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Domestic Final Demand As A Determinant Of R&D Activity In Selected Central And Eastern European Countries

Abstract

This article presents the results of an empirical study conducted based on selected countries in Central and Eastern Europe. The study focused on the impact of domestic final demand for products manufactured by individual industries on the R&D activity in the country. The main research tools are the Leontief model and R&D multipliers. The application of the input-output methods allows domestic R&D expenditures to be broken down into institutional sectors to establish what part of the expenditures is embodied in products manufactured to meet final household demand, in exports, etc.

Keywords: *R&D in CEE countries, R&D multipliers, input-output model*

1. Introduction

The development of contemporary economies is mainly driven by knowledge and innovations. This is because innovations, treated as a product of knowledge, determine an economy's capacity to create and commercialise new,

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competitive products. They are also the main factor behind the systematic rise in economies' efficiency, meant as their ability to generate output involving less production factors than before.

One indication of an economy's innovativeness is research and development (R&D) activity. While modern concepts of innovativeness tend to depart further and further away from the linear model of innovation, R&D activity, particularly that stimulated by companies, is still considered to be crucial to creating and commercializing knowledge. In the present period of globalization, the possibility of absorbing knowledge from external sources also needs to be taken into account, as it can significantly facilitate economic development when one's own resources of knowledge are scarce. The absorption of knowledge from external sources depends on many factors, one of which is the availability of human capital. The results of many empirical studies (Frantzen 2003; Guellec, van Pottelsberghe de la Potterie 2004; Cameron, Proudman, Reeding 2005; Coe, Helpman, Hoffmaister 2009; Vogel 2012) point out that only open economies that have appropriate resources of human capital are capable of fully utilising the external sources of knowledge.

The rapid socio-economic transition that countries in Central-Eastern Europe (CEE) launched in the first half of 1990s almost immediately forced them to become competitive in global markets, particularly given the fact that the transition coincided with changes in the world economy. The changes especially affected the relations between key growth factors, giving more prominence to knowledge creation and absorption. It was clear that one of the main factors that led to the disintegration of central-command economies, i.e. their inability to absorb modern production technologies, had to be eliminated as fast as possible. Consequently, the process of transition in the CEE countries involved an accelerated absorption of foreign technologies (Kubielas 2009, pp. 167-168).

However, the awareness of the CEE countries that the sphere of science and technology was also in need of transformation did not, in and of itself, make its implementation any faster (Tiis, Kattel, Kalvetand Tamm 2008, p. 74) indicate that:

„While the changes in industry and services (…) were very rapid and often disruptive, education and R&D systems were left to their own devices in most CEE and NIS[1] *countries and with no significant structural change or resources of upgrading"*.

The CEE countries continued to follow the so-called 'technology push linear model', built around domestic R&D activity carrying the main responsibility for innovation-creation. At the same time, the limited market demand for domestic science and technology competence resulted in the inability

[1] NIS – newly independent states (countries of former USSR).

of the public R&D sector to cooperate and commercialize research results and cater to the needs of private enterprises (Tiis, Kattel, Kalvetand Tamm 2008, p. 76). The transformation processes in the CEE countries failed to fully rebuild their scientific and technical spheres, which were still less developed than in Western European countries. As the CEE countries have became part of EU structures the situation somewhat improved, but their R&D activity remains fairly limited and the structure of its sources of funding is quite unpromising (the enterprise sector still accounts for a fairly low proportion of allocations to R&D). These circumstances make it particularly important to indicate which economic activities in these countries are central to the expansion of the domestic R&D sphere.

The analysis presented below investigates the relationship between domestic final demand for products manufactured by individual industries and the intensity of R&D activity in the country. In other words, the analysis focuses on the demand side and primarily seeks to determine the degree to which final demand for domestic products from particular institutional sectors influences domestic R&D. Its research tools are the Leontief model and R&D multipliers. The R&D multipliers are instrumental in identifying which industries in the economy manufacture products that "embody" (directly and indirectly) the largest amounts of domestic R&D expenditures. The application of input-output methods allows domestic R&D expenditures to be broken down into institutional sectors to establish what part of the expenditures is embodied in products manufactured to meet final household demand, in exports, etc.

The study covers six CEE countries at different levels of economic development: Slovenia and the Czech Republic (which are recognised as economically the most developed in the CEE region), Poland, Hungary and Slovakia (representing an average level of economic development), and Romania. There is a special reason why 1995, 2000, 2005 and 2009 were selected for analysis.[2] The underlying intention was to find out whether, and how, the economic transition in the selected countries and their later becoming EU member states brought about any changes in their R&D spheres.

The article is organised as follows. Section two briefly characterises the R&D spheres in the countries under consideration. Section three explains the construction and application of the R&D multipliers. Section four presents the sources of data utilised in the research. Section five shows research findings and major conclusions. Section six sums up the discussion.

[2] Because the 2009 statistics on Romania were not available, the 2008 data were used instead.

2. R&D activity in CEE countries

As has already been mentioned in the introduction to this article, economic transition in the CEE countries only slightly modified their R&D spheres, which can be partly explained by the countries' technological closeness to developed countries in Western Europe from which they absorbed technologies basically from the onset of the transition process (owing to an increasing volume of trade and FDI inflows). The Eurostat data show that between 1995 and 2012 the R&D expenditures of 12 CEE countries[3] (henceforth referred to as EU-12) accounted for 4%-6.7% of that made in EU-27, rising slightly from 2002. In the same period, the R&D expenditures in the six analysed CEE countries (listed above) constituted more than 92% of that in EU-12, distinctly increasing after 2004. The most important were Poland (a share of around 30%), the Czech Republic (over 20%), Hungary (over 11%), and also in the early period Romania.

Table. 1. R&D expenditures in selected EU-12 countries (as % of total expenditure in EU-12)

Country	*1995*	*2000*	*2005*	*2010*	*2012*
Czech	20.6	24.8	25.6	23.5	25.3
Hungary	12.1	13.4	15.5	13.4	11.8
Poland	30.4	34.6	28.6	32.9	34.0
Romania	15.2*	6.7	8.0	7.2	5.4
Slovenia	6.7	6.5	6.5	7.3	7.6
Slovakia	7.4	5.3	4.2	4.7	5.1

* - estimated by the author

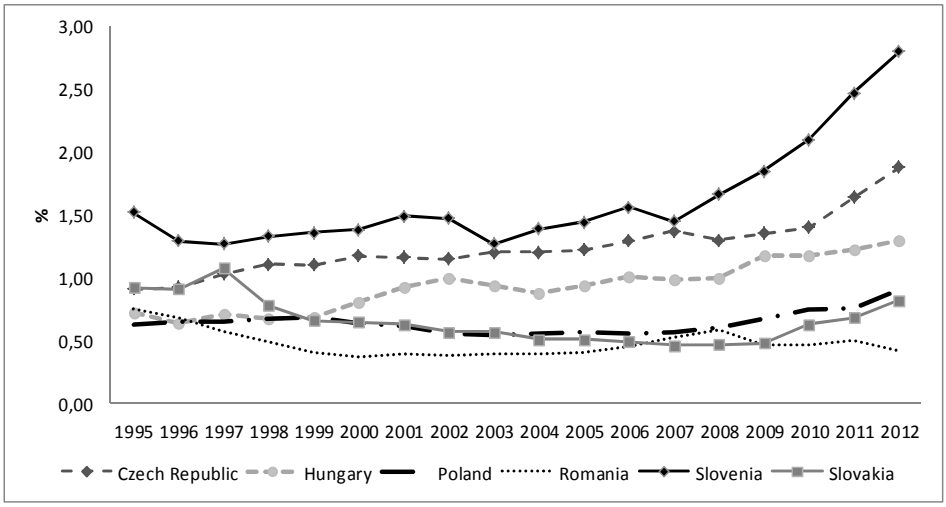
Source: developed by the author based on Eurostat data.

Because the amount of R&D expenditures in the economy is largely determined by its size, the structure of the expenditures shown in Table 1 above is not surprising. However, when the countries' R&D expenditures are shown in relation to their GDP (the so-called GERD indicator), their rankings change significantly. Between 1995 and 2012 Slovenia has the highest GERD value (Fig. 1). After 2007 its value rises rapidly from 1.45% to 2.8%, placing the country at a level comparable with that of Belgium, France and the UK. In 1995 the Czech Republic and Slovakia have similar GERD values of around 0.9%, but the Czech GERD steadily rises in the analysed period to 1.88% in 2012. In Slovakia, the trend is completely reverse. The Slovak GERD, having initially risen to 1.08% (in 1997), systematically declines in the following years to 0.48% in 2007, the lowest value among all analysed countries. In the following years the situation slightly

[3] CEE countries that became EU members before 2012.

improves and in 2010 the Slovak GERD is estimated at 0.82%. The same pattern can be observed in Poland too; in the analysed period (1995-2012) Poland's R&D expenditures rank highest in 2012 with a GERD value of 0.9%. Romania fared the worst in this respect, as its GERD did not exceed 0.5% throughout the analysed years.

Figure 1. R&D expenditures as % of GDP in selected CEE countries between 1995 and 2012



Source: developed by the author based on the Eurostat data.

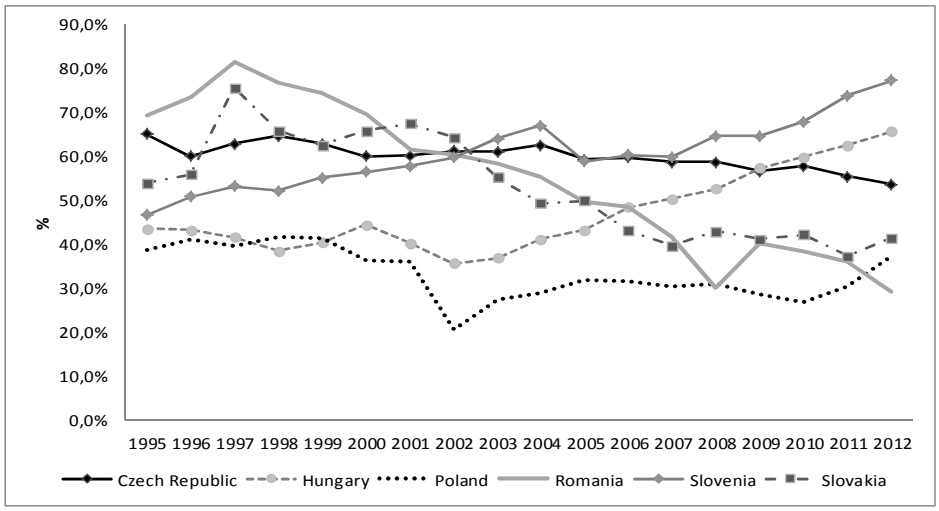
Where R&D funding originates from determines how effective the activity will be.[4] Most CEE countries finance R&D activities through the state budget, like the former Eastern bloc countries all did to handle their science and technology systems.[5] In 1995, in most EU-12 countries the enterprise sector contributed less than 50% of R&D funding. The exceptions were the Czech Republic and Romania (according to the Eurostat data, the enterprise sectors in each of these countries contributed over 60%). In Romania the percentage decreased dramatically to 30% by 2012 (while the state budget's financial contribution to R&D rose from 23% to 47.6% in 2012). In Slovakia and Poland

[4] The main providers of R&D funding are the government sector, the enterprise sector, the tertiary education sector, the non-profit sector, and foreign sources. The tertiary education sector ranks third in the amount of R&D expenditures; in the period under consideration its contribution rose systematically in most of the studied countries (excluding Slovenia and Hungary). In 2012, it ranged from 10% (Slovenia) to 34% (Poland and Slovakia).

[5] A detailed analysis of the differences between Western countries and the so-called Eastern bloc countries regarding their science and technology systems is provided in the study by Radosevic (1999).

the situation was similarly unfavourable, because in the later years of the 1995-2012 period enterprises accounted for around 40% of R&D funding. Slovenia and Hungary were the only two countries where the enterprise sector increased its financial allocations to R&D.

Figure 2. R&D expenditures of the enterprise sector as a percentage of all R&D expenditures in the selected CEE countries between 1995 and 2012



Source: developed by the author based on the Eurostat data.

The sectoral structure of R&D expenditures in the investigated countries shows manufacturing companies as the major provider of this funding.[6] Slovakia seems to be an exception here, because according to the OECD data the proportion of R&D funding provided by its manufacturing industry was comparable to that coming from the service providers, or even smaller (excluding the year 2009). In most countries in the analysis, the manufacturing industry's share is diminishing while the services sector is increasing its allocations (with the already mentioned exceptions of Slovakia and Slovenia). In all selected countries, among manufacturing industries making the

[6] The data on R&D expenditures by type of activity was derived from the OECD database – ANBERD database (the Analytical Business Enterprise Research and Development database). This database has been developed to provide analysts with comprehensive and internationally comparable data on industrial R&D expenditures. It presents industrial expenditure data broken down into 60 manufacturing and services sectors for OECD countries and selected non-member states (www.stats.oecd.org).

largest payments to R&D activity the medium- and high-tech sectors prevail, such as the manufacture of transport equipment (particularly in the Czech Republic and Poland, although in Hungary and Romania its share increased too), the manufacture of chemicals and chemical products (these have the largest shares in Hungary and Slovenia), the manufacture of electrical and optical equipment (this category encompasses the manufacture of electrical machinery and apparatus, office, accounting and computing machinery, RTV and communications equipment, the manufacture of medical, precision and optical instruments) and of machinery and equipment.

Table 2. R&D expenditures (in %) in selected CEE countries by sector of economic activity

Activity sectors	1995	2000	2005	2009
Czech Republic				
Agriculture, hunting, forestry and fishing	0.2	0.4	1.1	0.4
Mining and quarrying	1.4	0.3	0.5	0.2
Manufacturing	75.6	66.7	67.4	65.8
Electricity, gas and water supply	0.1	0.0	0.8	0.2
Construction	0.7	1.2	1.3	1.2
Services	22.0	31.4	28.9	32.2
Hungry				
Agriculture, hunting, forestry and fishing	16.3	1.2	1.4	1.9
Mining and quarrying	0.2	0.0	0.0	0.0
Manufacturing	76.3	79.0	79.0	68.1
Electricity, gas and water supply	2.2	0.9	0.4	0.2
Construction	0.5	0.1	0.2	0.7
Services	4.5	18.9	19.0	29.1
Poland				
Agriculture, hunting, forestry and fishing	2.0	2.3	2.9	0.8
Mining and quarrying	4.8	4.3	4.6	3.1
Manufacturing	73.9	68.5	62.7	63.9
Electricity, gas and water supply	1.0	1.8	2.0	1.1
Construction	3.0	3.9	2.1	1.5
Services	15.9	19.2	25.7	29.6

Activity sectors	1995	2000	2005	2009
Romania				
Agriculture, hunting, forestry and fishing	12.5	11.4	14.6	14.0
Mining and quarrying	5.7	9.2	3.2	2.3
Manufacturing	58.7	66.8	60.5	43.6
Electricity, gas and water supply	11.2	8.7	7.9	9.7
Construction	2.4	1.3	2.6	2.8
Services	9.4	2.6	11.2	27.6
Slovenia				
Agriculture, hunting, forestry and fishing	0.7	0.1	0.0	0.1
Mining and quarrying	2.3	3.9	1.7	1.3
Manufacturing	76.7	76.7	90.0	83.1
Electricity, gas and water supply	0.0	0.0	0.1	0.3
Construction	1.1	0.0	0.0	0.1
Services	19.3	19.3	8.2	15.2
Slovakia				
Agriculture, hunting, forestry and fishing	0.0	1.3	2.4	1.2
Mining and quarrying	0.0	0.0	0.0	0.0
Manufacturing	51.6	41.9	42.1	61.2
Electricity, gas and water supply	0.0	0.0	0.0	0.0
Construction	0.6	0.3	0.3	0.2
Services	47.7	56.6	55.2	37.3

Source: calculated by the author based on the OECD data (ANBERD Database).

3. R&D multipliers – calculation and interpretation

The input-output multipliers are one of the basic tools used as part of the input-output methods applied to perform economic analyses at the industry level. The multipliers allow for determining how final demand affects specific and explicitly interpretable economic values (for more than that, see Miller, Blair 2009, pp. 243-259 and ff; Lenzen 2001, pp.65-92; Przybyliński 2012, pp. 86-88). They are constructed based on the standard input-output model and

the production multipliers obtained from it. The standard input-output model can be written as:

$$\mathbf{x} = \mathbf{Ax} + \mathbf{y} \tag{1}$$

where:

$\mathbf{x} = \begin{bmatrix} X_1 \\ X_2 \\ \vdots \\ X_n \end{bmatrix}$ and $\mathbf{y} = \begin{bmatrix} y_1 \\ y_2 \\ \vdots \\ y_n \end{bmatrix}$ are the vectors of, respectively, the gross output of each of the n industries and final demand for the products of each of the n industries in the economy, and $A = [a_{ij}]_{n \times n}$ is a matrix of direct input coefficients defined as $a_{ij} = \frac{x_{ij}}{X_j}$. The value of a_{ij} represents the value of inputs (raw materials, intermediate inputs and services) of industry *i* that are necessary for industry *j* to create a unit of gross output.

By solving the above model for gross output **x** we obtain:

$$\mathbf{x} = \mathbf{(I - A)}^{-1}\mathbf{y} \tag{2}$$

The $(\mathbf{I} - \mathbf{A})^{-1} = [l_{ij}]$ matrix is known as the Leontief inverse or the total requirements matrix (Miller, Blair 2009, p. 21). Its element l_{ij} shows the amount by which the gross output of industry *i* will increase when final demand for industry *j*'s products grows by a unit. It represents the so-called total effects of an increase in the *i*-th industry's gross output, i.e. both direct and indirect effects observable in that industry (an increase in gross output because of intermediate linkages between industries). The sum of the elements in the *j*-th column of the Leontief inverse matrix ($M_j = \sum_{i=1}^{n} l_{ij}$) is known as the simple input-output (I-O)

multipliers (Miller, Blair 2009, p. 245). A simple I-O multiplier for the *j*-th industry shows how much the gross output in the economy will expand because of a unit increase in final demand for the products of the *j*-th industry.

Models (1) and (2) can also be written in terms of domestic output, i.e.:

$$\mathbf{x}^{k} = \mathbf{A}^{k}\mathbf{x}^{k} + \mathbf{y}^{k} \tag{3}$$

and

$$\mathbf{x}^{k} = (\mathbf{I} - \mathbf{A}^{k})^{-1}\mathbf{y}^{k} \tag{4}$$

In this case, vectors $\mathbf{x}^k$ and $\mathbf{y}^k$ denote, respectively, gross domestic output and final demand for domestic goods, and the elements of matrix $\mathbf{A}^k = [a_{ij}^k]_{n\times n}$ defined as $a_{ij}^k = \frac{x_{ij}^k}{X_k^k}$ indicate the amount of domestic inputs of industry *i* that are necessary for industry *j* to create a unit of domestic gross output (Przybyliński, 2012, pp. 25-26; 81-83). The matrix $(\mathbf{I}-\mathbf{A}^k)^{-1} = [l_{ij}^k]_{n\times n}$ is the total requirement matrix for domestic goods. The element l_{ij}^k stands for the amount of industry *i*'s gross output that is necessary to meet a unit of domestic final demand for industry *j*'s products or, in marginal terms, it is an increase in the gross domestic output of industry *i* resulting from a unit increase in final demand for domestic goods supplied by industry *j*. Similarly, a simple I-O multiplier can be interpreted as an increase in gross domestic output caused by a unit increase in final domestic demand.

To assign the multiplier effects to other economic categories, including R&D expenditures, the direct input coefficients must be defined for each industry. The coefficients show the amount of factor input in industry *i* per unit of its gross output. With information on the *i*-th industry's expenditures on R&D (RD_i) the industry's coefficient of direct R&D expenditure can be defined as:

$$r_i = \frac{RD_i}{X_i^k} \tag{5}$$

The value of the coefficient indicates the amount of domestic R&D expenditures in industry *i* per unit of its gross domestic output.

Based on relations (5) and (4), the total R&D expenditure in the economy can be written as:

$$RD = \sum_i RD_i = \begin{bmatrix} r_1 & r_2 & \dots & r_n \end{bmatrix} \begin{bmatrix} X_1^k \\ X_2^k \\ \vdots \\ X_n^k \end{bmatrix} = \mathbf{r}^T \mathbf{x}^k = \mathbf{r}^T (\mathbf{I} - \mathbf{A}^k)^{-1} \mathbf{y}^k = \tag{6}$$

$$= \begin{bmatrix} \rho_1 & \rho_2 & \dots & \rho_n \end{bmatrix} \begin{bmatrix} y_1^k \\ y_2^k \\ \vdots \\ y_n^k \end{bmatrix} = \boldsymbol{\rho}^T \mathbf{y}^k = \rho_1 y_1 + \rho_2 y_2 + \ldots + \rho_n y_n$$

The element *j* of vector $\boldsymbol{\rho}$, i.e. ρ_j, is the amount of domestic R&D expenditures per unit of final demand for the domestic product of industry *j* or, in marginal terms, an increase in domestic R&D expenditures brought about by a unit increase in final demand for the domestic product of industry *j*. Accordingly, the element can be called an R&D multiplier for industry *j* (Dietzenbacher, Los 2000, 2002; Belergi-Roboli, Michaelides 2005; Gurgul 2007).

Final demand consists of the following components: consumption (of households, non-profit institutions serving households and the government), gross accumulation and export. Relation (6) allows the domestic R&D expenditures to be broken down in accordance with these components. In this way, additional information such as the amount of domestic R&D expenditures embodied in domestic products manufactured for export etc. can be obtained.

4. Sources of statistical data

For the R&D multipliers to be calculated, R&D expenditures by industry and the symmetric input-output tables must be known. For the purpose of this study, the data on R&D expenditures were derived from the OECD's database ANBERD (The Analytical Business Enterprise Research and Development Database) where information (by currency and also for fixed prices) is available for 60 manufacturing and services sectors. In the case of most CEE countries, the

information goes back as far as1995.[7] The symmetric input-output tables used to analyse the selected countries were obtained from the WIOD (World Input-Output Database, www.wiod.org).[8] The tables have been constructed for a system of 35 industries by 35 industries, and they account for the flows of domestic goods and imports in US$ million.[9] Considering that the first quarters of the tables contain zero rows (for all selected countries), the original system was reduced to 28 industries by 28 industries. The aggregation procedure involved in the first place certain branches in the services sector (mostly transportation and non-market services).

5. Empirical results

An analysis of multipliers calculated for individual industries in the selected CEE countries shows them to be the highest for industries where the intensity of domestic R&D expenditures measured by the direct input coefficient is the greatest (5). These are mainly the medium and high-tech sectors of the manufacturing industry and knowledge-intensive services (IT and R&D). In most countries in this study, the values of the multipliers fell between 2005 and 2009 (see Figs. 3a-3f) for most of the analysed activities. The decline in 2005 may have been caused by the countries' entry into the European Union (this, naturally, does not apply to Romania). Easier access to West European technologies may have been a reason for the countries to scale down their domestic R&D activity. The unfavourable changes in 2009 may have been brought about by the economic crisis that decreased also the intensity of R&D expenditures in most branches in the analysed countries.

The only country to resist the trends to some extent was Slovenia (Fig. 3f), where multipliers' values increased in 2009, particularly for the chemical industry (manufacture of chemicals and chemical products, category 9), the electrical and optical equipment industry (14) and the transport equipment industry (15). In Slovenia, the manufacturing branches have much higher values of the multipliers

[7] For most countries, the most recent data available on R&D expenditures by industry came from the year 2009, the only exception being Romania where the last year is 2008.

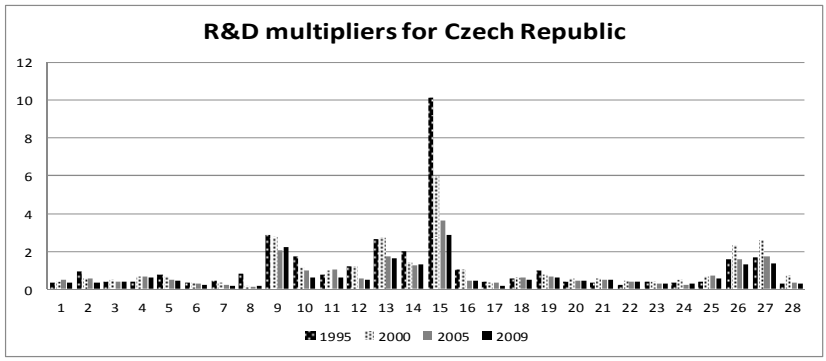
[8] The World Input-Output Database provides time series of world input-output tables for forty countries worldwide and a model for the rest-of-the-world, covering period from 1995 to 2011 (www.wiod.org).

[9] The database contains tables presenting current prices and previous year's prices. In this study, the first type of table was used. The values of the coefficient of direct R&D expenditures were determined with data on R&D expenditures expressed also in current prices in million USD.

than services do, one reason for which was the weak R&D activity of the services sector (see Section 2 of the article).

Figure 3. R&D multipliers[10] in the selected CEE countries, years 1995, 2000, 2005 and 2009[11]

3a)



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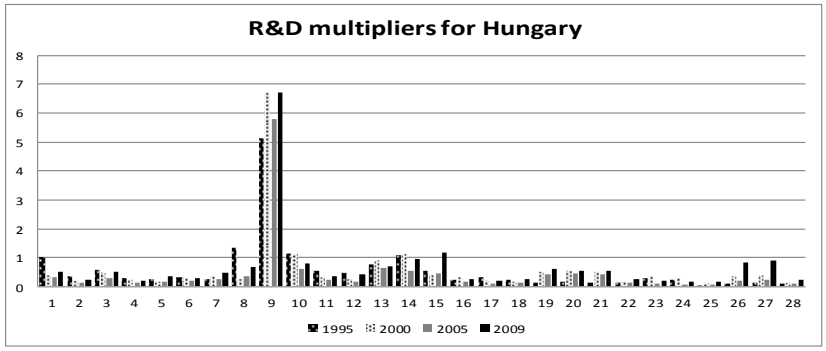

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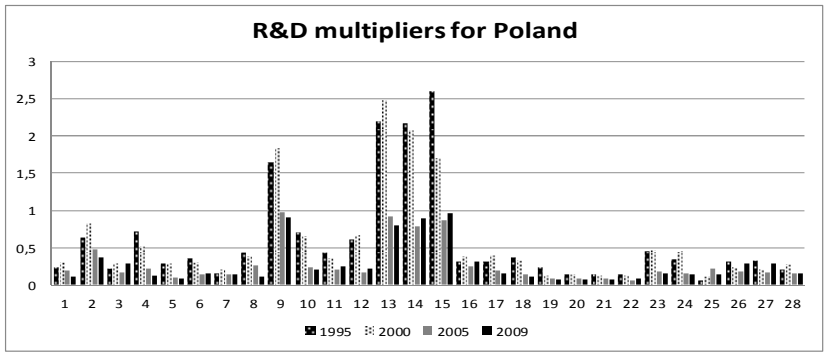
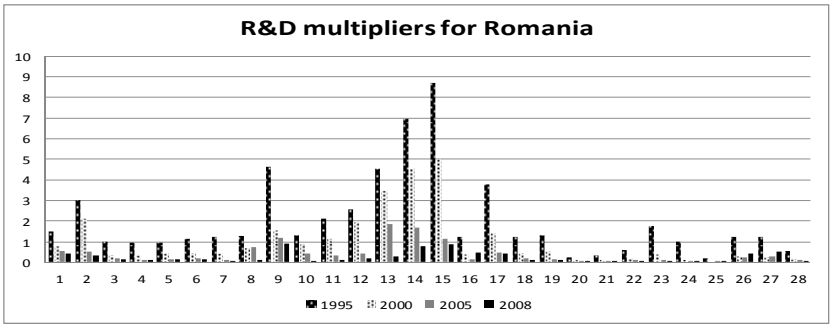


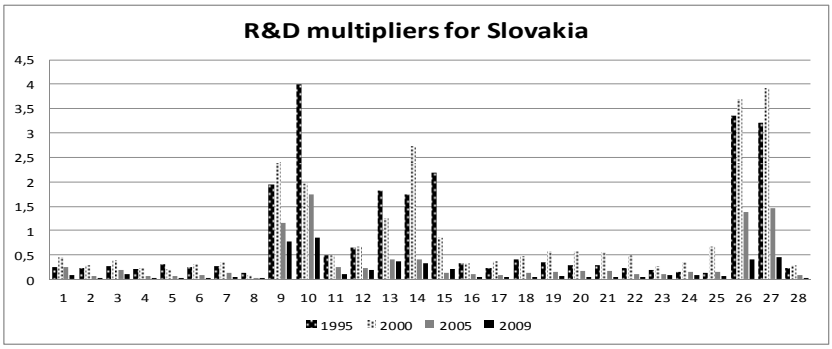
[10] They have been multiplied by 100.

[11] 2008 in the case of Romania.

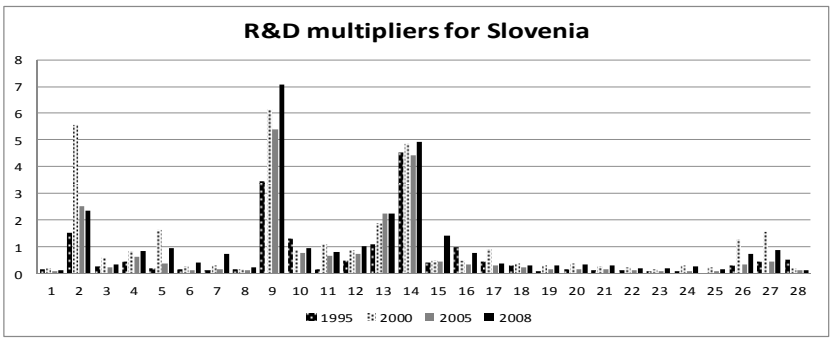
3d)



3e)



3f)



Categories: 1 – agriculture, hunting, forestry and fishing; 2 – mining and quarrying, 3 – manufacture of food products, beverages and tobacco; 4 – manufacture of textiles and textile products; 5 – manufacture of leather and leather products; 6 – manufacture of wood and products of wood and cork; 7 – manufacture of pulp, paper and paper products, publishing and printing; 8 – manufacture of coke, refined petroleum products and nuclear fuel; 9 – manufacture of chemicals and chemical products; 10 – manufacture of rubber and plastic products; 11 – manufacture of other non-metallic and mineral products; 12 – manufacture of basic metals and fabricated metal products; 13 – manufacture of machinery and equipment n.e.c.; 14 – manufacture of electrical and optical equipment; 15 – manufacture of transport equipment; 16 – manufacturing n.e.c., recycling; 17 – electricity, gas and water supply; 18 – construction; 19 - sale, maintenance and repair of motor vehicles and motorcycles; retail sale of fuel; 20 - wholesale trade and commission trade, except for motor vehicles and motorcycles; 21 - retail trade, except of motor vehicles and motorcycles; repair of household goods; 22 – hotels and restaurants; 23 – transport and storage; 24 – post and telecommunication; 25 – financial intermediation; 26 – real estate activities; 27 – renting and business activities; 28 – other services.

Source: calculations by the author.

The situation in Hungary was similar to that in Slovenia. The main engine of Hungarian R&D was manufacture of chemicals and chemical products. Increasing final demand for these products contributed the most to the rise in R&D expenditures, but the transport equipment industry (category 15) and the electrical and optical equipment industry also played an important role (particularly in the last year of analysis).

As far as the Czech Republic is concerned, the most disadvantageous changes can be observed in the transport equipment industry. The increase in the demand for its products had a much weaker effect on the growth of domestic R&D expenditures than in the mid-1990s.It is difficult to establish which activity in the Czech economy deserves the title of the main stimulator of R&D activity in the last analysed year.

The conclusions about Poland are similar. In the second half of 1990s the demand for domestic products delivered by the transport equipment industry (category 15), the electrical and optical equipment industry (14), the machinery and equipment industry (13) and the chemicals and chemical products industry was the key factor behind the increase in R&D expenditures in the economy. In 2000 and 2005 the role of these industries considerably diminished, even though in 2009 they had the greatest multipliers.

The situation in Slovakia and Romania was fairly unpromising. A considerable proportion of R&D expenditures in the first country came from the services sector. This had an effect on the multipliers' values, which were high for real estate services (category 26) and business services (27). The latter activity encompasses IT and R&D services that fall under the category of knowledge-intensive services. Among the manufacturing activities, manufacture of rubber and plastic products (category 10), of chemicals and chemical products (9), of electrical and optical equipment (14) and of transport equipment (15) deserve special attention, because demand for these products was the main factor stimulating R&D activity in Slovakia. It must be noted, though, that these observations actually apply only to the years 1995 and 2000, because the values of the R&D multipliers clearly declined in 2005 and 2009, particularly those for the aforementioned types of services. The highest multipliers in 2009 were calculated for the manufacture of chemicals and chemical products and of rubber and plastic products.

In Romania, the multipliers were the highest in 1995 and 2000, mainly for products manufactured by medium and high-tech industries (categories 9, 13, 14, and 15). Relatively high multipliers were also obtained for electricity, gas and water supply (17) and mining and quarrying (2), but this situation was not maintained in the following years. In 2005 and 2008 the Romanian R&D multipliers considerably declined, particularly in services and low-tech industries

(categories 3, 4, 5, 6 and 7). This situation was caused by particular economic sectors making major cuts in their R&D expenditures, which considerably reduced the intensity as well of the multipliers.

In the study, the R&D multipliers were also used to divide R&D expenditures into demand categories. This procedure was aimed at determining what part of domestic R&D expenditures was embodied in products purchased by households and government institutions, etc., and what part was embodied in exports (see Table 3). In most countries in the sample, the distinct majority of domestic R&D expenditures were embodied in the country's exports, with a steadily increasing role of export as a booster for domestic R&D activity. The leader was Slovenia, where exports accounted for more than 80% of domestic R&D expenditures. In the other countries the rate was somewhat smaller, varying between 50% and 70%. In Romania, in the period under consideration most R&D expenditures were embodied in products purchased by households (over 40%; an exception was the year 2000 where export was more important), preceding export in the ranking. In the Czech Republic, Poland and Romania, intermediate goods accounted for a considerable proportion of R&D expenditures, particularly in the early investigated years.

Table 3. R&D expenditures in the selected CEE countries by final demand category (in %)

Categories of final demand	1995	2000	2005	2009
Czech Republic				
Consumption expenditure by households	23.3	21.2	18.1	18.9
Consumption expenditure by non-profit institutions	0.1	0.2	0.2	0.2
Consumption expenditure by government	5.3	7.4	5.7	5.7
Gross capital formation	17.2	12.7	11.0	10.7
Exports	54.1	58.4	65.0	64.5
Hungary				
Consumption expenditure by households	34.2	19.6	18.4	18.3
Consumption expenditure by non-profit institutions	0.2	0.2	0.3	0.3
Consumption expenditure by government	9.1	5.4	7.3	5.8
Gross capital formation	8.7	12.7	6.2	4.6
Exports	47.7	62.1	67.7	70.8

Categories of final demand	1995	2000	2005	2009
Poland				
Consumption expenditure by households	33.8	30.1	30.5	28.2
Consumption expenditure by non-profit institutions	0.4	0.5	0.4	0.4
Consumption expenditure by government	8.8	9.1	9.0	9.0
Gross capital formation	17.8	17.1	8.3	8.2
Exports	39.2	43.2	51.8	54.2
Romania				
Consumption expenditure by households	44.5	34.1	40.2	41.3
Consumption expenditure by non-profit institutions	0.1	0.2	0.3	0.2
Consumption expenditure by government	5.4	4.8	5.5	5.1
Gross capital formation	22.7	17.2	13.2	18.3
Exports	27.3	43.7	40.8	34.6
Slovenia				
Consumption expenditure by households	19.0	20.2	8.6	11.3
Consumption expenditure by non-profit institutions	0.7	0.1	0.1	0.1
Consumption expenditure by government	12.0	3.8	2.1	2.4
Gross capital formation	10.6	10.4	7.6	4.6
Exports	57.7	65.5	81.6	81.6
Slovakia				
Consumption expenditure by households	34.2	30.1	28.8	21.9
Consumption expenditure by non-profit institutions	0.2	0.5	0.3	0.5
Consumption expenditure by government	7.3	6.6	4.6	4.1
Gross capital formation	9.6	10.0	12.5	5.2
Exports	48.7	52.8	53.8	68.3

Source: calculations by the author.

6. Conclusions

The purpose of this analysis was to establish the effect of final demand realised by individual institutional sectors on R&D activity in selected countries of Central and Eastern Europe. The period of transition that the countries entered into in the first half of 1990s transformed many areas (changing the ownership structure, market organization, financial systems and enterprise organization, as well as liberalising foreign trade), but its impact on their R&D spheres was fairly weak. R&D expenditures still represent a small percentage of these countries' GDP, and the enterprise sector's financial contribution to R&D activity continues to be limited. Even so, the CEE countries' structure of R&D expenditures by industry is similar to that in highly developed countries, where high-tech and medium industries and knowledge-intensive services are the major contributors. This means that the demand for their products is a crucial factor in the expansion of domestic R&D. This finding has been confirmed by the results of the multiplier analysis.

The research results also show, however, that final demand for domestic goods is exerting an ever weaker influence on R&D intensity in economies (as proven by the declining values of the multipliers in the successive years of analysis), a phenomenon that is quite worrying. In fact, these negative changes can be seen in most of the studied countries. The only exception is Slovenia, which resembles Western European countries regarding its R&D expenditures (in relation to GDP), the structure of funding sources (the major contributors to R&D are enterprises) and the positive evolution of the multiplier effects.

A large part of domestic R&D expenditures was found to be embodied in countries' exports. Moreover, this phenomenon was systematically expanding in the successive years of analysis in all countries except Romania. Household consumption and demand for investment goods were also established as important factors stimulating the growth of R&D activity in a country.

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Streszczenie

POPYT FINALNY NA PRODUKTY KRAJOWE A DZIAŁALNOŚĆ SEKTORA B+R W WYBRANYCH KRAJACH EUROPY ŚRODKOWO-WSCHODNIEJ

W artykule przedstawiono wyniki badań empirycznych przeprowadzonych dla wybranych krajów Europy Środkowo-Wschodniej. Badania te dotyczyły zależności między popytem finalnym na produkty określonych gałęzi gospodarki, które są wytwarzane

w kraju a aktywnością krajowej sfery badawczo-rozwojowej. Głównym narzędziem badawczym jest model Leontiefa oraz mnożniki nakładów na B+R. Zastosowane metody pozwalają także na dekompozycję krajowych nakładów na B+R według sektorów instytucjonalnych, czyli np. określenie jaka część krajowych nakładów na B+R zostaje ucieleśniona w produktach wytwarzanych na zaspokojenie popytu finalnego gospodarstw domowych, czy w produktach przeznaczonych na eksport.

***Słowa kluczowe**: B+R w krajach Europy Środkowo-Wschodniej, mnożniki B+R, model input-output*