

GAP ANALYSIS OF THE RESOURCES AND RESULTS OF THE NATIONAL RESEARCH-DEVELOPMENT SYSTEM FROM THE PERSPECTIVE OF TECHNOLOGY TRANSFER PROCESSES

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ABSTRACT

The gap analysis aimed to determine the gaps between Romania and the European Union average or between Romania and the Eurozone average both for the resources allocated to the national research-development and innovation system and for the results of the research-development and innovation activity that are most frequently the object of technology transfer processes between the research system and the productive sector. The gap analysis was performed in order to prefigure the solutions to reduce the gaps and to determine the period of elimination of the gaps Romania - EU average existing in terms of resources and results of the research system from the perspective of the possibility of integrating them in technology transfer processes.

KEYWORDS: *technology transfer, processes, gap*

1. INTRODUCTION

The relationship between the national research-development and innovation (RDI) system and the assimilation of development research results by different fields in the productive sector is, in the case of Romania, one of the elements that concern both researchers and decision-makers in the field of research-development in Romania. Equally important, from the perspective of both categories of entities involved in technology transfer processes (research entities and organizations in the productive sector) are the existing gaps in this field between Romania and the European Union. It has also existed in the past and there is still a concern about the time needed to reduce / recover these gaps.

The gap analysis aimed to determine the gaps between Romania and the European Union average or between Romania and the Eurozone average both for the resources allocated to the national RDI system and for the results of the RDI activity that are most frequently the object of technology transfer processes between the RDI system and the productive sector. The gap analysis was performed in order to prefigure the solutions to reduce the gaps and to determine the period of elimination of the gaps Romania – EU average existing in terms of resources and results of the RDI system from the perspective of the possibility of taking them in technology transfer processes.

2. LITERATURE REVIEW

In the literature, before this research, there were several approaches to the relationship between the resources allocated to national RDI systems and research results that can be input into technology transfer processes with final beneficiaries in the productive sector. The subject was equally interested, in different periods, both researchers focused on the analysis of national systems of RDI and those who analyzed the effects of assimilating the results of research – development as a result of technology transfer processes.

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Vitola and Erina (2015) conducted for the Baltic States an analysis of the relationship between universities' research and development expenditures and research and development performance indicators. The results obtained from the research conducted by Vitola and Erina (2015) showed that not all performance indicators of the RDI systems of the analyzed states were equally influenced by the financing of research and development expenditures of universities. A limitation of this research is the fact that other component entities of the national research system were not taken into account, such as research and development institutes financed from public sources, but also research and innovation from private companies. In Romania, for instance, many SMEs are involved in innovation (Nicolescu L. & Nicolescu C., 2012) and their contribution to the national economy is significant (Nicolescu, 2013).

Nilsen, Raknerud and Iancu (2020) analyzed the link between public support for research and development and the performance of firms in economic sectors that received support. The analysis took into account three forms of public support for research and innovation: innovation-oriented policies, tax reduction schemes and other forms of support. The effect of most forms of public support for R&D has been positive for R&D-starters, while no significant effect was found in case of R&D-incumbents.

Catching-up models were initially developed on the assumption that countries that technologically mimic advanced ones benefit from faster economic growth than the latter. For analysis of the recovery of the gaps applicable in the field of research – development, specific models were developed by Sung and Carlsson (2003), Lackenbauer (2004), Havlik (2005). In Romania, the application of catching-up models for determining the periods of elimination of gaps was made by Goschin Z., Sandu and Goschin G.G. (2015) and Sandu and Păun (2009).

3. RESEARCH METHODOLOGY

The gap analysis was performed based on the determination of the Romania – European Union and Romania – Eurozone gap indices (chain-based indices) and the study of their evolution over time. The data on which the analysis was performed are those from Eurostat databases.

The gap analysis regarding the resources of the research-development and innovation system in Romania was performed, as we mentioned before, having two reference systems: the average of the EU area and the average of the Euro Zone. As resources of the research systems in the gap analysis were taken into account: total expenditures on research and development activity and expenditures for research and development at regional level.

The gap analysis regarding the results of the national research-development and innovation system was performed for those results that can constitute the inputs of the technology transfer processes: industrial design applications submitted at community level; industrial design applications registered at Community level; trademark applications at EU level.

Catch-up models were used to determine the gap elimination period. In the research we applied the model used by Sandu and Păun (2009) which is a particularization for the field of research – development and innovation of those made by Nelson and Phelps (1966), who considered that the rate at which theoretically possible technology can be assimilated in practice depends on the level of education and the gap between the level of theoretically possible technology and the level of technology applicable in practice. In the model proposed by Nelson and Phelps, the gap was measured as the difference between the level of technology theoretically possible and that of technology applied in practice (and as a ratio between this difference and technology applied in practice).

The catching-up model was applied to determine the gaps between the Romanian RDI system and the European Union average in terms of resources and results related to the RDI system.

Table 1. Variables used in research

Indicator	Unit of measurement	Period	Reference
R&D personnel	Full-time equivalent	2010-2018	Eurostat (2020a)
Total R&D expenditure	Million euro	2010-2018	Eurostat (2020b)
R&D expenditure (macroregions and regions)	Euro per inhabitant	2014-2017	Eurostat (2020c)
Total expenses with research and development activity	Million euro	2010-2018	Eurostat (2020b)
Government sector research and development expenditures	Million euro	2010-2018	Eurostat (2020b)
Private sector research and development expenditures	Million euro	2010-2018	Eurostat (2020b)
Industrial design applications submitted at Community level	Number	2014-2016	Eurostat (2020d)
Industrial design applications registered at Community level	Number	2014-2016	Eurostat (2020e)
Trademark applications at EU level	Number	2014-2016	Eurostat (2020f)

Source: authors according to the mentioned references

4. RESEARCH RESULTS

From the analysis of the data presented in Figure 1 it is observed that the evolution of the EU-Romania gap media indices and the Eurozone average – Romania regarding the research-development personnel is relatively similar:

- the period 2010-2013 is one of reducing the gaps in terms of research and development staff both for the EU-Romania average gap and for the Eurozone-Romania average gap (with a single point of increase of the gaps – 2011);
- the period 2014-2018 is a resumption of the upward trend of the gaps in terms of research and development staff both for the EU-Romania average gap and for the Euro area -Romania average gap (except for 2016);
- surprisingly, over the whole period analyzed, the EU-Romania average gap is higher than between the Eurozone average and Romania, a situation that can be explained by the relatively low dynamics of staff turnover in the research and development system in developed Eurozone countries.

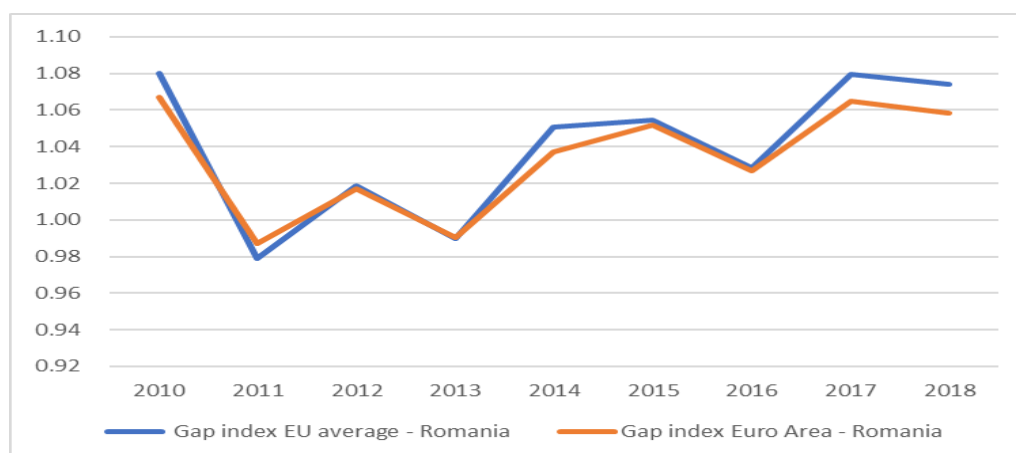


Figure 1. Evolution of EU-Romania average gap indices and the mean of the gap Eurozone - Romania in terms of research and development personnel

Source: own calculations based on Eurostat (2020a)

Regarding the personnel involved in the research-development and innovation activity, the way of reporting the statistical data at national and European level can create some problems of interpretation as not always the personnel reported by the private sector as R&D personnel is also certified personnel in research and development. Also, in the statistical reports both at national and European level, the personnel reported as research-development personnel is not always the one who holds employment contracts related to positions corresponding to occupations in the COR classification specific to research and development.

The analysis of the evolution of the gap indices regarding the total expenditures with the research – development activity both for the Romania – European Union gap and for the Romania – Eurozone gap is presented in Figure 2.

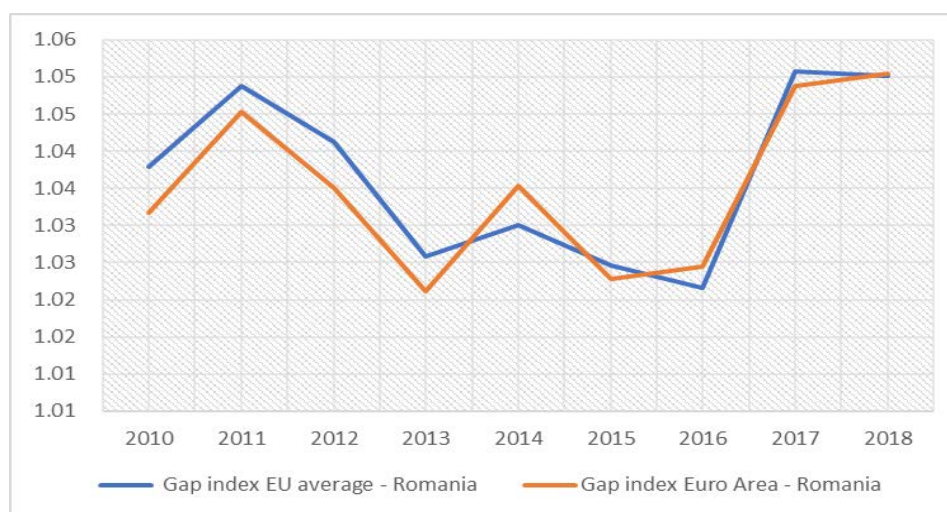


Figure 2. Evolution of the EU-Romania average gap indices and the Eurozone-Romania average in terms of total expenditure on research and development

Source: own calculations based on Eurostat (2020b)

However, we consider that regarding the statistical data related to the expenditures for the research-development activity of the private sector there are a series of uncertainties regarding their concordance with the financial-accounting reports which include the exclusive expenditures of the private organizations made exclusively for research services – development. Regarding the research-development and innovation system in Romania, not only the expenditures made at national level but also those made at regional level are important. In this sense, in the research we determined the gap of the regions in Romania compared to the average of the European Union and to the Eurozone in terms of expenditures for research and development at regional level expressed in euro / inhabitant. The EU 27 average gap for R&D expenditure at regional level (expressed in euro / capita) is presented in Table 2.

The gaps compared to the European Union average are different at macro-regional and regional level in terms of expenditure on research and development. Significant differences are also found in the evolution of gap indices from one year to another compared to the European Union average. In general, the macro-regions and regions where concentrations of strong research centers are found at territorial level (in research institutes and / or universities as is the case in the North-West, Bucharest-Ilfov or West regions) register smaller gaps over the whole period considered in relation to the situation in macro-regions or regions that include fewer publicly funded research centers.

Table 2. EU 27 average gap index for R&D expenditure at regional level expressed in euro / capita

Explanations / Years	2014	2015	2016	2017
Macroregion one	0.12	(8.19) *	0.12	(1.21)
North-West	8.63	(2.60) *	(0.29) *	0.99
Center	(0.15) *	1.81	1.24	0.18
Macroregion two	1.07	0.61	1.85	1.18
North-East	1.14	0.01	126.82	1.25
South-East	1.02	0.97	1.01	1.12
Macroregion three	1.03	1.33	1.25	1.28
South	(1.10) *	0.88	5.09	0.41
Bucharest -Ilfov	1.00	1.33	1.21	1.30
Macroregion four	1.85	(0.19) *	1.13	1.24
South-West	1.22	0.75	1.37	0.70
West	(26.51) *	(2.14) *	1.30	0.83

Note: * negative values that show that there is no gap but on the contrary in the period considered the region / macro-region is above the EU average

Source: own calculations based on Eurostat (2020c)

There are strong fluctuations of the gap indices from one year to another even in the case of some regions that include research centers of some universities, national institutes or institutes of the Romanian Academy. This situation revealed by the research carried out on the basis of Eurostat data has as causes:

- the accentuated discontinuity of the research funding at regional and macro-regional level in Romania;
- the dependence of important research centers at regional level on the flow of publicly funded research projects;
- the dependence of the extent of research and development expenditures on the frequency of competitions at the level of national public research and development financing programs;
- focusing research funding at regional level on public sources and less on private sources.

The accentuated discontinuity of research funding at regional and macro-regional level in Romania leads to staff fluctuations due to the impossibility of ensuring a continuous flow of projects and the loss of important human resources for the future national research-development and innovation system. A second consequence of the discontinuity is the cessation of the activity of some important research centers but located, at territorial level, outside the areas where the important university centers are located (Table 3).

The gap index compared to the euro area average for R&D expenditure at regional level expressed in euro / capita shows higher gaps for most regions compared to the European Union average but with a less pronounced gap dynamics (in the case of the Euro area average benchmark). The situation is explicable given that the Eurozone is the most developed country in the European Union, with significant public and private allocations for research and development expenditure. With the exception of the Western region in one year (2015), there are no situations in which there are reports of deviations from the Eurozone average.

Table 3 Gap index compared to the euro area average for R&D expenditure at regional level expressed in euro / capita

Explanations / Years	2014	2015	2016	2017
Macroregion one	0.76	0.57	1.66	1.16
North-West	1.24	0.35	2.82	1.04
Center	0.48	0.91	0.96	1.39
Macroregion two	1.05	0.83	1.30	1.11
North-East	1.07	0.66	1.79	1.13
South-East	1.03	1.00	1.02	1.08
Macroregion three	1.02	1.44	1.30	1.33
South	0.90	1.04	0.76	1.33
Bucharest -Ilfov	1.00	1.37	1.23	1.32
Macroregion four	1.28	0.50	1.01	1.01
South-West	1.12	0.89	1.17	0.88
West	1.61	(0.06)	4.51	0.24

Source: own calculations based on Eurostat (2020c)

In the case of industrial design (see figure 3), it is important to study the dynamics of the gap with regard to industrial design applications submitted at European level and those of industrial design registered at European level. The available data that have been analyzed are those from 2014-2016.

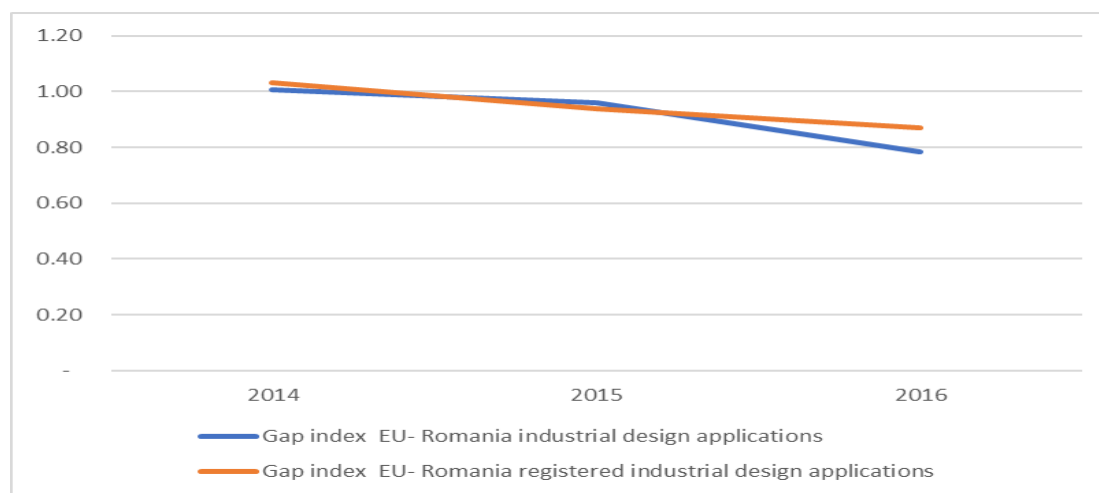


Figure 3 Dynamics of gap indices for industrial design applications submitted at Community level and for industrial design applications registered at Community level

Source: own calculations based on Eurostat (2020d; 2020e)

As in the case of the dynamics of gap indices regarding industrial design (according to Eurostat data and indices determined on the basis of them) and those related to trademarks a decline in the gap between the national research and development system in Romania and the European Union average. Although in absolute values the difference between the average number of trademarks registered at Community level and the number of trademarks registered in Romania is very high, the trend in the analyzed years is a certain one of reducing the gaps (Figure 4)

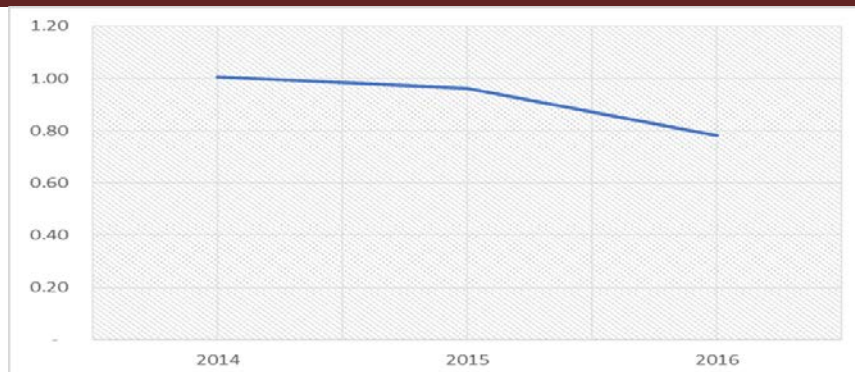


Figure 4 Dynamics of gap indices for trademarks

Source: own calculations based on Eurostat (2020f)

The results obtained for determining the gap elimination period by using catching-up models regarding the resources allocated to the Romanian RDI system are presented in table 4.

Table 4. The period for eliminating the gaps in the resources allocated to the R&D system in Romania

No.	Explanations	Recovery period (years) compared to the EU average
1	Government sector research and development expenditures	70
2	Private sector research and development expenses	58

Source: own calculations based on Eurostat (2020b)

There is a very long period of recovery of the gaps in terms of research and development expenditures of the government sector. A relatively shorter gap recovery period occurs for private sector spending. It was not possible to determine the gap elimination period by using catching-up models for research and development staff because in the case of this indicator the average annual rate in the European Union is higher than the annual rate of the indicator in Romania. In the case of this indicator, the tendency is therefore to accentuate the gaps, not to reduce them.

Another important element regarding the reduction of the gaps is the determination of the average annual growth rate necessary for the reduction of the gaps to be achieved in a more optimistic perspective than the one resulting from the application of the chosen catching-up model. Thus, the following landmark periods for reducing the gaps were chosen: 30 years, 20 years, 10 years. The results obtained are presented in the following table.

Table 5. Average annual rates needed to reduce the gap elimination period in terms of resources allocated to the R&D system in Romania

No.	Explanations	Average annual rate required to close the gap in 10 years (%)	Average annual rate required to close the gap in 20 years (%)	Average annual rate required to close the gap in 30 years (%)
1	Total expenses with research and development activity	56	30	20.5
2	Government sector research and development expenditures	31	16,5	11.5
3	Private sector research and development expenses	60	32	22.5

Source: own calculations based on Eurostat (2020b)

Analyzing the data in the previous table, we can see the huge effort that the Romanian research system should make regarding the expenditures allocated by the governmental and private sectors to recover the existing gaps compared to the European Union average during only 10 years (rates average annual growth rates between 31% and 60%). The scenarios for recovering the gaps in the perspective of 20 or 30 years seem much more probable, although in these cases there are double-digit annual growth rates, relatively difficult to achieve in the current context of financing the research system in Romania.

The results obtained for determining the gap elimination period by using catching-up models regarding the results of the Romanian RDI system are presented in table 6. The results that matter most from the perspective of the inputs of the technology transfer process were followed.

Table 6 The period of eliminating the gaps in the results of the RDI system in Romania, which constitute inputs in the technology transfer processes

No.	Explanations	Recovery period from the EU average (years)
1.	Industrial design applications submitted at Community level	10
2.	Industrial design applications registered at Community level	19
3.	Trademark applications at EU level	50

Source: own calculations based on Eurostat (2020d; 2020e; 2020f)

The data presented in Table 5 show the relatively short gap recovery periods in terms of industrial design applications / models and the very long ones in terms of trademarks or patents. The more the commercial potential of the results that can constitute inputs in the technological transfer processes increases, the bigger the gaps that must be recovered by the Romanian research system in relation to the European Union average.

5. CONCLUSIONS

The research presented in this article focused on the analysis of the gap between the resources and the results of the national research-development and innovation system in Romania and the average of the European Union or the Eurozone. The analysis of the gaps in terms of results was performed mainly for those types of results of the activity of applied research, technological development and innovation that may be the subject of technology transfer. The results obtained seem to confirm the existence of significant gaps in the resources allocated to research and development and innovation (especially research and development expenditures). Large gaps can also be observed in the research results that are the subject of technology transfer.

Due to these reasons, the time needed to recover the gaps compared to the European Union average is very long and the pace at which the national research and development system should benefit from resources is much higher than the current or past situation. For this reason, the importance of the results presented for the management of the national research and development system is obvious.

At macro-regional and regional level, the gaps compared to the European Union average are different both in terms of the results of the research activity and the resources allocated to this activity. Macro-regions and regions where concentrations of strong research centers (universities or research institutes) are found at territorial level have smaller gaps than the European Union average. Between the lack of resources of the research and development sector in Romania and the reduced capacity of this sector to provide results to be transferred to the entities in the productive sector

seems to be a relationship that is decisive for the difficulties of Romanian organizations to innovate at the pace they have companies from other European countries.

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REFERENCES

- Eurostat. (2020a). *Total R&D personnel by sectors of performance, occupation and sex (rd_p_persocc)*, retrieved August 8, 2020, from: https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=rd_p_persocc&lang=en.
- Eurostat. (2020b). *Intramural R&D expenditure (GERD) by sectors of performance and type of costs [rd_e_gerdcost]*, retrieved August 8, 2020, from https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=rd_e_gerdcost&lang=en.
- Eurostat. (2020c). *Intramural R&D expenditure (GERD) by sectors of performance and NUTS 2 regions [rd_e_gerdreg]*, retrieved August 10, 2020, from https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=rd_e_gerdreg&lang=en.
- Eurostat. (2020d). *Community design (CD) applications [ipr_da_tot]*, retrieved August 10, 2020, from https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=ipr_da_tot&lang=en
- Eurostat. (2020e). Registered Community designs (RCD) [ipr_dr_tot], retrieved August 10, 2020, from, https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=ipr_dr_tot&lang=en
- Eurostat. (2020f). *European Union trade mark (EUTM) applications [ipr_ta_tot]*, retrieved August 10, 2020, from: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=ipr_ta_tot&lang=en.
- Goschin, Z. (2014) R&D as an Engine of Regional Economic Growth in Romania, *Romanian Journal of Regional Science*, Romanian Regional Science Association, 8(1), 24-37.
- Goschin, Z., Sandu, S. & Goschin, G.G. (2014) New Trends In R&D Disparities Among EU Countries. A Sigma Convergence Approach, *Annals of Faculty of Economics, University of Oradea, Faculty of Economics*, 1(1), 461-470.
- Goschin, Z., Sandu, S. & Goschin, G.G. (2015) How soon could Romania close the R&D gaps against EU-28?, *Procedia Economics and Finance*, 22, 160 – 167, doi: 10.1016/S2212-5671(15)00251-8.
- Havlik, P. (2005). Central and East European Industry in an Enlarged European Union: Restructuring, Specialisation and Catching-up, *Economie Internationale*, 102, 107-132.
- Lackenbauer, J. (2004) Catching-up, Regional Disparities and EU Cohesion Policy: The Case of Hungary, *Managing Global Transitions*, 2(2), 123-162.
- Nicolescu, L. & Nicolescu, C. (2012). Innovation in SMEs – Findings from Romania. *Economics & Sociology*, 5(2a), 71-85.
- Nicolescu, C. (2013) Romanian SMEs in context of national and international complex evolutions, *Proceedings of the International Management Conference*, 7(1), 366-373.
- Nelson, R.R. & Phelps, E.S. (1966). Investment in humans, technological diffusion and economic growth, *American Economic Review*, 56(2), 69-75.
- Nilsen, Ø.A., Raknerud, A. & Iancu, D.-C. (2020) Public R&D support and firm performance: A multivariate dose-response analysis, *Research Policy*, 49(7), 1040672, doi: 10.1016/j.respol.2020.104067.
- Sandu, S. & Paun, C. (2009) Evaluarea posibilitatilor de recuperare a decalajelor dintre Romania si UE in domeniul CD&I, *Studii Economice*, 3-26.
- Sung, T.K. & Carlsson B. (2003) The evolution of a technological system: the case of CNC machine tools in Korea, *Journal of Evolutionary Economics*, 13(4), 435-460.
- Vītola, L. & Eriņa, J. (2015) R&D Expenditures by Higher Education Sector and Analysis of Performance Indicators of Baltic States, *Procedia – Social and Behavioral Sciences*, 213, 223-228, doi: 10.1016/j.sbspro.2015.11.430.