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The Influence of RDI on Competitiveness and Specialisation of Production and Export in Europe

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THE INFLUENCE OF RDI ON COMPETITIVENESS AND SPECIALISATION OF PRODUCTION AND EXPORT IN EUROPE[*]

DAN OLTEANU

This study analyses how the relative specialisation indexes of production and export for various categories of products are correlated with the technological level of a country expressed in RDI expenditures and number of patent applications to the EPO. We showed that the countries investing in research and achieve performance in innovation specialize in technology-intensive activities that benefit the national economy. Moreover, with regard to product differentiation (irrespective of industry), the countries produce and export high quality goods which embed significant RDI expenditures and human capital, benefiting from high export prices. Considering the classification of production by stages at production, their specialisation is achieved in goods having the highest value added, which also embed significant expenditures on RDI (components, accessories and capital goods).

Key words: *RDI, competitiveness, technological specialisation.*

JEL: *O33 , C21.*

1. Introduction

The new theories of international trade point out the central role of research, development and innovation (RDI), more exactly the companies' ability to bring new products, services and production processes into the market. That is why the determinants of this progress are largely studied. Technological progress plays an increasing role in competitiveness rise both at the microeconomic and macroeconomic levels. The technological capacity of a country becomes an essential element of competitiveness, while the price of products moves to the second place.

On the other hand, the new theories are not basically meant to explain the factors that determine the statistical specialisation of the countries. Instead of dealing with optimum allocation of resources specific to each geographical area in the world, these theories focus on a mutual influence between economic development (to which technological progress greatly contributes) and trade (specialisation).

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The competition between countries depends more and more on innovation and imitation. So, the stress is laid on the microeconomic level, while the RDI activity is mostly achieved by firms. The model of international trade is no longer static as it undergoes continuous changes, caused by technological dynamics and the growth rate of knowledge stock of the countries.

The technological superiority acquired through a cumulative process of learning by doing is what causes a comparative advantage by generating new products/production processes. But this advantage is only temporary (at least theoretically), until external competitors manage to decodify the manufacturing technologies through various methods and to imitate the new products, as the cost of imitation is significantly lower than the cost of innovation. When the initial gap vanishes, the traditional factors resume their role of determinants of trade. The countries which were initially leaders might become now even importers of new products, if the production costs are disadvantageous to them. Further, companies try again to get monopoly profits from innovation, which causes new gaps and the phenomena repeat.

According to Dosi (1988), this dynamic advantage is *absolute* not relative. It is the absolute advantage that determines the international trade when the pace of technological progress differs between countries. In neoclassical theory, the comparative advantage is based on the difference between relative prices (when the economy is closed), and these prices will converge with trade opening and generate a quick economic restructuring. On the contrary, the absolute advantage consists of different paces of productivity (which is no longer an exogenous variable, like in Ricardo's model), because of the technological advantages produced by cumulative processes. Instead of focussing on an equilibrium of the factor price on the international level, now the stress is laid on continuous and lasting differences in the technological progress rate and the economic growth rate.

In this type of models, equilibrium is temporary and accidental. The dynamics of comparative advantages is basically characterized by disequilibrium. First, fierce competition does not allow the monopoly to last, since it diminishes the leaders' motivation to invest continuously in research and technological development. Moreover, the motivation will also disappear if competitors manage to imitate and trade the new products very fast, since the profit made by the innovator is lower than the expenditures on the RDI. But it does not happen because intellectual property rights are established.

2. Gaps in Knowledge Stocks between Countries

Besides the theoretical approach to specialisation dynamics, we have to study the advantages and disadvantages of this economic phenomenon in relation to the two categories of countries: developed ones, which usually are technological leaders and, especially, those trying to keep up with new technologies. Apparently, both parties win. The developed countries are stimulated to invest in research to keep their superiority over competitors. If there were not such competitors, the pace of their technological progress would considerably low down. Similarly, the less developed countries are stimulated to develop their technological capacity as their position in the world market is gradually shattered. Without the above-mentioned leaders and gaps, the latter countries would evolve at a much lower pace regarding the RDI and, implicitly, the industry.

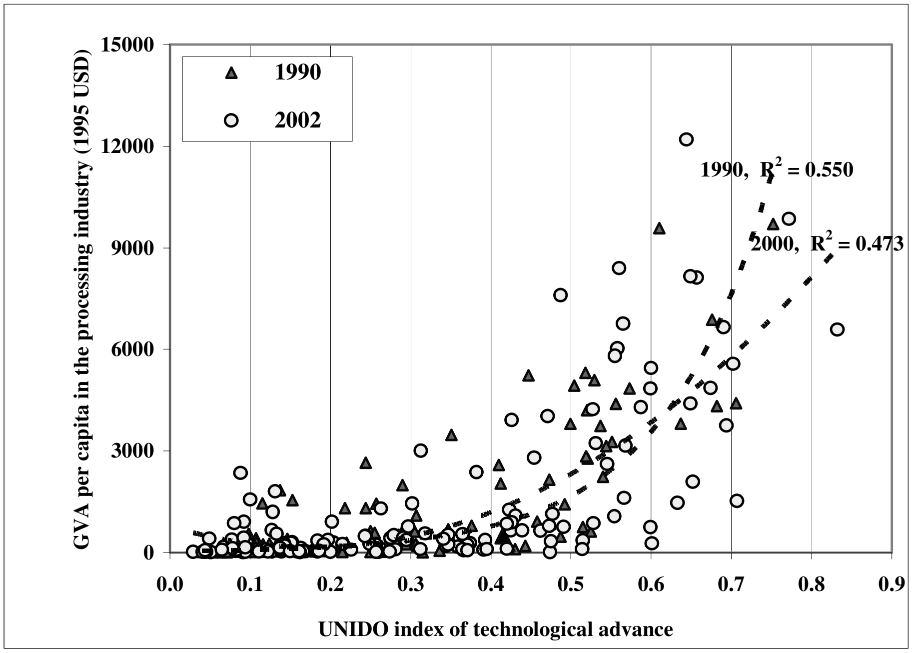
Considering the realities, this phenomenon seems to be more complex than described by theory. The division of the countries into two categories – leaders and followers or North and South – which stimulate each other seems simplistic. The leaders' position has not been threatened for long by less developed competitors. The differences between countries in the knowledge stock cover today decades and can hardly be diminished because of the vicious circles that affect the backward countries.

The traditional theory considers the convergence of factor costs after trade opening, which causes the elimination of the gap in productivity between countries. This optimistic vision of an adjustment by a general equilibrium is not valid, especially when the essential factor is technology. Also, increasing mobility of production factors did not bring on the uniformisation of the levels of availability among countries. On the contrary, there even is a trend of concentration of resources and production capacities, especially those required by technology-intensive activities. This trend has a cumulative character because of institutional and infrastructure development, scale economies, economic clustering (external effects) and other factors that can hardly be covered by statistics. The endowment with such elements increases a country's attractiveness to investors; incomes rise and the market gets gradually attractive to high quality products. Moreover, the attractiveness to human capital is ever higher.

For these reasons, once gaps in technological competence occur they tend to go on. Unless there is a technology transfer free of barriers between countries, the gap can be diminished only by strong governmental measures in support of RDI.

Figure 1 presents the correlation between the level of gross value added (GVA) per capita in the processing industry and a compound index of technological progress computed by the UNIDO [1] on the basis of the share of high and medium technology products in all production and export for 140 countries.

[1] United Nations Industrial Development Organisation.



Source: Statistical data from the UNIDO (2006), p. 157–163.

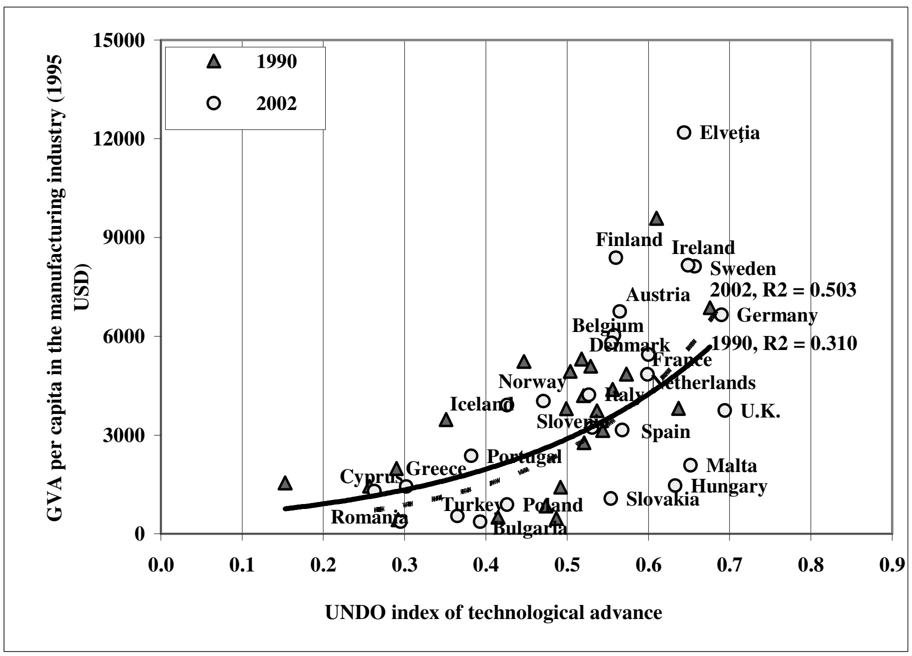
Figure 1. Correlation between the technological level and productivity, 1990 and 2002.

The correlation between the technological index and productivity is obvious and indicates an exponential trend. One can notice a technological threshold of about 0.4 from which the trend slope becomes steeper; therefore, the dependence of the variables becomes stronger. The countries placed below the technological threshold are the less developed ones, which produce and export natural resource-intensive goods and low qualified workforce. The technological infrastructure and high-ranked industrial branches exist to a very low extent. Exceeding the threshold, companies acquire some technological capacity, which enables them to start learning by doing. As for these countries, the improvement of workforce qualification and technological capacity (characteristic of economic development) enables them to develop high technology-intensive activities. In turn, these activities generate a higher value added and allow to maintain competitiveness, even if wages rise.

The graph shows that the differences between countries persisted (in the period 1990–2002). It means that many poor countries cannot go beyond the minimum threshold, so that they might climb the technological ladder faster. The gaps also persisted due to the cumulative effect of specialisation.

In some countries (among them, CEE countries, including Romania), technology performance and production performance diminished in the period considered. Since the differences in the potential of economic growth between technology-intensive activities and other activities are greater, the reason could be that the backward countries enter a vicious circle. The specialisation in traditional final/intermediate goods leads to low income per capita and discourages investments in RDI. The underdevelopment of this sector, if compared to developed countries, will perpetuate the existing type of specialisation. Moreover, there will be structural changes in the economy, which will hinder the growing potential.

The same correlation – only for European countries – leads to the figure below.



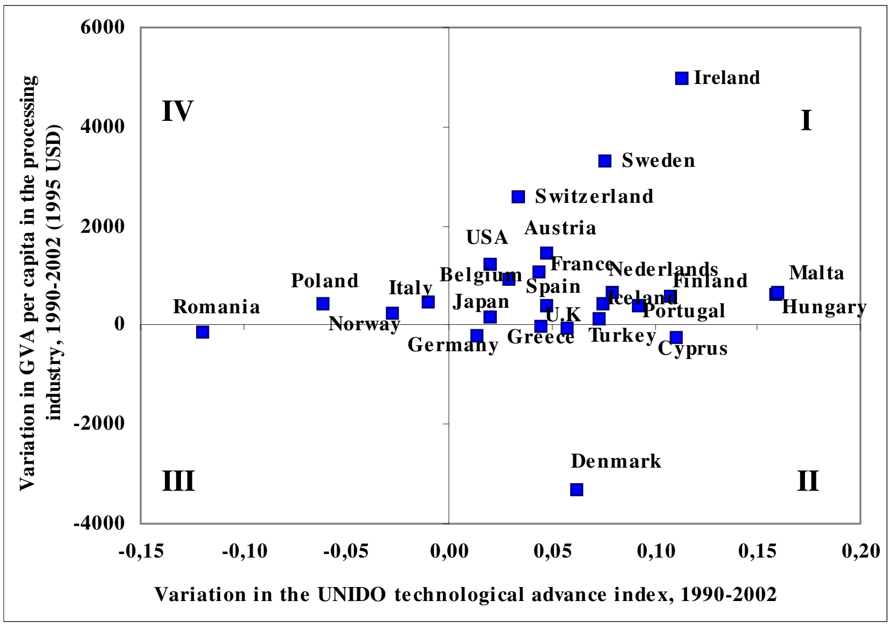
Note: The marked countries correspond to the year 2002.
Source: Statistical data form the UNIDO (2006), p. 157–163.

Fig. 2. Correlation between the technological level and productivity, in 1990 and 2002, for European countries.

Similarly to Figure 1, differences between countries remain high, which shows that technological gaps persisted. However, there is a small shift in 2002 trend, which causes a rise in the slope; it could mean a slight intensification of the correlation.

The countries with a 2002 technological index below 0.4 (Bulgaria, Romania, Cyprus, Greece, Latvia, Lithuania, Turkey) are included – as expected – in the CEE group. However, there are countries of the above group which are placed above the threshold, such as Hungary – 0.63, Slovenia – 0.53, Slovakia – 0.55 and Poland – 0.43.

Analysing the *absolute increases* in technological performance and productivity of labour of the European countries, the USA and Japan, between 1990 and 2002, we find a generally positive correlation but not in all countries:



Source: Own computation based on statistical data from the UNIDO (2006), p. 157–163.

Figure 3. Correlation between the variation in technological level land the variation in productivity, 1990–2002, for European countries, the USA and Japan.

The above graph presents four cases corresponding to the four squares:

i) countries in which the rise in the technological index determined an increase in productivity (square I);

ii) countries in which the rise in the technological index did not generate an increase in productivity (square II);

iii) countries in which the decrease in the technological index is accompanied by a decrease in productivity (square III);

iv) countries in which productivity increased, although the technological index decreased (square IV).

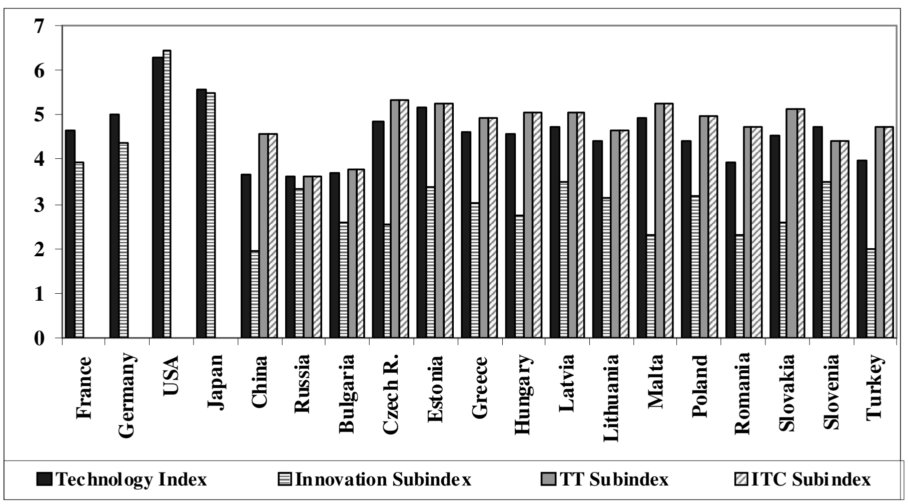
Out of the twenty-five countries in Figure 3, 16 countries (64%) are in square I, 5 countries in square II, one country in square II, and 3 countries in square IV.

The positioning of most countries in square I and II confirms the positive correlation between the two variables.

The difference in dynamics between the CEE countries are great. Unfortunately, Romania, besides Poland, holds the most unfavourable position in this respect. In a opposite position we find Hungary, with an increase in technological level higher than that of the WE countries, the USA and Japan, but this increase did not turn into higher productivity.

As for the developed countries, their own RDI activities represent the essential factor for technological progress. In most of the CEE countries, technological knowledge comes from external sources through various channels of technological transfer.

The report on competitiveness drawn up by the World Economic Forum (WEF, 2004) – in which technology is considered one of the basic pillars of competitiveness – presents a technological index made up of three components: (a) innovation; (b) technological transfer (TT); (c) information technology and communications (ITC). Figure 4 shows that the weights of the three subindexes in the technological index differ from one country to another.



Source: Statistical data from the WEF (2004).

Figure 4. Technological index and its components, in 2003.

In France, Germany, the USA, Japan and Russia, the innovation subindex is – in value – very close to the total technological index. Except for Russia, the hypothesis that innovation is the essential means to rise the technological level is confirmed for the countries close to the technological frontier. On the contrary, in the CEE countries the innovation subindex is much lower than the TT subindex and ITC subindex. For example, in Romania, its own innovation activities have a contribution about two times lower than the technological transfer and ITC.

So far, we presented the involvement of the technological factor in supporting external competitiveness and in the dynamics of a country's trade model. In the following sections, we deal with the influence of RDI performance on the type of specialisation of production and export.

3. RDI Influence on Technological Specialisation of Production

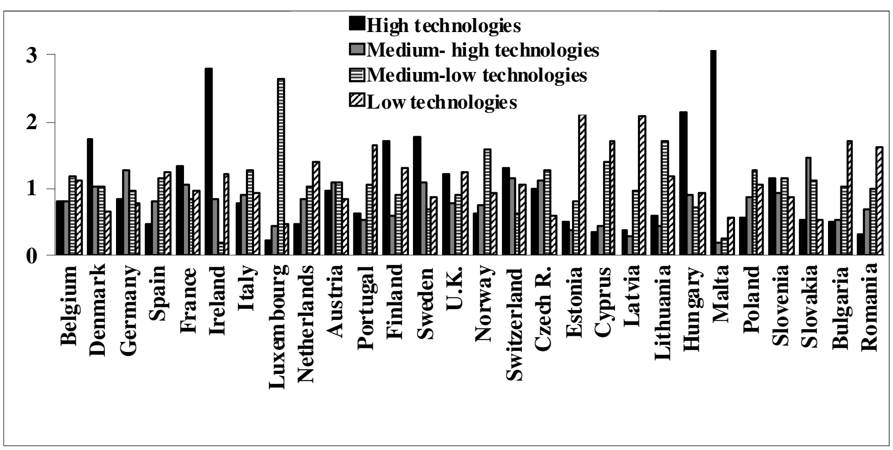
We shall compute below the degree of relative specialisation of production by technological groups of processing industry branches (we used the classification presented in Annex 1) for the leading European countries and, further, we shall analyse the RDI influence on specialisation.

The degree of *relative specialisation* (S_{ci}^R) was computed by means of the Balassa index (1965), which compares – for each country – the share of the production of one industrial branch in the total of the analysed countries with the share of the total production of that country. The index takes on values above unit for the relative specialisation of an economy in the production of an industry *i*, and below unit in the other case:

$$S_{ci}^R = \frac{P_{ci} / \sum_c P_{ci}}{\sum_i P_{ci} / \sum_i \sum_c P_{ci}} \in (0, \infty) , \quad (1)$$

where: *i* = groups of industries, *c* = countries, *P* = production value.

Using this computation relation, we present in the figure below the indexes of relative specialisation of production for European countries:



Source: Own computation, based on Eurostat (http://epp.eurostat.cec.eu.int).

Figure 5. Index of relative specialisation of production in the processing industry, by technological groups of activities, 2003.

We notice that more than half of the WE countries (9 out of 16) are specialized in industries using high or medium-high technology, in comparison with one-third (4 out of 12) of the CEE countries. Among the latter, Malta and Hungary stand out for their high values of the index, even compared to WE countries; besides Slovenia they are the only Eastern countries specialized in high technology production. Opposed to them, the Baltic countries (Estonia, Latvia, Lithuania) together with Cyprus, Romania and Bulgaria reached a very low level of performance. In Romania, the relative specialisation of production obviously tends towards low technologies (natural resource-intensive), followed at a significant distance by medium-low technologies.

Further, we analyse *the correlation between the expenditures on RDI per capita and the number of applications for EPO patents per one million people, on one hand, and the index of production specialisation for the four groups of industries, on the other hand*. We did not include both factorial variables in the equations at the same time, because they influence one another. Annexes 2. and 3. present the above correlations.

By ignoring accidental values, we estimate a positive correlation between the RDI performance and the relative production specialisation, except for low technologies. In the latter case, specialisation increases in inverse proportion to the causal variables considered.

We deal further with econometric estimations of the correlation intensity. Because of the accidental values of the specialisation indexes, we excluded Malta and Ireland from the sample, in the case of high technologies, and Luxembourg, in the case of medium-low technologies.

Considering the forms of dependence shown in the graph, we built the following log-log functions:

(a1) $\ln SPTI_i = \ln c + \beta_3 \ln D_i$; (a2) $\ln SPTI_i = \ln d + \beta_4 \ln B_i$;

(a3) $\ln SPTMI_i = \ln c + \beta_3 \ln D_i$;(a4) $\ln SPTMI_i = \ln d + \beta_4 \ln B_i$;

(a5) $\ln SPTMJ_i = \ln c + \beta_3 \ln D_i$;(a6) $\ln SPTMJ_i = \ln d + \beta_4 \ln B_i$;

(a7) $\ln SPTJ_i = \ln c + \beta_3 \ln D_i$; (a8) $\ln SPTJ_i = \ln d + \beta_4 \ln B_i$;

where:

$SPTI_i$ = index of production specialisation in high technologies;

$SPTMI_i$ = index of production specialisation in medium-high technologies;

$SPTMJ_i$ = index of production specialisation in medium-low technologies;

$SPTJ_i$ = index of production specialisation in low technologies;

D_i = expenditures on RDI per capita, expressed in euro PPP;

B_i = number of patent applications to the EPO per one million inhabitans.

Table 1 presents the results of the econometric analysis for each of the above equations. The elements of the table represent estimated parameters and in brackets we find the computed value of the Student test (t) for a significance degree α = 0.05. The last three rows present the simple and adjusted determination degree R^2 as well as the computed value of the test F, concerning the validity of the equation considered.

Table 1

Econometric estimations of RDI influence on production specialisation, by technological groups of activities

	Dependent variable:							
	ln SPTI		***ln SPTMI***		***ln SPTMJ***		***ln SPTJ***	
Factorial variables considered	**Estimated parameters of the factorial variables considered (computed value of test t)**							
	(a1)	**(a2)**	**(a3)**	**(a4)**	**(a5)**	**(a6)**	**(a7)**	**(a8)**
Free term	-1.99*	-0.97*	-1.12*	-0.60*	-0.72**	-	1.33*	0.52**
	(-6.21)	*(-6.43)*	*(-3.71)*	*(-4.23)*	*(-3.68)*	0.30**	*(4.73)*	*(3.59)*
ln D	0.34*	-	0.17**	-	0.13*	*(-3.14)*	-0.25*	-
	(5.65)		*(2.99)*		*(3.39)*	-	*(-4.75)*	
ln B	-	0.21*	-	0.10**	-		-	-0.14*
		(5.59)		*(2.89)*		0.07**		*(-3.83)*
						(2.71)		
No. of obs.	25	25	26	26	25	25	26	26
R^2	0.58	0.58	0.27	0.26	0.33	0.24	0.48	0.38
R^2 **adjusted**	0.56	0.56	0.24	0.23	0.30	0.21	0.46	0.35
***F* test**	31.89	31.21	8.97	8.34	11.51	7.34	22.57	14.66

*,**,*** = significant parameter for α = 0.01; 0.05; 0.10.
Source: Own computation.

We notice that all parameters are significant, some of them even for α = 0.01. Parameter β (slope of the regression line) is a little higher for expenditures on RDI in comparison with patents. Also, $|\beta|$ takes on the highest values for the production specialisation in high technologies, it diminishes for medium technologies, and then increases again for low technologies, but in this case with a negative sign. The same evolution is specific both to the determination degree R^2, and to the calculated value of F.

By replacing the estimated parameters, we get the following equations:

(a1) $\ln SPTI_i = -1,99 + 0,34 \ln D_i$; (a2) $\ln SPTI_i = -0,97 + 0,21 \ln B_i$;

(a3) $\ln SPTMI_i = -1,12 + 0,17 \ln D_i$; (a4) $\ln SPTMI_i = -0,60 + 0,10 \ln B_i$;

(a5) $\ln SPTMJ_i = -0,72 + 0,13 \ln D_i$; (a6) $\ln SPTMJ_i = -0,30 + 0,07 \ln B_i$;

(a7) $\ln SPTJ_i = 1,33 - 0,25 \ln D_i$; (a8) $\ln SPTJ_i = 0,52 - 0,14 \ln B_i$.

Considering the results, we conclude that there is a correlation, not very strong, between the considered factors and the type of production specialisation: positive for high technologies and negative for low technologies. This confirms that countries that invest in RDI are specialized in producing technology-intensive goods, and the other countries, in low-technology goods. From the statistical perspective of the comparative advantage, this model of specialisation is optimum, that is, it leads to an efficient allocation of resources on the regional level and maximizes the total output. But if we recall the theory of dynamic comparative advantage presented above, there is a risk that the marginal European countries enter vicious circles that might affect their development.

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The classification of industrial branches by technological intensity is not always relevant. In practice, there are not industries based on fully high or low technology. Each of them manufactures also technology-intensive products and labour-intensive and natural resource-intensive goods. Of course, the proportion of the two categories of products vary significantly from one industry to another, which led to the classification in Annex 1. But, in the last decades, technological progress has influenced all branches. Therefore, due to the vertical and horizontal differentiation of products, technological specialisation is basically achieved by categories of products within the same economic activity, not only by industries as a whole. Also, the specialisation by production stages is very important since value added differs significantly as regards the segments of the value chain (basic intermediate products, semifabs, machinery and equipment, etc.). Classifications of this type are not available for production, but for trade only, and for this reason we intend to analyse below the technological specialisation of export.

4. RDI Influence on Technological Specialisation of Export

To analyse the trade structure, we classify traded products both by level of technology intensity and by quality level and production stage (elements of the value chain), and then, similarly to production, we study the degree of RDI influence on specialisation.

Although most of the commercial exchanges of the Eastern countries are made with Europe (as for Romania, about 85%), in our opinion it is useful to include in our analyses the USA, Japan and China, besides the European countries. The relative specialisation of each country – which shows a comparative advantage in trade – will be computed in relation to the average of all countries considered, and not only in relation to European countries, as we did with production.

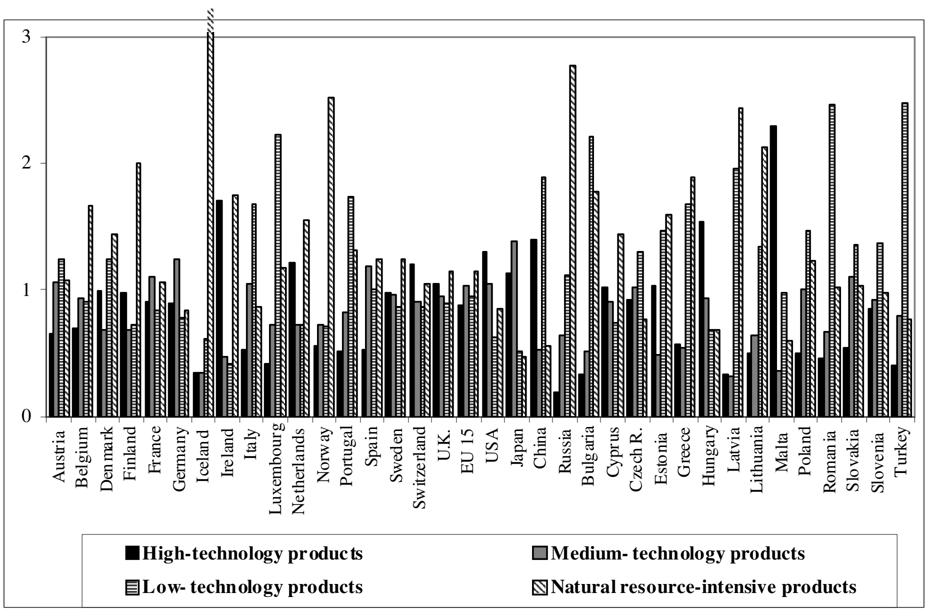
The computation formula is the same.

Relative specialisation (comparative advantage):

$$S_{ci}^{R} = \frac{X_{ci} / \sum_{c} X_{ci}}{\sum_{i} X_{ci} / \sum_{i} \sum_{c} X_{ci}} \in (0, \infty). \quad (2)$$

We denoted by i = groups of products, by c = countries, and by X = export value.

In the beginning, we analyse the export structure and specialisation by four technological groups of products (see Annex 4.), using the Standard International Trade Classification (SITC 2): natural resource-intensive products; low-technology products; medium-technology products; high-technology products.



Source: Own computation, based on United Nations Comtrade Database (http://unstats.un.org/unsd/comtrade).

Figure 6. Index of relative specialisation of export, by technological groups of products, 2004.

We notice an asymmetrical structure and specialisation of export by groups of products. Generally, symmetry increases with the size and the development level of the country. This happens because large countries have diversified resources and can produce a wide variety of products, and developed countries with high RDI performance specialize in high quality products in every industrial branch, as we shall see in the next sections. On the one hand, countries such as Germany, France, Sweden, the United Kingdom or Switzerland (a small country with a high development level) have specialisation indexes of close values between the groups of products. On the other hand, we find small or less developed countries such as Iceland, Luxembourg, Portugal, Latvia, Lithuania, Estonia, Malta, Romania, Turkey and Russia, with great differences between groups.

A special category consists of Northern countries (Sweden, Finland, Norway and Iceland), which export significant quantities of natural resource-intensive products, in comparison with other categories of products. Ignoring the values recorded by these countries and Malta, we estimate that WE countries have a relatively balanced specialisation by groups of considered products, while CEE countries are mainly specialized in exporting low-technology products and natural resources. As regards the latter, *Romania* is characterized by an obvious relative specialisation in exporting low technologies, with an index of 2.46, while in high and medium technologies, the indexes are 0.67 and 0.46, respectively.

We shall further study *the correlation between expenditures on RDI per capita and the number of applications for EPO invention patents per one million people, on one hand, and the index of export specialisation for the four categories of products, on the other hand*. Annexes 5 and 6 present the correlations in a graphic form.

We can see in the graphs that there is no correlation in the whole sample for the export of natural resources. It is structured as two negative parallel trends corresponding to CEE countries and WE countries, which confirms the theory. They are determined by great differences in RDI performance between the CEE and WE countries. For this reason, we introduce a binary variable, *DUM*, to influence the free term, in order to check numerically for the two parallel trends. According to Annexes 5 and 6, the binary variable takes on *value 1* for Norway, Ireland, Belgium, the Netherlands, the United Kingdom, Austria, France, Denmark, Finland, Germany, Switzerland, Luxembourg, Sweden, Japan and the USA, and *value 0* for Latvia, Lithuania, Greece, Bulgaria, Estonia, Cyprus, Portugal, Spain, Romania, Poland, Slovakia, Slovenia, Turkey, the Czech Republic, Italy, Hungary and Malta. We notice that the latter include the CEE group, to which 3 peripheral European countries are added: Spain, Portugal and Italy.

On the basis of the correlations in the annexes, we build the following log-log functions, which we estimated in Table 2:

(b1) $\ln SETI_i = \ln a + \beta_1 \ln D_i$; (b2) $\ln SETI_i = \ln b + \beta_2 \ln B_i$;

(b3) $\ln SETM_i = \ln a + \beta_3 \ln D_i$; (b4) $\ln SETM_i = \ln b + \beta_4 \ln B_i$;

(b5) $\ln SETJ_i = \ln a + \beta_3 \ln D_i$; (b6) $\ln SETJ_i = \ln b + \beta_4 \ln B_i$;

(b7) $\ln SERN_i = \ln a + \beta_0 DUM_i + \beta_3 \ln D_i$; (b8) $\ln SERN_i = \ln b + \beta_0 DUM_i + \beta_4 \ln B_i$.

where:

$SETI_i$ = index of export specialisation in high technologies;
$SETM_i$ = index of export specialisation in medium technologies;
$SETJ_i$ = index of export specialisation in low technologies;
$SERN_i$ = index of export specialisation in natural resources;
D_i = expenditures on RDI per capita, expressed in euros PPP;
B_i = number of patent applications to the EPO, per one million inhabitants.

Table 2

Econometric estimates of RDI influence on export specialisation, per technological groups of products

	Dependent variable:							
	ln SETI		***ln SETM***		***ln SETJ***		***ln SERN***	
Factorial variables considered	**Estimated parameters of the factorial variables considered (computed value of test t)**							
	(b1)	**(b2)**	**(b3)**	**(b4)**	**(b5)**	**(b6)**	**(b7)**	**(b8)**
Free term	-1.34* *(-4.31)*	-0.74* *(-5.44)*	-0.82* *(-3.38)*	-0.40* *(-3.52)*	1.49* *(5.36)*	0.66* *(5.55)*	1.30** *(2.53)*	0.36** *(2.11)*
DUM							0.54*** *(1.89)*	0.28 *(0.92)*
ln *D*	0.20* *(3.43)*	-	0.12** *(2.62)*	-	-0.28* *(-5.17)*	-	-0.27** *(-2.15)*	-
ln *B*	-	0.13* *(3.73)*	-	0.06** *(2.02)*	-	-0.17* *(-5.55)*	-	-0.08 *(-1.06)*
No. of obs.	31	31	31	31	30	30	31	31
R^2	0.29	0.32	0.19	0.12	0.49	0.52	0.14	0.04
R^2 **adjusted**	0.26	0.30	0.16	0.09	0.47	0.51	0.08	-0.03
***F* test**	11.79	13.95	6.87	4.08	26.79	30.81	2.32	0.56

*,**,*** = significant parameter for α = 0.01; 0.05; 0.10.

Source: Own computation.

By replacing the estimated parameters, we get the following:

(b1) $\ln SETI_i = -1{,}34 + 0{,}20 \ln D_i$; (b2) $\ln SETI_i = -0{,}74 + 0{,}13 \ln B_i$;

(b3) $\ln SETM_i = -0{,}82 + 0{,}12 \ln D_i$; (b4) $\ln SETM_i = -0{,}40 + 0{,}06 \ln B_i$;

(b5) $\ln SETJ_i = 1{,}49 - 0{,}28 \ln D_i$; (b6) $\ln SETJ_i = 0{,}66 - 0{,}17 \ln B_i$;

(b7.1) $\ln SERN_i = 1{,}84 - 0{,}27 \ln D_i$, for countries with *DUM*=1;

(b7.2) $\ln SERN_i = 1{,}30 - 0{,}27 \ln D_i$, for countries with *DUM*=0;

(b8.1) $\ln SERN_i = 0{,}64 - 0{,}08 \ln B_i$, *DUM*=1; (b8.2) $\ln SERN_i = 0{,}36 - 0{,}08 \ln B_i$, *DUM*=0.

Regarding the high, medium and low technologies, the parameters are significant for a threshold $\alpha = 0.01$ for high and low technologies and $\alpha = 0.05$ for medium technologies. As for natural resources, the introduction of the binary variable does not produce significant results either for parameters or for the equation as a whole, because both the degree of determination and the value of test *F* are very small, especially in equation (b8). It is caused by the broad distribution of countries corresponding to *DUM=1* around the trend.

β parameters (slope of regression line) are higher for expenditures on RDI, that is, the sensitivity of specialisation to the variation of this factor is greater. Values of β (in modulus) are the highest for the specialisation in low-technology export (with a negative sign), smaller for medium technologies, and again higher for high technologies. The same evolution occurs with the determination degree R^2, as well as with the computed value of *F*.

Considering the graphs and the numerical results, we may conclude that there is a correlation, not very strong, between the factors considered and the type of export specialisation: positive for high and medium technologies, and negative for low technologies and natural resources. It means that countries which invest in RDI specialize in exporting technology-intensive products, and the other ones in low-technology, labour- and natural resource-intensive products.

5. RDI Influence on Qualitative Specialisation of Export

The vertical differentiation and the horizontal one lead to simultaneous export and import of products (IIT), either having different quality levels (vertical differentiation) or having different characteristics (horizontal differentiation).

IIT is closely linked to the term "industry". Unfortunately, there is no single criterion for defining this concept, since there are certain nuances in the level and the type of homogeneity of products constituting an industry. In the Heckscher-Ohlin model, "industry" represents the multitude of enterprises that produce perfectly homogeneous goods. But goods have a multitude of characteristics, which leads to the absence, in practice, of two perfectly interchangeable products in relation to all these characteristics. Statisticians recommend the Standard International Trade Classification based on three-digit aggregation (SITC 3) as the optimum means to compute the IIT. The criterion of this classification is just the substituibility of products in consumption and in the necessary amount of production factors.

Taking the statisticians' advice, we determined the percentage of the IIT, using SITC3 and, as computation method, the Grubel-Lloyd index (1975):

$$GL_{ci} = \frac{\left(X_{ci} + M_{ci}\right) - \left|X_{ci} - M_{ci}\right|}{\left(X_{ci} + M_{ci}\right)} * 100, \quad GL_{ci} \in [0,100]. \qquad (3)$$

X_i, M_i represent the export and import of product *i* of country *c*. Index *GL* takes on value zero if $X_i = 0$ or $M_i = 0$ and value 100 if $X_i = M_i > 0$.

The aggregation at the level of group *j* of products (with $i \in j$) or at the national level is done as follows:

$GL_j = \sum_{i \in j} w_i * GL_i$, where w_i represent the weight of the trade value of product *i* in total value of the trade of group *j* (or total trade of country *c*):

$$w_i = (X_{ci} + M_{ci}) / \sum_{i \in j} (X_{ci} + M_{ci}) .$$

The IIT share does not tell us anything about *product quality* in which every country tends to specialize. To determine it, we have to calculate the unit value of exported goods, since price is a measure of quality, maybe the only one that can be statistically quantified. The methodological stages for determining the qualitative level of exported goods are the following:

Unit value (price) is computed by dividing the export value of a product (at the maximum level of disaggregation), exported by a country, in a certain period, by the exported quantity:

$$U_{ci} = V_{ci} / C_{ci} , \quad (4)$$

where: V = export value, C = exported quantity, i = product, c = country.

Then, we determine the ratio of unit value of each country's export to the average unit value of the analysed countries:

$$R_{ci} = U_{ci} / \overline{U}_i , \quad (5)$$

with $\overline{U_i} = \sum_c U_{ci} / n$, and n = number of countries considered.

This ratio can be aggregated at the level of group *j* of products or the level of total export, by weighting with the value of export of each product in the export of group *j* or the total export of the country:

$$R_{cj} = \sum_{i \in j} v_i * R_{ci} \infty , \quad (6)$$

where: $v_i = X_{ci} / \sum_{i \in j} X_{ci}$.

The ratio R_{cj} expresses the quality of exported goods. In relation to R_{cj} we can classify the export into three quality categories, as follows:

– *high* quality, if $R_{cj} > 1.15$;

– *medium* quality, if $0.85 < R_{cj} < 1.15$;

– *low* quality, if $R_{cj} < 0.85$.

Since full data on the quantities exported by the analysed countries were not available, we used unit values of export from a data base of the UNCTAD / WTO[2].

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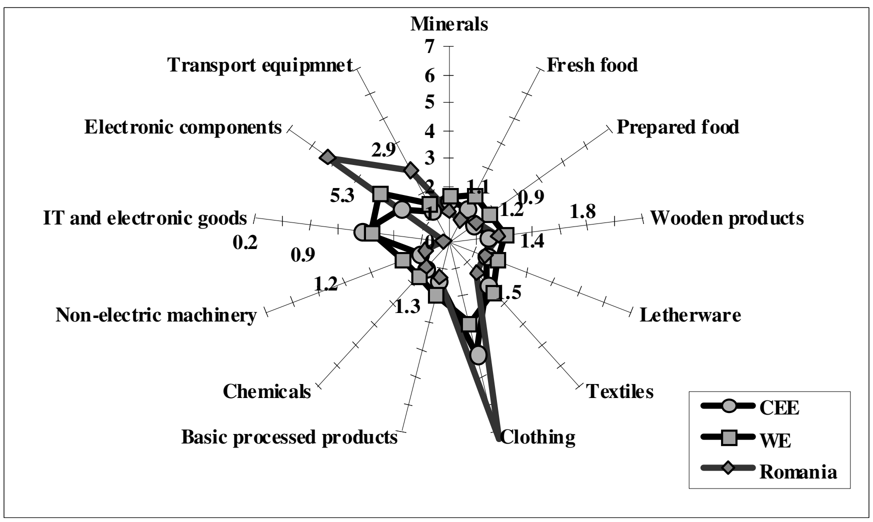
[2] International Trade Centre UNCTAD / WTO (http://www.intracen.org).

Figure 7 presents the values corresponding to the main processing branches of the CEE and WE countries.

Let us recall the composition of the two groups of European countries considered for the average computation: (i) *Central and Eastern European (CEE) countries:* the Czech Republic, Cyprus, Estonia, Latvia, Lithuania, Greece, Hungary, Poland, Slovenia, Slovakia, Bulgaria, Romania and Turkey (excluding Malta for accidental values, which distort the group average); (ii) *Western European (WE):* Belgium, Denmark, Germany, Spain, France, Ireland, Italy, Luxembourg, the Netherlands, Austria, Portugal, Finland, Sweden, the United Kingdom, Norway and Switzerland (excluding Iceland for the same reason as Malta).

As regards the world average, both WE countries and CEE countries export products of medium and high quality (R_{cj} > 0.85). If the average were only computed for the countries considered, the differences would be a little greater. Nevertheless, we may see in Figure 7 that WE countries export most categories of processed products at higher prices. CEE countries are ranked higher only for clothing, and IT and electronic goods.



Note: Values correspond to Romania

Source: Statistical data from the International Trade Centre UNCTAD / WTO (http://www.intracen.org).

Figure 7. Unit value of export (world average = 1) for CEE countries, WE countries and Romania, 2003.

For clothing, as well as other branches on the right side of Figure 7 (textiles, leatherwear, etc.), the production processes use intensively labour and natural resources. The low cost of the above factors – specific to CEE countries – brings on a higher attractiveness of these areas to foreign investors, who locate their production units here and export their (high quality) products made in WE countries at high prices. This has a positive impact on employment, but less on labour training.

As regards IT and electronic goods, the higher unit value is caused by the fact that these goods are final products assembled in CEE countries (Hungary, Latvia, Estonia, Cyprus, etc.) for the same reason of low labour cost, similarly to the previous case. Their components and subassemblies are usually made in WE countries, as we shall see in the next section concerning the specialisation by production stages. In this case, the amounts collected from sales are transferred to the countries of origin of the companies. Only as far as both the components and the final products are made locally (a rare case) we may speak about qualitative superiority. The same is valid for non-electric machinery and transport equipment.

Romania shows very asymmetrical unit values of export by categories of products. For 8 of 13 groups of products, the unit value of Romania's export is slightly below the CEE average. In the other five groups, with a higher unit value, we notice transport equipment, clothing and electronic components, which have unit values much above the CEE average. The explanation could be the outward processing system for clothing or the assemblage of final products for transport equipment. Only in the case of electronic components we could say that a higher price of export is a real benefit to the national economy.

To compute the influence of RDI on the qualitative specialisation of export, first we grouped the average unit values of export by two categories of products:

– *Technology-intensive products*: transport equipment, electronic components, IT and electronic products, non-electrical machinery, chemicals (i.e., on the left side of Figure 7);

– *Labour and natural resource-intensive products*: minerals, food, wooden products, leatherwear, textiles and clothing (i.e., on the right side of Figure 7).

For either category we computed the average unit value of export as a simple average of unit values of the listed products.

In Annexes 7 and 8. we provide a graphic presentation of the correlations between expenditures on RDI and the number of patents, on the one hand, and the unit value of export, on the other hand. The correlations are directly proportional to both the labour and natural resource-intensive products and the technology-intensive products.

In most graphs we clearly see the two groups of countries (CEE and WE), owing to the distant values of corresponding causal variables. However, we cannot perceive the creation of two trends. The introduction of a binary variable did not produce a substantial rise in the significance degree of parameters, and this is the reason why we ignored this variable in equations.

The analysed functions are:

(c1) $\ln VU1_i = a + \beta_3 \ln D_i$; (c2) $\ln VU1_i = b + \beta_4 \ln B_i$;

(c3) $\ln VU2_i = \ln a + \beta_3 \ln D_i$; (c4) $\ln VU2_i = \ln b + \beta_4 \ln B_i$.

where:

$VU1_i$ = unit value of export for labour and natural resource-intensive products;

$VU2_i$ = unit value of export for technology-intensive products;

D_i = expenditure on RDI per capita, expressed in euros PPP;

B_i = number of patent applications to the EPO per one million inhabitants.

As regards the technology-intensive products, we eliminated from computation Ireland, Iceland and Latvia, since they recorded extraordinary unit values (see Annexes).

The estimates are presented in the table below:

Table 3

Econometric estimations of the influence of RDI on the unit value of export, by technological groups of products

	Dependent variable:			
	ln VU1		***ln VU2***	
Factorial variables considered	**Estimated parameters of the factorial variables considered (computed value of test t)** (c1)	(c2)	(c3)	(c4)
Free term	0.25* *(1.43)*	0.50* *(6.11)*	-0.10 *(-0.59)*	0.31* *(4.38)*
ln *D*	0.08** *(2.36)*	-	0.14* *(4.42)*	-
ln *B*	-	0.04** *(2.07)*	-	0.09* *(4.76)*
No. of obs.	33	33	30	30
R^2	0.15	0.12	0.16	0.23
R^2 **adjusted**	0.12	0.09	0.14	0.21
***F* test**	5.57	4.31	5.96	9.12

*,**,*** = significant parameter for α = 0.01; 0.05; 0.10.

Source: Own computation.

(c1) $\ln VU1_i = 0,25 + 0,08 \ln D_i$;(c2) $\ln VU1_i = 0,50 + 0,04 \ln B_i$;

(c3) $\ln VU2_i = -0,10 + 0,14 \ln D_i$;(c4) $\ln VU2_i = 0,31 + 0,09 \ln B_i$.

The parameters of factorial variables are significant. The correlations have low intensity, but a little higher for technology-intensive products. Nevertheless, there is a rising trend of the unit value of export, as RDI performance is improving.

6. RDI Influence on Export Specialisation by Production Stages

Considering the advantages of some regions/countries (low cost of labour, availability of raw materials and human capital, etc.), companies tend to a greater extent to locate some production stages in a country other than that in which the company headquarter is located. Intermediate products (spare parts, components, etc.) can be exported to the country of origin of the company, where the production cycle continues to obtain the final products or to another country in which the company located the next production stage. Final products can be locally sold or exported to other countries, including the country of origin (see Box 1, below).

The fragmentation and international location of production led to another type of trade specialisation: by production stages. Taking into account the factor endowments, countries ”host” various production stages. They specialize in either making less processed basic products or producing subassemblies, spare parts or capital goods or only assembling components of the final product.

Each of these categories of products requires certain production factors. Basic products are usually natural resource-intensive and, for this reason, they will be made in regions in which such resources are available. Spare parts, subassemblies and capital goods require high-qualified employees (human capital) as well as advanced production technologies, which, in turn, require specialized firms for maintenance, etc.; for this reason, the level of knowledge stock is the essential criterion for choosing the location of the production line. In case of simple assembling of final products, it is necessary to have access to cheap labour, as well as to larger trading markets (both the domestic market and the neighbouring markets).

Considering the above criteria, the developed WE countries are expected to specialize in categories of physical and human capital-intensive products, while the CEE countries will produce, for the most part, intermediate goods and final products. The implications for this specialisation are related to the varied prices of the above-mentioned categories of products as well as the externalities of various activities (their contribution to the national stock of knowledge, etc.).

To determine the specialisation by production stages, we used the trade classification by broad economic categories (BEC), which we restructured by the processing level of the product. Five categories of products resulted: consumer goods, basic intermediate products, processed intermediate products, components and accessories, and capital goods (Annex 9).

Box 1: Categories of products by processing level

Consumer goods are sold to end consumers. They do not undergo changes during the production process or assemblage. Therefore, the importing country does not add value to this type of product. That is why the import of final products contribute the least to the domestic product (only throug distribution).

Intermediate goods (basic, processed, components and accessories) require further processing in the importing country before being sold to end consumers. Therefore, these products accumulate more value added. According to the degree of processing, they may be divided into basic intermediate goods, processed goods, components and accessories. Usually, the latter incorporate most knowledge, while subsequent assemblage only requires medium-skilled employees. Moreover, the trade in this type of products is an important channel of technology transfer.

Capital goods are destined for immediate use, especially by firms, as input in the production process in order to produce other intermediate or final goods. Importing such goods is vital for transferring technology and, consequently, maintaining the external competitiveness of internal producers. Importing capital goods involves several additional costs, linked to know-how, technical assistance, etc.

On the basis of this classification, we calculated indexes of relative specialisation of European countries' export by categories of products and processing degree. In Annexes 10 and 11, we present the correlation between RDI and specialisation. In most of the graphs, we notice the two groups of countries (CEE and WE), but they do not follow distinct trends, so that the introduction of a binary variable does not produce significant results.

As regards the intermediate goods, dependence consists of two parallel trends, corresponding to the two groups of countries considered in our paper. The slope is negative for basic intermediate goods and positive for processed intermediate goods, components and accessories. We do not introduce these three categories of products in our numerical analysis, since the regression line is horizontal for the whole sample, and if we analyse the two groups of countries separately, the introduction of a binary variable does not produce significant results.

Considering the forms of dependence shown by the graphs, we built log-log functions only for consumer goods and capital goods:

(d1) $\ln BC_i = \ln a + \beta_3 \ln D_i$; (d2) $\ln BC_i = \ln b + \beta_4 \ln B_i$;

(d3) $\ln BK_i = \ln a + \beta_3 \ln D_i$; (d4) $\ln BK_i = \ln b + \beta_4 \ln B_i$.

where:

BC_i = index of export specialisation in consumer goods;

BK_i = index of export specialisation in capital goods;

D_i = expenditures on RDI per capita, expressed in euros PPP;

B_i = number of patent applications to the EPO per one million inhabitants.

Table 4

Econometric estimations of the influence of RDI on export specialisation by production stages

	Dependent variable:			
	ln BC		***ln BK***	
Factorial variables considered	**Estimated parameters of factorial variables considered (computed value of test t)**			
	(d1)	**(d2)**	**(d3)**	**(d4)**
Free term	1.26*	0.54*	-1.34*	-0.81*
	(3.63)	*(3.32)*	*(-3.78)*	*(-5.00)*
ln *D*	-0.23*	-	0.18*	-
	(-3.47)		*(2.67)*	
ln *B*	-	-0.14*	-	0.12*
		(-3.21)		*(2.77)*
No. of obs.	32	32	32	32
R^2	0.29	0.25	0.19	0.20
R^2 **adjusted**	0.26	0.23	0.16	0.18
***F* test**	12.05	10.29	7.13	7.66

*,**,*** = significant parameter for α = 0.01; 0.05; 0.10.

Source: Own computation.

The following regression equations resulted:

(d1) $\ln BC_i = 1,26 - 0,23 \ln D_i$; (d2) $\ln BC_i = 0,54 - 0,14 \ln B_i$;

(d3) $\ln BK_i = -1,34 + 0,18 \ln D_i$; (d4) $\ln BK_i = -0,81 + 0,12 \ln B_i$.

The significant parameters confirm the influence RDI on export specialisation, directly proportional for capital goods and inversely proportional for consumer (final) goods. Therefore, the higher the technological level of a country is, the higher the specialisation is in processed intermediate goods, components, accessories and capital goods, along with a lower specialisation in exporting final products and basic intermediate goods.

7. Conclusions

We pointed out in this paper the implications of the technological factor for supporting competitiveness abroad and for the dynamics of a country's trade model. Using various classifications of production and export, we analysed how indexes of relative specialisation of a country in various categories of products are correlated with the technological level of that country, expressed in expenditures on RDI and number of patent applications to the EPO. More exactly, the countries investing in research and achieving high performance in innovation specialize in technology-intensive activities, which benefit the entire national economy. Moreover, as regards the differentiation between products (irrespective of industry), countries produce and export goods of higher quality, which involve important expenditures on RDI and human capital, and thus take advantage of high export prices. Finally, in accordance with the classification by production stages, the specialisation involves goods taking on the highest value added, which also incorporate expenditures on RDI (components, accessories and capital goods).

Annex 1

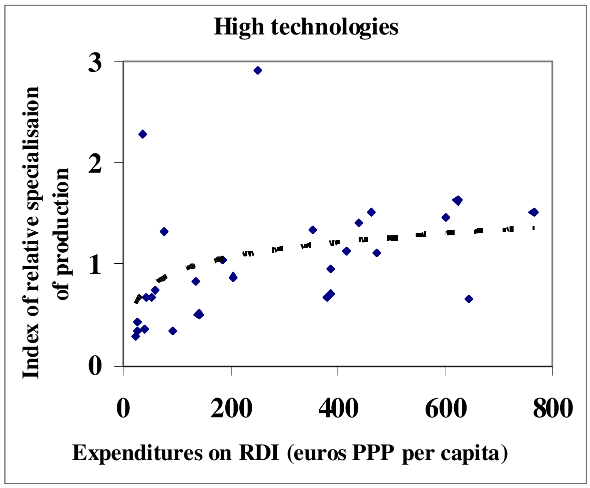
The classification of activities in the processing industry by technology intensity

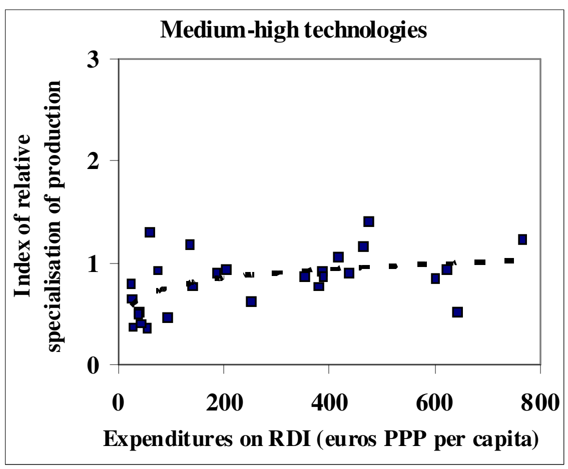
Group	Industrial branches (NACE 1)
1. High technology branches	– Aerospatial vehicles (353) – Pharmaceuticals (2441+2442) – Computerisation and office equipment (30) – Radio and TV sets and communication equipment (32) – Medical, optical and precision apparatus and instruments (33)
2. Medium-high technology branches	– Electrical machinery and equipment (31) – Motor vehicles (34) – Chemicals, except for pharmaceuticals (24–2441-2442) – Road and railway transport equipment (352+354) – Non-classified machinery and equipment (29)
3. Medium-low technology branches	– Building and maintenance of sea transport means (351) – Rubber and plastic products (25) – Coke, refined oil products and nuclear fuel (23) – Other non-metallurgical mineral products (26) – Basic and processed metallurgical products (27+28)
4. Low technology branches	– Non-classified processed products; waste recovery (36+37) – Wood processing; pulp, paper and cardboard; publishing and printing (20+21+22) – Food; beverages and tobacco (15+16) – Textiles; leatherwear and footwear (17+18+19)

Source: OECD (2005), p. 182–183.

Annex 2

The correlation between the expenditures on RDI per capita (1995–2003 average) and the specialisation index of production (2003) by technological groups of the industry





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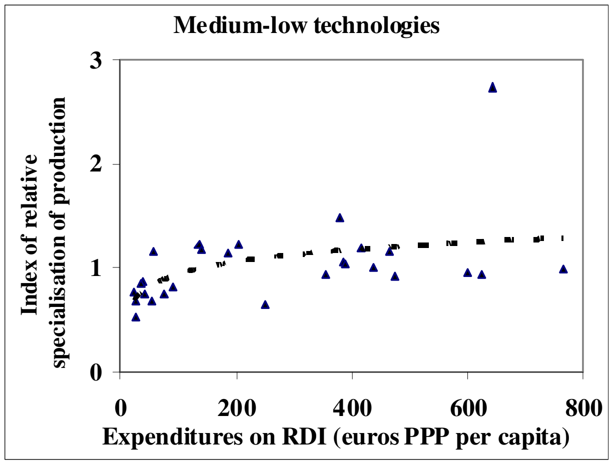
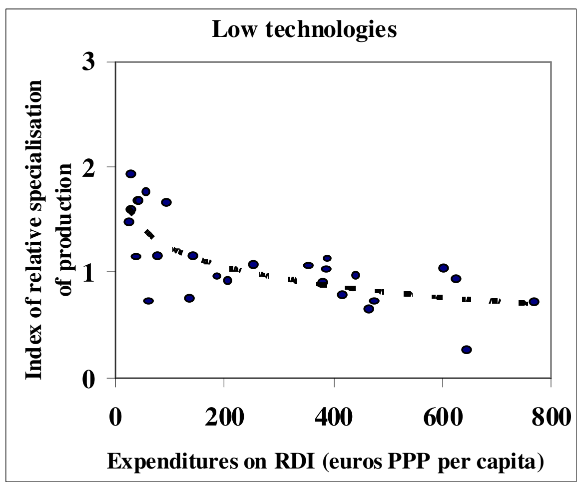
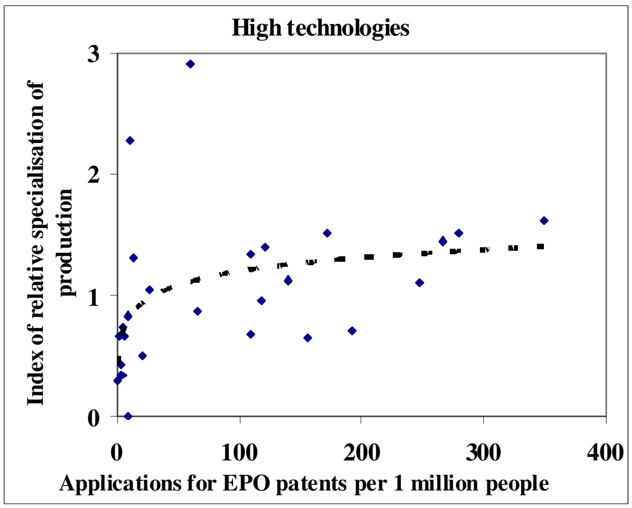


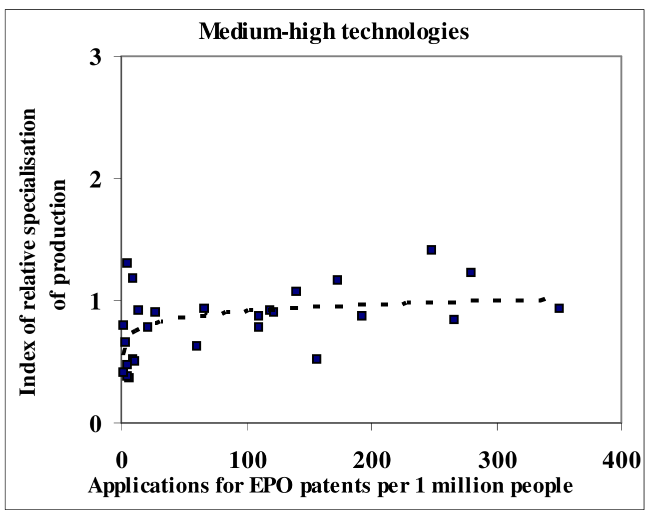


Source: Eurostat (http://epp.eurostat.cec.eu.int).

Annex 3

Correlation between the number of applications for EPO (1995–2003 average) and the index of specialisation of production (2003) by technological groups of the industry





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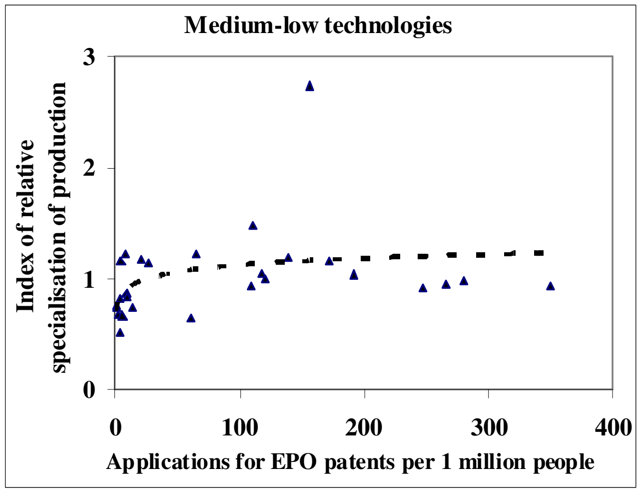
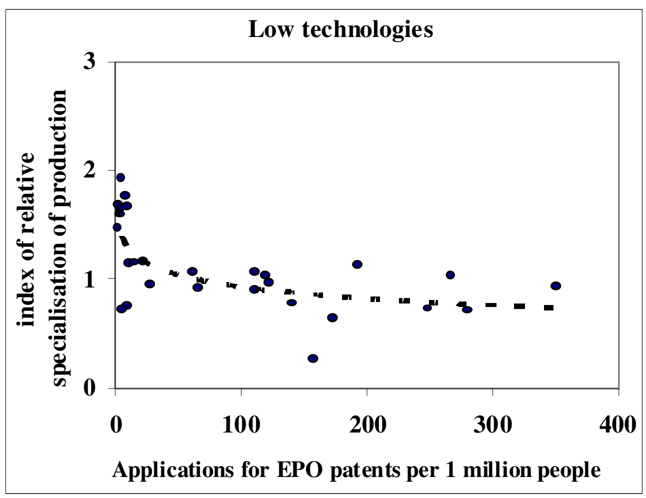




Source: Eurostat (http://epp.eurostat.cec.eu.int).

Annex 4

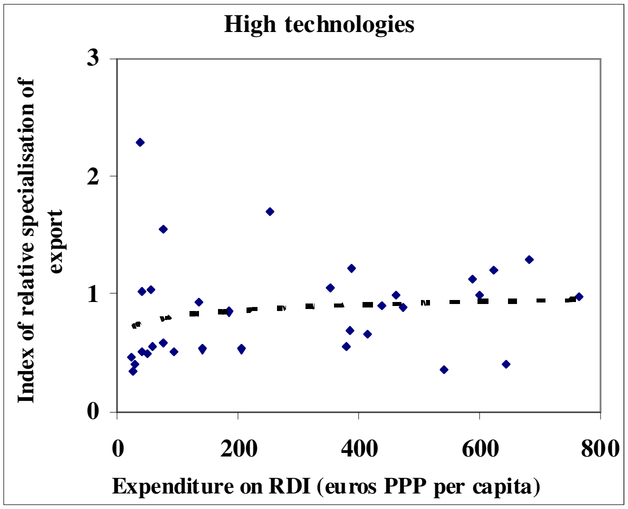
Categories of traded products by technological level

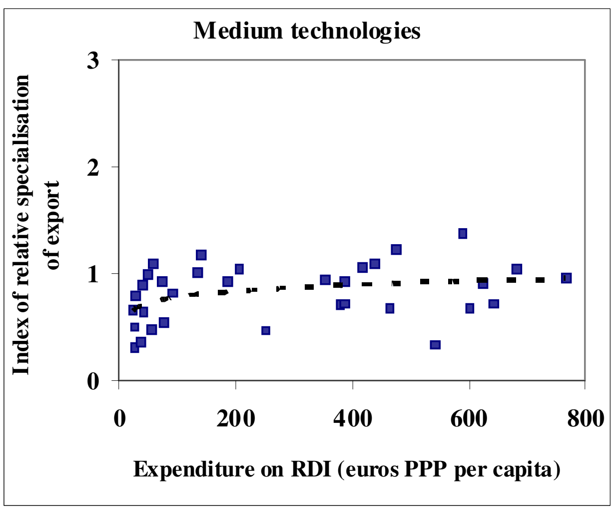
Group	Products (code SITC 2)
1. High-technology products	01 (-011), 023, 024, 035, 037, 046, 047, 048, 056, 058, 06, 073, 098, 1(-121), 233, 247, 248, 25, 264, 265, 269, 323, 334, 335, 4, 51(-512, 513), 52(-524), 53(-533), 551, 592, 62, 63, 641, 66(-665, 666), 68
2. Medium-technology products	61, 642, 65(-653), 665, 666, 67(-671, 672, 678), 69, 82, 83, 84, 85, 89(-892, 896)
3. Low-technology products	266, 267, 512, 513, 533, 55(-551), 56, 57, 58, 59(-592), 653, 671, 672, 678, 711, 713, 714, 72, 73, 74, 762, 763, 772, 773, 775, 78, 79(-792), 81, 872, 873, 88 (-881), 95
4. Natural resource-intensive products	524, 54, 712, 716, 718, 75, 761, 764, 77 (-772, 773, 775), 792, 871, 874, 881

Source: UNIDO (2005), p. 155.

Annex 5

The correlation between the expenditures on RDI per capita (1995–2004 average, 1995 constant prices) and the index of export specialisation (2004) by technological groups of products





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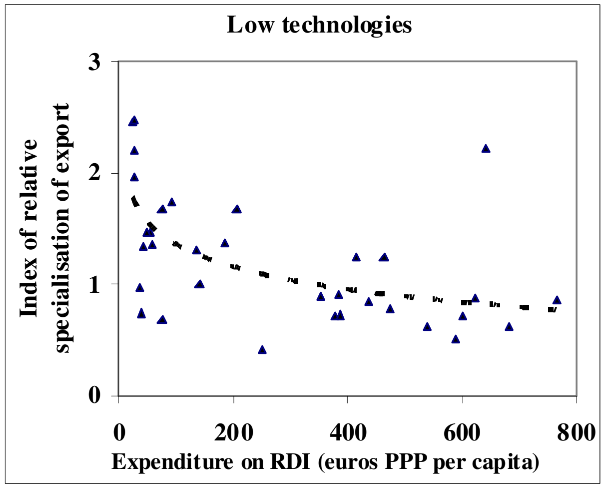
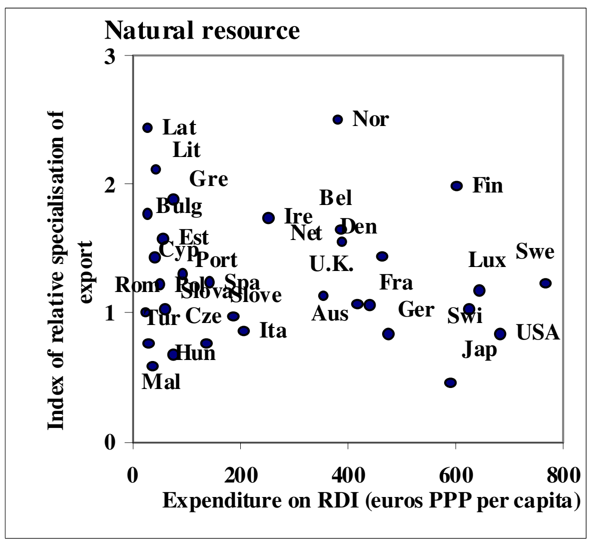
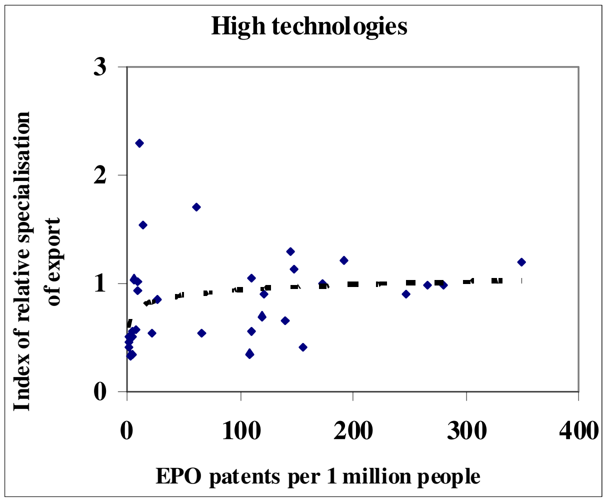


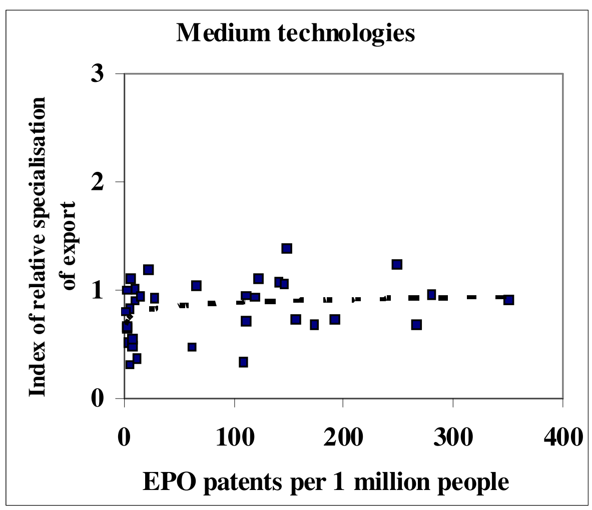


Source: Eurostat (http://epp.eurostat.cec.eu.int)
and United Nations Comtrade Database (http://unstats.un.org/unsd/comtrade).

Annex 6

The correlation between the number of applications for EPO patents (1995–2003 average) and the index of export specialisation (2004) by technological groups of products





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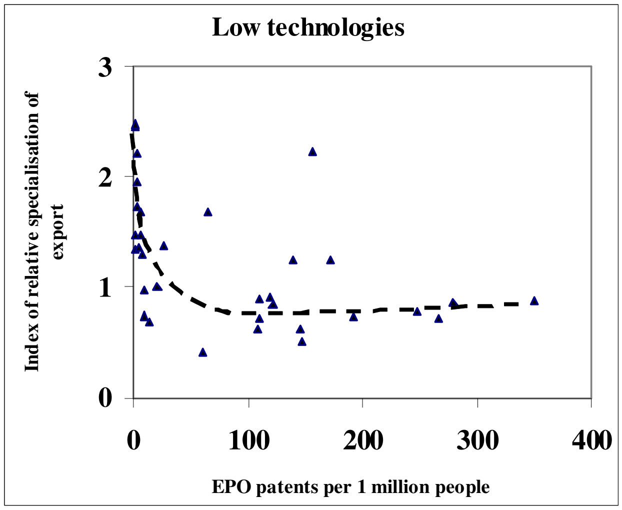
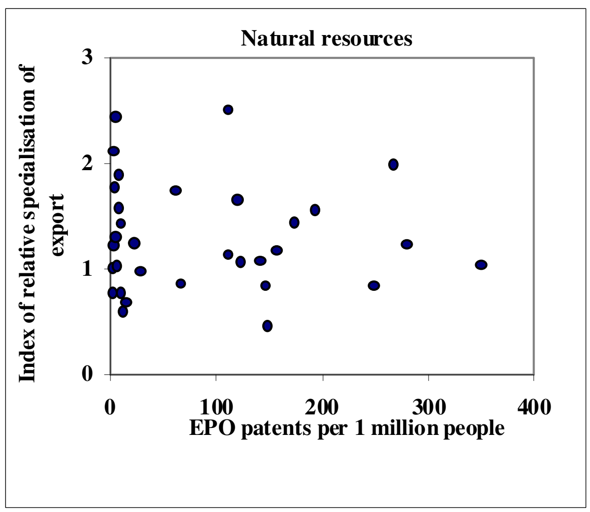
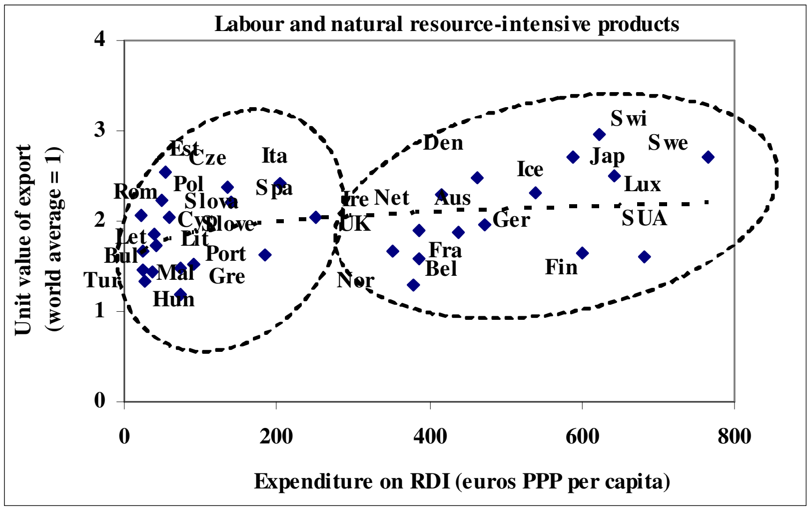


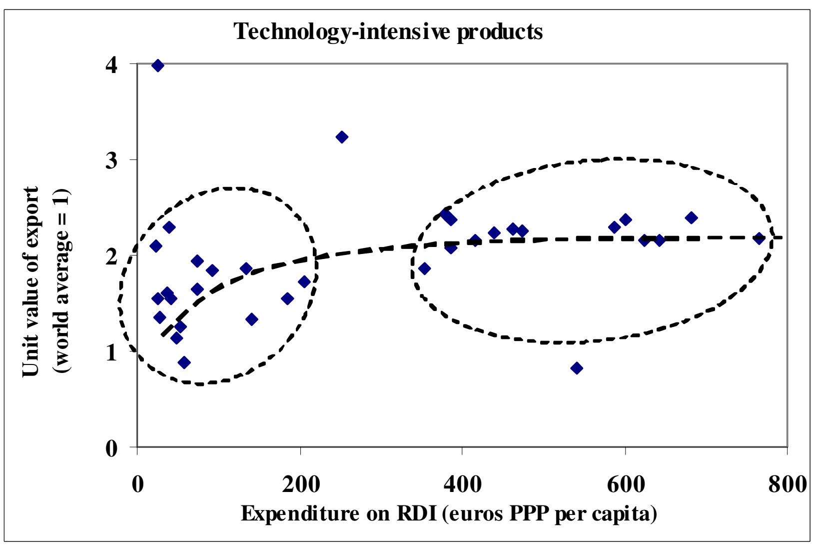


Source : Eurostat (http://epp.eurostat.cec.eu.int)
and United Nations Comtrade Database (http://unstats.un.org/unsd/comtrade), own computation.

Annex 7

The correlation between the expenditures on RDI per capita (1995–2004 average, 1995 constant prices) and the unit value of export (2003) by technological groups of products

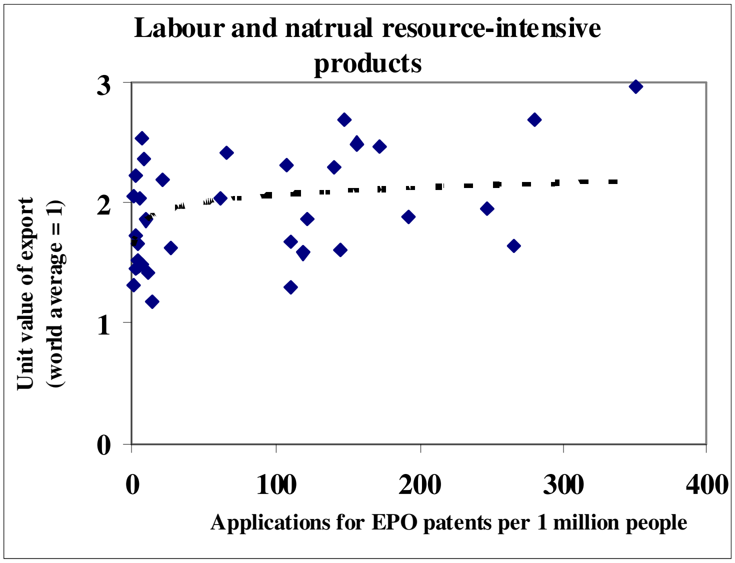


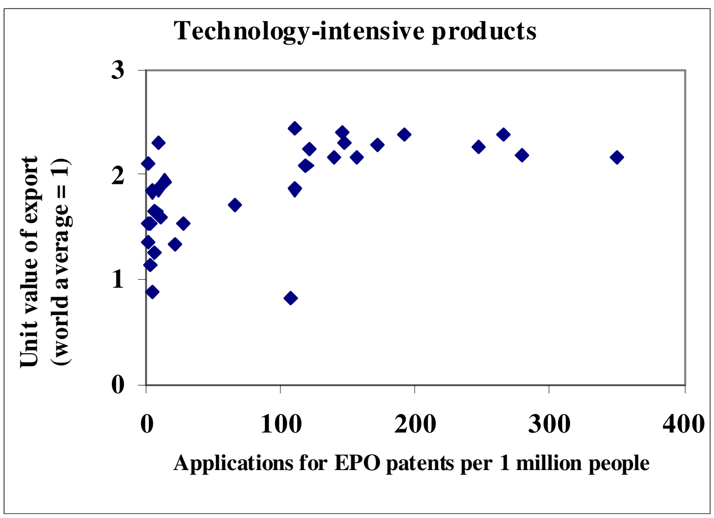


Source: Eurostat (http://epp.eurostat.cec.eu.int) and
International Trade Centre UNCTAD / WTO (http://www.intracen.org).

Annex 8

The correlation between the number of applications for EPO patents (1995–2003 average) and the unit value of export (2003) by technological groups of products





Source: Eurostat (http://epp.eurostat.cec.eu.int) and International Trade Centre UNCTAD / WTO (http://www.intracen.org)

Annex 9

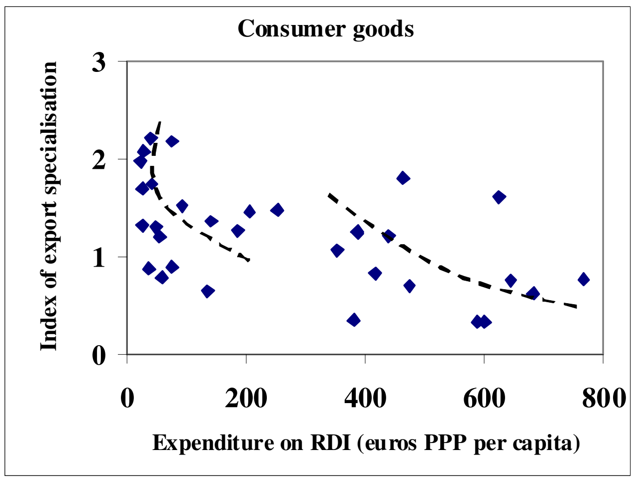
Categories of products by processing level

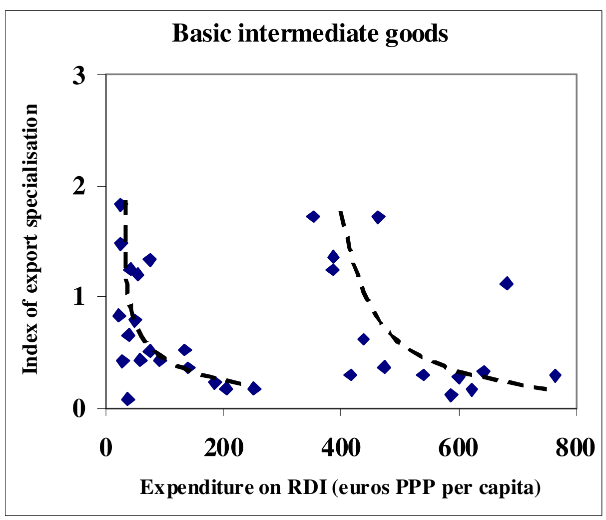
Groups	Products (BEC)
1. Consumer goods	– Basic food and beverages, mostly for domestic use (112) – Processed food and beverages, mostly for domestic use (122) – Transport equipment, not for industrial use (522) – Durables, not classified somewhere else (61) – Semidurables, not classified somewhere else (62) – Non-durables, not classified somewhere else (63)
2. Basic intermediate goods	– Basic food and beverages, for industry (111) – Primary industrial supplies, not specified somewhere else (21) – Basic fuels and lubricants (31)
3. Processed intermediate goods	– Processed food and beverages, for industry (121) – Processed industrial supplies, not specified somewhere else (22) – Processed fuels and lubricants (322)
4. Components and accessories	– Subassemblies, parts and accessories for capital goods (42) – Subassemblies, parts and accessories for transport equipment (53)
5. Capital goods	– Capital goods, excepting transport equipment (41) – Transport equipment, for industry (521)

Source: Romania's Statistical Yearbook, Foreign Trade by Broad Economic Categories (BEC).

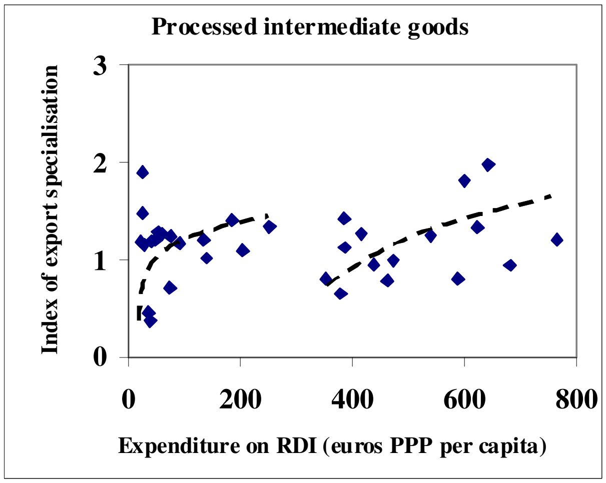
Annex 10

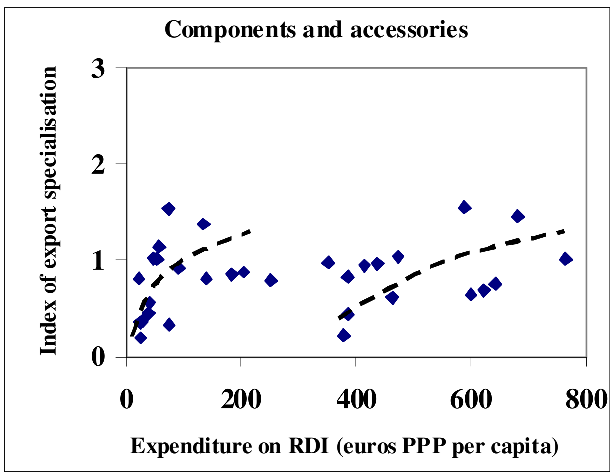
The correlation between the expenditures on RDI per capita (1995–2004 average, 1995 constant prices) and the index of export specialisation (2004) by production stage

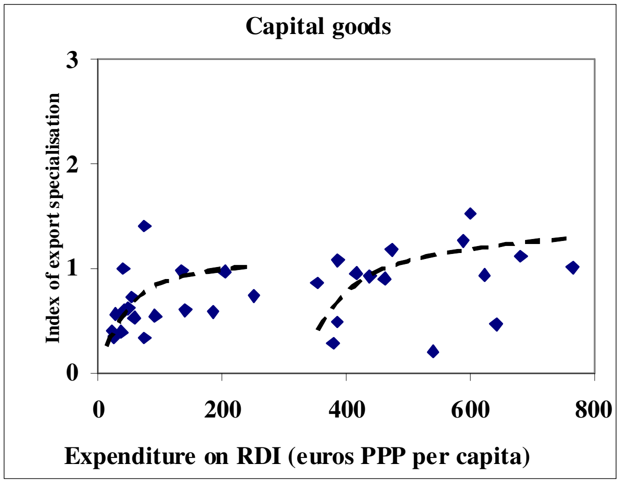




Annex 10 (continued)



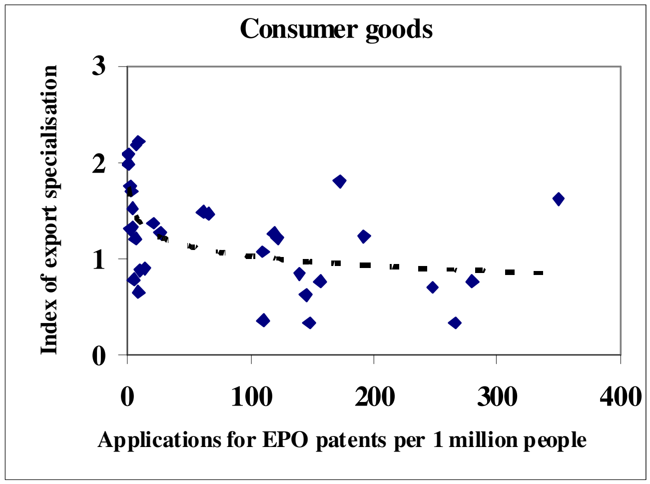


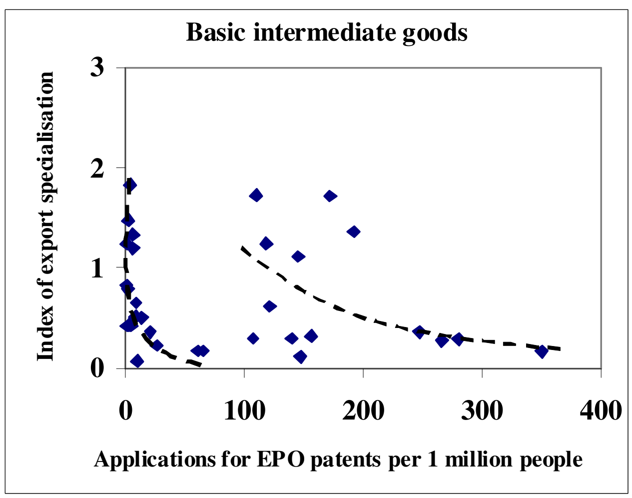


Source: Eurostat and International Trade Centre UNCTAD / WTO, own computation.

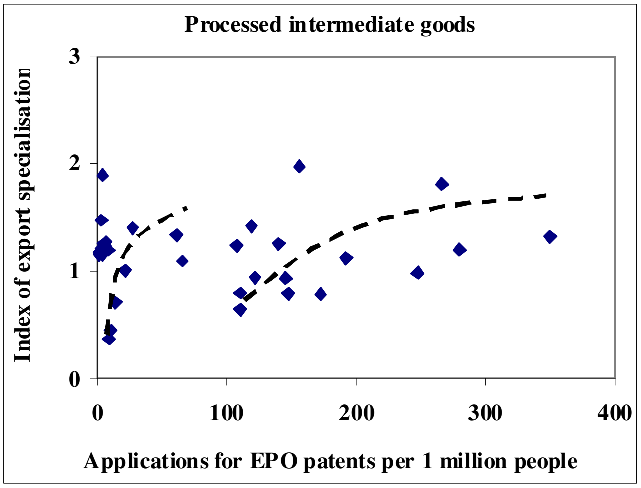
Annex 11

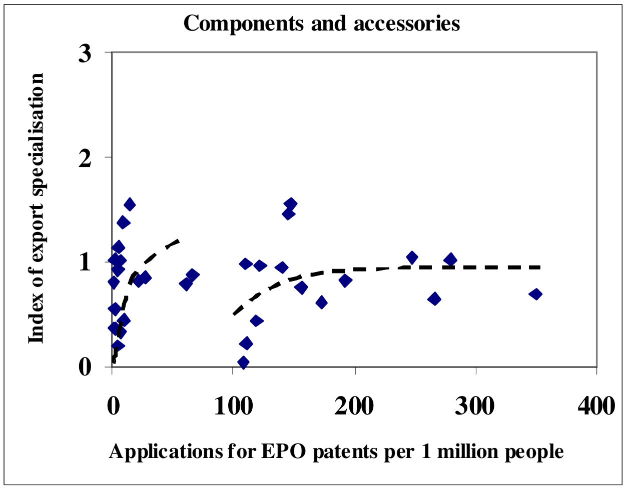
The correlation between the number of applications for EPO patents (1995–2003 average) and the index of export specialisation (2004) by production stages



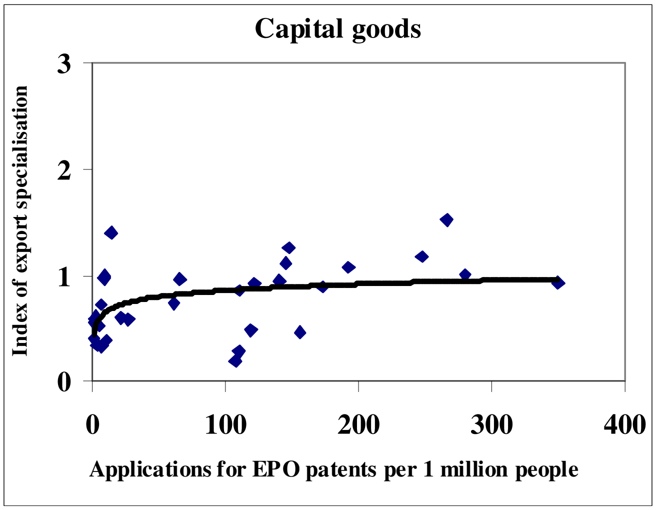


Annex 11 (continued)





Annex 11 (continued)



Source: Eurostat and International Trade Centre UNCTAD / WTO, own computation.

BIBLIOGRAPHY

1. Aghion, P.; Howitt, P. (1992), "A Model of Growth through Creative Destruction", *Econometrica*, 60.
2. Aghion, P.; Howitt, P. (1998), *Endogenous Growth Theory*, Cambridge, MIT Press.
3. Arrow, K. (1962), "The economic implications of learning by doing", *Review of Economic Studies*, Vol. 29.
4. Balassa, B. (1965), "Trade Liberalization and Revealed Comparative Advantage", *The Manchester School of Economic and Social Studies*, 23 (2).
5. Coe, D.T., Helpman, E. (1993, 1995), "International R&D Spillovers", *European Economic Review*, 39; NBER Working Paper, 5048.
6. Dosi, G. *et al.,* 1988, "Technical Change and Economic Theory", London, Frances Pinter.
7. Eaton, J.; Kortum, S. (1999), "International Patenting and Technology Diffusion: Theory and Measurement", *International Economic Review*, 40.
8. Grossman, G.M.; Helpman, E. (1991), "Innovation and Growth in the Global Economy", MIT Press, Cambridge.
9. Grossman, G.M.; Helpman, E. (1994), "Technology and Trade", NBER Working Paper, No. 4962.
10. Grubel, H.G.; Lloyd, P.J. (1975), "Intra-Industry Trade: The Theory and Measurement of International Trade in Differentiated Products", New York, John Wiley.
11. Olteanu, D. (2009) – "Influența CD&I asupra competitivității și specializării producției și exportului, la nivel european", *Studii Economice*, Institutul Național de Cercetări Economice, http://www.studii-economice.ro/2009/seince090902.pdf.
12. Romer, P. (1986), "Increasing Returns and Long-Run Growth", *Journal of Political Economy*, 94, 1002-37.
13. Romer, P. (1990), "Endogenous Technological Change", *Journal of Political Economy*, Vol. 98.
14. Xu, B.; Wang, J. (1999), "Capital Goods Trade and R&D Spillovers in the OECD", *Canadian Journal of Economics*, 32.

15. UNIDO, (2006), United Nations Industrial Development Organization, "Industrial Development Report 2005. Capability building for catching-up", Vienna.
15. WEF (2004), World Economic Forum, "Global Competitivenes Report", 2004.