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State of the Romanian Research & Development and Innovation System and its Contribution to Increasing Industrial Competitiveness

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Abstract

The article deals with the evolution of the R&DI system in Romania after 2000, analyzed from the perspective of the level of some relevant indicators - the share of R&D expenditures in GDP, the R&D expenditures per capita by performance sectors, the number of employees and researchers in the system, the number of innovative enterprises in the manufacturing industry, the number of patent applications and patents granted -, as well as of the European Commission's assessment. The overall conclusion is that the situation of the system deteriorated over the period under review, which prevented it from playing its natural role in supporting the modernization of the Romanian economy and manufacturing industry.

Keywords: *research, development; innovation; design; patent; performance sector; innovative enterprise; industrial competitiveness*

JEL Classification: *O3*

Introduction

The modernization of the economy and, within it, of the manufacturing industry implies the making of structural changes capable of increasing their capacity to produce superior VA and competitiveness. Making these changes is possible only based on decisive contributions of investment, R&DI, and adequate workforce qualification.

Under the conditions of modern economy, whose development is based on knowledge (a knowledge-driven economy), the role of R&DI is considerably growing, constituting the very basis of such an economy and development.

R&DI is a set of scientific activities - research -, and applicative - technological development and innovation, i.e. the assimilation in manufacturing of new products, technologies, systems and methods of organization successfully validated by the market. The performance of these activities determines the scientific and innovation potential of the reference entity, which in its turn, as far as it is connected to the latest trends in technological progress, conditions the competitiveness of the economic entity.

Between investment, R&DI, structural change and competitiveness, there are cross-linkages: investment leads to structural changes according to their orientation and stimulates R&DI corresponding to those changes; structural changes and R&DI ensure increased competitiveness of the branches and sectors in which they have occurred, which increases the potential of those

branches and sectors to invest increasingly in their development, and the cycle resumes to a higher level of efficiency. Most countries in the world are currently applying strategies and policies to support this cycle at an alert rhythm and to stimulate intensely R&DI activities, given their vital importance for sustainable economic and social development.

The Drastic Restriction of the System after 2000

The current state of the R & D system in Romania, assessed on the basis of the indicators reflecting it as below, is far from allowing it to play that role. The situation has worsened worryingly in recent years, as a result of the authorities' lack of interest in developing and strengthening the system, despite official rhetoric, a fact that is convincingly demonstrated by the level of relevant indicators presented by EUROSTAT and national statistics.

Thus, the share of total R&D expenditures (GERD) in GDP declined after 2007, when and then it was modest, according to figures in the following figure.

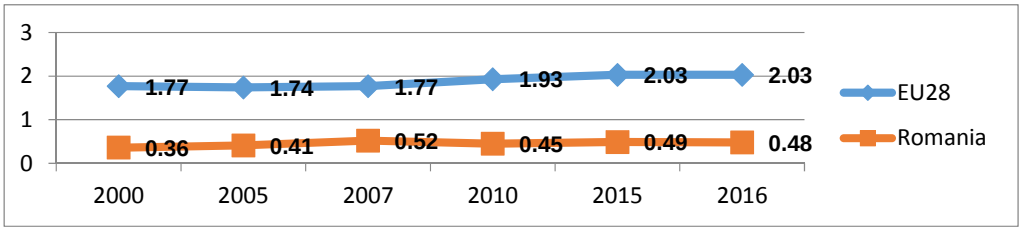

Fig. 1. The share of GERD in GDP, EU28 and Romania, 2000 .... 2016 (%)

Note: for EU28, in 2000 – estimated, and in 2016 – provisional

Source: EUROSTAT. Intramural R&D expenditure (GERD) by sectors of performance [rd_e_gerdtot]

The share of total R&D expenditure in GDP recorded by Romania was constantly well below that achieved by the EU28 throughout all reference years, decreasing from 29.4% in 2007, when reached the peak, to 23.6% in 2016. It is worth pointing out that, in 2016, the level of this indicator for other countries was: Belgium - 2.49%; Austria - 3.09%; Germany - 2.94%; Czech Republic - 1.68%; Italy - 1.29%; Estonia - 1.28%; Hungary - 1.21%; Poland - 0.97%.

The same total expenditure allocated to R&D activities relative to the number of inhabitants increased in the period under review, as a result of the country's population decline; the disaggregation of the level of this indicator by performance sectors shows developments concordant only partially with those produced at the EU28 level, according to figures in the following figure.

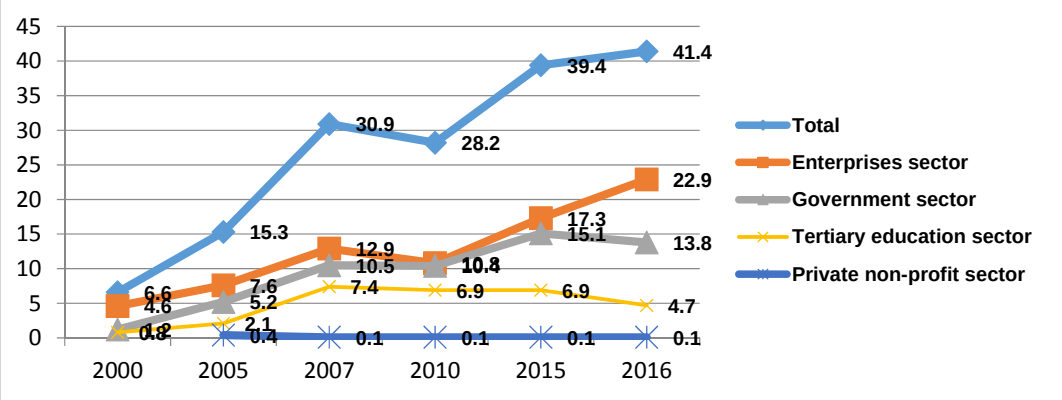

Fig. 2. Total R&D expenditure / inhabitant, by sectors of performance, 2000 .... 2016 (euro / inhabitant)

Source: EUROSTAT. Intramural R&D expenditure (GERD) by sectors of performance [rd_e_gerdtot]

The total R&D expenditure per capita and the contribution of the enterprise sector to these expenditures have increased over the period under review, which is in line with the trend manifested in this sense in the European Union. Government spending has also risen, contrary to European trends, and the contribution of the higher education sector was at a low level, a reality that is different from European practice.

Contributions of the four performance sectors to total R&D expenditure per inhabitant differ significantly between the EU28 and Romania; to illustrate this difference, we precise that in 2016 the share of contributions of the four sectors in the order of the table was 65.2%, 11.2%, 22.7%, 0.9% respectively in EU28, and 35.3% in Romania (slightly more than half of the European average), 33.2% (three times the European average), 11.3% (half), 0.2% respectively. The one-third contribution of public funds to R&D funding reflects the still low business climate availability for R&D support, although there is a clear awareness that the level of competitiveness of their own productive activities and perspectives for their development depend essentially on the scientific and innovation potential they possess. The contribution of tertiary education to the funding of these activities is also maintained to a modest limit, different from the important role universities and other tertiary education institutions in Western countries have in this respect.

The staff engaged in R&D activities at national level and researchers in the field of engineering and technology sciences (of which a significant part works for manufacturing) had developments in the analyzed period presented in the following figure.

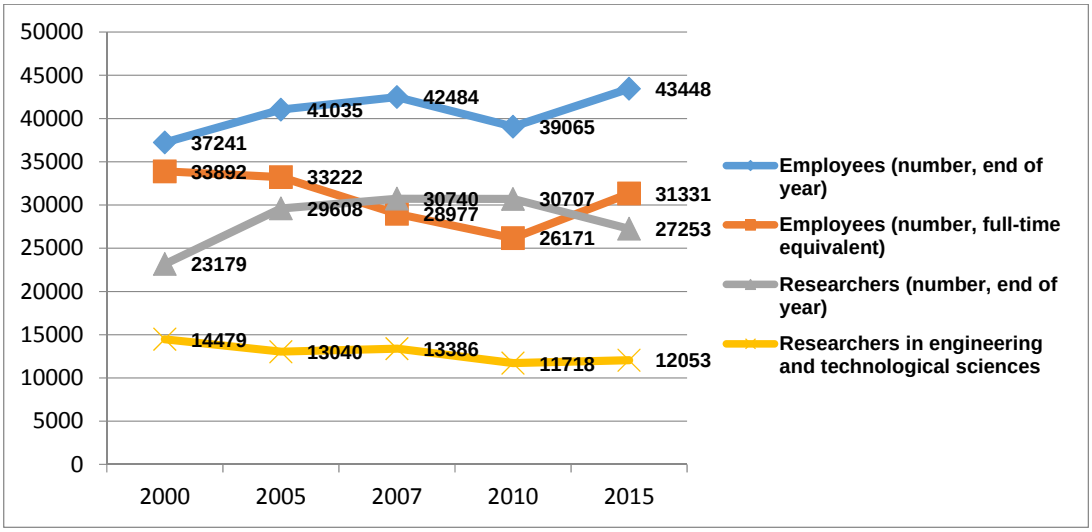

Fig. 3. Number of employees and researchers in R&D, 2000 ... 2015

Source: NIS. Romanian Statistical Yearbook 2011 series, tables 13.1.,13. 2. şi 13.7.; Romanian Statistical Yearbook 2016, tables 13.1., 13.3. şi 13.4.

The differences between the number of employees at the end of the year and that of full-time equivalent employees, which have constantly been high in all the years for which figures were presented (13507 employees in 2007 and 12117 employees in 2015), reflect the over-staffing in R&D units, unrelated to the volume of activities carried out (the share of the full-time equivalent number of employees in the number of employees at the end of the year was, in 2000, 91.0%, and, in 2015, 72.0 %, proving the high proportion of staff employed partly in the units).

The number of researchers increased until 2007, when it reached a peak (in the years shown), after which it decreased by 11.2% in 2015, but this last level was still higher by 17.6 % compared to 2000. Evolution with the shown fluctuation is relevant, as researchers are the most

important component of the R&D staff, which determines their scientific and innovative potential and, implicitly, their performance.

Fluctuating was also the number of researchers in engineering and technological sciences, i.e. those working in profiles corresponding to manufacturing activities, the reduction of this number in 2015 compared to the level in 2000 with 16.8% being worrying and confirming the existence of an increasing deficit in the labor force with a qualification corresponding to the real market requirements.

The evolution of the structure of the full-time equivalent number of employees by performance sector, highlighted by the figures in the following graph, presents other concerning issues.

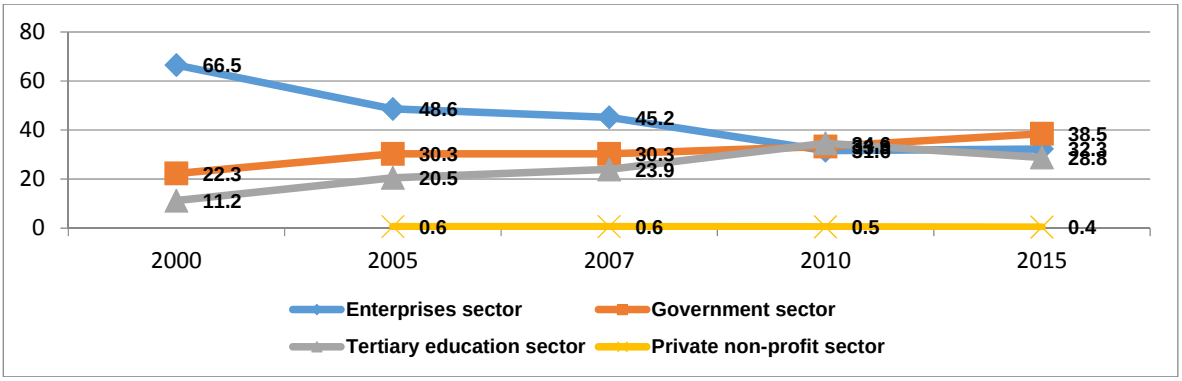

Fig. 4. Structure of employees in R&D activities by performance sectors, 2000...2015 (%)

Source: NIS. Romanian Statistical Yearbook 2004, Table 16.1.3.; 2011, Graph 13.G1; 2016, Graph 13.G1

The diminution to less than half of the share of full-time equivalent number of employees in the business sector in the 2000-2015 period also proves the low interest of private enterprise management in developing R&D activities by increasing the number of employees. The trend is contrary to the interests of these firms, knowing that the prospects for their development depend on their own scientific and innovative potential, indispensable for keeping them on the market at a level of competitiveness at least equal to or close to that of competitors.

Such a drop of the above mentioned share was offset by the increase in the share of the employees number in the governmental and higher education sectors, a reverse evolution as for the first sector to that of the EU27; in this respect, we mention that in 2015 the structure of R&D personnel at the EU 28 level was quite different from that presented for Romania in the above graph: the enterprises sector - 54.7%; government sector - 13.0%; higher education sector - 31.4%; private non-profit sector - 0.9%. Figures show that in the EU28, in terms of the share of R&D employees, the most important performance sectors are enterprises and higher education, while in Romania, the government sector, the public sector, comprises the largest number of employees.

Reducing the R&DI Potential of the Manufacturing Industry

In manufacturing, as a whole, in the business sector, the number of researchers declined by 49.3% in 2015 compared to 2010, and in some sectors the number decreased more drastically, sometimes until the R&D activities ceased, as evidenced in the following table.

Table 1. Number of researchers in R&D activities in manufacturing and its sectors, business sector, 2000 2015

	2000	**2005**	**2007**	**2010**	**2015**
Manufacturing industry	9033	6727	3879	2907	1474
Food, beverages, tobacco	22	124	70	21	36
Textiles, wearing apparel, leather and footwear	209	93	31	25	8
Manufacture of wood and of products of wood	21	-	-	-	-
Pulp, paper and products of papere	75	51	30	7	-
Crude oil processing, coal coking and nuclear fuel treatment	78	293	252	43	:
Chemicals and chemical products	673	457	357	295	62
Basic pharmaceutical products and pharmaceutical preparations				158	222
Rubber and plastic products	88	113	69	47	2
Other non-metallic mineral products	256	41	3	13	11
Metalurgy	789	388	295	107	16
Fabricated metal products				165	85
Metallic construction, machinery and equipment	6623	5074	2761		
Computers, electronic and optical products				232	121
Electrical equipment				276	140
Machinery and equipment n.e.c.				299	105
Motor vehicles, trailers and semi-trailers				798	632
Other transport equipment				329	7
Furniture and other industrial activities n.e.c.	199	93	11		
Furniture				5	4
Other industrial activities				11	8
Repair, maintenance and installation of machinery and equipment				76	15

Source: NIS. Romanian Statistical Yearbook 2008, Table 13.8.; 2011, Table 13.8.; 2016, Table 13.8.

The figures in the table are eloquent about the drastic reduction in the number of researchers in the manufacturing industry and its activities. For the manufacturing industry, the number of registered researchers in 2015 accounted for only 16.3% of that registered in 2000. Some activities which in 2007 reached a peak in the number of researchers, experienced dramatic cuts in this number until 2015: Chemicals and chemical products - by 82.6%; Metallurgy - by 94.6%, Food, beverages, tobacco (with the peak in 2005) - by 71.0%. For the Manufacturing of wood and of wood products sector, which in the past had a research and design institute, R&D activity ceased since 2005, according to statistical data. Between 2010 and 2015, with the exception of the Food, beverage, tobacco group of sectors and Pharmaceutical sector, all other sectors have greatly reduced their number of researchers, including the Motor vehicles sector which absorbed massive investment funds after 2000.

In the field of innovation, i.e. in the successful launch of new products, technologies, systems (including organizational, managerial and marketing systems), statistical data show the same worrying potential evolution. In this respect, the evolution of the number of innovative enterprises by types of incomes produced during the analyzed period and illustrated in the following figure is edifying.

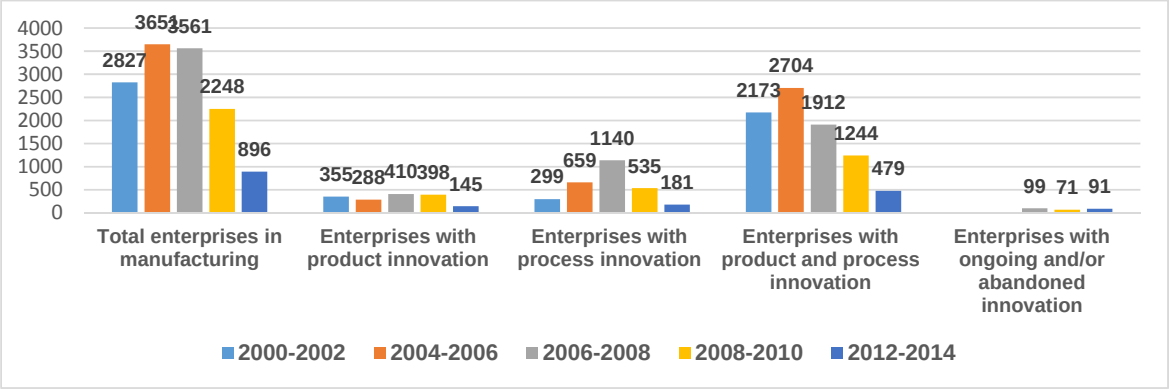

Fig. 5. Number of innovative enterprises in manufacturing, by type of innovation, 2000...2014

Note: Manufacturing in 2000-2002 şi 2004-2006 – except enterprises with ongoing and/or abandoned innovation

*Source***:** NIS. Romanian Statistical Yearbook 2011 series, Table 13.17.; 2012, Table 13.15.; 2016, Table 13.15.

The number of innovative enterprises in manufacturing registered in the period 2012-2014 accounted for only 31.7% of that of the period 2000-2002, a sharp decrease after the period 2006-2008, which covered the year of Romania's integration into the European Union. The sharply narrowing of the innovative potential of the manufacturing industry after 2007 may be the result of the free access of Romanian producers to the Single European Market and the facilitation of obtaining licenses for many products and technologies. In addition, the presence in the Romanian manufacturing industry of many multinational companies from the European Union, which came with their own products and technologies, reduced the producers' interest in the realization of innovations; the share of R&DI own activities was only about 26% of the total technological knowledge in the whole economy, the rest being covered by technology transfer, i.e. direct and indirect import of technology, especially in the inter-industry trade with partners in other member countries.

The largest reductions in the number of enterprises by types of innovation were recorded in product and process innovation, with 78%, i.e. the most efficient ones, which simultaneously achieve the improvement of the constructive and functional characteristics of the products and of the production technology parameters.

By dimensional enterprise categories, the number of innovative enterprises in manufacturing industry evolved over the same reference period according to figures in the following figure.

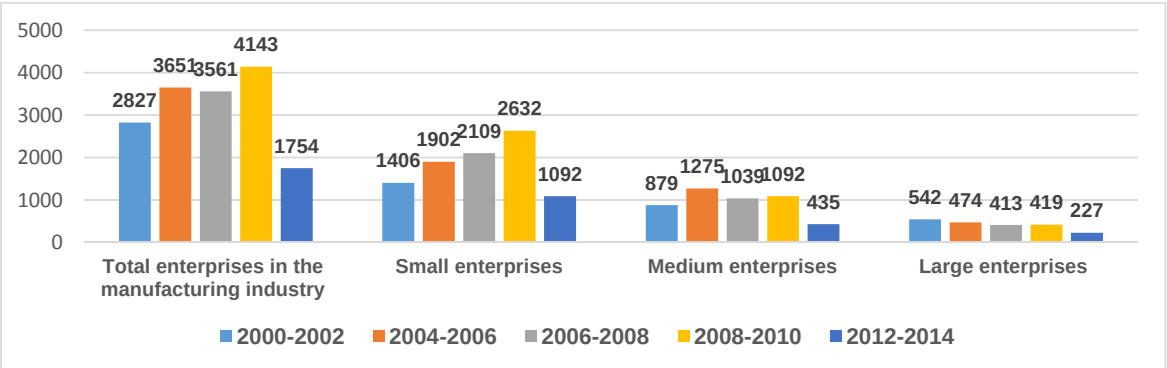

Fig. 6. Number of innovative enterprises in manufacturing by size class, 2200....2014

Source: NIS. Romanian Statistical Yearbook 2011 Series, Table 13.17.; 2012, Table 13.16.; 2016, Table 13.16.

The difference between the number of innovative enterprises shown in Figure 6 and Figure 5 is due to the inclusion in the first number, after 2008, of companies with innovations in organizational and / or marketing methods, which does not include the second number.

The reduction of the number of innovative enterprises in the manufacturing industry occurred during the analyzed period in all their size classes: in small enterprises - by 22.3%, in the medium ones - by 50.5%, in the large ones - by 58.1 %. The most significant reduction in the number of large innovative enterprises is the most unfavorable, as they have the highest economic and financial potential and superior availability for the innovative effort.

Similar to the situation shown in Figure 5, Figure 6 shows that the peak of the number of enterprises in the manufacturing industry in 2004-2006 or 2008-2010 periods was followed by the drastic reduction of this number for all size class of enterprises, from the shown causes.

Reducing the Final Results of R&D Activities

Decreasing the innovation potential across the economy has, as expected, reduced the final performance of R&D activities, some of the most relevant indicators in this respect being the number of patent applications and the number of granted and published patents; their evolution is presented in the following table.

Table 2. Number of submitted patent applications and number of granted and published patents, total and by technical fields, 2000....2014

	2000	**2005**	**2007**	**2010**	**2014**
Number of submitted patent applications	1292	1100	926	1418	1053
of which: by technical fields					
Human necessities		195	164	308	274
Performing operations, transports		226	165	227	190
Chemistry, metallurgy		173	132	213	89
Textiles, paper		12	18	22	10
Mechanical engineering, lighting, heating		178	151	202	126
Number of granted and published patents	834	790	461	430	329
Ratio Number of granted and published patents/Number of submitted patent applications	0,65	0,72	0,50	0,30	0,31
Number of European invention patents *		818	1591	2036	2733

Note: * - European patents with effects in Romania
Source: NIS. Romanian Statistical Yearbook 2015, tables 13.36. şi 13.37.; 2016, tables 13.24. and 13.25.

The decrease in the innovative capacity of the entire R&D system expressed by these relevant indicators is mirrored by the decrease in 2014 compared to 2000 of the number of submitted patent applications by 14.5% and that of the patents granted by 58.4%. In all the technical areas shown in the table, which correspond to the productive activities of the manufacturing industry, there have been decreases in the number of submitted patent applications, except in the field of Human necessities, which means that these negative developments have affected most of the activities. The ratio of the number of granted and published patents to the number of submitted patent applications also decreased, as a result of the reduction of the innovative capacity but, probably, also of the increase of the State Office for Inventions and Trademarks exigency in the analysis and evaluation of the applications. In contrast, the number of European invention patents that have produced effects in Romania has steadily increased, which confirms the increasing intensity of indirect technology imports from other member countries.

Instead, the number of submitted patent applications registered by Romania to the European Patent Office (EPO) increased steadily after 2000 and saw a spectacular leap after 2010, a trend that is in line with the European trend in this regard. The same greatly evolving trend has been in the number of patent applications for high-tech inventions, with the same significant

multiplication after 2010. From the following table, which presents these developments at the level of the EU28 and some Member Countries, Romania between them, results that there are enormous differences between the creative potential of the respective countries due to the very varied ways in which their national R&D systems are organized, funded and operating, and the ways in which the determinants of the functioning and performance of these systems are stimulated and synergistically combined.

Table 3. Number of EPO patent applications per priority year and high-tech invention patent applications at EU28 and some Member Countries, 2000 ... 2014

		2000	2005	2007	2010	2014 [e]
EU28	**Number of patent applications**	51757	57209	58578	56769	56758
	Number of patent applications / 1 million active population		245.60	246.80	232.71	234.02
	Number of high-tech patent applications / 1 million active population *		45.61	44.54	40.70	33.07 [p]
Bulgaria	**Number of patent applications**	7	23	12	17	47
	Number of patent applications / 1 million active population	2.21	7.03	3.48	4.98	14.09
	Number of high-tech patent applications / 1 million active population *	0.42	0.86	0.50	0.15	0.92 [p]
Czech Republic	**Number of patent applications**	67	108	189	193	270
	Number of patent applications / 1 million active population	12.96	20.79	36.41	36.55	50.95
	Number of high-tech patent applications / 1 million active population *	0.96	2.85	3.16	2.97	4.22 [p]
Finland	**Number of patent applications**	1435	1344	1277	1392	1863
	Number of patent applications / 1 million active population	554.24	512.74	477.38	521.04	695.21
	Number of high-tech patent applications / 1 million active population *	124.14	117.39	90.96	79.45	57.65 [p]
France	**Number of patent applications**	7314	8390	8644	8490	9134
	Number of patent applications / 1 million active population	285.29	305.52	310.35	298.83	316.84
	Number of high-tech patent applications / 1 million active population *	29.76	30.17	31.28	32.02	25.94 [p]
Germany	**Number of patent applications**	22116	24065	24397	23444	20755
	Number of patent applications / 1 million active population	558.76	588.86	588.41	564.12	494.62
	Number of high-tech patent applications / 1 million active population *	50.87	41.07	41.44	37.68	27.69 [p]
Poland	**Number of patent applications**	43	128	202	361	609
	Number of patent applications / 1 million active population	8.49	7.47	12.00	21.10	34.95
	Number of high-tech patent applications / 1 million active population *	0.12	0.60	1.03	1.69	2.31 [p]
Romania	**Number of patent applications**	**6**	**29**	**33**	**35**	**102**
	Number of patent applications / 1 million active population	**0.52**	**2.92**	**3.26**	**3.70**	**11.03**
	Number of high-tech patent applications / 1 million active population *	**0.09**	**0.27**	**0.77**	**0.35**	**0.71 [p]**
Hungary	**Number of patent applications**	121	136	191	195	222
	Number of patent applications / 1 million active population	29.74	32.26	45.35	46.52	50.02
	Number of high-tech patent applications / 1 million active population *	3.38	2.25	3.89	5.12	4.31 [p]

Note: e – estimation; p – provizional; * - data for 2013

Source: EUROSTAT. Patent applications to the EPO by priority year [pat_ep_ntot] ; High-tech patent applications to the EPO by priority year [pat_ep_ntec]

The number of patent applications submitted by the Romanian specialists at the EPO increased 17 times from 2000 to 2014 (EU28 increase - 9.65%), but the starting point was very low and throughout the period Romania was, from this point of view, in the last place among the countries shown in the table. In terms of the active population, the number of patent applications in Romania increased more markedly over the same period - 21.2 times, but the level reached in 2014 continues to account for only 4.7% of that achieved across the EU28 and was inferior to those achieved by the other Central and Eastern European countries (representing 78.3% of Bulgaria, 21.6% of the Czech Republic, 31.9% of Poland and 22.1% of Hungary)

The same unfavorable situation for Romania is perceptible with regard to the number of high-tech invention patent applications per 1 million active population, both as the value of the ratio and the ratio between this ratio and the total number of patent applications per 1 million active population. This latter rate, in 2013, for which data was provided by EUROSTAT, had the following values: Romania - 7.7%, compared to EU28 - 14.1%, Bulgaria - 7.8%, Czech Republic - 9%, Finland - 8.8%, France - 8.3%, Germany - 5.4%, Poland - 7.3%, Hungary - 8.7%. If with regard to the share of the number of high-tech patent applications in the total number of submitted patent applications to EPO Romania recorded performances close to that of the other countries taken in comparison, the number of these applications - both total and high-tech - is worrying.

Diagnosis of the European Commission of the R&D System in Romania

On all the plans reviewed - expenditures, staff, performance, innovation capacity - the levels of specific indicators show an almost continuous recoil of R&D activities after 2000, explained by the worsening of the conditions under which the national R&D system operates. This fact is summed up in the section devoted to Romania in the European Innovation Scoreboard 2017, which makes a comprehensive diagnosis of the conditions and performance of R&D activities in the member countries; in this document, Romania is included, with Bulgaria, in the Modest innovators group, according to the evaluation standards of the European Union.

The EIS evaluation framework comprises the following four groups, each with their dimensions written between brackets: Framework Conditions (Human resources, Attractive research systems, Friendly innovation environment); Investments (Financing and support, Corporation investment); Innovation activities (Innovators, Links, Intellectual assets); Effects (Effects on product usage, Effects on sales).

In the period 2010-2016, the Innovation Index registered by Romania fell almost continuously compared to the EU27 average, as shown by the figures in the following table, which also includes the scores of several member countries.

Table 4. The innovation index of EU28 and some member countries, 2010 2016

	2010	2011	2012	2013	2014	2015	2016
EU28	0.493	0.496	0.489	0.495	0.489	0.497	0.503
Bulgaria	0.234	0.245	0.199	0.223	0.223	0.227	0.234
Czech Republic	0.434	0.439	0.423	0.421	0.412	0.421	0.416
Finland	0.671	0.664	0.667	0.660	0.642	0.645	0.646
France	0.525	0.527	0.517	0.522	0.526	0.522	0.539
Germany	0.627	0.635	0.635	0.636	0.614	0.617	0.609
Poland	0.261	0.263	0.251	0.254	0.251	0.257	0.270
Romania	0.236	0.242	0.217	0.205	0.168	0.157	0.167
Hungary	0.277	0.276	0.254	0.265	0.243	0.267	0.270

Source: * * * European Innovation Scoreboard 2017. Annex F: Summary Innovation Index (SII), time series, p. 90

Romania's performance was 47.9% compared to the EU27 level in 2010 and only 33.2% in 2016 (for comparison, Bulgaria, framed beside Romania in the Modest Innovators group, recorded, in the same years, 47.5% and, respectively, 46,5%).

The dimensions of the index to which Romania made progress in the period 2010-2016 were: Population with tertiary education; International scientific co-publications; The most cited publications; Broadband communication penetration, Opportunity-based entrepreneurship; R&D expenditure in the business sector; PCT (Patent Cooperation Treaty) patent applications; Trademark applications; Industrial model applications; Employment in knowledge-based activities; Enterprises with fast growing workforce; Exports of high and medium technical products.

The dimensions to which the changes were negative during the period mentioned were: New doctoral graduates; Lifelong learning; Doctoral students; R&D expenditures in the public sector; Capital-risk expenditures; Non-R&D innovation expenditures; Product / process SMEs innovations; Marketing / organization SMEs innovation; Internal innovation in SMEs, Innovative SMEs collaborating with other companies; Public-private co-publications; Private co-financing of public R&D expenditures; Exports of knowledge-intensive services; Sales of innovations of new firms on the market.

The diagnosis so detailed of the performances recorded by the Romanian R&DI system clearly shows its strengths and weaknesses, i.e. the directions in which the efforts to remove the existing dysfunctions need to be intensified, a very complex and lasting approach, requiring the existence of a science and technology strategy which, for the time being, is missing.

Conclusions

- The R&DI system, whose essential role is to ensure the penetration of scientific and technological progress in all areas of society, and in the economy and manufacturing industry - their modernization and the increase of their competitiveness -, continued, after 2000, its unfavorable development 1990. This reality is reflected by most of the indicators that concern the different dimensions of the system - its financing, the workforce used, its performance, the inclination towards innovation of the enterprises, the participation of the performance sectors in supporting the activities;
- The reasons for the drastic reduction of the R&D system, some perpetuated from the planned economy period, chronicled and manifested more pronouncedly after 1990, were under-financing, precarious state of the technical infrastructure, lack of adequate staff motivation, onerous privatization of numerous institutes and centers of research/development/design and loss or fraudulent appropriation of their technical archive (intangible assets, good will), modest demand for research and design projects from enterprises, legislative gaps, bureaucracy, burdensome taxation and insufficient incentives in the field of intellectual property, lack of risk-capital in financing the activities;
- The evolution of the system is shown by the almost continuous decline of the Innovation index ascribed by the European Innovation Scoreboard to Romania, which is determined on the basis of an in-depth assessment of the state of the system in the member countries, taking into account its dimensions and indicating the progress and regression elements that registered each dimension. Structured, according to the level of this aggregate index, in the Modest Innovators group, Romania ranks last among the member countries. The strengths of the Romanian R&D system highlighted in the European Innovation Scoreboard 2017 publication demonstrate that - with a judicious science and technology strategy and

appropriate policies to put it into practice aiming to overcome existing malfunctions -, the system can be reestablished to fully fulfill its mentioned role.

References

1. Chivu, L., Ciutacu, C. and Georgescu, G., 2016. *Descompunerea şi recompunerea structurilor industriale din România. Repere de strategie* (De-composition and re-composition of industrial structures in Romania. Strategy reference points), Centrul de Informare şi Documentare Economică, Bucharest.
2. European Commission, 2017. Innovation Union Scoreboard.
3. EUROSTAT, different websites.
4. Iancu, A., 2003. Decalaje şi convergenţe tehnologice între ţările centrale şi cele periferice europene (Technological disparities and convergence between central and peripheral European countries), *ŒCONOMICA*, no. 4/2003, Societatea Română de Economie, Institutul Român pentru Libera Iniţiativă, Bucharest, 2003.
5. National Institute of Statistics (NIS). *Anuarul Statistic al României* (Romanian Statistical Yearbook), different yearly issues.
6. Organization for Economic Cooperation and Development, 1992. Programme on technology and the economy, OECD, Paris.
7. Porter, M., 2004. Competitive advantage: creating and sustaining superior performance, Free Press, New York.
8. Russu, C., 2015. Specializarea industriei prelucrătoare din România în cadrul Uniunii Europene (Specialization of the Romanian manufacturing industry within the European Union), Academia Română, Institutul Naţional de Cercetări economice, Centrul de Economia Industriei şi Serviciilor, Bucharest.
9. Voinea, L., Simionescu, L., 2005. *Annual Survey Report on Research, Development, Innovation and Competitiveness in the Romanian Industry*, Group of Applied Economics – GEA, Bucharest.
10. World Economic Forum, 2014. *The Europe 2020 Competitiveness Report. Building a more Competitive Europe. Insight Report*, 2014 Edition, Geneva.
11. World Economic Forum, 2017. *The Global Competitiveness Report 2017*-2018, Insight Report, Geneva.