TRADE PERFORMANCE AND STRUCTURAL COMPETITIVENESS DEVELOPMENTS IN THE EURO AREA: ARE MEMBER STATES EQUIPPED TO MEET THE GLOBALISATION CHALLENGES OF THE 21ST CENTURY?

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Abstract

The increased globalisation of the recent decades has been reflected in a sharp rise in trade flows worldwide and a more rapid diffusion of new technologies to emerging economies. Competitive pressures on world markets have risen substantially and new global players have emerged. As a result, production processes are increasingly integrated internationally and the traditional separation in terms of comparative advantage between developed and developing countries has become increasingly blurred. This paper uses structural decomposition analysis to determine whether the change in a country's share in world patenting is due to its specific specialisation pattern (structural technology effect); a movement into sectors with fast growing technological activity (technology growth effect); a movement out of sectors with generally stagnating technological activity (technology stagnation effect), or to other factors not associated with the sectoral distribution of technological activity (technology share effect). A similar decomposition is applied to world export market shares. A change in a country's share of world exports may be due to its specific sectoral specialisation pattern (structural market effect); a movement into fast growing markets (market growth effect), a movement out of slow growing/stagnating markets (market stagnation effect) or to other factors not associated with the sectoral distribution of exports (market share effect). The two decompositions illustrate that many of the euro area countries do relatively poorly in terms of shifting their technological and export activities towards fast growing sectors, as opposed to emerging countries such as China and India which are developing their innovative capacities and gaining market share in sectors offering more high tech opportunities. These examples also serve to illustrate the positive relationship between exploiting innovative activities and export performance.

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1. Introduction

The increased globalisation of the recent decades has been reflected in a more rapid diffusion of new technologies to emerging economies. Production processes have become increasingly integrated internationally and there has been a sharp rise in trade flows worldwide. Competitive pressures on world markets have risen substantially and new global players have emerged. Moreover, the traditional separation in terms of comparative advantage between developed and developing countries has become increasingly blurred. While initially the diffusion of innovative technologies developed in the more advanced countries was the primary source of technological change in emerging economies, in recent years developing countries have started to develop such new technologies domestically.

The objective of the paper is to analyse structural changes that may help explain the trade performance of the euro area and of its individual Member States. The focus of our analysis is on the relation between trade performance and the degree of technological development .

A country's trade performance is often viewed as an indicator of its international competitiveness, i.e. the ability to realise central economic goals – growth in income and employment – without running into balance-of-payment difficulties (Fagerberg, (1988)). There is some empirical evidence suggesting that differences in the international competitiveness and growth across countries are determined not only by price factors (*cost competitiveness*) but also by structural factors such as technological opportunities[3] and production capacities (*structural competitiveness*)[4].

[3] There is broad evidence suggesting that technology is one of the key determinants of trade patterns (Dosi, Pavitt and Soete (1990); Grossman and Helpman (1991); Krugman (1995); Lall (1992, 2000), Montobio and Rampa (2005)).

[4] Amable and Verspagen (1995), Fageberg (1998)

Technological change is a multi-faceted process not easily captured by a single measure. It results from R&D and innovation activities undertaken by both, the public and the private sector within a specific institutional framework. A more developed national innovation system (NIS)[5] enables to reach the technological frontier in a greater number of production areas, guaranteeing thus better technological opportunities. Consequently, the country reaches higher levels of product and exports diversification, which leads to early domination of new markets and greater exports stability[6]. Therefore, the greater technological opportunities of today, the better export outlook and stronger competitive position of tomorrow.

This paper aims to capture the progress made in developing the NIS by analysing changes observed in the number of patents granted by the United States Patent and Trademark Office (USPTO) during the period 1989-2001. While this is not a perfect measure of technological change, it has the important advantage that if offers information on patenting behaviour of companies world wide. The observed change in the number of patents granted to a country is decomposed into four elements in order to determine the origin of this change. The structural decomposition (SD) method used was developed by Fagerberg and Sollie (1987) and refined by Laursen (1999).

In order to make the link between technological change and trade performance, the same structural decomposition method was applied to trade data. The paper is based on the proposition that a high degree of correspondence between the decomposition of patents granted and trade performance would offer convincing evidence of the existence of such a link. Once established, the relationship between technological change and trade performance will need to be confirmed through econometric analysis.

The paper is organised as follows. Section 2 starts by presenting some stylised facts on the export specialisation and trade performance of the euro area compared to its main competitors at the world level. Section 3 presents the patent and trade data used. Section 4 describes the structural decomposition method used and applies it to the data available on the number of patents granted by the USPTO and export market shares. Section 5 aims to establish the link

[5] Firms do not innovate in vacuum but in *interaction* with other actors (firms, universities, banks, venture capitalists, governmental agencies and consumers) within a specific institutional framework (laws, rules, regulations, norms and standards), creating thus a *system* affected by a wide spectrum of public policies (Edquist (2001))

[6] Da Cunha Resende and Torres (2008)

between the decomposition of patents granted to and export market of the different countries under investigation. The concluding section 6 describes the further work needed to establish a causal relationship between technological change and trade performance.

2. Stylised facts on the export specialisation and trade performance of the euro area

The acceleration of the process of globalisation over the past decade can be associated with substantial reductions in transportation and information costs world-wide, which have been brought about by the increasingly widespread application of newly developed Information and Communication Technology (ICT) tools. As a result of the more rapid diffusion of new technologies the competitive environment has changed radically worldwide, which is reflected in a sharp increase in trade flows and a radically changed patterns of production and trade. Production processes have become increasingly integrated internationally and the traditional division between developed and developing countries in terms of comparative advantage has become increasingly blurred. Given this changed international environment, it is important to determine the ability of the euro area to adjust and find new areas of specialisation offering a sustained comparative advantage.

This section presents some stylised facts regarding the euro area's factor intensity and geographical specialisation compared to that of its main competitors as well as its global export performance.

The examination of export market shares by factor intensity (see annex for a breakdown of trade according to factor intensity) reveals that in comparison with the US and Japan, euro area exporters have the highest export market shares in all product categories (see table 1). The euro area and Japan are particularly strong in the difficult-to-imitate research-intensive and capital-intensive products, while the US registers the highest export market shares in the difficult-to-imitate research-intensive goods only. China has become an important global export competitor not only in the field of low-tech and labour-intensive industries but increasingly in higher technology and capital-intensive industries as well.

Table 1: Export market shares by factor intensity (2005)[1] *(as a percentage of world exports)*

	TOTAL goods (2005)	Research-intensive goods (2005)			Capital-intensive goods (2005	Labour-intensive goods (2005)	Raw material-intensive goods (2005)
		Difficult-to-imitate research-intensive goods	Easy-to-imitate research-intensive goods	Total research-intensive goods			
ea13[2]	**15.7**	**18.9**	**15.8**	**17.6**	**18.8**	**15.9**	**8.3**
US	9.4	13.9	9.5	12.1	7.7	7.4	6.3
Japan	6.2	9.9	5.6	8.2	10.2	2.5	0.7
China[3]	11.0	10.0	18.4	13.4	4.4	21.6	2.9

Source: Commission Services

Note: [1]Export market share by factor intensity: $\frac{Exports_{country_i \, sector_j}}{Exports_{WORLD \, sector_j}}$; [2]Extra-ea13-export; [3]Incl. Hong-Kong.

An investigation of the specialisation of exports by the world's major economies, as defined by the Balassa specialisation index, shows that the euro area is specialised in capital-intensive products. Contrary to the US and Japan the euro area is not specialised in the export of research intensive goods (see table 2). Moreover it has not increased its specialisation over the recent period. A similar conclusion is reached by Ilzkovitz et al. (2007) which takes a longer term perspective and which showed that the EU single market did not sufficiently contribute to the development of new areas of specialisation in research intensive activities. Japan is most specialised in capital-intensive goods, but it also shows a specialisation in research-intensive goods and over 90% of its exports are research- or capital-intensive products. However, Japan's comparative advantage in research-intensive goods shrank in 2000-2005. The US, on the other hand, strengthened its position in research-intensive products while becoming even less specialised in exporting raw-materials-intensive and labour-intensive goods. It is worth noting that even China is more specialised in the export of research-intensive goods than the euro area. Even if China's specialisation in research-intensive goods reflects to a large extent its strong performance in the easy-to-imitate product category, it is also rapidly increasing its specialisation in the difficult-to-imitate product category.

Table 2: Sectoral specialisation by factor intensity (2005)[1]

	Balassa specialisation index			
Countries	**Research-Intensive goods**	**Capital-Intensive goods**	**Labour-Intensive goods**	**Raw Materials Intensive goods**
EA13[2]	**101**	**129**	**101**	**69**
US	128	81	78	67
JP	131	165	40	12
CN[3]	122	40	196	26

Source: Commission Services

Note: [1] Sectoral specialisation (Balassa index): $\frac{EXPORT_{country i \, sector j}}{EXPORT_{country}} \div \frac{EXPORT_{WORLD \, sector j}}{EXPORT_{world}}$;

[2] Extra-ea13-export; [3] Incl. Hong-Kong

This would lead one to conclude that the euro area is not sufficiently specialised in the export of research-intensive goods compared with other industrialised countries such as the US and Japan. Moreover, it appears that the specialisation in research-intensive industries is no longer the privilege of developed economies only, but is increasingly becoming a characteristic of emerging economies as well. It is therefore important to determine why the euro area does not have a similar specialisation in terms of research-intensive products as its main competitors at the global level. Is it because the euro area concentrates its innovative capabilities in sectors offering low technology opportunities rather then high technology opportunities? Is it a question of a lack of "technological competitiveness" which may be associated with inadequate policies? Or is it a problem of a too strong historical specialisation in low technology opportunity sectors that has created path dependency and is making it difficult to switch innovative capabilities towards technologically dynamic sectors? The structural decomposition of patents granted, which is presented in section 4.1 should contribute to answering these questions.

The analysis of export performance (see table 3) shows that the euro area, similarly to other industrialised countries such as the US and Japan, lost market share over the 1989-2006 period while emerging economies such as China and India gained market share over the same period. While part of this evolution can undoubtedly be explained by the natural catching-up occurring in the emerging countries, it is important to consider whether other factors may also be contributing to this result.

Table 3. Export performance of the euro area and of its main global competitors

Country	Export Market Share 1989	Export Market Share 2006	Total Change (%)
EU12	21.10	17.06	-19.16
Japan	12.22	6.48	-46.95
US	13.46	10.07	-25.20
Brazil	1.24	1.07	-13.91
India	**0.63**	**1.00**	**59.50**
China	**2.39**	**10.02**	**319.17**
Hong Kong	3.72	1.00	-73.11

The loss in market share by the euro area may be explained in part by its geographical specialisation pattern and its weak presence in the most dynamic world markets. Table 4 shows the export market shares by destination markets of the euro area and of its main competitors. We notice that the euro area's export market share (8%) in China is similar to that of the US, but lower than the share of Japan (14%). The euro area share in the ASEAN market is below the share of the US and Japan. However, unlike the US and Japan, the euro area gained export market share over 2000-2005 period in all main emerging markets: Brazil, China, India, Russia and ASEAN. The presence of euro area exporters on the Russian market as well as in Brazil and India is particularly strong. It appears therefore that the euro area has started to take advantage of opportunities in the fast growing emerging markets, but further improvements in the important Asian markets would seem necessary as the euro area still has a relatively low market share in these markets. Table 4 also reveals that the global pattern of geographical specialisation is influenced by geographical and cultural proximities as predicted by standard gravity trade models. These factors limit the scope for policy intervention.

Table 4: Export market shares by destination markets (2005)[(1)] *(as a percentage of world exports)*

	Destination countries								**Destination regions**		
	ea13	**UK**	**US**	**Japan**	**Brazil**	**China**[(2)]	**India**	**Russian Fed.**	**ASEAN**	**CEEC**[(3)]	**Other Asian countries**[(4)]
ea13[(5)]	**:**	**52**	**15**	**10**	**25**	**8**	**20**	**42**	**8**	**43**	**8**
US	5	8	:	14	23	8	9	3	10	3	11
JP	2	3	9	:	4	14	4	4	15	1	16

Source: Commission Services

Note: [(1)]Export market share by destination market: $\frac{Exports_{country_i \rightarrow country_j}}{Exports_{WORLD \rightarrow country_j}}$;

[(2)]Incl. Hong-Kong; [(3)]CEEC: Albania, Belarus, Bosnia Herzegovina, Croatia, Montenegro, Moldavia, Serbia, Turkey, Ukraine, F.Y.R. Macedonia; [(4)] Other Asian countries: Bangladesh, Bhutan, East Timor, Korea Rep., Maldives, Mongolia, Nepal, Pakistan, Sri Lanka [(5)]Extra-ea13-exports;

Another factor explaining the euro area's overall loss in export market share may be its sectoral specialisation pattern. In this respect it is important to determine whether the euro area has a production structure that is geared towards sectors benefiting from strong growth in world demand or, on the contrary, it is geared towards sectors with stagnating world demand. The euro area's historical specialisation pattern may have created path dependencies that are still negatively impacting its global export performance. Alternatively, the euro area may be suffering from competitiveness problems caused by other factors (price and cost competitiveness problems associated with insufficient competition on the home market or

with lagging productivity growth) that are preventing euro area firms from being competitive on world markets. The structural decomposition analysis applied to export market shares in section 4.2 will provide answers to these questions.

Finally, the evolution of the export market shares of the euro area and of its main global competitors is determined in part by the capacity to innovate. Firms innovate with the aim of exploiting their new inventions commercially through the creation of new market opportunities. This leads them to concentrate their innovation capabilities in the sectors offering the opportunity for technological development and export growth. In section 5 we will examine whether a link exists between the decompositions applied to patent shares and export market shares respectively.

3. Data

The analysis considers eleven countries of the Euro zone (Austria, Belgium/Luxemburg, Finland, France, Germany, Greece, Ireland, Italy, the Netherlands, Portugal and Spain)[7], the US, Japan and three emerging economies: Brazil, India and China. In the case of China we distinguish between mainland China and Hong Kong given that Hong Kong still follows a specialisation pattern that is more closely linked to the developed rather then emerging economies.

In order to measure technological opportunities we use the number of patents granted to firms by the USPTO. Due to data availability, the structural decomposition applied to patent shares covers the period 1989-2001[8].

The choice of patents as a measure of technological opportunities was determined by their clear advantages over the alternative indicators. Firstly, patent counts are readily available from Eurostat at the country and sector level (NACE 2 digits), the latter being crucial to the analysis. Secondly, patents being officially registered legal documents are not subject to

[7] We only analysed the old euro zone Member States without including new members Slovenia, Malta and Cyprus since the data series available for the latter three countries were too short for our analysis.

[8] The patent series used in this paper were obtained from Eurostat based on USPTO data. This was done because Eurostat matches the data according to technology classes reported by the USPTO to the NACE classification system. The Eurostat series end in 2001. While more recent patent data is available directly from the USPTO, it has the disadvantage of not being matched to the NACE classification system and therefore was not used in this paper.

uncertainty and measurement errors. Thirdly, considering patents granted only by one institution with standard criteria of quality assessment and common procedures of approval allows obtaining a consistent time series, comparable over time and over countries. Nevertheless, there are a number of caveats that one should bear in mind when interpreting the patent series. Industry sectors may differ substantially in their tendencies to patent[9] and the importance of patents differs across technology areas. Consequently, countries observed to be moving into high technology opportunity sectors are actually strengthening their position in those industries that tend to patent more. Even though firms prefer to patent those inventions from which they can extract the highest reward, in certain cases the companies may decide to patent for strategic reasons in order to block their competitors.

We have chosen to use the number of patents approved by the USPTO as a proxy for technological progress because the United States is not only the largest and most important technology market in the world, but also the largest export market. Therefore, in the presence of increasing competitive pressures, companies that seek patent protection are more likely to register their inventions in the US than in any other office[10]. Indeed the number of foreign applications filed for example at the Japanese Patent Office (JPO) is relatively low. Of course, in the case of the USPTO, American firms will exhibit higher rates of patenting activity due to the so-called home advantage bias[11]. Nevertheless, since the focus of this paper is not an assessment of the innovation performance of the euro area relative to that of the US, but rather to investigate the performance of the euro area Member States in light of the increased competition from emerging economies such as China and India, it is appropriate to use USPTO data.

The data on exports were taken from the UN's COMTRADE database for the period of 1989-2006[12] and later converted from the SITC classification system into NACE.

9 A good example is aeronautics where due to the high costs incurred and long project duration, secrecy is preferred over patenting or other means of intellectual protection.

10 Montobio *et al.* (2005)

11 Proportionate to their inventive activity, domestic firms tend to apply more frequently for patents in their home country than foreign applicants.

4. The empirical analysis

4.1 Structural decomposition analysis applied to patents

In this section we apply the structural decomposition analysis developed by Fagerberg and Sollie (1987) and perfected by Laursen (1999) to patent shares which are taken as a proxy for technological opportunity. We use this decomposition analysis because it allows us to examine different elements that may explain why the euro area is not as specialised in the export of research intensive products as its main competitors. Considering technology as potentially being an explanation behind the euro area's lower specialisation in research intensive goods is important given that the literature has found technology to be an important determinant of trade patterns. This is due to the fact that technology accumulation is found to lead to the development of capabilities that make changing export structures difficult (see Grossman and Helpman (1991), Lall (1992, 2000)).

The aim of the analysis is to decompose the change in a country's share of world patents Δv_j into different elements. The share of patents of country j in total world patents v_j can be defined as:

$v_j = \frac{\sum_i P_{ij}}{\sum_i \sum_j P_{ij}}$ where P_{ij} is the number of patents granted to country j in sector i.

In turn, a country's share of world patents depends on its share y_{ij} in patents in sector i as well as on the importance of sector i in world patenting w_i:

$y_{ij} = \frac{P_{ij}}{\sum_j P_{ij}}$ which is the share of world patents of country j in sector i

$w_i = \frac{\sum_j P_{ij}}{\sum_i \sum_j P_{ij}}$ which is the share of total world patents of sector i

The change in a country's share of world exports can then be decomposed into three main elements:

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12 Except for China and Hong Kong where data was available only from 1992 onwards.

$$\Delta v_j = v_j^t - v_j^{t-1} = STE_j + TEA_j + TSE_j$$

where t-1 and t refer to the base year and the final year respectively.

$STE_j = \sum_i y_{ij}^{t-1} \Delta w_i$ is the **structural technology effect** which measures what the change in country j's share of world patents would be, if its shares in individual sectors remained constant. It shows whether a country is gaining or loosing its world patent shares as a consequence of its initial specialisation in sectors having developed their technology and which patent more at world level. The effect is therefore driven by the change of technological opportunities of sector i at the world level and reflects whether the country's historical specialisation pattern is providing it with an advantage or a disadvantage in terms of its overall evolution in world patent shares.

$TAE_j = \sum_i \Delta y_{ij} \Delta w_i$ is the **technology adaptation effect** which indicates the change in the sector composition of country j's technological activities according to structural changes in global patterns of technological opportunities. A positive technology adaptation effect suggests that the share of country j's patents increases in the sectors with a growing share of world patents, i.e. country j is moving into high technology opportunity sectors. This last term is further decomposed into two terms to shed more light on whether a country increases (decreases) its shares in both expanding (high technology opportunity) and declining (low technology opportunity) sectors (Laursen (1999)):

$$TAE_j = TGAE_j + TSAE_j$$

where

$TGAE_j = \sum_i \Delta y_{ij} \frac{\Delta w_{ij} + |\Delta w_{ij}|}{2}$ is the **technology growth effect** and is different from zero only if $\Delta w_{ij} > 0$, i.e. if sector i has high technology opportunity at the world level. Accordingly, a positive value for this term shows that country j is moving into high technology opportunity sectors. A negative value for this term means that country j is loosing patent share at the world level in the high technology opportunity sectors.

$TSAE_j = \sum_i \Delta y_{ij} \frac{\Delta w_{ij} - |\Delta w_{ij}|}{2}$ is the **technology stagnation effect** and is different from zero only if $\Delta w_{ij} < 0$, i.e. if sector i has low technology opportunity at world level. A positive value for this term indicates that country j is moving out of low technology opportunity sectors, whereas a negative value indicates that country j is gaining patent share in low technology opportunity sectors.

$TSE_j = \sum_i \Delta y_{ij} w_i^{t-1}$ is the **technology share effect** which measures the gains country j would make in terms of its share in world patents assuming that the world sector structure of patenting activities would remain fixed over time (it abstracts from changes in the sectoral distribution of technological activity at world level). This effect can be interpreted as measuring country j's "technological competitiveness" under the assumption of an unchanged sectoral distribution of patenting activities at world level. The gains or losses for country j in terms of world patents can be attributed to various national policy developments that raise or decrease its "technological competitiveness" such as for example the institutional framework conditions conducive to innovation (access to venture capital, adequate supply of skilled workers, investment in knowledge, degree of flexibility of product and labour markets, etc.).

Table 5 presents the results of the structural decomposition applied to patent shares. It shows that the US had the highest share of world patents in 2001, which can be partially explained by the home bias effect, but which is also due to the fact that the US patents more at world level. The euro area not only registers fewer patents than the US but it also patents less frequently than Japan, which is not affected by a home bias effect. In contrast, the world patent share of emerging countries such as China, India and Brazil is small. Nevertheless, an examination of changes in world patent shares between 1989 and 2001 shows that China and India recorded significant gains over that 12-year period. While most of this gain may be due to a catching-up effect, part of it can certainly be associated with a voluntary effort to increasing the specialisation in technologically dynamic sectors. Brazil and the US also gained patent shares over the 1989-2006 period. In contrast, the euro area and Japan both lost patent shares over the same period.

Table 5. Technology performance of the euro area countries, the US, Japan and selected emerging countries (1989-2001)

Country	Share of world patents 1989	Share of world patents 2001	Total rate of change (%)	Structural Technology Effect	Technology Growth Adaptation Effect	Technology Stagnation Adaptation Effect	Technology Share Effect
Austria	0.42	0.33	-21.25	-7.08	-0.00	2.36	-16.53
BE/LUX	0.42	0.34	-1.90	-0.84	0.00	-0.21	-0.84
Finland	**0.38**	**0.40**	**7.50**	**-5.00**	**7.50**	**2.50**	**2.50**
France	3.32	1.73	-47.96	-3.32	-5.13	6.03	-45.55
Germany	8.11	5.78	-28.72	-6.16	-2.09	4.07	-24.65
Greece	0.01	0.01	-49.38	-0.00	-0.00	0.00	-49.38
Ireland	**0.05**	**0.11**	**101.94**	**-0.00**	**20.39**	**-0.00**	**81.55**
Italy	1.38	0.89	-35.58	-6.53	-2.90	4.36	-30.50
Netherlands	1.05	0.68	-35.55	0.00	-6.55	6.55	-35.55
Portugal	0.00	0.01	275.17	-0.00	0.00	-0.00	275.15
Spain	**0.17**	**0.18**	**5.87**	**-11.74**	**5.87**	**-0.00**	**11.74**
EU12	15.33	10.46	-31.72	-5.22	-2.61	4.37	-28.26
Japan	24.71	19.46	-21.23	7.70	-6.00	2.07	-25.00
US	**49.71**	**55.36**	**11.36**	**-1.43**	**1.99**	**-1.69**	**12.48**
Brazil	*0.06*	*0.07*	*15*	*-6.00*	*-1.05*	*-5.1*	*28.3*
India	**0.03**	**0.29**	**911.01**	**-0.00**	**70.08**	**-210.23**	**1051.16**
China	**0.04**	**0.29**	**618.10**	**-2.45**	**71.47**	**-81.75**	**631.52**
Hong Kong	0.13	0.29	120.12	0.10	13.03	-17.12	124.14

Source: Author's calculation on Eurostat data

While the examination of individual euro area Member States is rendered more difficult by the fact that we do not control for country size and therefore large countries will tend to patent more then small countries, we can still compare patent shares among the large euro area members. We observe that Germany had a higher world patent share than France in 2001 and that both countries patented substantially more compared with Italy and Spain. When examining the change in patent share over the 1989-2001 period, we see that nearly all of the euro area countries have lost world patent share, the only exceptions being Finland, Ireland, Spain and Portugal. While Portugal has made large gains in percentage terms, its share of world patents remained very low in 2001.

Increases in world patent shares appear to be driven by the technology share effects (TSE) which indicates that "technological competitiveness" plays the most important role in determining whether countries gain or loose patent shares at world level. Furthermore, it appears from table 5 that there is a link between the technology share effect and the technology growth and stagnation effects respectively. Effectively, we notice that there is a group of countries with a positive TSE effect that at the same time moved into sectors offering higher technological opportunities and registered negative or close to zero technology stagnation effects. Conversely, countries that experienced losses in terms of their TSE effect were weakening their position in the expanding sectors, while registering positive market stagnation effects. This is confirmed by the strong positive correlation between the technology share effect and the technology growth effect, as well as by a strong negative correlation between the former effect and the technology stagnation effect.

Finally, table 5 also shows that the euro area as a whole is losing technology share overall while at the same time moving out of the sectors offering low technology opportunities, but also losing patent shares in the sectors offering high technology opportunities. This pattern is similar to Japan. In contrast, the US exhibits a pattern similar to that of emerging countries such as China, India and Hong Kong which have gained technology shares overall and have actively moved into sectors offering high technology opportunities while at the same time gaining patent shares in the sectors offering low technology opportunities. The results for China and India suggest that the general perception that they are a location for assembly production based on high-tech imports or that they are just simply imitating existing technologies may not be accurate as these countries also seem to be expanding their innovation capabilities in the industries offering the highest technology opportunities. The results for China are confirmed by Di Mauro and Forster (2008) which find that patenting activity has gained momentum after 2000 and that while the levels still remain low, China is catching-up fast in high tech industries. Brazil is the only emerging country in the sample that is behaving differently from the others in that while it has gained technology shares overall in the 1989-2001 period, this seems to be due to a consolidation of its position in the sectors offering low technology opportunities, while it lost patent shares in the sectors offering high technology opportunities.

The structural technology effect shows that the euro area's historical specialisation pattern contributed to its loss of overall technology shares, while Japan's historical specialisation

pattern attenuated its overall loss in patent shares. The initial specialisation patterns of the US, Brazil, India and China had a negative impact on their overall evolution in patent shares.

The examination of the patent share decomposition at **the euro area Member State level** shows a heterogeneous picture among countries. Finland, Ireland, Portugal and Spain have gained technology shares overall. However, while Finland has clearly been moving out of sectors offering low technology opportunities and into sectors offering high technology opportunities, Ireland, Spain and Portugal have been increasing their patent shares in sectors offering high technology opportunities while also seeming to increase patent shares in sectors offering low technology opportunities.

The other euro area countries, namely Austria, Belgium/Luxembourg, France, Germany, Greece, Italy and the Netherlands have lost technology shares overall in the 1989-2001 period. For most of these countries, i.e. Austria, France, Germany, Greece, Italy and the Netherlands the loss in overall technology shares is accompanied by a movement out of the sectors offering low technology opportunities, but also by a loss of patent shares in the sectors offering high technology opportunities. The fact that these countries are loosing patent shares overall (negative technology share effect) signals that they are not "technologically competitive" at the world level. This result seems to confirm the lower overall capacity to innovate in many euro area countries, reflecting their less well-developed innovation systems with relatively low levels of investment in knowledge and institutional frameworks still somewhat unfavourable towards innovation activities (stringent regulatory environment, difficulty to access venture capital, etc.).

The countries' performances in terms of the TSE effect may also be explained by the structural reforms that they have implemented in the past to improve their innovation systems, as the countries that are doing well in terms of the technology share effect (Finland, Ireland and Spain) are also the ones that have successfully implemented structural reforms during the 1990s.

The structural technology effect shows that in the case of nearly all of the euro area countries, their historical specialisation pattern exacerbated their overall loss in patent shares. The only exceptions are the Netherlands and Portugal whose initial specialisation patterns did not significantly influence their global change in patent shares. The table also shows that the

countries that had the lowest initial world patent shares experienced the highest gains in patent shares over the 1989-2001 period which can be due to the natural catching-up process taking place in the less developed markets that at the same time undergo a profound structural change.

4.2. Structural decomposition analysis applied to export market shares

This section presents the application of the structural decomposition analysis to export market shares which allows us to determine whether a given country is helped or penalized by its initial sector specialization and whether it is increasing its specialisation in the sectors with the strongest growth in world demand.

To this end, the change in the world exports share of country j, Δa_j, is decomposed into three main effects: the market share effect (MSE), the structural market effect (SME) and the market adaptation effect (MAE).

The export market share of country j can be defined as:

$a_j = \frac{\sum_i X_{ij}}{\sum_i \sum_j X_{ij}}$ where X_{ij} represents the exports of country j in sector i

The change in country j's export market share depends on its share of exports in sector i, b_{ij} , as well as on the importance of sector i in total world exports, c_i:

$b_{ij} = \frac{X_{ij}}{\sum_j X_{ij}}$ which is the world exports market share of sector i in country j to the total world exports of sector i

$c_i = \frac{\sum_j X_{ij}}{\sum_i \sum_j X_{ij}}$ which is the world exports market share of sector i

Laursen (1999) shows that the change in a country's market share depends on the developments in terms of the export performance of that country in the different sectors and on changes in the share of sector exports in the world total.

$\Delta a_j = a_j^t - a_j^{t-1} = SME_j + MAE_j + MSE_j$ where

$SME = \sum_i b_{ij}^{t-1} \Delta c_i$ is the **structural market effect** which measures whether country j's historical specialisation pattern creates an advantage or a disadvantage to its current overall export performance.

$MAE = \sum_i \Delta b_{ij} \Delta c_i$ is the **market adaptation effect** which measures whether country j is gaining or loosing market shares due to a movement into the sectors providing high market opportunities or exit out of the sectors providing low market opportunities. This last term is further decomposed into the following two terms (Laursen (1999)):

$MAE_j = MGAE_j + MSAE_j$ where

$MGAE = \sum_i \Delta b_{ij} \frac{\Delta c_i + |\Delta c_i|}{2}$ is the **market growth effect** which is different from zero only if $\Delta c_{ij} > 0$, i.e. if sector i is a fast growing sector. The positive (negative) value of this term indicates that country j is moving into (out of) fast growing sectors. It measures thus whether country j is increasing or decreasing its market shares in the sectors characterized by a strong growth in world demand.

$MSAE = \sum_i \Delta b_{ij} \frac{\Delta c_i - |\Delta c_i|}{2}$ is the **market stagnation effect** which is different from zero only if $\Delta c_{ij} < 0$, i.e. if sector i is a slow growing sector. The positive (negative) value of this term suggests that country j is moving out of (into) the stagnating sectors. This effect shows whether country j is decreasing or increasing its market shares in the sectors with weak demand at the world level.

$MSE = \sum_i \Delta b_{ij} c_i^{t-1}$ is the **market share effect** which shows the change in the world export market share of country j, assuming that the sectoral distribution of world exports remains constant over time. It therefore represents the change in country j's export market shares assuming out changes in the structure of world exports. The gain or loss in export market share for country j is due to a number of factors that determine its export competitiveness such as price and cost competitiveness (measured by exchange rate indicators or unit labour costs) as well as the institutional and political framework and other factors that strengthen competition and raise productivity thereby allowing the country's firms to better compete internationally.

Table 6 shows presents the results of the above decomposition. It shows that the euro area 12 had the largest world export market share in 2006, followed by the US, China and Japan, while the export market shares of India and Brazil remained relatively marginal. The change in world export market shares between 1989 and 2006 shows that the euro area, the US and Japan have been losing market share in favour of emerging countries such as China and India. We also see that China has gained substantial world export market share over the 1989-2006 period and went from a marginal level of market share in 1989 to a level comparable to the US in 2006.

Table 6: Export performance of the euro area countries, the US, Japan and selected emerging countries (1989-2006)

Country	Export Market Share 1989	Export Market Share 2006	Total Change (%)	Structural Market Effect	Market Growth Adaptation Effect	Market Stagnation Adaptation Effect	Market Share Effect
Austria	1.38	1.35	1.73	-2.05	-1.42	-0.67	2.40
Bel/Lux	3.95	3.48	-11.71	-4.65	0.70	2.19	-9.95
Finland	1.03	0.73	-28.98	-15.85	1.92	8.80	-23.85
France	7.01	4.71	-32.78	-1.26	-3.52	2.03	-30.04
Germany	14.96	11.27	-24.69	-0.80	-2.89	0.86	-21.86
Greece	0.28	0.16	-39.71	-9.54	-0.15	6.11	-36.13
Ireland	**0.94**	**1.16**	**23.31**	**1.89**	**6.91**	**3.30**	**11.21**
Italy	6.13	4.04	-34.20	-5.35	-2.56	3.32	-29.61
Netherlands	4.21	3.26	-22.43	-5.87	-0.47	6.08	-22.17
Portugal	0.54	0.39	-27.51	-6.90	-1.61	3.74	-22.92
Spain	**1.71**	**2.01**	**17.65**	**-5.11**	**1.36**	**-4.65**	**26.05**
EU12	21.10	17.06	-19.16	-2.64	-1.42	1.54	-16.64
Japan	12.22	6.48	-46.95	11.28	-12.00	2.45	-48.68
US	13.46	10.07	-25.20	1.86	-4.52	2.29	-24.82
Brazil	1.24	1.07	-13.91	-10.55	-0.76	-0.43	-2.17
India	**0.63**	**1.00**	**59.50**	**-2.86**	**3.62**	**-7.30**	**66.05**
China	**2.39**	**10.02**	**319.17**	**-10.44**	**44.76**	**-36.84**	**321.69**
Hong Kong	3.72	1.00	-73.11	-2.22	-10.81	10.10	-70.18

Source: Author's calculation on Eurostat data

When comparing the large euro area Member States amongst themselves we notice that Germany has by far the highest market share at world level followed by France, Italy and Spain. Spain is following the pattern of catching-up economies and has gained world market share, while Germany, France and Italy all lost market share during the 1989-2006 period. Nevertheless, the German loss in terms of market share was less than that of then France and Italy. We also observe that nearly all of the euro area Member States lost market share during this period, the only notable exceptions being Austria, Ireland and Spain.

Similarly to the results for the patent share decomposition, the change in export market shares between 1989 and 2006 is largely driven by the market share effect, i.e. a quantitative increase in market share assuming a fixed structure of world exports over the entire period. The negative market share effect in nearly all of the euro area countries as well as in the US

and Japan may not just be a consequence of the natural catching-up phenomenon of emerging countries such as China and India, but may also be caused by other factors that weigh down on overall export competitiveness. It appears from the table that in general, the countries that have a positive MSE effect are actively moving into the most dynamic sectors, but are also consolidating their positions in the industries with a more stagnant world demand. Conversely, the countries with a negative MSE effect are also loosing market shares in the dynamic sectors while actively moving out of stagnating sectors. These patterns are confirmed by the strong positive correlation between the market share effect and the market growth effect, as well as by the strong negative correlation between the market share effect and the market stagnation effect. The examination of correlation coefficients also reveals a strong negative and significant correlation between the structural market effect and the market growth effect which shows that generally the countries which have been initially disadvantaged by their historical specialisation pattern are the ones that are actively moving their production structure into the most dynamic sectors. Similarly, the countries that have initially benefited from their initial specialisation pattern are the ones that are loosing market shares in the most dynamic sectors.

Table 6 also shows that the loss in market share in the euro area, the US and Japan has been accompanied by an active movement out of stagnating sectors as well as by a loss of market share in dynamic sectors. In contrast, the gain in overall market share in China and India is accompanied by gains in market shares in expanding industries and a consolidation of their position in stagnating industries. The latter effect might be path dependant, in the sense that both countries deepen their specialisation in the sectors where they have been already strong (Krugman (1995)). A similar phenomenon is observed for patents, which suggests that by innovating in the stagnating sectors, countries are moving up the quality ladder, which in turn allows them to improve their trade performance. In addition, Hong Kong is found to share the specialisation pattern of the developed countries: it has lost market share over the 1992-2006 period, it is actively moving out of the sectors with stagnating world demand, however it is loosing market shares in the sectors with strong world demand.

In Brazil, the overall loss in market share is due to the fact that it was not able to compensate its loss of market share in dynamic sectors and its initial disadvantage given by its historical specialisation pattern by a consolidation of its position in stagnating industries.

The structural market effect shows that the loss in global market shares in the euro area was exacerbated by its historical specialisation pattern, while the latter had a dampening effect on the loss of market share for the US and Japan. China and India's initial specialisation patterns had a limiting impact on their overall gain in market shares.

When we examine **euro area countries individually**, we can observe a certain degree of heterogeneity in terms of behaviour patterns. Nearly all of the euro area countries have lost market share over the 1989-2006 period with two notable exceptions, namely Ireland and Spain which have gained market share during this period. The market share effect is negative for all of the euro area countries with the exception of Austria, Ireland and Spain. The negative market share effect was accompanied by a movement out of stagnating sectors and a loss of market share in dynamic industries in the cases of France, Germany, Greece, Italy, the Netherlands and Portugal. In Spain the gain in the overall export market share is due to an expansion in dynamic industries, but also to a consolidation in market share in the more mature stagnating industries.

The gain in overall export market share in Ireland is due to an active movement out of stagnating and into dynamic sectors. In contrast, Finland and Belgium/Luxembourg's movements out of stagnating and into expanding industries are not enough to compensate for their initial disadvantage in terms of specialisation pattern such that they are still loosing market share overall. Finally the positive market share effect for Austria is explained by a consolidation of its position in stagnating sectors, but not by an expansion into dynamic ones.
The structural market effect shows that nearly all of the euro area members have been disadvantaged by their historical specialisation pattern, the only exception being Ireland whose sector specialisation in 1989 had a positive effect on its overall export performance.

5. Putting the analysis for market shares and patents together

In this section we bring together the analysis on technology and on export market shares. The literature suggests that product innovation leads to trade specialisation, but the monopolistic power of technology leaders is temporary (see Krugman (1979)). Furthermore, there is empirical evidence that the changes in the world export shares can be explained by a set of technological variables at the country and sector level (see for example Fagerberg (1988), Amendola et al. (1993), Greenhalg (1990), etc.). In order to examine more closely whether

there is a relationship between technology and market shares in our data, we define four categories in terms of market and technology opportunities in which we can classify the countries in our sample: low, low-medium, medium-high and high market and technology opportunities respectively.

The countries that are classified into the **low market opportunities** category are the ones that are moving into sectors with stagnating world demand and are loosing market share in the industries with dynamic world demand (negative market growth and stagnation effects).

The countries classified into the **low-medium market opportunities** category are moving out of stagnating sectors, but are also loosing market share in dynamic sectors (negative market growth and positive market stagnation effects).

The countries in the **high-medium market opportunity** category are moving into dynamic sectors while also consolidating their position in stagnating industries (positive market adaptation and negative market stagnation effects). A country that is situated in this last category is in a relatively better position than a country that has a positive stagnation effect and a negative adaptation effect (low-medium market opportunities), as it is in fact gaining market shares in both expanding and stagnating sectors, whereas a country in the low-medium market opportunity category is loosing market shares in both types of sectors.

Finally, a country is considered to display **high market opportunities,** if it is moving into dynamic sectors and out of stagnating industries (positive market growth and stagnation effects). The countries with high market opportunities (i.e. positive market adaptation and stagnation effects) are in a better position than countries with high-medium market opportunities (i.e. positive growth and negative stagnation effects) because a country with high market opportunities is shifting its entire production structure towards sectors that are benefiting from a strong growth in world demand, whereas in the case of countries having high-medium market opportunities, the shift of the production structure towards sectors with strong growth in world demand is only partial.

Table 7 summarizes the definition of the four types of opportunities categories according to the signs of the growth and stagnation effects:

Table 7. Summary of the types of opportunities categories

	Low market opportunities	Low-medium market opportunities	High-medium market opportunities	High market opportunities
Dynamic sectors	⇘	⇘	⇗	⇗
Stagnating sectors	⇗	⇘	⇗	⇘

"⇗" indicates that the country is moving into the sectors in question

"⇘" indicates that the country is moving out of the sectors in question

We used a similar classification for the technology share effects. A country is considered to have **low technology opportunities** if it is loosing patent share in high technology opportunity sectors and moving into low technology opportunity sectors; it displays **low-medium technology opportunities** if it is moving out of sectors with low technology opportunities but loosing patent share in high technology opportunity sectors; **high-medium technology opportunities** if it is concentrating its innovation capabilities in sectors with high technology opportunity and also consolidating its position in low technology opportunity industries; and finally, it reveals **high technology opportunities** if it is simultaneously moving into sectors with high technology opportunity and out of sectors with low technology opportunities. The interpretation of technology opportunities classes follows the one presented for market opportunities.

Given the four categories summarized above, table 8 classifies the different countries under investigation according to both market and technology opportunities effects.

Table 8: Classification of countries with respect to their technology and market effects

	Low market opportunities	Low-medium market opportunities	Medium-high market opportunities	High Market opportunities
Low technology opportunities	Brazil			
Low-medium technology opportunities	Austria	France Germany Italy Netherlands Japan		
		Greece		
Medium-high technology opportunities		US Hong Kong	Spain India China	Belgium/Luxembourg Ireland
		Portugal		
High technology opportunities				Finland

Source: Author's calculation. Greece and Portugal registered only marginal changes with respect to their patent specialisation. While in terms of sign they belong to the same categories as France, Germany, Italy, Netherlands and Japan for Greece and US and Hong Kong for Portugal respectively, their levels remain extremely low.

The shaded diagonal shows the countries that are in the same category both in terms of market and technology opportunities. Most of the countries under consideration are located along the shaded diagonal which gives some preliminary evidence of the link between technology and market opportunities. We assume that the countries investing in high technology opportunities today will have high market opportunities tomorrow. The impact of technology on market opportunities is well documented in the literature. For example, Posner (1961) showed that technical change led to an increase in exports for a given country during the time it took for other nations to imitate the innovation carried out by the country in question. Similarly, Mansfield (1981) showed that once imitation occurs, exports are influenced by other traditional factors of adjustment. If innovation, however, is continuous, then this can continuously raise exports and positively influence export performance.

Given the impact of technology on exports and the four opportunity categories defined above, a country is in the most difficult position if it is located in the group characterised by both low market and low technology opportunities. In that case, countries would be consolidating their

positions in stagnating sectors while loosing market shares in dynamic sectors and at the same time they would be concentrating their innovative activities in the sectors that offer low technology opportunity. This could lead to the situation that the country in question would continue to be affected by low export market opportunities in the future. Our results suggest that Brazil is located in this lowest end of the spectrum.

Conversely, a country is in a very good position if it is located in the group with high export market and technology opportunities. It would mean that a country is expanding its market share in the sectors experiencing the most dynamic world demand, concentrating at the same time its innovative activities in the sectors offering the highest technology opportunities, thereby increasing the probability of benefiting from high market opportunities in the future. To this group we could qualify only one country, namely, Finland.

All of the other situations are intermediate cases. Many of the euro area countries, including most of the largest Member States, as well as Japan, are situated in the low-medium market and technology opportunities categories since they are moving their production structure out of stagnating industries but not gaining market share in expanding sectors and at the same time they do not manage to concentrate their innovative activities in the sectors offering the highest technology opportunities. The emerging countries of India and China as well as Spain exhibit medium-high market and technology opportunities. Accordingly, they are gaining market shares in both stagnating and expanding industries and, simultaneously, concentrate their innovative activities in sectors offering both high and low technology opportunities.

A small number of countries is located "off" the diagonal. Austria currently is in the low market opportunities category and has low to medium technology opportunities. Accordingly, it is shifting its innovative activities away from the sectors offering low technology opportunities, but it is not yet gaining patent shares in sectors with high technology opportunities. This can translate into a similar future market structure as in the case of countries that are gradually moving out of stagnating sectors, but not gaining market shares in the expanding industries.

The US, Hong Kong and to lesser extent Portugal have low-medium market opportunities, but medium-high technology opportunities. They are therefore increasing their patent shares in sectors offering both high and low technology opportunities. If the technology opportunities

are transformed into market opportunities, then these countries can in the future expand their market shares in both stagnating and expanding sectors and therefore move to the right on the diagonal.

Finally, Belgium/Luxembourg and Ireland have high market opportunities - moving out of stagnating sectors and into expanding industries - but are still locked in the medium-high technology opportunity category. As they are gaining patent shares in both high and low technology opportunity sectors, they may gain market shares in both expanding and stagnating industries in the future, moving thus into the medium-high market opportunities category.

6. Conclusions

The paper confirms a positive relationship between technology and market opportunities from a descriptive statistics point of view. It seems that countries that are concentrating their innovative capacities in sectors offering high technology opportunities are also shifting their production structure towards the sectors benefiting from the strongest growth in world demand. Conversely, countries that are patenting in sectors offering low technology opportunities are also developing their production structure in sectors with low growth in world demand. Furthermore, the changes in patent and export market shares are driven by the technology and market share effects respectively. Therefore, it seems that national policies that determine a country's technological and export competitiveness play an important role in determining a country's export and innovation performance at world level. Within this context, the role of structural reforms will be examined more closely in the econometric analysis since it appears that the countries which are the best performers in terms of technology and market opportunities are also the ones that have successfully implemented structural reforms during the 1990s. Further work is therefore necessary in order to confirm the relationship between technology and export performance econometrically, as well as to better examine the role played by structural reforms and other national policies within this process.

Subject to econometric verification, we conclude that first, many of the euro area members (especially the large member states) are not very successful in concentrating their innovation capacities in the sectors offering the best technological prospects. At the same time, they are

not adequately reorienting their production structure towards the industries with the most dynamic world demand. This reflects to a certain extent their relatively less well-developed innovation systems with low levels of investment in knowledge and institutional frameworks still not well supporting innovation activities (stringent regulatory environment, difficulty to access venture capital). The relative weakness of the innovation systems may explain in part the fact that most euro area countries are not able to gain market share in the most dynamic sectors at world level.

Second, it appears that emerging countries such as China and India are simultaneously developing their innovation capacities in sectors offering more high tech opportunities. The gain in overall export market share by these countries at the world level cannot be explained by the diffusion of new technologies developed by the industrialized countries only, but also by a targeted effort to transform their structure through increased investment in research and development. If this is indeed the case, then the need for Europe to raise R&D spending and to accelerate the development of an Internal Market for knowledge becomes even more pressing.

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Annex: Breakdown of total trade by factor intensity

Raw Material-Intensive Goods

SITC 0	Food and Live Animals
SITC 2	Crude Material, Inedible, Except Fuels (excluding 26)
SITC 3	Mineral Fuels, Lubricants and Related Materials (excluding 35)
SITC 4	Animal and Vegetable Oils, Fats and Waxes
SITC 56	Fertilizers

Labour-Intensive Goods

SITC 6	Manufactured Goods Classified Chiefly by Material (excluding 62, 67 and 68)
SITC 8	Miscellaneous Manufactured Articles (excluding 87 and 88)
SITC 26	Textile Fibres (Other Than Wool Tops and Other Combed Wool) and Their Wastes (Not Manufactured into Yarn or Fabric)

Capital-intensive Goods

SITC 1	Beverages and Tobacco
SITC 35	Electric Current
SITC 53	Dyeing, Tanning and Colouring Materials
SITC 55	Essential Oils and Resinoids and Parfume Materials; Toilet, Polishing and Cleansing Preparations
SITC 62	Rubber Manufactures, n.e.s.
SITC 67	Iron and Steel
SITC 68	Non-Ferrous Metals
SITC 78	Road Vehicles (Including Air-Cushioning Vehicles)

Easy-to-imitate Research-intensive Goods

SITC 51	Organic Chemicals
SITC 52	Inorganic Chemicals
SITC 54	Medicinal and Pharmaceutical Products
SITC 58	Plastics ain Non-Primary Forms
SITC 59	Chemical Materials and Products, n.e.s.
SITC 75	Office Machines and Automatic Data-Processing Machines
SITC 76	Telecommunications and Sound-Recoding and Reproducing Apparatus and Equipment

Difficult-to-imitate Research-Intensive Goods

SITC 7	Machinery and Transport Equipment (includes semiconductors, excludes 75, 76 and 78)
SITC 57	Plastics in Primary Forms
SITC 87	Professional, Scientific and Controlling Instruments and Apparatus, n.e.s.
SITC 88	Photographic Apparatus, Equipment and Supplies and Optical Goods, n.e.s.; Watches and Clocks

Source: Yilmaz, B. (2002), "Turkey's competitiveness in the EU", *Russian and East European Finance and Trade* based on earlier work by Hufbauer, C.G. and J.C. Chilas (1974), "Specialization by industrial countries: extent and consequences" in H. Giersch (Ed) "The international division of labour: problems and perspectives"