THE IMPACT OF INNOVATION POLICY ON THE SECTORAL STRUCTURE OF THE ESTONIAN ECONOMY

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Abstract

The current global economic crisis has increased the awareness of the role of knowledge-based economy in raising international competitiveness. For contributing to faster economic restructuring, knowing the quantitative effects of innovation policy decisions is relevant. Using an exports structure as an indicator of a production structure, a pooled data approach allows estimating the elasticity of the exports structure on innovation indicators. Admitting estimation limitations of the short time series available, the estimation results confirm a statistically significant effect of enterprises' expenditures on research and development, and labour productivity on exports structure. The elasticity of the specialisation on higher technology intensity industries is generally higher than the elasticity of lower technology intensity industries. Knowing quantitatively confirmed effects in the past contributes to more effective competitiveness supporting policy decisions ahead.

Keywords: innovation, competitiveness, catching-up, specialisation, knowledge-based economy, structural change, medium-high technology (MHT) and high technology (HT) intensity industries

Introduction

The role of innovation policy has increased in catching-up economies like Estonia, where the sources of international cost-competitiveness are about to be exhausted. The Estonian economy has benefited from a comparative advantage arising from relatively low labour costs over the last 10-15 years. Strong cost-competitiveness has attracted extensive investments and has allowed the economy to converge with the advanced economies at a fast pace. For further convergence, the Estonian economy needs a significant qualitative shift towards more productive production structures. The authorities can initiate and contribute to the shift by creating a supportive environment, including developing and implementing innovation policy.

Estonia has recognised the crucial role of innovation capability of the corporate sector for sustainable growth of the economy and has established a supportive framework. The government has adopted a research and development and innovation strategy "Knowledge-based Estonia 2007-2013" and implements it on a continuous basis. The effectiveness of the policy can be measured by respective indicators, also listed in the implementation plan of the strategy. In regular policy assessments the effect of policy decisions on actual changes in production structures are not common, therefore lacking quantitative impact estimations. The current paper aims at providing additional quantitative information on the elasticity of production structures on changes in the research and development and innovation environment. The estimates of the linkages in the past can be used for assessing the expected impact of future policy decisions. The adequate policy measures, including innovation policy decisions, have become even more relevant in the context of the current global economic crisis. The faster the economy can adjust in the changed environment, the higher the probability of achieving sustainable growth.

In the following analysis, a traditional pooled data approach is used in order to increase the number of observations for statistically representative results. The methodology allows estimating an impact of a research and development indicator on a pool of higher technology intensity industries. Changes in the production structure or the dependent variable is measured as changes in the exports of the respective industries. Exports structure is directly linked to the production structure of the exporting sectors and reflects generally the changes in specialization. Additionally, the innovation strategy is focused on improving international competitiveness of firms, therefore exports structure serves as an adequate indicator for structural changes.

Theory and empirical findings

In contemporary economics it is widely accepted that the economic growth is faster the higher the openness of the economy, i.e. the more the country exports and imports (see e.g. Perera-Tallo 2003). Innovation is increasingly seen as an additional source of economic growth that increases international competitiveness (e.g. León-Ledesma 2002). An introduction of modeling endogenous innovation gained followers increasingly in the 1990s (see e.g. Grossman and Helpman 1990).

The literature on the economics of product variety agrees that the "*degree of product variety increases with the competitiveness of the market*", which is mainly seen in the context of market structure: "*the variety is greater under monopolistic competition than under monopoly*" (Lancaster 1990). The concept could be augmented to a macro-economic approach, suggesting that a more competitive economy produces and exports a greater variety. The introduction of product variety or product diversity in trade models roots back to extensions of the traditional Heckscher-Ohlin model (see e.g. Lawrence and Spiller 1983), also referred to as the new trade theory (Borkakoti 1998). The new trade theory takes into account market imperfections, mostly referring to monopolistic competition in international trade (see Helpman 1988). After the opportunities of inter-industry specialisation have been exploited (e.g. specialisation in textiles or machinery), intra-industry specialisation in similar products (e.g. specialisation in sports cars or passenger cars) takes over in further integrating international trade (Balassa 1966). The trade partners specialise in similar products belonging to the same industry in order to differentiate the exported products from the production of the destination country.

In recent studies export variety has been analysed mainly in the context of its impact on economic growth, as in Ventura (1997) and Jones (1998). Ventura (1997) shows in his theoretical setup how economic growth is driven by physical capital accumulation and that countries specialise according to comparative advantage, explaining export-led growth. He also notes that exporting manufacturers specialising in capital-intensive sectors may have played a key role in the rapid East Asian growth process.

Jones (1998) also acknowledges that countries investing more strongly in physical capital tend to be richer. A simple semi-endogenous growth model is provided in which economies become more productive as a widening of the spectrum of available products occurs. The model emphasizes the importance of product variety since the steady state income level depends on the degree of product variety. In the model, increased product variety accelerates per capita income levels by more fully realising dynamic economies of scale. Similarly, Feenstra and Kee (2006) introduce a growth model with similar aspects as the Melitz (2003) monopolistic competition model. They show that in the presence of monopolistic competition and heterogeneous firms relative export variety enters positively in the GDP function.

The linkages between innovation and a catching-up process (incl. convergence in productivity levels) have been empirically tested on OECD countries, confirming positive elasticities (León-Ledesma 2002). Additionally, a statistically significant favourable role of technological upgrading in OECD economies' international competitiveness has been empirically shown (Montobbio 2003; Madsen 2008). The empirical evidence on the US confirms that net exports have a positive elasticity on industry productivity growth and support "*the technology-gap model of trade*" (Wolff 2003). In case of the UK it has been concluded that "*innovation improves the average quality and the variety of products of offer which attracts more demand*" (Greenhalgh *et al*. 1994). Empirical studies on the US suggest that "an institutional environment favourable to innovation" has strongly contributed to the development of high-tech sectors, and consecutively to a generally strong economic growth (Simonazzi 2003). On the other hand, by increasing research and development expenditures, imports needs might decrease, favouring a sustainable development in terms of external balances (Anderton 1999).

Together with innovation and technological upgrading, product variety has been empirically confirmed to be a determinant of general export performance in OECD countries (Madsen 2008), contributing to international competitiveness and to the catching-up process. A continuously widening product differentiation or product variety increases globally trade and welfare (Hummels and Klenow 2005 and Broda and Weinstein 2004). Several studies have confirmed "*a direct link between export variety and productivity*" (Feenstra and Kee 2004), i.e. a positive effect of a variety to country's productivity (Feenstra *et al*. 1999; Funke and Ruhwedel 2001, 2002, and 2005). The specialisation in variety can be measured in comparison to a trade partner (e.g. CES production function approach, see Feenstra 1994), but also as a count-based approach for one country (number of products produced, exported or imported). For Eastern European transition economies export variety has been measured relative to the export variety in the U.S., based on CES production function approach (Funke and Ruhwedel 2005). The results for 14 Eastern European countries show that export variety in Estonia lags far behind that in Czech Republic, Hungary, Poland and even Russia and Lithuania, but is leading Latvia. As an alternative measure, Funke and Ruhwedel (2005) apply product counts. Denoted as "the simple count-based measure", this alternative method leads to a similar ranking of the countries, except for indicating a higher diversity in Estonian exports compared to Lithuanian exports. The authors also distinguish between capital intensive and labour intensive goods, and find much higher export variety in capital intensive goods in Estonia. For labour intensive goods, a huge drop in export variety was registered for Estonia in 1998 with a gradual increase afterwards, reflecting the impact of the Russian crisis.

Innovation policy in Estonia

Estonian innovation policy focuses on ensuring innovation and growing capability of Estonian enterprises, using a variety of supportive measures. Innovation policy addresses both the development of internationally competitive production higher technology-intensity industries, and the promotion of innovation and technology-intensity in traditional and also currently competitive industries. Estonian innovation policy is implemented by the Ministry of Economy and Communication.

For increasing the efficiency of innovation policy, Estonia has adopted the research and development and innovation strategy 2007-2013 "Knowledge-based Estonia" (Estonian … 2007). The strategy focuses on 1) coordinating research and development activities, 2) entrepreneurship and competitiveness, and 3) the public sector and the formation of research and development and innovation policy.

The strategy prioritises increasing the innovation capability of enterprises, by raising it to one of the three main objectives of the strategy: innovative entrepreneurship contributing to the value added of the global economy. Innovation capability of enterprises is directly addressed by one of the four main measures of the strategy (Measure 3).

The research and development and innovation strategy is implemented based on its implementation plan (Eesti … 2007). General implementation plan for 2007-2013 foresees the Measure 3 "Increasing the innovation capability of the enterprises" to provide a number of expected results. For the structural change, the directly related indicators are an increase of new products and services, increase of their sales revenues in total turnover, an increase of research and development and innovation investments in total turnover, and an increase in total productivity of enterprises. Additionally, the strategy targets acceleration of the increase of technology-intensive industries and the increase of the share of medium-high and high technology industries in value added, exports and employment.

The effectiveness of meeting the priorities set in the strategy is measured by specific indicators defined in respective governmental research and development programmes. The achievements of meeting the objective of the strategy "Increasing the innovation capability of the enterprises" have been relatively significant in terms of increasing expenditure on research and development (in 2001-2007), while sales revenues of new products remained low (Eesti … 2008). The current analysis complements the innovation strategy intermediate report results by focusing directly on the effect of innovation policy measures on exports behaviour. Additionally, while the intermediate report presents innovation indicators of relative shares and indices, the current analysis provides estimates of elasticity-type linkages of processes.

Estonian exports structure

Estonia is a highly open small economy with merchandise exports above 50% of GDP. The Estonian exports structure is relatively heterogeneous, dominated by machinery exports (20% of total merchandise exports in 2007), and followed by metals and metal products (10%), and timber products (10%). For statistical reasons, Estonia reports high exports of mineral products (10% of total merchandise exports in 2007) that reflects transit related trade of motor fuels. Transit-type trade transactions also trigger a high share of motor vehicles in Estonian exports (9% in 2007).

In terms of technology-intensity, Estonian exports are dominated by medium-low technology intensity exports, mainly due to a high share of motor fuels in total exports (see Chart 1). Excluding transit-type exports-transactions (incl. motor vehicles that are classified as production of medium-high technology intensity industries), Estonia exports mainly products of low technology intensity: timber products, food and beverages, and textiles and clothing (see Annex 1 for the complete classification).

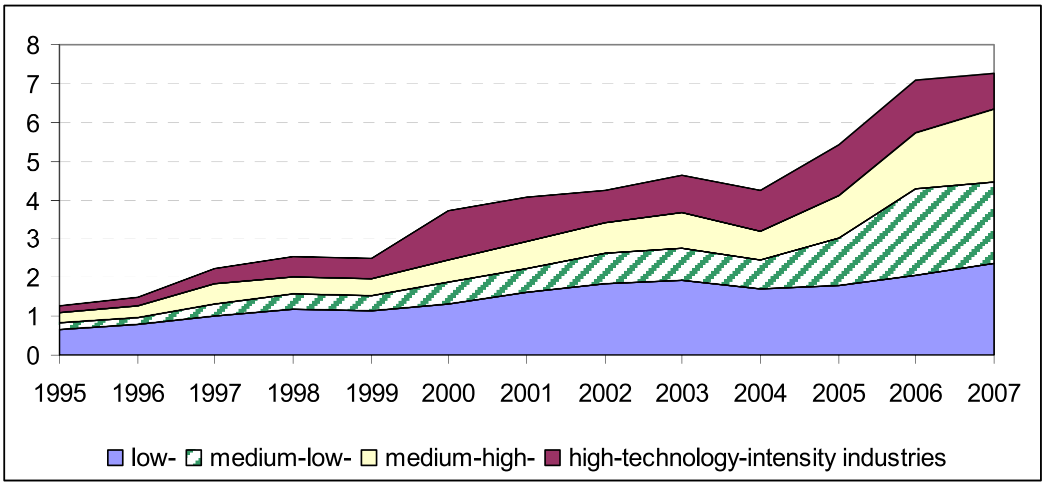

Chart 1. Structure of Estonian manufacturing exports based on technology intensity of industries, 1995-2007 (bn EUR). (Eurostat Comext database)

In terms of export product variety, the ranking of industries does not overlap with the ranking in terms of export value. The most diversified in terms of Harmonised System (HS) 6-digit products has been the export of non-electrical machinery. Over the 10 years, the industry contributed up to 5% of total manufacturing export value. Of total number of HS 6-digit products exported, non-electrical machinery products constitute 11-12%, comparable to diversification of textiles, chemicals and food industries.

Although the increase in export value of an industry can be related to introduction of new products exported, it does not mean that the largest exporting industries have the highest number of products exported. For example, in case of food industry the value of exports amounted to 25% of total manufacturing exports while food products constituted only 12% of total manufacturing products exported. Also, the exports of one of the largest exporters, the wood and pulp industry, have a relatively low diversification in products, wood and pulp products constituting 2% of total manufacturing products exported. The same applies for electronics-communication products, the share of which in total products exported has remained at 2% although its contribution to total manufacturing exports value has increased to 16%.

In terms of relative concentration, product diversification has been distributed somewhat more evenly across industries compared to export value. In contrast to the more significant changes in relative shares of industries in exporting value, there are no large changes over time in relative shares of products exported across industries. The total number of exported manufacturing products increased by 20% between 1994 and 2007. The largest absolute increase took place in the textiles industry. Large relative increases of exports product variety in electronics-communication and wood and pulp industries match the strong increases in export value of these industries, confirming the positive correlation between two growth rates.

In the distribution of export products according to technology-intensity based groups, the relative shares of four groups have remained relatively unchanged, confirming the results discussed above (see Chart 2). Products of low-technology intensity industries still account for 40% of total manufacturing products exported, while the share of such industries in export value has dropped from 50% to 40%. Low-technology intensity industries include food, textiles, clothing and other manufacturing products that are among the industries with the highest product diversification, but also the wood and pulp industry with a relatively low product variety but a high contribution to export value.

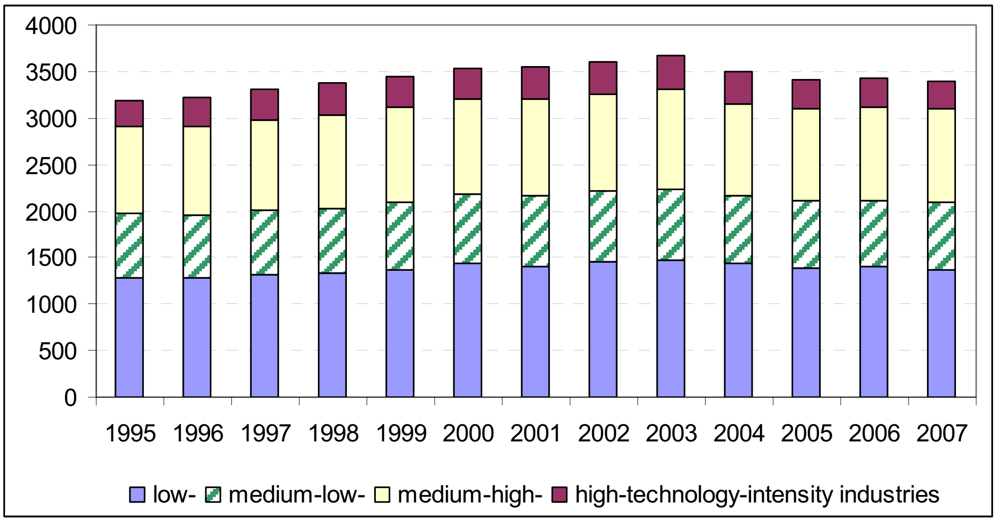

Chart 2. Structure of the product variety of Estonian manufacturing exports based on the technology intensity of industries, 1995-2007 (number of product groups). (Eurostat Comext database)

The share of the exported products of medium-high technology intensity industries (including high product variety industries in Estonia: chemicals and non-electrical machinery) has remained 30%, while the share of products of medium-low-technology intensity industries (incl. basic metals and fabricated metal products) still constitutes 20%. The share of high-technology intensity products (incl. scientific instruments) has remained at about 10%. In the trade statistics, some slight decrease in low-technology products and a slight increase in high-technology intensity products can be distinguished over the years (about 1 percentage point), but as this can also be due to small errors in data collection, so no firm conclusions can be drawn.

Methodology and data

The impact of innovation policy on exports structure is estimated based on the pooled data approach, using the traditional ordinary least squares estimation method. The estimation test an hypothesis whether innovation indicators have a statistically significant positive effect on exports, more specifically on exports structure. Four alternative exports variables are used for the dependent variable ($structure_{it}$), distinguishing four groups of manufacturing sectors, based on technology-intensity:

$$\Delta \ln structure_{it} = \alpha \Delta \ln innovation_t + \varepsilon_{it}$$

The issue of exports structure is addressed by estimating the effect of innovation indicators on higher technology intensity industries (excluding low technology intensity industries) and comparing the results to the estimates for the total set of industries. Innovation indicators are not industry-specific, therefore explanatory variables are common for all industries, varying only across time ($innovation_t$). According to standard ordinary least squares estimation method, the estimation includes residuals (ε_{it}). For eliminating the unit root from series, first differences (Δ) are used for estimating the coefficients (α) or the effects of innovation indicators.

Exports structure is used as an indirect proxy for production structure of the economy, partly reflecting the international competitiveness of the industries. To estimate product variety in Estonian exports, disaggregated foreign trade statistics of Estonian exports are necessary. The current paper uses the disaggregated Comext database of trade statistics provided by Eurostat.

As the focus of the study is on differentiated products, it is important to limit the data to manufactured products (Classification of economic activities in the European Community NACE Rev. 1.1 at 2-digit level the levels 15-36). The highest available disaggregated product level is the 6-digit level of the Harmonised System (HS) classification that is used in the following analysis.

From the perspective of competitiveness and sustainable economic growth the changes in product variety of high-technology products is especially important. In order to estimate the relevance of changes in product variety of technology-intensive products in Estonian exports, the grouping of industries according to the Eurostat classification of manufacturing industries by technology intensity has been used. Eurostat classifies all manufacturing industries into four technology-intensity based groups (see also Annex 1):

1) high-technology (aerospace, pharmaceuticals etc.),
2) medium-high-technology (electrical machinery, motor vehicles, etc.),
3) medium-low-technology (rubber and plastic products, non-metallic mineral products, etc),
4) low-technology (food, beverages and tobacco, textile and clothing, etc.).

The Eurostat classification of economic activities by technology intensity is based mainly on NACE 2-digit level aggregation. From chemicals (NACE 24) the pharmaceuticals (NACE 24.4) are classified as high-technology products, while the remaining chemicals are classified as medium-high-technology products. NACE 3-digit classification is also applied for transportation equipment, classifying aerospace (35.3) as high-technology, shipbuilding as medium-low-technology (35.1) and other transportation equipment as medium-high-technology industries.

Estonian foreign trade statistics are product-group based and are classified according to NACE 2-digit aggregation level but not according NACE 3-digit aggregation level. In order to follow the technology intensity classification of Eurostat, pharmaceutical (NACE 24.4), aerospace (NACE 35.3) and shipbuilding (NACE 35.1) products are distinguished by the verbal product description in trade statistics in the following analysis. Despite its subjectivity, this is the only possible approach the to NACE 3-digit industries product classification. As the descriptions on 6-digit aggregation level are relatively detailed the possible bias should not be very significant and therefore should not seriously influence the results of the analysis. The number of industries included in the analysis is 27, distinguished according to Eurostat's economic activities technology intensity based classification (NACE 2-digit and 3-digit).

Innovation policy intermediate results are measured in terms of standardised innovation and research indicators, provided by Eurostat (Eurostat. Structural ...). Taking into account time series length limitations and the relevance of the indicators for exports structure, the effect of the following indicators was tested:

- Spending on human resources, in terms of total public expenditure on education as a percentage of GDP;
- Gross domestic expenditure on research and development;
- The share of the enterprise sector in total gross domestic expenditure on research and development;
- Patent applications to the European Patent Office EPO, number of applications per million inhabitants.

Additionally an indicator of labour productivity per person employed was used, partly reflecting changes in the general economic background. All data are of annual basis, starting generally in 1997 or 1998, and ending in 2006 or 2007.

Estimation results

Estimation results are consistent with general economic intuition and confirm the hypothesis that innovation indicators have contributed to changes in exports structure. Three innovation indicators of the tested four show a statistically significant impact on exports, and an additional structural indicator labour productivity shows also a statistically significant effect on exports value structure in the estimation period 1996-2007.

Due to data availability, the sample period varies across innovative indicators, implying a varying number of observations (see Annex 2). The estimates of the impact on all industries are based on 30-40 observations, while the estimates of the impact on more technology-intensive industries is by one fourth lower, as the data on low technology-intensity industry are excluded from the dependent variable. The shortest estimation period (seven years) is for the research and development expenditure in the business enterprise sector, while for labour productivity and education expenditure variables the estimation period is the longest (nine years).

In case of structural changes, the changes in earlier periods of innovation indicators or lagged impact might affect exports variables. In the current analysis, statistically significant lagged effects were confirmed for four variables. An increase in a previous period (*t-1*) in expenditure on education had a statistically significant effect on the number of products exported. An increase in two periods earlier (*t-2*) in the number of patent applications and in the business sector expenditure on research and development had a statistically significant effect on both exports values and the number of exported products. An increase in labour productivity and in expenditure on education had a statistically significant effect on exports value in the same period.

The effect of innovation indicators is stronger on exports of more technology intensive industries in case of all tested variables, indicating the effectiveness of innovation policy. While innovation policy aims at increasing innovation in all industries, for increasing international competitiveness and ensuring sustainability of economic growth the development of more technology-intensive industries is of high priority.

Conclusions

Innovation policy is one of the government's main tools to promote and contribute to the structural change that the economy needs for sustainable growth. The current global economic crisis has speeded up the need for considerable changes in the economic structure in order to face slowing or declining external and domestic demand. The efficiency of innovation policy has now become even more important. Well targeted policy measures could be used for helping the enterprises to adjust quickly and smoothly to the changed economic environment and to build a basis for longer-term international competitiveness.

While the need for innovation is inevitable, the quantitative strength of the linkages between innovation policy and actual changes in economic structure are rather unclear. The current analysis contributes to the background knowledge of the impact of earlier policy measures on the economic structure. Knowing the likely impact of the measures in the past might increase the efficiency of the following policy decisions.

Estonian economic structure is dominated by low technology-intensity industries that have to introduce innovative changes in their production in order to maintain international competitiveness. For further sustainable economic growth, the currently low share of higher technology-intensity industries has to increase both in production and in exports. Estonian innovation policy, supported by ongoing implementation of a medium-term research and development and innovation strategy, targets an increase of new products and services, introduction of new technologies, and development of technology-intensive industries.

Distinguishing exporting manufacturing industries by their technology intensity, detailed exports data allows estimating the impact of changes in innovation indicators on exports structure. The elasticity of exports structure on changes in innovation environment is estimated by using Eurostat data of innovation indicators as intermediate results of Estonian innovation policy. Pooled data estimations of annual data of 1998-2007 show that out of the five tested variables, four indicators are statistically significantly and positively related to exports value and three indicators are statistically significantly and positively related to the number of exported products. In all cases the effect of higher technology intensity industries is stronger than on total number of industries. The estimations confirm expectedly that an increase in 1) total public expenditure on education, 2) the enterprises' expenditure on research and development, 3) patent applications to the European Patent Office and 4) the overall increase in labour productivity increase the exports value. Labour productivity does not have a statistically significant effect on the increase in the number of exported products, while the other three tested indicators show a statistically significant contribution to the increase of the number of products exported. Research and development expenditure of all economic sectors (including the public sector) does not have a statistically significant effect neither on exports values nor the number of products exported probably due to a too high aggregation level of data. For further more detailed assessments, estimations could be run on firm-level based innovation data, collected by the European Union-wide *The Community Innovation Survey* (CIS). Estonian firms have participated in three surveys (CIS3, CIS4 and CIS5), covering information up to 2006. The data would also allow international comparisons across EU Member States, providing information on relative effectiveness of Estonian innovation policy compared to policies of other Member States.

The analysis confirms the existence of statistically significant linkages between innovation indicators and the Estonian exports structure in the recent decade. The knowledge of a size and significance quantitative effects might be used as a background knowledge for assessing possible impact of current of future policy measures and contribute to more effective innovation policy.

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Annex 1. Classification of industries according to technology-intensity

Technological intensity group	***NACE*[1] Rev. 1.1 industries**
High-technology	Aerospace (*NACE* 35.3) Pharmaceuticals (24.4) Computers, office machinery (30) Electronics-communication (32) Scientific instruments (33)
Medium-high-technology	Electrical machinery (31) Motor vehicles (34) Chemicals (excl. pharmaceuticals) (24 excl. 24.4) Other transport equipment (35.2+35.4+35.5) Non-electrical machinery (29)
Medium-low-technology	Coke, refined petroleum products and nuclear fuel (23) Rubber and plastic products (25) Non-metallic mineral products (26) Shipbuilding (35.1) Basic metals (27) Fabricated metal products (28)
Low-technology	Other manufacturing and recycling (36+37) Wood, pulp, paper products, printing and publishing (20+21+22) Food, beverages and tobacco (15+16) Textile and clothing (17+18+19)

Source: Eurostat.

[1] *NACE* – Classification of economic activities in the European Community.

Annex 2. Pool estimation results

Explanatory variable		Dependent variable: Value of exports in all industries	Value of exports, excl. low technology intensive industries	Number of exported products in all industries	Number of exported products, excl. low technology intensive industries
1. Labour productivity per person employed	Coefficient value	2.6118***[2]	2.974***	0.055	0.016
	Std. error	0.734	0.948	0.111	0.139
	No. of observations	40	30	40	30
	R-squared	0.031	0.048	0.005	0
	sample	1998-2007	1998-2007	1998-2007	1998-2007
2. Total public expenditure on education as a percentage of GDP (t and t-1)	Coefficient value	2.265***	2.671***	0.212**	0.135*
	Std. error	0.815	1.034		
	No. of observations	40	30	40	30
	R-squared	0.241	0.219	0.056	0.059
	sample	1996-2005	1996-2005	1996-2005	1996-2005
3. Patent applications to the European Patent Office (EPO): Number of applications (t-2)	Coefficient value	0.301***	0.335***	0.027***	0.035***
	Std. error	0.076	0.099	0.01	0.0125
	No. of observations	36	27	36	27
	R-squared	-0.001	-0.022	0.155	0.22
	sample	1997-2005	1997-2005	1997-2005	1997-2005
4. Gross domestic expenditure on research and development (t-1)	Coefficient value	-0.029	-0.059	-0.02	-0.059
	Std. error	0.045	0.055	0.0459	0.055
	No. of observations	32	24	32	24
	R-squared	0.001		0.001	0.027
	sample	2000-2007	2000-2007	2000-2007	2000-2007
5. Gross domestic expenditure of research and developments: Business enterprises sector (t-2)	Coefficient value	0.754***	0.84**	0.097**	0.126**
	Std. error	0.287	0.371	0.0436	0.053
	No. of observations	28	21	28	21
	R-squared	0.033	0.056	0.123	0.19
	sample	2001-2007	2001-2007	2001-2007	2001-2007

[2] Statistical significance of the coefficients is indicated as follows: *** - statistical significance at 99% level, ** - at 95% level, and * - at 90% level.