly technology-intensive chemical sector. Hence, the sectoral classification includes considerable heterogeneity regarding the basis of competition.

In this paper, we argued that each sector contains a number of 'niches' which differ in novelty. For instance, if we take the pharmaceutical sector, we can distinguish the niche of 'ethical drugs' and 'generic products'. In the ethical drug part of the industry, competition is based on new products, whereas in the generic part the price factor plays a bigger role. In the same vein, one could argue that in a low-tech industry such as textiles, part of the competition is based on new products (e.g. the quality labels such as Donaldson) whereas part is based on price and scale (the large warehouse store clothing). One could even think of a co-evolution between the size of the high tech part in the industry and the business cycle of the total sector. For instance in chemicals, we have shown that this high tech part is rather low (average of 5-10%) while in younger industries such as computers the high tech part easily adds up to 90% of the total exports.

For one particular kind of industry, namely the technology-intensive, economists have found a useful way of distinguishing between the part in which 'new products' are important and the 'rest of the industry'. A list of 'high tech products' is available which allows one to make a distinction between the export of commodity goods and the export of high tech products. Although the list remains a proxy for 'basis of competition' in a segment of an industry, it is a first step.

The main hypothesis put forward in the paper is that technological investments have a direct effect on 'high tech export market shares'. Consequently, their influence on the non-high tech part of the market shares is mainly indirect, namely through high tech products. No direct link between technology and non-high tech market shares was hypothesized. We found substantive support for the direct and, related, indirect link between technology investments and high tech or non-high tech export performance. However, we also found an, admittedly weaker, *direct* relation between technology and non-high tech exports. This relation was explained by the Utterback/Abernathy model of technology evolution. The model indicates that in the early phases of the business cycle product innovation prevails while in the later phases process innovation is the most important. A direct relation between patents and non-high tech exports can then be explained by the presence of process innovation as a basis for competition. Equally, we find that in industries such as chemicals, the direct effect of technology is more important than in sectors such as computers which are in an earlier stage of development.

Further, the influence of the cost of employment on non-high tech products was hypothesized to be significant and negative across sectors. This hypothesis only found support in the aerospace industry. In fact the results for the price variable are quite confusing and indicate that this factor includes much more than the real price differences. We suggested in the paper that high costs of employment may indicate the use of highly skilled personnel and hence proxy the presence of process innovations.

Thirdly, we found the fixed investment factor to be quite powerful in explaining high tech market shares across sectors, but very weak in explaining the non-high tech part. No theoretical model was found to further explain this result.

Finally, the paper sheds some further light on the 'systemic approach' towards innovation. It is far beyond the scope of this paper to enter this debate, but the results show that, although the systemic approach is extremely useful to map the complexity of the innovation process, it should not reduce the linear view to scrap. In fact, the indirect effect of technology via the exports of high tech products on economic performance is clearly shown in this paper. This indicates that, although innovation is the result of a complex interaction process between different actors, for technology intensive sectors, part of economic performance is still the result of a linear sequence of investments in R&D, which result in first commercial results (high tech exports) and finally in general economic performance.

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APPENDIX:
OECD HIGH-TECHNOLOGY PRODUCT LIST
(SITC REV.3 NOMENCLATURE)

1. Aerospace

792 = *Aircraft and associated equipment, excluding 7928, 79295, 79297*
714 = *Aeroplane motors, excluding 71489, 71499*
87411 = *Other navigational instruments*

2. Computers - office machines

75113 = *Word-processing machines*
7513 = *Photo-copying apparatus excluding 75133, 75135*
752 = *Computers:excluding 7529*
75997 = *Parts and accessories of group 752*

3. Electronics - telecommunications

76381 = *Video apparatus*
76383 = *Other sound reproducing equipment*
764 = *Telecommunications equipment excluding 76493, 76499*
7722 = *Printed circuits*
77261 = *Electrical boards and consoles 1000V*
77318 =*Optical fibre cables*
77625 =*Microwave tubes*
77627 =*Other valves and tubes*
7763 = *Semi-conductor devices*
7764 = *Electronic integrated circuits and microassemblies*
7768 =*Piezo-electric crystals*
89879 =*Numeric recording stays*

4. Pharmacy

5413 = *Antibiotics*
5415 = *Hormones and their derivatives*
5416 = *Glycosides, glands, antisera, vaccines*
5421 = *Medicaments containing antibiotics or derivatives thereof*
5422 = *Medicaments containing hormones or other products of heading 5415*

5. Scientific instruments

774 = *Electro-diagnostic apparatuses for medicine or surgery and radiological apparatuses*
871 = *Optical instruments and apparatuses*
87211 = *Dental drill engines*
874 = *Measuring instruments and apparatuses excluding 87411, 8742*
88111 = *Photographic cameras*
88121 = *Cinematographic cameras*
88411 = *Contact lenses*
88419 = *Optical fibres other than those of heading 7731*
8996 = *Orthopedic appliances excluding 89965, 89969*

6. Electrical machinery

7786 = *Electrical capacitors, fixed, variable or adjustable excluding 77861, 77866, 77869*
7787 = *Electrical machines having individual functions*
77884 = *Electric sound or visual signalling apparatus*

7. Non-electrical machinery

71489 = *Other gas turbines*
71499 = *Part of gas turbines*
7187 = *Nuclear reactors and parts thereof, fuel elements etc..*
72847 = *Machinery and apparatus for isotopic separation*
7311 = *Machine-tools working by laser or other light or photon beam, ultrasonic electro-discharge or electro-chemical processes*
7313 = *Lathes for removing metal excluding 73137, 73139*
73153 = *Other milling machines, numerically controlled*
7316 = *Machine-tools for deburring, sharpening, grinding, lapping etc; excluding 73162, 73166, 73167, 73169*
73312 = *Bending, folding, straightening or flattening machines, numerically controlled*
73314 = *Shearing machines, numerically controlled*
73316 = *Punching machines, numerically controlled*
7359 = *Parts and accessories of 731- and 733-*
73733 = *Machines and apparatuses for resistance welding of metal fully or partly automatic*
73735 = *Machines and apparatuses fir arc, including plasma arc welding of metal; fully or partly automatic*

8.Chemistry

52222 = *Selenium, tellurium , phosphorus, arsenic and boron*
52223 = *Silicon*

52229 = *Calcium, strontium and barium*
52269 = *Other inorganic bases*
525 = *Radio active materials*
531 = *Synthetic organic colouring matter and colour lakes*
57433 = *Polyethylene terephthalase*
591 = *Insecticides, disinfectants*

9. Armament

891 = *Arms and ammunition*