"Increasing the capacity of the RDI system to respond to global challenges. Strengthening anticipatory capacity to develop evidence-based public policies" - POCA 127557, SIPOCA 592

Analysis of the factors that obstruct the diffusion of innovation

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EXECUTIVE SUMMARY

The report tries to shed light on the barriers of the diffusion of innovation in Romania.

Innovation is critical in the modern economy. The total factor productivity growth (TFP), the "unexplained part" of the GDP growth, such as technological progress, human capital, and institutional and cultural factors is considered the best predictor of cross-country variations in living standards (OECD, 2011) and the main determinant of long-term economic growth (Global Competitiveness Report (GCI), 2019)[3]. The innovative activity is considered the most important component of long-term economic growth.[4] As the relative national advantage of cheap labour force errodes, there is a need to shift focus towards innovation driven economic growth. A strong innovation ecosystem requires macroeconomic stability, strong institutions, good infrastructure, ICT readiness, stable regulatory frameworks and a market that is receptive to new ideas. **Investing in people (education, health, wellbeing) is a fundamental building block of growth**. There is need also for strong entrepreneurial culture, companies embracing disruptive ideas, multistakeholder collaboration, critical thinking, meritocracy, social trust, a strong entrepreneurial culture and innovation capability. '*With the right skills, workers can become the actors of the economic transformation rather than becoming victims of it*.' (Global Competitiveness Report, 2018)[5]

The analysis, herein provided, integrates all the elements *of the Quadruple Helix and Isenberg´s model of entrepreneurship ecosystem*. These are presented in a holistic approach in the body of the report. For simplification the elements are clustered within the four main knowledge domains: *resource mobilization knowledge production knowledge circulation knowledge demand* which are herein further analysed from the perspective of the Theory of Diffusion of innovation (DoI) (Rogers, E., 1962)[6]. **Diffusion here signifies the phenomenon through which an innovation spreads**. Rogers proposes that **five main elements** influence the spread of a new idea:(1) the **innovation[7],** (2) the **communication channel**s through which this spreads, (3) the potential **adopters** and their features, (4) the **social system in** which the whole process takes place and (5) the **time** that need to pass for the whole process to happen. All **the elements must be analysed when trying to promote the innovation**. Depending on the characteristics of these elements, **different strategies should be adopted.**

Adoption of the innovation does not happen simultaneously: some adopters are more able/willing to adopt the innovation than others. There are five established adopters categories: **innovators, early adopters, early majority, late majority, laggards**.

[3] GCI 2019, https://www.weforum.org/reports/global-competitiveness-report-2019
[4] https://www.brookings.edu/wp-content/uploads/2016/06/08_innovation_greenstone_looney.pdf
[5] GCI 2018
[6] Rogers, E. (1962) Diffusion of innovation
[7] innovation = new or significantly improved product (good or service),. or process,. a new marketing method, or a new organizational method in internal business practices or in the open workplace" (OECD, 2005))

The report identifies the regional disparities, but focuses on those cross-cutting, significant problems, present in all regions and NACE fields. The legislation, regulation are national and do not have regional specificity. The problems are common in all regions, but specific attention should be given to the **biomedical, ICT, energy** field where the relevant legislation/regulation/characteristics of these sectors may require a distinct analysis. Some examples are provided in the report.

No detailed, sound analysis/evaluation assessing the integrated impact of SNCDI 2014-2020 on specific smart specialisation domains was available at the date of the report. Neither any comprehensive, recent analysis of the whole RDI system (performance of institutions, policies, governance, programmes, institutions) has been performed. This type of analysis goes well beyond the scope and the resources of this report.

The reader **should bear in mind that the low level of the R&D funding, significantly below the targets assumed by the strategy, further aggravated by the lack of predictability, can not have a significant positive impact on the science base/knowledge production and even less at the macroeconomic level**. The smart specialisation domains are broad and include several NACE sectors/scientific fields. Author's analysis of statistical data regarding time evolution of input – output indicators (such as public R&D expenditures on specific smart specialisation domains, HRST in business sector, BERD, output indicators by NACE/scientific fields etc) could not identify any significant correlation at the time of the analysis (funding under SNCDI 2014-2020 will continue until 2023). A thorough evaluation of all R&D funding instruments on specific smart specialisation domains must be performed ex-post in order to identfy correlation and impact.

Specific obstacles were identified at all levels of the innovation ecosystem/of the diffusion of innovation. The problems identified are **severe and chronic**. Some are **transversal, systemic challenges** and affect the 'social **system**' as a whole. While data are provided across the report to position Romania in the EU28 landscape, the analysis tries to go **beyond these data and see the push-pull factors that have shaped the current situation.**

The analysis provides evidence that unless the main **systemic challenges** will be addressed, RDI policy measures may not have the strength to produce the change.

For diffusion of innovation to happen, **firstly quality research has to be performed, in order to generate new knowledge that could lead to innovation**. Various empirical studies demonstrate that **the quality of research is key to maximising its economic and social impact**. There is a positive correlation between the quality of research results and those elements essential to its capitalisation, such as the involvement of researchers in collaboration or commercialisation activities (patents, start-ups). The research must be undertaken by a critical mass of **researchers**, having the relevant skills and expertise, connected to the international community and using state-of-art research equipment. **In the context of chronic underfunding, the science base has been under strain. The knowledge production is low in EU comparison.**

Communication channels. Rogers mentions **ties**, **opinion leaders**, **social learning**, and **critical mass** as important concepts. In Romania, the ties are still weak, the voices of the opinion leaders are low, while the social learning is emerging. Social modeling can happen through networks as well as through public displays (i.e. mass media). The connection with international peers is weak, while display of the success through innovation in popular media is mainly absent.

Adopters. The SME landscape is dominated by laggards/late majority with **some notable exceptions** of top innovators, particularly in ICT and automatization. The innovators are mainly among the large companies, multinationals.

Besides the systemic challenges, and chronic underfunding, many other elements affect the diffusion process. They are summarised below.

Systemic challenges

These affect significantly the capacity of RDI performers to produce knowledge and particularly the capacity of potential adopters to undertake research, development and innovation (RDI) activities/ or to adopt innovation.

Skills and human resources shortages are identified as the main obstacle perceived by the business sector in considering performing RDI. This is reflected also in the lowest scores on the pillars Skills / Human Capital dimension & Health in Global Competitiveness Index (GCI) 2018[8] and European Innovation Scoreboard 2019 (EC, 2019)[9]. Romania's position is particularly low in the GCI ranking of 140 economies in the dimensions Skillset of graduates (131), Ease of finding skilled employees (133), Internal Labour mobility (135). The shortages are generated by a combination of factors:

- There is a **negative natural demographic trend** (INSSE, 2019). This will lead to a decrease of the population to around *15 million by 2050 in the case of zero migration and constant mortality/ constant fertility*. To this adds the **high level of emigration**. Romanian **diaspora is the fifth largest** in the world and has the highest growth rate in recent years. Around 3.6 million, 17% of Romanians live in OECD countries (OECD, 2019)[10]. The demographic decline will **entail also changes in the various sub-populations** (school population, population of childbearing age, working age population). "*Without the recovery of the birth rate, the demographic decline and depopulation of the country will increase in size, and the further deterioration of the age structure and the accentuation of the demographic aging will aggravate the economic and social consequences of large imbalances between the elderly and working age population." (Ghetau V, 2016)*[11]
- **Brain drain**: In 2015/2016 Romania **had the highest emigration rate of highly educated,** rate which increases more rapidly than the number of national tertiary graduates. (OECD, 2019). Around **760,000 highly educated Romanians** live in OECD countries.
- Various academic studies show that the level of **citizens' education is one of the most important determinants for innovation** (McNeal et al. 2007[12]; de Guzman, 2012). **The national education system fails to equip the bulk of the students with the relevant skills**. Education in Romania is chronically underfunded. Dropout rates are high. Access to quality education and the acquisition of basic and digital skills is limited. One in five students fail to make the transition to upper secondary education. In 2016, 23.6% of the population aged between 25 and 34 had not completed lower secondary education, compared to the EU average of 16.6% (EC,

[8] https://www.weforum.org/reports/the-global-competitveness-report-2018
[9] European Commission (2019), European Innovation Scoreboard 2019, Country Profile, available at: https://ec.europa.eu/docsroom/documents/35908
[10] OECD (2019(a)), Talent Abroad: A Review of Romanian Emigrants, OECD Publishing, Paris, available at: https://doi.org/10.1787/bac53150-en
[11] https://www.zf.ro/suplimente/vasile-ghetau-populatia-romaniei-la-10-ani-de-ue-16004069
[12] McNeal, R., et al. (2007). "E-disclosure laws and electronic campaign finance reform: Lessons from the diffusion of egovernment policies in the States" Government Information Quarterly 24(2): 312-325.

2018). A **significant share of 18 years** population **will not reach** the baccalaureate level (UEFISCDI, 2017).[13] International surveys (i.e. Programme for International Student Assessment - PISA)[14] point to severe deficiencies in basic skills among Romanian teenagers. Romanian education system currently enables only a minority of its students to excel. And many of the high achievers go abroad and do not return.

- **Romania faces important challenges regarding the decreasing number of students in tertiary education**: from 2006 to 2016 the total number of students dropped by 17%. Tertiary educational attainment (age 30-34) in 2017 was 26.3 % compared to 40.6% in EU28.
- The supply of skills is NOT correlated with the needs of the economy.
- The labour market relevance of vocational education and **training (VET)** is still a challenge. In 2018, only 0.9% of adults aged 25 to 64 had a recent learning experience (compared to EU28 average of 11.1%). (EUROSTAT 2019)

The persistent loss of the high-level professionals, in whom the country invested, while failing to provide a flexible, coherent education to the bulk of the young population, may be on long term one of the most damaging systemic challenge.

In general, a positive association seems to exist between **community wealth and the likelihood of innovating** and its adoption to happen (Ahn, M. 2011[15]; Manoharan, A 2013[16])**.** Sweden, Denmark and Finland have not only become among the world's most technologically advanced, innovative and dynamic economies in the world, but are also providing better living conditions and better social protection, are more cohesive, and more sustainable (GCI, 2019). The recent economic growth in Romania has not be transferred in a significantly improved quality of life.

The **volatility of the legal framework**, the **unpredictability**, both from the market and taxation point of view generate significant time efforts for companies to understand and comply to changing requirements. The National Council for Small and Medium Private Enterprises in Romania (CNIPMMR) concluded that **1,388 normative acts were adopted in 2017**.[17] In addition, 3,344 orders were issued by the Minister of Finance and 1,907 orders by the Minister of Labor."[18] In the Community Innovation Survey (CIS) 2016 study, a large share of companies (31.3%, second highest in EU28) considered that **tax regulation** creates uncertainty.[19] A higher share of SME compared to large companies (more than 250 employees) perceive taxation as a major factor hindering innovation.

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[13] UEFISCDI, (2017) Policy brief - Analiza datelor statistice privind accesul și rezultatele candidaților care au participat în cadrul celor două sesiuni de bacalaureat - 2017, No.2, 2018 https://uefiscdi.gov.ro/Publicatii-1

[14] PISA is the OECD's Programme for International Student Assessment. Every three years it tests 15-year-old students from all over the world in reading, mathematics and science.

[15] Ahn, M. J. (2011), Adoption of E-Communication Applications in U.S. Municipalities: The Role of Political Environment, Bureaucratic Structure, and the Nature of Applications. The American Review of Public Administration 41(4): 428-452

[16] Manoharan, A. (2013), "A Study of the Determinants of County E-Government in the United States." American Review of Public Administration 43(2): 159-178.

[17] http://cnipmmr.ro/wp-content/uploads/2019/05/CATALOG-INTERIOR.pdf

[18] POCA project Creșterea capacității administrative a Ministerului pentruMediul de Afaceri,. Comerț și Antreprenoriat de dezvoltare și implementare a sistemului de politici publice bazate pe dovezi"code SIPOCA 5
https://www.digi24.ro/stiri/actualitate/politica/consiliul-imm-urilor-in-2017-290-de-modificari-la-codul-fiscal-861338

[19] https://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do Innovative enterprises whose innovation activities have been affected by legislation or regulations by subject of the regulation/legislation, type of effect, NACE Rev. 2 activity and size class

The **low quality of the large infrastructure** (transport in particular, telecommunications, energy) etc. is listed also as one of the top ten major challenges faced by SMEs in The White Book of SMEs (2019).[20]

Overly cautious / burdensome regulations also affect the innovation.

Resource mobilisation

The innovation leaders in EU are those Member States (MS**) with the highest RDI investments (SE, DK, Fi, DE). The correlation is evident also for modest innovators: RO has had one of (if not) the lowest GERD and has had one of the lowest innovation performance in the recent years.**

- The R&I system is **chronically underfunded**. Romania, allocated in 2018 the lowest GERD per capita in EU28 (52.5 EUR per capita, compared to 656.8 EUR the EU28 average). In 2019, the public intensity for RDI was around 0.12% (vs the target of public investement in R&D of 1% by 2020).
- The **National Strategy for Research Development and Innovation (SNCDI) 2014-2020 is in theory based on multi-annual planning.** The R&D investement **target is 2%** by 2020 (1% public+1% private). All national governments committed in strategic documents to the GERD targets, but this has remained **political rhetoric.** The **lack of science awareness** increases the vulnerability of the national R&D budget.
- The **low importance of R&D in the political agenda** is demonstrated also by the **low share of cohesion funds** allocated for the thematic objective 'Research&innovation" in the current policy cycle. Romania has the lowest share of ESIF allocated for R&I for 2014-2020 in the region (Curaj, A 2015). If Romania has the 6th largest European Structural and Investment funds (ESIF) budget allocation among all the EU countries, it drops to the 13th position for the thematic area R&I (Chioncel, M.2017).[21] The lack of the predictability of the funding, delays in implementation have further deteriorated the situation. The planned ESIF budget for R&I is 1,174,629,463 EUR. By December 2019, only 34% of this budget has been spent and 57% decided, placing RO on the fourth lowest position (only above CY, GR, SK) in EU28 (according to DG-Regio data).[22]
- The **low R&D funds are dissipated across a fragmented and polarised R&I system which lacks institutional funding schemes rigorously based on the results of regular evaluation of the performance**. From 1993 to 2017, the number of researchers has reduced (from 38612 to around 17,000), while the total number of R&D centers has increased. More RDI centers implies higher administrative costs, **lower capacity to compete internationally**, lower concentration of expertise, equipment and increased dissipation of financial efforts.
- **Business expenditure on R&D (BERD) intensity in Romania is low**, showing a revival starting 2014. It increased from 0.16% of GDP in 2014 to **0.29% in 2017**. However, it remains significantly **lower than EU28 average (1.3%).** The increase of the private investement in R&D (from simple to double) is not reflected in a similar increase of the human resources in RDI in the BES sector. Tax credits available for organizations and persons for R&D projects may have fueled the visibility and the increase of R&D funding/spending by Business Enterprise Sector (BES) due to reporting rules.
- The number of researchers in business enterprise sector (BES) holding a doctorate

[20] http://cnipmmr.ro/wp-content/uploads/2019/07/Prezentare-Ovidiu-Nicolescu.pdf
[21] https://cohesiondata.ec.europa.eu/2014-2020/ESIF-2014-2020-Fin-Implementation-total-costs-by-T/vyjd-jfhd
[22] https://cohesiondata.ec.europa.eu/themes/1

sharply **decreased to half from 2017 to 2018.** The finalisation of RDI projects supporting researchers working in BES/or the need to comply to conditions imposed for participation in R&D schemes may have triggered a temporary and lacking long term sustainability increase.

- The RDI activity is risky. Fiscal incentives, among other measures, can stimulate R&D in companies. The cost of R&D tax support was equivalent to 0.006% of GDP in 2016, counting to around 15% of the total government support for BERD (OECD, 2019).[23] Since 2016, significant fiscal incentives were introduced for RDI. No data are available regarding the impact of these measures. Yet, surveys indicate that **companies take limited advantage** of these facilities. Companies claim that ambiguous methodology restricts the larger usage. However, it could be also considered that many SMEs do not have the capacity to create an R&D department / to demonstrate the R&D activity as required by the methodology for expenditures to be eligible for R&D fiscal incentives.
- Author's analysis of R&D costs by category of expenses (staff, equipment, procurement, etc.) shows that their shares in the total budget are aligned to those of EU28, yet significantly lower as euro per head. Expenses related to staff shows the highest increase in the current cycle. This trend is not correlated with a similar increase of the staff number and likely is due to the wages' increase and the new rules related to the medical and social insurance.
- The **number of researchers per 1000 employees in Romania in 2018 was 1.99,** compared to **8.71 in EU28** (OECD). In the period 2000-2018 the gap between Romania and EU28 has increased. **Romania continues to face substantial challenges, both for increasing the number of researchers and for reducing the serious brain-drain phenomenon**. Those who have chosen to remain face significant obstacles in a system lacking predictability.

Policy. Governance

Many studies show that the **quality of governance** is an important determinant in policy design and implementation.[24,25]

- Various Strategies were designed and have been implemented during 2014-2020 policy cycle. They were not designed/nor implemented in a coordinated and integrated manner.
- The governance of the RDI has been hindered also by a fragmentation amongst Ministries and Agencies. There is no evidence that the coordination mechanisms were functional/operational. Division of responsibilities and activities added a layer of complexity and lack of clarity. The Ministry holding responsibilities for Research and Innovation, in various institutional formula (MEN, MCI, ANCSI, MEC) has had around **30** ministers since 1989 (four ministers in 2018). In November 2019, a new government entered office. The governmental reshuffle led to the reorganisation of the Ministry of Education and the Ministry of Research and Innovation, as Ministry of Education and Research (MEC). Various consultative councils were proposed during 2014-2020, some functioning for very short periods. All the frequent political changes entailed various modifications of RDI policies, delays of implementation.
- The RDI system remains **vulnerable to political and ad-hoc changes**, **stakeholders' pressure** to align the RDI priorities to specific group interest and to

[23] OECD, 2019 "R&D Tax Incentives: Romania, 2019", https://www.oecd.org/sti/rd-tax-stats-romania.pdf
[24] https://qog.pol.gu.se
[25] EC, DG-JRC, various Rhomolo papers

avoid funding based on rigorous evaluations of institutions' performance and international peer review for grant funding (since 2017).

- Most of the relevant RDI legislation/regulation is prior to Romania's accession to EU, although it underwent post-accession amendments/modifications and completions (eg the last revision of research law OG 57 is dated 2020, the R&D staff law 319 was revised in 2018, law 206 revised in 2016). However, there is need for a better alignment with the European regulation, recent changes, particularly with care to avoid contradictions in the policy design/ decision process /governance of the RDI.
- R&I governance has suffered by low administrative capacity, poor coordination, lack of human resources/expertise in foresight, evaluation, frequent legislative and institutional changes. The mid-term SNRDI 2007-2013 evaluation correctly assessed that "*while the strategy identified tool, good practices, benchmarking mechanisms, the information regarding the readiness and capacity of institutions to deploy all these tools was rather vague*" (Technopolis, 2012)[26]. Since then, no evaluation of the RDI governance has been performed, neither of the PN2, or mid term evaluation of PN3. No reviews for the implementation of RDI Strategies 2007-2013 and 2014-2020 took place.
- As far October 2019, the development regions, in line with the relevant laws, **are not administrative-territorial units nor legal entities** (Law 315/200[27], Romanian Constitution). The NUTS2 regions exist primarily for the purpose of coordinating development projects.
- In August 2019, the Committee for the Coordination of Smart Specialisation was established and became operational.

Knowledge Production

Studies show that the countries scoring low on research excellence are also those that spend less on R&I: a 'critical mass' of 1.5 % of GDP is needed to achieve excellence (S Hardeman et al, 2013).[28]

- Romania has one of the **lowest Adjusted Research Excellence scores**[29]. Indicators of the quality of the research activity, the number of total and top 10% most cited publications, the ERC success rate are **extremely low**. Romania has a low share (around 0.45% of EU total) of the H2020 funding. The low integration in ERA limits the country connection to international networks.

[26] Technopolis Group, GEA Consulting, FMMC (2012), Mid-Term Evaluation of the National Strategy and of the National RD&I Plan 2007-13 (Evaluarea intermediară a Strategiei Naționale și a Planului Național CD&I 2007-2013), București.
[27] LEGE nr. 315 din 28 iunie 2004
[28] Hardeman, S., Van Roy, V., Vertesy D. (2013), An analysis of national research systems (I): A Composite Indicator for Scientific and Technological Research Excellence, JRC Scientific and Technical reports. https://www.researchgate.net/publication/265260316_An_analysis_of_national_research_systems_I_a_composite_indicator_for_scientific_and_technological_research_excellence
[29] The Research Excellence index is a composite of four components: share of top 10% most highly cited publications per total publications (data source: CWTS); PCT patent applications per population (OECD, World Bank); Participation in Marie Skłodowska-Curie Actions (DG-EAC); ERC grants per public R&D (DG-RTD, Eurostat, OECD).

- Romania is on the **40th position in the global Scimago**[30] country ranking. The number of scientific articles (from Scopus, using the fractional method) with country affiliation Romania, increased from 2601 in 2003 to 11061 in 2012 and fluctuates around this values afterward. The increase is partially due to the demand 'publish or perish' in the academic career. During 2014-2019, Romania produced **0.44%** of the total number of scientific publications (20.07 million) in the Web of Science categories. Only **7.6% of the articles are among the 10% most cited** (compared to 12.32%, EU28 average)[31]**.**

- Out of more than 100000 Web of Science (WoS) documents produced during 2014-2020, **only 665 documents are highly cited (0.66% of the total) and 54 are hot papers**. The large majority of the highly cited papers (if not all) are written in **collaboration with top world** universities/research institutes. The top funder is the EU. **This emphasizes the need of research to be connected to the international trends and research leaders in the field**.

- During **2009-2014**, Physics and Mathematics were the two fields with the highest relative output share and normalized citation impact, while Space Science had the highest normalized citation impact but only modest contribution in comparison to the total global output share (Thomson Reuters, UEFISCD, 2015)[32]. Author's analysis of SCOPUS WoS publications (total and highly cited) during **2014-2019** show to some extent similar pattern. SCIMAGO ranking by field, indicates chemistry, materials science, mathematics, physics, engineering, computer science, health above the country ranking. **Further, rigorous scientometrics analysis is required.**

- In 2018, 2019, 2020 four, respectively five and two universities were listed in the 1000 Top QS[33] (and only one in top 500 employability ranking). None of the Romanian university has ever been included in the **Shanghai top 500** HEIs and **only two** are in top **1000 Shanghai 2019 ranking**. [34]

- Analysis of the United States Patent and Trademark Office (USPTO) database[35], using the search query: RO Inventor, RO Applicant, RO Assignee returns **30 granted USPTO** patents over the whole period covered by the database (1978-2020). Analysis of the Worldwide Statistical Patent **Database** (PATSTAT) database maintained by the European Patent Office (**EPO**) identifies around 1421 patents awarded during **2014-2020,** worldwide with a Romanian inventor. The number reduces to around 600 patents, having a Romanian inventor and a Romanian applicant. There are around **251 EPO** applications, with **RO inventor&RO applicant** during the period 2014-2020 and less than 20 EPO were granted. The Romanian contribution to **triadic patents** is low, counting to around **0.09% of EU28 total during** 2014-2019 period. During **2014-2019**, the **National Office for Inventions and Trademarks** (Oficiul de Stat pentru Inventii si Marci OSIM) registered **6416 patent applications** by nationals. Around 2092 patents (32.6% of the applications) were

[30] The SCImago Institutions Rankings (SIR) is a classification of academic and research-related institutions ranked by a composite indicator that combines three different sets of indicators based on research performance, innovation outputs and societal impact measured by their web visibility.
[31] [SEI2020S5a-35] - https://ncses.nsf.gov/pubs/nsb20206/data#supplemental-tables
[32] Thomson Reuters&UEFISCD (2015) Bibliometric Analysis of Romania's Research Output, 2005-2014
[33] http://www.topuniversities.com/university-rankings/world-university-rankings/2016
[34] http://www.shanghairanking.com
[35] https://www.uspto.gov/patent

granted.[36] The highest share of patent applications by nationals belong to persons (**47%),** around **21% to PROs**, **16% to HEIs** and **16%** to companies (author's calculation based on OSIM data). The cost of OSIM patents is not high and therefore the applications can be a good **practice in artificially producing good output indicators**. The analysis should go further, **analysing the economic impact of these patents**.

- Romania had (Corlan A, 2015)[37] and continues to have one of the **highest ratio of articles per triadic patent**. This signals that the **public research is disconnected from economic needs**.
- There are also other factors that affect the low patent activity: high USPTO, EPO patenting costs, the long 'time to patent', while the multinationals (MNC) transfer the IPR to the headquarters in order to optimise the costs and the benefits related to inventions. **Motivational factors act mainly as disincentives** for potential inventors.
- On the good side, the PN3 programme '**award' of the research results**[38] managed by UEFISCDI has offered generous financial rewards for authors of selected scientific publications and patents.

Knowledge circulation

The rate of innovation adoption is also influenced by the social system in which an innovation diffuses. Rogers mentions **weak ties**, **opinion leaders**, **social learning**, and **critical mass** as important concepts that help understand the diffusion of innovations through social networks.

- There is low level of collaboration public-private. Both sectors function in silos, responding to distinct pressures.
- In the EIS 2019[39], Romania has one of the lowest score in linkages and the **lowest position in the dimension "innovative SMEs collaborating with others"**. Some progress has been made. However, there is much space for improvement.
- The communication networks are still weak. There are some notable examples of innovative SME/start-up outperforming. However, MNC are the main innovators.
- There is **no evidence that generally technology transfer occurs from MNC to local companies**. There are **weak heterophilic** relations between the innovators and laggards. **Renault** could be identified that through networking, collaboration with local companies and the standards imposed, has supported such transfer. However, this is the advantage of a well standardized industry, as is the case of the automotive industry. Other good practice may exist (i.e. Continental), yet they are not well documented. The clusters may also play a potential role as framework.
- In Romania, the **job-to-job mobility of HRST is the lowest in EU** (2% compared to 7.8% in EU). (EUROSTAT)

[36] https://osim.ro/despre-osim/statistici-publicate-in-2020/
[37] Corlan, A. (2015), România în "Science & Engineering Indicators 2014".I. Statistica Descriptiv˘a a Indicatorilor si Ratelor. (Romania in "Science & Engineering Indicators 2014".I. Descriptive Statistics of Indicators and Rates) REVISTA DE POLITICA STIINTEI SI SCIENTOMETRIE, Vol. 4, No. 2, iunie 2015, p. 110–123, available at: http://rpss.inoe.ro/articles/205/file
[38] https://uefiscdi.gov.ro/premierea-rezultatelor-cercetarii-brevete
[39] https://interactivetool.eu/EIS/EIS_2.html

- There has been limited support to clusters.

Knowledge demand. Adopters

The target population must be assessed to understand the features that may support or hinder adoption of the innovation.

In 2018, the share of employment in agriculture of total employment (23.1% in 2018) is five times higher than in EU28. The share of employment in industry is slightly higher (19.3% compared to 15.4% in EU28), while in services (47) is substantially lower than the EU28 average (71.4%) (EUROSTAT, 2019). The number of SMEs per capita is one of the lowest in the EU (29 in Romania versus 58 average in the EU28) (EC, 2019: Annual Report of European SMEs 2018/2019).[40] The share of high-tech exports was 8.4% in 2018, less than half of the EU average (EUROSTAT, 2019).

- The Romanian companies are mainly producers, with no significant roles in the other value chain segments.
- The **total turnover in new products new to the market** is very low and dominated by **large companies**.
- The Romanian **SMEs show very low innovation activity**, with low performance in all the components (product/process, marketing/organizational, innovating in house). The poor reporting may be another reason for the poor performance.
- The national SMEs have the lowest BERD share in EU28 comparison (0.06% of GDP, 2013, the latest data available). SMEs have low capacity to develop RDI departments. Out of **824817** companies active in industry, construction and services (except insurance), **382800 (46%) were companies with 0 employees** (EUROSTAT, 2019).
- Between 2014-2017 there was a net growth rate of the number of companies, the rate increasing from 0.89% to 2.29% (EUROSTAT, 2019). Romanian start-ups have **a low survival rate over the threshold of five years**. Among the factors that determine this situation are: lack of B2B support services (legal advice, accounting), lack of access to finance for business development, lengthy and complex administrative procedures, unpredictability of the legislative framework, excessive bureaucracy, lack of adequate corporate governance, lack of sound business models and managerial expertise (EU Startup Monitor, 2015).
- The efforts to involve businesses in the policy making process were limited in the past and even when done, the expected level of participation was not reached. Recent efforts undertaken by regional and national authorities to engage the business sector in the entrepreneurial discovery process in the identification of the smart specialisation priorities may create a momentum for the business to become an active partner in the RDI policy design.
- The venture capital (VC) market is at incipient stage, with few visible venture capital providers on the market.
- The share of high growth innovative companies, and the rate of scale-up are very low (author's analysis). There is no evidence that the champions received public support. Over 20 Romanian companies entered the **Deloitte's 2018 Technology competition** that recognizes the most dynamic technology companies in Central Europe. **UiPath**, a robotic process automation software vendor founded in 2015, is the first RO business ever to win a special distinction for the **Most Disruptive Innovation** Award. The company is also the first Romanian unicorn and the fastest growing enterprise software company ever.

[40] European Commission, (2019): Annual Report of European SMEs 2018/2019

- **There are no specific policies targeting start-ups** (as defined by the EC: '*younger than 10 years, innovative, intention to grow*'), High Growth Innovative companies, scale-ups. Romania has no mechanisms, neither institutions (an entity such as Enterprise Romania or Innovation Romania) to support business driven innovation and the development of the entrepreneurial ecosystem (EC-PSF, 2017)**.**[41]
- The national **innovation culture can be assessed as weak**. The 2019 Start-up Barometer[42] provides evidence that one of the main obstacles of the ecosystem is the **fear of failure**. Bringing innovative ideas to market takes time, requires a culture that supports innovative ideas and people. The national market may lack sophistication and purchasing power; hence, the reduced demand for new and innovative products and services.

Notable aspects and differences compared to EU28

- The GERD intensity in most **EU28 countries has increased, while in RO has stagnated/decreased**. This has further widened the gap. Romania has the slowest progress towards the GERD target.
- BERD intensity is low. The SMEs have very low RDI activity and capacity to develop R&D activities: around 46% SME have zero employees, and 86% have zero to four employees.
- The BERD intensity almost doubled from 2014 to 2018. The number of HRST show a less significant increase, from 10128 to 12081. This aspect requires further analysis.
- A **significant share (>50%) of national public funds is not dispersed through transparent competitive allocation mechanisms based on performance indicators and/or peer review**. Only the GOV sector (National Institutes of R&D (INCD) + Academia Romana + other public R&D centers) has access to block funding for R&D. GOV sector performs the highest share of the public budget for R&D in EU28 comparison (70% in RO compared to 32% in EU28). GERD performed by higher education sector (HES) counts to around 18% of public GERD (compared to 57% in EU28). The EU countries with the best RDI performance, the innovation leaders, allocate the highest share of funding through mechanisms based on research performance and involve monitoring and evaluation (Doussineau. M et al, 2013).[43]
- Across EU, countries try to reduce the fragmentation of the RDI system in order to increase the concentration of expertise, capacity to compete (EC, ERA Progress Report 2018)[44] In Romania, the number of RDI centres increased, while the number of researchers has decreased.
- The number of **PhD graduates** f**ollowed an increasing trend until 2013.** The number of PhD dropped significantly from **1.1** per thousands population aged 25-34**: 2013 to 0.3 in 2014** and stabilises at this value afterwards. The increase of the number of PhD holders had not been reflected in a similar HRST/researchers trend. This shows a strategic failure in policy design or/and implementation.

[41] European Commission, (2017(a)). Start-ups, Scale-ups and Entrepreneurship in Romania https://ec.europa.eu/growth/smes/promoting-entrepreneurship/action-plan_en
[42] https://www.impacthub.ro/barometrul-startup-urilor-2019/
[43] DOUSSINEAU, M., MARINELLI E., CHIONCEL M.,HAEGEMAN K., CARAT G., BODEN M. (2013), ERA Communication Synthesis Report, https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/era-communication-synthesis-report
[44] EC, (2018), ERA Progress Report https://ec.europa.eu/info/publications/era-progress-report-2018_en

- Various rankings have been provided in the report (publications, H2020 participation, patent activity). **Few notable INCDs concentrates the scientific output of INCDs, in terms of quantity and quality**. Similar pattern is seen in all the rankings. Comparative analysis of various rankings show that these are dominated by HEIs (GERD performed by HES = 0.05% GDP, GERD performed by GOV = 0.15%), while the **international patent activity** is dominated by MNC.
- The scientific output (both publications and patents) is concentrated by the first 10 top institutions (more than 50%). This triggers the attention to the **effect of fragmentation.**
- The **highly cited papers (a minor share of the total)** involve international collaboration with international S&T leaders.
- The number of **EPO/USPTO/triadic patents is particularly low.** However, one aspect which requires particular attention is that a significantly lower number of inventions produced by Romanians is owned by Romanian entities. While MNCs generally, try to optimise their benefits, and delegate one central branch to deal with all patents, **RO is the EU country with the highest** (and the majority of 51%) **share of national inventions owned by another country**. **This signals a specific national problem that should be further analysed and addressed.**

Lessons learned from the previous cycles

The **main RDI policy instruments** in the 2014-2020 policy cycle are: (1) the National Plan for RDI 2015-2020 (PN3); (2) The Competitiveness Operational Program (POC), Priority Axis 1, RDI supporting economic competitiveness with a total budget € 952.57 million; (3) The Operational Programme Regional Development 2014-2020, PA1, 'Technology transfer', POR-AP1 (€206.5 million). These three programmes, PN3, POC-AP1 and POR-AP1 partially or totally target the investement in smart specialisation domains. To these instruments, various other programmes provide support for R&D activities. Among the most important as funds allocated are Nucleu Programme (institutional funds for INCD), the Research Plan of the Romanian Academy (RA)- block funds allocated through a distinct state budget line to the R&D Institutes of the RA and the sectoral plans of different ministries, etc.

There **is no official information** on the impact of National Plan II for RDI (PN2), which was not evaluated ex-post. While POS-CCE programme implementation reports are available, these mainly provide data related to the implementation and do not offer solid evidence regarding the efficiency, effectivness, impact of this programme; the use and sustainability of the research infrastructures has not been assessed. A mid-term evaluation of **National Strategy for RDI 2007–2013 (SNCDI 2007–2013)** was published in 2012, but the ex-post evaluation was not performed.

The so named, **Mid Term Evaluation, assessing the impact of the National Strategy for RDI 2013-2020** (INCSMPS, 2019) on the smart specialisation domains was conducted within the project "*Development of the Administrative Capacity of the Ministry of Research and Innovation*[45] *for the implementation of actions set out in the National Strategy for Research, Technological Development and Innovation 2014-2020 (code SIPOCA27).*[46]

[45] *currently the Ministry of Education and Research*
[46] http://sipoca27.ro

PN3 started in 2016, two years later after its approval. Both POC and PN3 had delays and lack of predictability of calls and funding. The call under POR, AP 1 was launched with delay. The budget allocated for PN3 has not followed the increasing expenditure trend to reach the 1% target by 2020, being, on average, 1/3 od the total annual public R&D budget. Output, outcome SNCDI indicators are correlated with input indicators to which budget allocation does not comply.

The **Sipoca Mid Term evaluation of SNCDI 2014-2020** covered **four PN3** funding programmes (582 projects) finalised by March 2019, out of **16** funding programmes, explicitly targeting the smart specialisation domains, and the aggregated data from 46 POC, AP1 projects, finalised by March 2019. As a mid-term evaluation, its scope should have been **formative not summative**. Therefore the ‚impact' results should be interpreted with caution. Also, given the limited numbers of the funding programmes included in the evaluation, this is not an evaluation of the National Strategy for RDI, of its impact on the smart specialisation domains, neither of the PN3 but merely the evaluation of few PN3 funding programmes, managed by one of the funding bodies, UEFISCDI. **PN3 allocates only approximately of a third of the public national R&D budget and out of this only 4 programmes were evaluated.** Bearing all these limitations in mind, below are the main conclusions of the *Mid Term evaluation of SNCDI 2014-2020.*

- There is an appropriate mix of project based funding instruments. All instruments which were evaluated show a positive, however low, impact.
- The main problems highlighted by the RDI performers were related to the low level of funding, high competition and the discouraging low success rate. The lack of predictability of calls opening, proposals evaluation and contracting further hamper the efficiency of the funding. This does not allow the RDI performers to establish an institutional R&D strategy, affects their capacity to develop/maintain the existing infrastructure, to attract and retain the human resource and establish partnerships with large companies, which develop corporate strategies generally 12 months in advance.
- Other obstacles relate to heavy bureaucracy involved by the RDI programmes funded by structural funds. The lack of planned opening of calls, based on annual calendars of competitions, represents a hindrance.
- The evaluation of the proposals was assessed in some programmes as too long, further delayed by the long period between results of the evaluation and implementation.

Individual evaluation of PN3. POC. POR. NUCLEU

PN3. Annual reports are produced by the Executive Agency for Higher Education, Research, Development and Innovation Funding (UEFISCDI) for the PN3 subprogrammes under its management accounting. The reports, available online with open access, provide comprehensive data regarding the number of applications, the implementation of the projects, and other important elements of descriptive statistics (see ‚Rapoarte de activitate PNCDI III[47]). There is one stop shop platform providing easy access to information regarding calls (see footnote[48]). The presentation in a structured, searchable format of the PN3 information recommands the UEFISCDI platform as a good practice. However, not all the PN3 programmes are managed by UEFISCDI.

[47] https://uefiscdi.gov.ro/rapoarte-de-activitate-pncdi-iii
[48] https://www.uefiscdi-direct.ro

POC, AP1[49]**.** Two independent evaluations of the impact of POC, AP1 on smart specialisation domains were planned to date (in 2017, and the second semester 2019). No further information was available in October 2019. The evaluation was contracted in 2020. Since October 2019, the website was reorganised and the information is presented in a more searchable way. Aggregated data regarding 46 POC projects finalised by March 2019, were provided to the evaluators and included in the Mid Term Evaluation of SNCDI 2013-2020.

POR, AP1 was launched with delay. The first evaluation of the programme was scheduled for the third semester 2019. *No further information was available in October 2019.*[50]

The **NUCLEU and the Romania Academy (AR) funds** account for a large share of the national R&D budget. However, these mechanisms were assessed in past block institutional rather than competitive funding (Curaj A, 2015[51], Zulean 2015)[52]. The NUCLEU programme has raised significant concern regarding the lack of transparency, '*the obscure spiral through which circulates a third of the Ministry of Research and Innovation budge*t",[53] and the opening of calls over short period of times, often during holiday periods. The author, based on the evidence publicly available (or better said its absence) can just observe the lack of external evaluation of these funding mechanisms and the controversy related to them.

NUCLEU[54] programme allocates similar budget as the competitive funds allocated by PN3. The information related to Nucleu Programme in a comprehensive format is missing. *No information regarding external evaluation of this long term funding scheme is available.*

Romanian Academy[55] is the beneficiary of a distinct R&D funding line from the state budget, similar in volume as NUCLEU programme (and PN3). The RA provides Annual Activity Reports. *No additional information regarding recent external evaluation is available.*

All National Research and Development Institutes (INCD) and universities should produce annual self-evaluation reports. The reports, if available (and often are not for the latest years), are mainly a list of achievements. This is also due to the lack of dedicated staff and scientific repositories.

DIGITISATION

Romania is part of the catching up cluster, ranking the second lowest in EU28 in the Digital Economies and Society Index (DESI).[56] Romania performs best in the Connectivity dimension (ranking on the 22nd position), due to the wide availability of fast and ultrafast

[49] http://www.poc.research.gov.ro
[50] https://www.fonduri-ue.ro/por-2014#rezultate-implementare
[51] Curaj, A (2015), Staiway to Excellence Country Report: ROMANIA; JRC Science and Policy Reports.
[52] Zulean, M., Ionita, I., Viiu, G.A. (2015), Raport de evaluare a guvernantei sistemului public de cercetare, dezvoltare si inovare din Romania, 2007-2013 (Assessment of the governance of the RDI system in Romania 2007-2013)
[53] https://mic-mic-anc.ro/2018/02/14/spirala-obscura-prin-care-circula-o-treime-din-bugetul-public-al-ministerului-cercetarii-si-inovarii/
[54] http://www.research.gov.ro/ro/articol/3768/programe-na-ionale-programe-nucleu
[55] https://acad.ro
[56] The Digital Economy and Society Index (DESI) is a composite index developed by the European Commission (DG CNECT) to assess the development of EU countries towards a digital economy and society, aggregating a set of relevant indicators structured around 5 dimensions: Connectivity, Human Capital, Use of Internet, Integration of Digital Technology and Digital Public Services.

fixed broadband networks. More than one fifth of Romanians have never used the internet. Only 9 % of Romanian enterprises are using social media (compared to 21 % EU average), 7% use the cloud services (compared to 18% inEU28). Romania's rank in Digital public services decreased each year one position since 2016, dropping to the lowest position in 2018.

- The country has very good IT specialists, **but they are too few**. The country ranking (17th) in terms of IT graduates decreases to 27th in the number of employees. Many of the best go abroad.
- An important share of its student population does not reach basic levels of ICT competence and leave school before graduating from upper secondary education.
- The number of ICT places in public universities is limited and there is a lack of ICT graduates.
- The national administration IT system is fragmented, with a low level of interoperability. The public sector, where is a significant need of IT specialists in order to ensure implementation and functioning of digital services cannot compete with the wages in the IT private sector.
- The medical system is still not covered by a centralised electronic system. The doctors remain under a significant administrative burden and do not benefit by centralised registries for epidemiological studies.

Logical frame: from barriers to interventions

The analysis attempts to put in **a logical frame the challenges/barriers and the relevant needs/interventions.** It should be noted that "*barriers" by definition includes a wide variety of obstacles to innovation, including those that arise within the bureaucracy, at the political level, and outside the public sector*" (Borins, 2001)[57].

Actions should be taken at all levels of the diffusion of innovation/ knowledge domains and in the larger social system. As already mentioned, the analysis provides evidence that **systemic challenges** should be tackled, a **new paradigm** should be thought for the **whole innovation ecosystem**, the funding should be increased with specific attention to **efficiency of the funding**. **Project based funding** should be allocated based on a clear and in advance multiannual planning. **Institutional competitive funding** should be open to all public RDI performers and should allow funding based on regular evaluations, using clear performance indicators. The evaluation procedures, either of staff, projects, institutions, programmes should be aligned with international standards of evaluations, enforcing transparency, ethics, international peer review.[58] The governance of the RDI system should be consolidated, and overarching coordination of different levels of policy and implementation must be ensured across all innovation system helices. Mergers are expected to streamline and simplify research and innovation support (particularly in monitoring and evaluation). Legislation should be revised.

More funds will not simply make the change. **Measures should NOT be thought in isolation**, **and should appropriately consider the many interlinked elements of the innovation ecosystem**.

Any scenario design should start from the Romanian reality. For example, the increase of the number of PhD graduates must consider the demographic decline of the relevant student sub-population, the cohort of pupils able to reach the third level of Bologna

[57] Borins, S. (2001). The challenge of innovating in government, PricewaterhouseCoopers Endowment for the Business of Government Arlington, VA.
[58] https://www.hceres.fr/sites/default/files/media/downloads/Hceres_campaign_2016_2017_Criteria_Research_Units.pdf

system, particularly in S&T fields, the number of academic staff habilitated for PhD supervision, adequate funding for research during and after the PhD studies, in topics addressing economic needs and societal challenges. The supply must be correlated to the market demand.

The majority of SME do not have the capacity, neither the willingness to perform RDI activity. They will not become innovators over night. Their features should be considered in deploying an adequate strategy.

The S&T prioritisation should consider the comparative national advantage of specific S&T fields, their position in global rankings, but also the funds which are needed to consolidate the field and the implicit collateral effects in an underfunded RDI system (significant financial for one field can lead to disappearance of other S&T domains).

Any missing link in these scenarios may produce damage rather than benefits.

Various type of actions must be considered: **appropiate funding instruments, principles for RDI funding, further revision of legislation and regulations, transparency, monitoring and evaluation, strengthening of the RDI administrative capacity, support to stakeholders to optimally use the measures and from them in the RDI policy co-creation**.

Relative importance of the volume of funding should be correlated to the characteristics / the needs of the system/specific S&T field. In a flexible, progressive manner this should allow the positive change to occur across the entire chain of knowledge diffusion:

- ➔ **increase the level and quality of knowledge production** addressing the economic and societal needs ++++++
- ➔ in parallel, **prepare the potential adopters** to make the behavioral change ++
- ➔ and with appropriate measures support the **innovators and early adopters** ++
- ➔ while **ensuring the communication among all stakeholders to allow distinct communities to bridge; provide support to heterophilic relations** as diffusion requires a certain degree of heterophily to introduce new ideas++

All these activities should be performed within a framework that enforces **transparency, efficiency of funds allocation, monitoring, evaluation and mechanisms of corrections.** Figure 1 integrates in a simplified manner the two perspectives: (1) diffusion of innovation and (2) knowledge domains, attaching to the challenges identified potential directions for action.

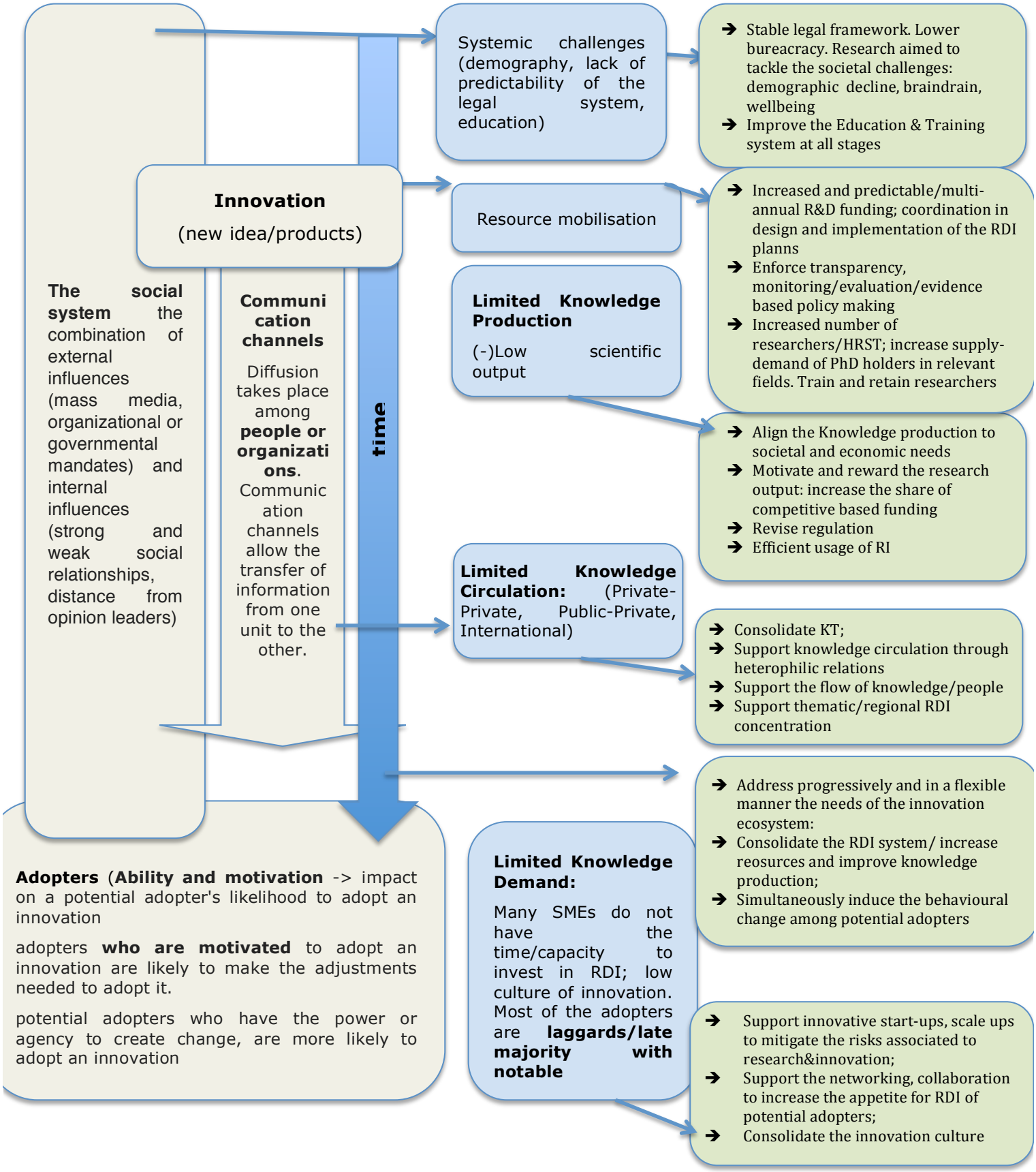

Figure 1. The intervention logic: from obstacles to objectives

1 INTRODUCTION

The report "*Analysis of the factors that obstruct the diffusion of innovation, including digitization*" addresses one the seven fulfillment criteria[59] under the specific thematic enabling condition '*Good governance of national or regional smart specialisation strategy*", as laid down by Common Provisions Regulation on the European Regional Development Fund, the European Social Fund Plus, the Cohesion Fund, and the European Maritime and Fisheries Fund[60,61]. The Common Provisions Regulation stipulates under each specific objective, prerequisite conditions for its effective and efficient implementation (*'enabling conditions'*).

In this specific context, the report was produced during *August-September 2019*, in the frame of the project "*Increasing the capacity of the RDI system to respond to global challenges. Strengthening anticipatory capacity to develop evidence-based public policies" – POCA, code 127557*, by the author, under expert contract with UEFISCDI. The report (in progress at that time) was presented in the first meeting (16.09.2019) of the National Committee for Coordination of the Smart Specialisation (Consiliul National pentru Coordonarea Specializarii Inteligenta) and circulated for feedback. The current version addresses those comments and integrates the feedback received. A new version of the Report was submitted to the European Commission in October 2019. In May 2020, in response to the few comments received from EC, a revised version addresses these comments and further enlarged the analysis to reflect also the needs of the entire system, from knowledge production to absorption of innovation.

The report tries to shed light on the barriers of the innovation process in Romania. The report must be read bearing in mind its purpose, the limited resources allocated to it, and the time constraints in which the analysis was conducted. Considering the short working time, the author invested significant efforts and benefited from information accumulated in other personal studies performed for European Commission. The report is not, and it was out of its scope, an impact evaluation of the National Strategy for Research, Development, Innovation. The report tries to provide an overall diagnosis of the innovation ecosystem, based on the information publicly available.

However, many aspects remain open for a further, thorough analysis which is well beyond the scope/resources of this report.

[59] Smart specialisation strategy(ies) shall be supported by: (1) *Up-to-date analysis of bottlenecks for innovation diffusion, including digitalisation*; (2) Existence of competent regional / national institution or body, responsible for the management of the smart specialisation strategy; (3) Monitoring and evaluation tools to measure performance towards the objectives of the strategy; (4) Effective functioning of entrepreneurial discovery process; (5) Actions necessary to improve national or regional research and innovation systems; (6) Actions to manage industrial transition; (7) Measures for international collaboration

[60] https://data.consilium.europa.eu/doc/document/ST-6147-2019-ADD-1/en/pdf

[61] https://ec.europa.eu/commission/sites/beta-political/files/budget-may2018-common-provisions_en.pdf

2 METHODOLOGY

The assessment is based on a thorough analysis of most recent data and studies publicly available (EUROSTAT, World Bank, European Commission, Country, Innovation Scoreboard, DESI, R&D Industrial scoreboard, OECD, European Science Foundation, National Institute for Statistics, Ministry of Education and Research (former Ministry of Research and Innovation), National Registry of Commerce, UEFISCDI data&publications, academic papers etc.). All the data, indicators considered in the analysis, are the latest available, as provided by EUROSTAT and the National Institute of Statistics (INS) (as valid in September 2019). The report focuses on the current policy cycle (2014 to date), but occasionally highlights trends over longer periods of time to emphasize specific aspects.

No detailed, sound analysis/evaluation assessing the SNCDI 2014-2020 or the integrated impact of all its implementation instruments on specific smart specialisation domains was available at the date of the report.

The report tries to analyse the conclusions of other relevant evaluation reports as far these are publicly available: *'The analysis of the evolution and current state of the SMEs and business sector in Romania (Academia Romana, (2018)*,[62] studies conducted by The National Council for Small and Medium Private Enterprises in Romania (CNIPMMR), *Major Companies Romania Reports (2016, 2017, 2018)*[63,64,65], the so called *Mid-Term Evaluation of the National Strategy for Research, Development and innovation (2014-2020)* (INCSMPS, 2019)[66] (as detailed in the body of the report this is barely an evaluation of some of the PN3 programmes/funding instruments), relevant *PriceWaterHouse / Deloitte report*s on fiscal incentives/technology awards.

The analysis heavily draws on previous work of the author on Research Innovation Observatory Country Reports: Romania (RIO 2016[67], 2017[68], 2019 unpublished).

[62] Analiza cu privire la evoluția și situația actuală a sectorului IMM și a mediului de afaceri din România Academia Romana, (2018), POCA project "Creșterea capacității administrative a Ministerului pentru Mediul de Afaceri, Comerț și Antreprenoriat de dezvoltare și implementare a sistemului de politici publice bazate pe dovezi" code Sipoca 5, Rezultat R1.1.: Analiza cu privire la evoluția și situația actuală a sectorului IMM și a mediului de afaceri din România, available at http://imm.gov.ro/wp-content/uploads/2018/11/Sipoca5-R1.1.pdf

[63] MAJOR COMPANIES IN ROMANIA, 2016 Edition. Edited by Doingbusiness.ro Edited by Doingbusiness.ro, available at https://doingbusiness.ro/media/downloads/MCR2016.pdf

[64] MAJOR COMPANIES IN ROMANIA, 2017 Edition. Edited by Doingbusiness.ro, available at https://doingbusiness.ro/media/downloads/MCR2017.pdf

[65] MAJOR COMPANIES IN ROMANIA, 2018 Edition. Edited by Doingbusiness.ro, available at: https://doingbusiness.ro/media/downloads/MCR2018.pdf

[66] http://sipoca27.ro

[67] Chioncel, M.F. Del Rio, J.C. 2018, RIO Country Report 2017: Romania, available at https://rio.jrc.ec.europa.eu/en/country-analysis/Romania/country-report

[68] Chioncel, Zifciakova J 2017, RIO Country Report 2016: Romania, available at: https://rio.jrc.ec.europa.eu/en/country-analysis/Romania/country-report

Alongside analysis of secondary data, a parallel UEFISCDI study summarises **179** in-depth open-ended interviews with Romanian innovation actors, out of which 159 were with representatives of the bussiness sector and 20 with representatives of universities, institutes and public research organisations, clusters, professional associations, hubs and business incubators.[69] The interviews were performed in 2017 and 2018, by regional 'observers', within the Project "*Development of the Administrative Capacity of the Ministry of Research and Innovation for the implementation of actions set out in the National Strategy for Research, Technological Development and Innovation 2014-2020 (code SIPOCA 27[70])"* with the purpose of investigating the potential of some areas to become smart specialization priorities at regional level. The interviews were conducted in all the eight development regions (Bucharest - Ilfov (B), South-East (SE), South-Muntenia (SM), South-West (SW), West (W), Center (C), North-West (NW) and North-East (NE). The questions were open and focused mainly on issues related to problems faced by companies in the RDI process. However, the interviews were not designed for the purpose of this report. **Therefore, this report uses the study only to provide evidence/examples of the perception of the RDI stakeholders on various aspects as identified as relevant by the statistical analysis.**

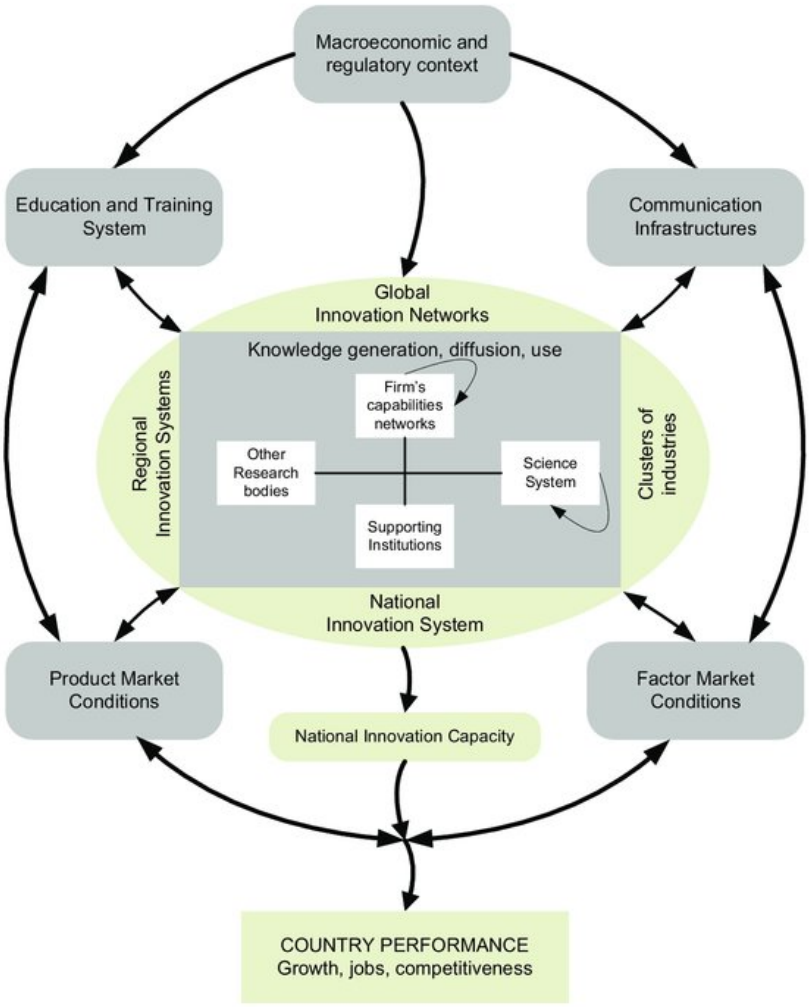

Figure 2. OECD National Innovation system

[69] conducted by Cristina Serbanica &Petrovan Medeea – Katerina
[70] http://sipoca27.ro

The analysis combines the *OECD national innovation system* (Figure 2) but extends the analysis to include elements from *Isenberg´s model of entrepreneurship ecosystem*, which defines tens of specific elements that are grouped for convenience into six ecosystem domains: Conducive culture, Enabling policies, Availability of appropriate Finance and quality Human capital, Venture-friendly markets for products, and a range of institutional and infrastructural Supports.

The analytical approach integrates all the elements of the *Quadruple Helix innovation model*[71]. If the Triple Helix innovation model[72] refers to a set of interactions between academia, industry and governments, to foster economic and social development and acknowledges explicitly the importance of higher education for innovation, the Quadruple Helix embeds the Triple Helix by adding as a fourth helix the 'media-based and culture-based public' and 'civil society'. Quadruple Helix encourages the perspective of the *knowledge society*, and of *knowledge democracy* for knowledge production and innovation. The Quintuple Helix innovation model[73] is even broader by additionally adding the helix of the 'natural environments of society', as drivers for knowledge production and innovation, thus defining opportunities for the knowledge society and knowledge economy.

The analysis covers all four knowledge domains: *resource mobilization, knowledge demand, knowledge production, knowledge circulation*. Although the analysis does not follow this domain structure. It takes into account also the lessons learned from the midterm evaluation of the impact of the National Strategy for RDI 2014-2020.

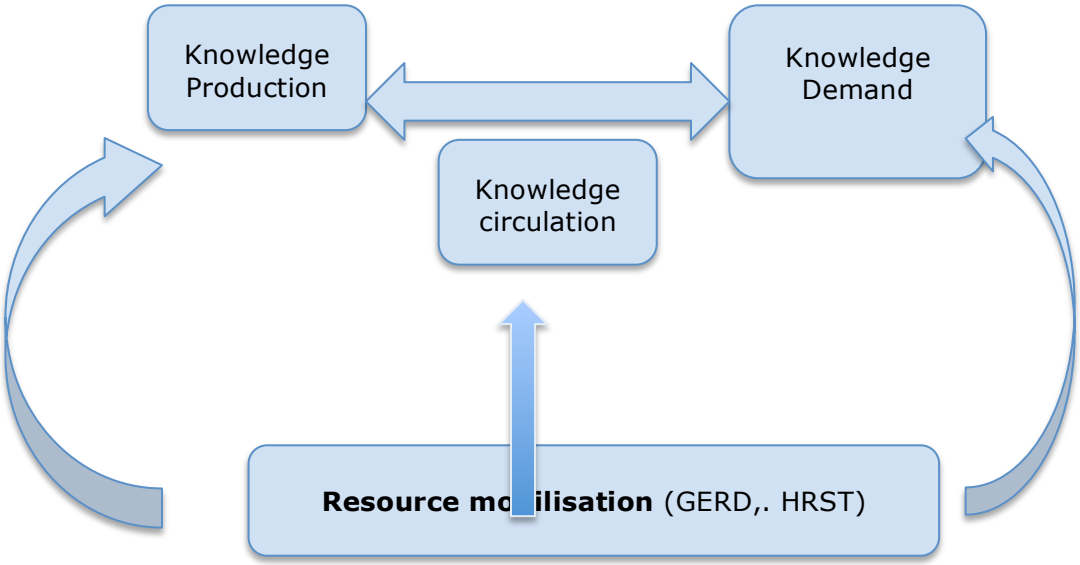

Figure 3 Building blocks of the innovation ecosystem (author's drawing)

[71] Carayannis, Elias G.. Campbell, David F.J. (2009). "'Mode 3' and 'Quadruple Helix': toward a 21st century fractal innovation ecosystem". International Journal of Technology Management. 46 (3/4): 201. doi:10.1504/IJTM.2009.023374. ISSN 0267-5730.

[72] Etzkowitz, H. Leydesdorff, L (1995-01-01) "The Triple Helix -- University-Industry-Government Relations: A Laboratory for Knowledge Based Economic Development". Rochester, NY.

[73] Carayannis, Elias G.. Campbell, David F.J. (2010). "Triple Helix, Quadruple Helix and Quintuple Helix and How Do Knowledge, Innovation and the Environment Relate To Each Other. A Proposed Framework for a Trans-disciplinary Analysis of Sustainable Development and Social Ecology". *International Journal of Social Ecology and Sustainable Development*. **1** (1): 41–69. doi:10.4018/jsesd.2010010105. ISSN 1947-8402.

All these elements are further integrated and analysed from the perspective of the Theory of Diffusion, developed by E.M. Rogers in 1962. Rogers proposes that f**our main elements influence the spread of the innovation**:

- **the innovation:** any idea, practice, or object that is perceived as new by an individual or other unit of adoption could be considered an innovation available for study the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in internal business practices or in the open workplace" (OECD, 2005). Given the comprehensive nature of the innovation concept an innovative activity might include research and development but not all the research and development activities necessarily lead to an innovative outcome
- **communication channels,**
- **adopters,**
- **time:** The passage of time is necessary for innovations to be adopted; they are rarely adopted instantaneously
- **social system**: the combination of external and internal influences (strong and weak social relationships, distance from opinion leaders).[74] which will affect the potential adopter.[75]

The adoption is "*the [voluntary and/or coercive] process through which [an organization] passes from first knowledge of an innovation, to forming an attitude towards the innovation, to a decision to adopt or reject, to implementation of the new idea, and to confirmation of this decision*". (Rogers E, 2003).

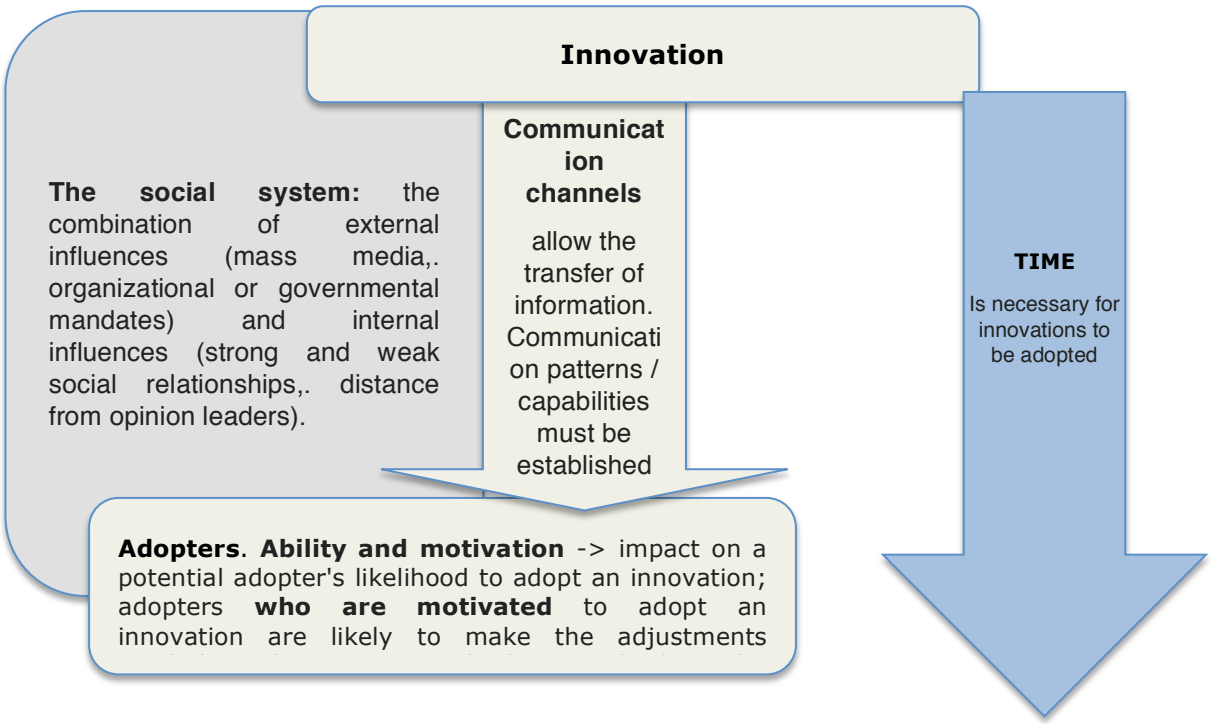

Figure 4. Diffusion of Innovation (author's drawing based on Roger's building blocks of theory of diffusion of innovation)

[74] https://en.wikipedia.org/wiki/Diffusion_of_innovations#cite_note-19
[75] https://en.wikipedia.org/wiki/Diffusion_of_innovations#cite_note-FOOTNOTERogers198324-20

The DoI process relies heavily on **human capital**. The innovation must be **widely adopted in order to self-sustain**. Within the rate of adoption, there is a point at which an innovation reaches critical mass.

When promoting an innovation to a target population, it is important to understand the characteristics of the target population that will help or hinder adoption of the innovation. The end result of this diffusion is that new idea, behavior, or products are adopted. Diffusion signifies a group phenomenon, which suggests how an innovation spread.

While some sectors are riskier than others, some common risks, regardless of the turnover, the size and the NACE field they operate, affect the whole business environment. The report highlights the regional disparities, identifies specificities but focuses on those cross cutting, significant problems, present in all regions and NACE fields. The legislation, regulation are at national level and do not have regional specificity. Specific attention should be given to the biomedical, energy and ICT field where the relevant legislation for these sectors may require a distinct analysis. While the analysis is centered on 'obstacles' obstructing the diffusion of innovation, there are good practices, and these should be noticed. Boxes identify such good practices.

The analysis starts with *National Context Chapter*, which provides a description and analysis of the national innovation ecosystem, aiming to identify underlying elements that may hinder the innovation. These may be related to the economy sectoral structure, business organisation, entrepreneurial ecosystem, policy framework. The following chapter focuses on RDI system and introduces elements of knowledge production and resource mobilisation. *Chapter 5* centers on barriers for innovation, identifying cross-cutting problems. *Chapter 6* provides some aspects (based on the publicly available information) the country performance in digitization and the barriers hindering a better performance. *Chapter 7* concludes the analysis, in some key messages and formulates some suggestions at a broader level.

3 NATIONAL CONTEXT

This section provides the description and analysis of the national innovation ecosystem, aiming to identify underlying elements that may hinder the innovation. These may be related to the sectoral structure, type of business organisation, policy framework.

3.1 Main economic indicators

	2013	2014	2015	2016	2017	2018	EU 28	2019
GDP per capita (euro per capita)	7190	7550	8090	8650	9580	10510	31960	11500
GDP growth rate (% change)	2.5	2.5	2.1	3.9	3.5	3.8	1.7	3.4
Budget deficit as % of GDP	-2.1	-1.2	-6	-2.6	-2.6	-2.9	-0.6 (2019)	-4.3
Government debt as % of GDP			37.8	37.3	35.1	34.7	79.3	35.2
Value added of services as share of the total value added (% of total)	57.44	58.96	61.18	61.96	63.32	63.9	73.74 (2018)	
Value added of manufacturing as share of the total value added (%)	23.09	23.7	22.28	22.43	22.02	20.7	16 (2018)	
Value added of knowledge-intensive services as share of total value added (%)	30.18	29.9	28.7	29.97	30.48	31.82	36.82 (2018)	
Value added of High and Medium-High Tech manufacturing as share of total value added (%)	5.84	6.05	6.47	7	7.03	6.57	4,.64 (2017)	
Employment in knowledge-intensive service sectors as share of total employment (%)	18.36	18.02	19.78	19.95	20.4	19.86	37.3 (2018)	20.26
Employment in High and Medium High Tech manufacturing sectors as share of total employment (%)	4.72	5.22	5.5	5.73	5.53		4.64 (2017)	
Employment in manufacturing as share of total employment (%)	17.6	18.18	17.9	18.63	18.84	18.89	13.78 (2018)	18.5
Employment in services as share of total employment (%)	41.8	42.1	45.27	46.42	46.69	47.28	74.05 (2018)	48.32
Share of Foreign controlled enterprises in the total nb of enterprises (%)	5.79	6.47	5.93	5.94	5.71			
Business Structure of the economy: Share of "From 0 to 9 persons employed" enterprises (%)	87.87	88.5	88.51	88.47	89.01		92.71 (2017)	
Business Structure of the economy: Share of "From 10 to 19 persons employed" enterprises (%)	6.29	5.88	5.78	5.86	5.56		3.9 (2017)	
Business Structure of the economy: Share of "From 20 to 49 persons employed" enterprises (%)	3.67	3.54	3.59	3.55	3.41		2.07	

Business Structure of the economy: Share of "From 50 to 249 persons employed" enterprises (%)	1.82	1.73	1.76	1.77	1.67		0.97	
Business Structure of the economy: Share of "250 persons employed or more" enterprises by size class	0.35	0.35	0.36	0.36	0.34		0.2	
Entrepreneurship performance indicator: Firms birth rate (Number of enterprise births divided by the number of enterprises active)	16.33	10.3	11.97	10.96	11.66			
Entrepreneurship performance indicator: Firms death rate (Number of enterprise deaths divided by the number of enterprises active)	15.47	8.52	8.58	8.62	9.06			
Entrepreneurship performance indicator: Firms survival rate (3 yrs threshold) (Number of enterprise divided by the number of enterprise births in t-3)	94.32	50.83	52.22	64.87	58.93			
Labour productivity (Index,. 2010=100)	117.7	121.3	128.3	135.1	140.7	107.2		
Innovation output indicator (Rank,Intra-EU Comparison)	23	22						
Summary Innovation Index (score,. relative to EU28 2010 = 100)	39.11	31.3	29.77	31.08	32.17	34.13		
Summary Innovation Index (rank)	28	28	28	28	28	28		

Table 1. Main economic indicators (Source Research Innovation Observatory, EC-JRC)

Romania had a budget deficit of 3% of GDP in 2018, five times wider than the average in the EU (0.6% of GDP). In 2019, the national budget deficit increased to the highest level in EU28. The average budget deficit in the EU narrowed from 1.0% of GDP in 2017 to 0.6% of GDP in 2019, while over the same period the gap widened from 2.76% to -4.3% in Romania.

3.2 Forecast. The COVID crisis impact

According to the latest (April 2020) World Bank[76] report, Romania's GDP growth was 4.1% in 2019 driven mainly by the **private consumption** (5.9%), supported by wage and pensions increases. The unemployment reached historic lows, the investment rose and budget revenues grew by 8.8%, reflecting better tax and social security contributions. Construction and ICT were the main drivers of production. The budget deficit widened to 4.6% of GDP, due to planned increases on public wages and social spending. Exports grew by 3.5% reflecting weaker demand in major export markets. (World Bank, 2020).

The COVID-19 pandemic strongly impacted the health sector, businesses, the labor market and households. The authorities acted promptly by declaring a state of emergency in mid-March. In this context, the economic growth is projected to slow significantly to **0.3%** in 2020, from an estimated 3.8% before the crisis. The projection

[76] World Bank, 2020, Fighting COVID-19, Office of the Chief Economist Spring 2020

is done under the assumption that growth would gradually bounce back in the second half of 2020 and further accelerate in 2021 to 4.4%.

The risk of a recession in 2020 is assessed as substantial and growing, with fiscal deficit expected to widen to around 5.5% of GDP in 2020. This induces the increase of the poverty. The projection is that 15% of working adults will face the risk of poverty, increasing also their vulnerability to health consequences. Additional deficit pressure comes from the new pension law which stipulates a 40 increase in pensions from September 2020. (World Bank, 2020). All data are available in Appendix 1.

The International Monetary Fund (IMF, April 2020) forecasts a **contraction of GDP of 5%** in 2020 and significant increase of the unemployment.

Subject Descriptor	Units	2018	2019	2020	2021
GDP, constant prices	Percent change	4.437	4.078	-5.000	3.900
GDP, current prices	Purchasing power parity; international dollars (Billions)	518.633	549.195	525.051	556.164
GDP per capita, constant prices	Purchasing power parity; percent change	5.043	4.751	-4.994	3.906
Inflation, average consumer prices	Percent change	4.631	3.825	2.245	1.455
Unemployment rate	Percent of total labor force	4.187	3.912	10.100	6.000
General government net lending/borrowing	Percent of GDP	-2.819	-4.583	-8.867	-6.992
Current account balance	Percent of GDP	-4.381	-4.719	-5.504	-4.685

Table 2. International Monetary Fund, World Economic Outlook Database, April 2020 (source: IMF, 2020)[77]

3.3 Structure of the economy (sectoral/industrial specialisation)

The country's economy is developing, as proven by the latest positive macroeconomic indicators, which underline diversity, complexity, decline of the unemployment rate. Romania is an upper middle-income economy, with many chances to climb the hierarchy in 2020/2021. [78,79] The GDP growth was 4.1% (2018) and it is estimated to reach 5.5% in 2019[80]. The contribution to the GDP growth was generated by services (2%), taxation (1%), industry (1%) and agriculture (1%). Construction had a negative impact (-0.3%). In 2018, the inflation registered the highest level in the last years (5.9%). Real GDP per capita in Romania has steadily increased since 2010, reaching €8,700 per capita in 2018. Despite the rapid growth, it remains the second lowest in the EU (Eurostat, 2019). **However, there is fear that this is not a long term sustainable growth, but more likely a volatile growth that is susceptible to be seriously affected by hidden**

[77] https://www.imf.org/external/pubs/ft/weo/2020/01/weodata/index.aspx
[78] According to the latest thresholds determined in July 2018 by the World Bank, low-income economies are defined as those with a GNI per capita, calculated using the World Bank Atlas method, of USD 995 or less in 2018, lower middle-income economies – between USD 996 and USD 3,895, upper middle-income economies – between USD 3,896 and USD 12,055, and high-income economies – USD 12,056 or more.
[79] http://business-review.eu/business/upper-middle-income-romania-fails-to-being-officially-recognized-as-a-developed-country-this-year-203564
[80] Comisia Nationala de Prognoza, Mai 2019

imbalances or by 'black swans'.[81] Competitiveness Index in Romania averaged 13.90 Points from 2007 until 2018, reaching an all time high of 63.46 Points in 2018.[82]

Sectoral structure of the economy. Services have the highest contribution to GDP (57.1% in 2018), with positive forecast. The agriculture recorded a significant decline from 22% (value added of GDP) in 1990 to 4.2% (2018). The industry contributed to 23.6% of GDP in 2018[83]. The wholesale and retail trade repair of automotive industry and motorcycles has the highest share in the turnover, followed by manufacturing, but the two sectors shift position when assessing the value added. ICT industry in on the third position, followed by transportation and storage. State-owned enterprises have a key role in critical infrastructure sectors such as energy and rail transport. However, the private companies are more performance-driven than the state-owned ones.

The Romanian state proved until recently to be an extremely 'complacent shareholder', having little interest in the economic performance of the companies which it owned (EC, (2018)).[84] Romania is a net exporter of unprocessed products. Within the structure of agricultural production, crop production is prevalent, with a 70.3% share in the total production in 2018, as compared to 28.3% for animal production and 1.4% for agricultural services. (INS, 2019 – Romania in Figures)[85] It has 3.7 million agricultural holdings, 14.6 million ha agricultural land, of which 9.4 million ha are utilized arable land (INS, 2019). Overall the country agriculture has the capacity to feed almost the double of its population, but it is underdeveloped and sluggish. The main problems are the lack of mechanization, inadequate farming structure, underdeveloped infrastructures, lack of managers, low productivity, lack of storage capacity, lack of digital transformation and the position in the value added network (NCH, 2016[86],Popescu A.,2013 (a)[87], (b)[88]).

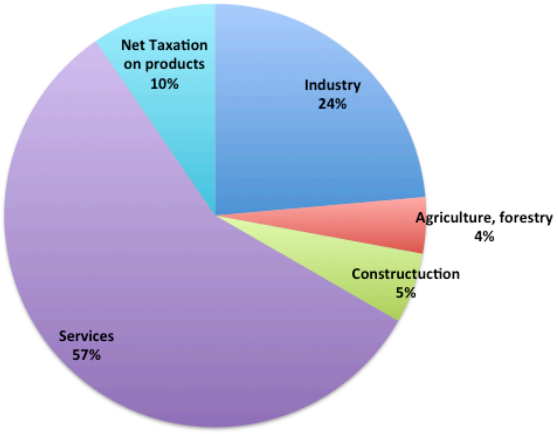

Figure 5. Structure of the Romanian GDP (based on: Proiecția principalilor indicatori macroeconomici 2019 – 2022, Comisia Nationala de Strategie si Prognoza)

[81] Nassim Taleb coined the term 'black swan as a highly improbable event with the principal characteristics: it is unpredictable, it carries a massive impact'
[82] https://tradingeconomics.com/romania/competitiveness-index
[83] http://www.cnp.ro/user/repository/prognoze/prognoza_2019_2022_varianta_de_primavara_2019.pdf
[84] EC, 2018 European Semester Country Report: Romania. Available at: https://ec.europa.eu/info/publications/2018-european-semester-country-reports_en
[85] INS, 2019 – Romania in figures, available at: http://www.insse.ro/cms/sites/default/files/field/publicatii/romania_in_figures_2019.pdf
[86] NCH, (2016) Discovering Romania as Business Hub, *A New Era of Internationalization through Enhanced Partnerships*
[87] Popescu, A, (2013a), Considerations on the Rural Population as a Resource of Labor Force in Romania, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, Vol.13(3):229-236
[88] Popescu, A., (2013b), Considerations on the main features of the agricultural population in the European Union, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, Vol.13(4):213-220

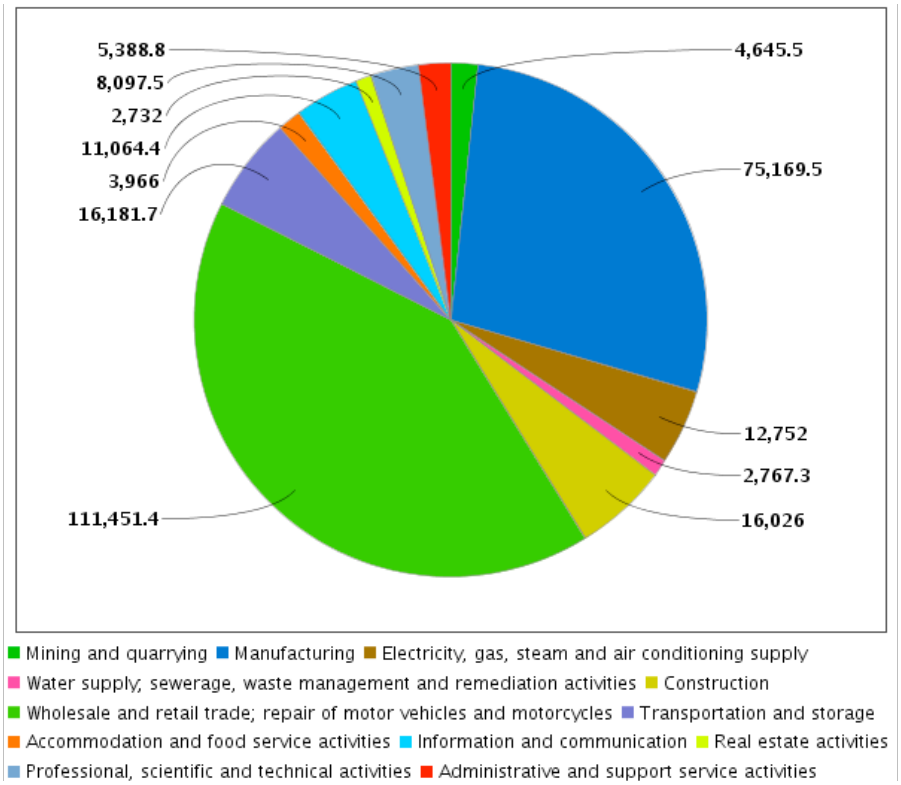

Figure 6. Turnover by NACE rev.2 – 2016, latest available data (source: EUROSTAT)

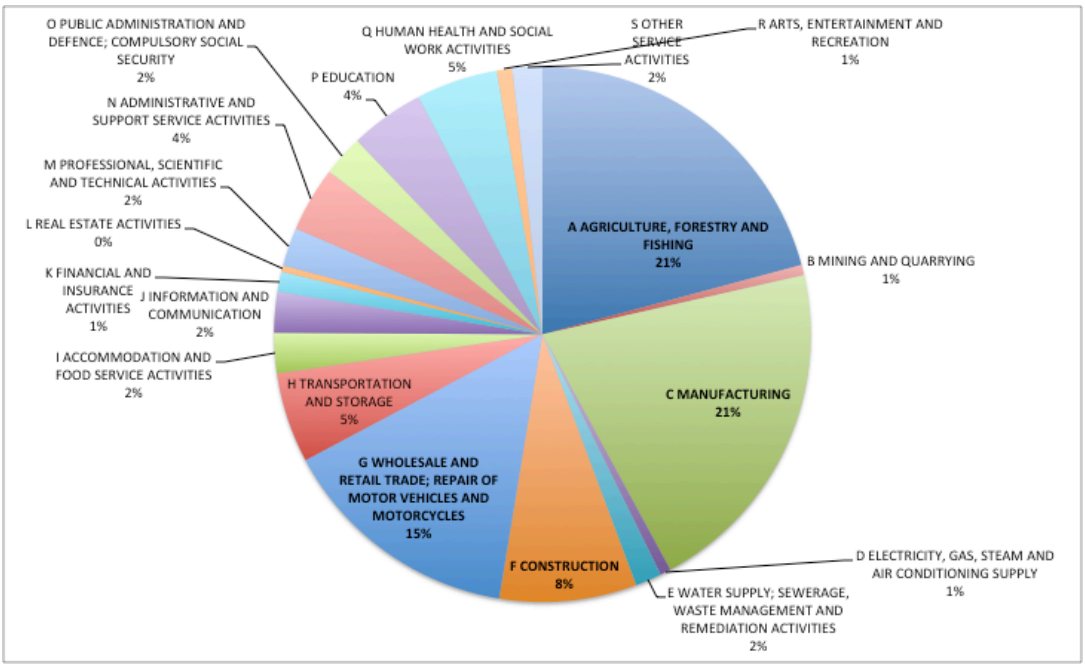

Figure 7. Employment distribution by NACE-2016 (source: INS[89])

[89] http://www.insse.ro/cms/sites/default/files/field/publicatii/balanta_fortei_de_munca_la_1_ianuarie_2018.pdf

The share of employment in "Agriculture, forestry and fishing", with a value of 20.8% (INSSE, 2018).[90] was the largest among the EU member states (MS) in 2018, regardless its significant and continuous decrease. Around **1.6 million working-age adults** are labeled as "self-employed in agriculture". A significant share of this population, according to some experts, represents unemployed workforce, hidden in the official statistics under this label.

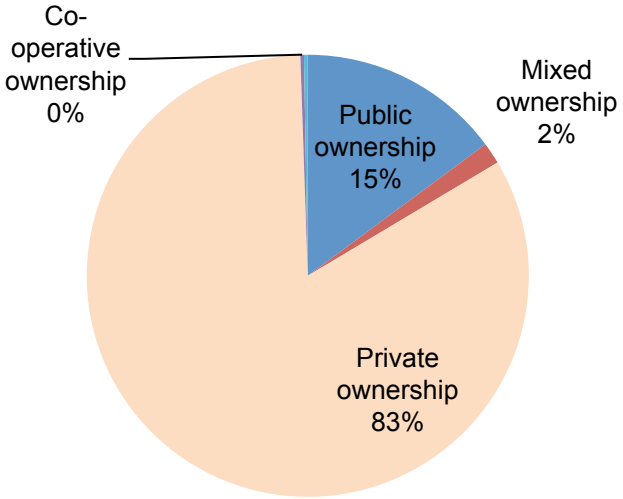

Figure 8 Employment distribution by property ownership (Data Source: INS)

In 2018, the share of persons employed in the private sector (83.0%) was 5.6 times higher than those of persons employed in the public sector (14.9%). The men held the majority share in the mixed (63.6%) and private (57.3%) sectors. Instead, women were prevalent in public sector (61.1%).

3.4 Innovation

Since 2008, the country innovation performance has had a negative trend. According to the European Innovation Scoreboard (EIS, 2019**), Romania is in the group of Modest Innovators** with an innovation performance level below the half of the EU28 average. Turnover from innovation as % of total turnover is among the lowest in EU for industry total and the lowest for services showing a descendent trend since 2006 when achieved the maximum value in all components.

The Employment in high- and medium-high technology manufacturing sectors and knowledge-intensive service sectors as share % of total employment is 22% (2018), the lowest in EU, increasing from 19.8% in 2010.

The analysis of turnover of innovative enterprises by size-class (INS - 2019 data), shows that in 2016, 57% is generated by large companies, 24% by medium and 19% by small companies (author's calculation).

[90] INSSE, 2018, available at: http://www.insse.ro/cms/sites/default/files/field/publicatii/balanta_fortei_de_munca_la_1_ianuarie_2018.pdf

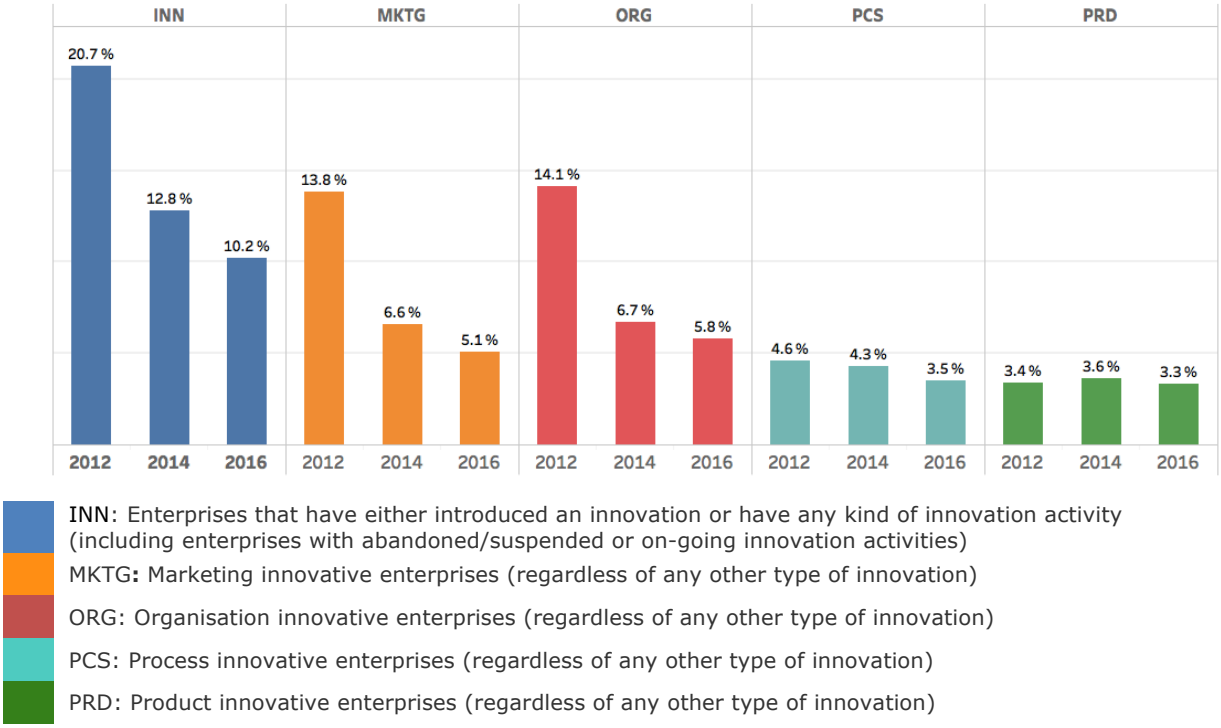

Figure 9. Innovative enterprises as % of total enterprises – by size class and type of innovation: 2012, 2014, 2016 (EC-JRC, RIO. Based on Community Innovation Survey (2012-2016)

The share of innovative companies decreased in all size classes and in all categories of innovative activity (EUROSTAT, CIS).

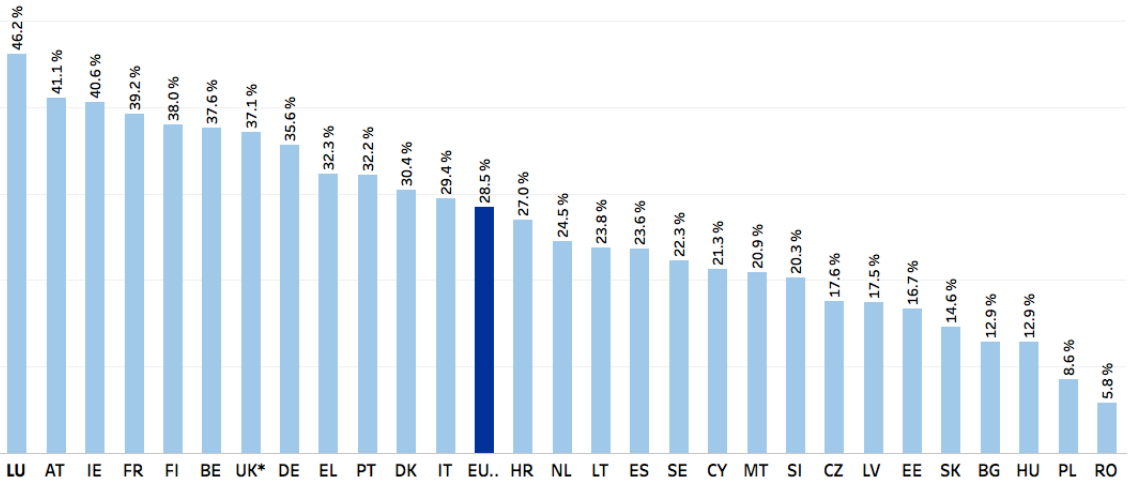

Figure 10. Innovative enterprises as % of total enterprises in EU28 MS (Source: DG-JRC, RIO, based on CIS 2012-2016)

Romania has the lowest share of innovative enterprises in EU28 (EUROSTAT, CIS2016).

High Growth Enterprises. Romania in 2017 (according to the July 2019 Eurostat data) has one of the lowest numbers of fast growing enterprises (HGE) in EU and the lowest proportion, 2.3%, of High Growth Innovative Enterprises (HGIEs). The highest shares of

HGEs are in wholesale and retail trade, repair of motor vehicles and motorcycles, followed by manufacturing, construction and information and technology.

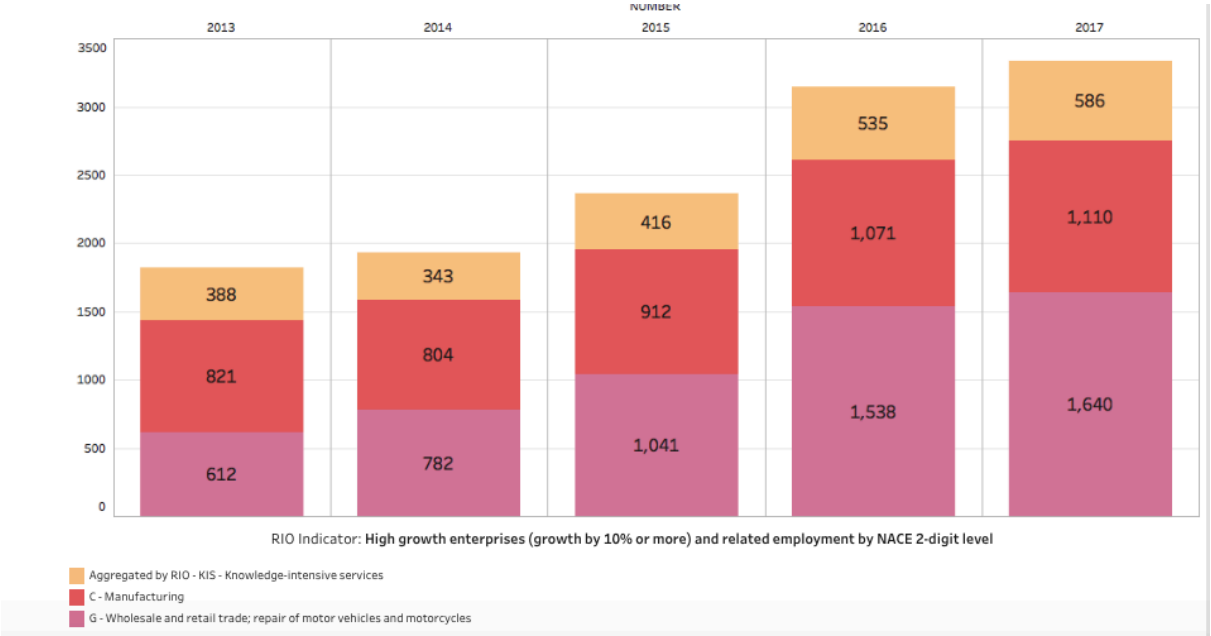

Figure 11. Number of HGE (growth by 10% or more) measured in turnover (source: EC, JRC – RIO)

In Romania, only 5.9% of the country's employees were employed in a rapidly growing firms in 2015, well below Hungary (20.7%) and Bulgaria (18.6%). An analysis of the growth of the companies performed over the period 1995-2015, concluded that in most cases, the firms remained in the same size class in which they were born; the rest move to a lower size class, while those which managed in time to increase the assets, employees or turnover were exceptions (Neagu, F. et al, 2016). International evidence shows that although most small firms do not grow (or only grow slowly), a few High Growth Enterprises are crucial for job creation (Davidsson, P., 2002). The Romanian company with the largest revenue growth rate (710%) was the company **Trencadis**. **Qualteh** entered the ranking in 2017 on the 39 place, with a growth rate of 388%. **Qualteh** provides development and customisation for innovative high-quality enterprise and mobile software solutions. With a 324% growth rate, **Tremend,** a software company from Bucharest with over 11 years of experience, came 47$^{th.}$ **Trencadis, Tremend**, **IT Access**, which recorded average growth rates between 75% and 125% in 2014-2017, entered the 2019 edition of the top 1,000 of the fastest-growing European ranking by the British Financial Times and the US portal Statista.com.[91, 92] Romania registered 24 scale-up companies with $0.4B (SEP, 2019).

[91] https://www.ft.com/content/cf0c5fce-3112-11e8-b5bf-23cb17fd1498
[92] https://www.zf.ro/business-hi-tech/trei-companii-de-it-din-romania-in-topul-financial-times-al-firmelor-europene-cu-cea-mai-rapida-crestere-a-cifrei-de-afaceri-17903378

3.5 Quality of life

Romania has the **second lowest life expectancy** in EU (total and female), and the **lowest for men**. Also, it has **one of the lowest age for healthy life**. Romanian women can expect to spend less than one third of their remaining years free of disability. Romania spends less than a third of the EU average on health care, the lowest level in EU28. Low funding and the inefficient use of resources limit the effectiveness of the healthcare system affected also by a significant shortage of doctors and nurses (EC, 2018 Country Report).

Infant mortality represents a particular challenge: at 7.6 deaths per 1 000 live births, it was the **highest in the EU** and over twice the average of 3.6 in 2015. **Heart diseases and stroke** are the biggest contributors to mortality, being two and a half times higher than the EU average and the second highest in the EU.

Deaths from some types of cancers have increased sharply and **infectious diseases** are a significant challenge: RO has the highest rate of tuberculosis in the EU. Undiagnosed viral hepatitis poses a significant problem with sub-optimal testing and surveillance.

The **mortality that could have been avoided through appropriate health care interventions** is the highest in the EU for women and the third highest for men. Wide inequalities exist in the prevalence of these chronic diseases by education level. (OECD, 2017 – The Country Health Profile)[93].

In 2015, the **consumption expenditure** per household was the lowest in EU28 (latest available EUROSTAT data, August 2019). In 2018, 32.5% of the population was at risk of poverty and social exclusion. The recent economic performance has not been translated in population's well-being. Neither, the economic growth was supported with measures to increase competitiveness and sustainable growth, which includes quality of life, access to good education and health care.

Net monthly earnings. Romania's average net monthly earnings reached (665 EUR) RON 3,142 in June 2019, rising by 15.5 percent compared to May 2018 (National Institute of Statistics, INSS). The highest wage increases were concentrated in the public sector. Real wages increased by 11.2% between June 2018 and June 2019, due to high inflation rate. Since the beginning of 2019, the government has increased the minimum gross wage from RON 1,900 to RON 2,080 and introduced a separate minimum wage for workers in construction of RON 3,000. However, Romania still has the second lowest average wage among the EU member states.[94]

[93] OECD, 2017 (The Country Health Profile, Romania), available at: https://www.oecd-ilibrary.org/docserver/9789264283534-en.pdf?expires=1569503879&id=id&accname=guest&checksum=A8BCC14894DDDB7B533D439CDCF570D8

[94] http://business-review.eu/business/romanias-average-wage-hits-eur-665-in-june-on-higher-earnings-in-the-public-sector-203797

3.6 Demography

There is a **negative demographic natural variation** (INSSE, 2019 Romania in Figures) considering the number of deaths and births. The emigration has been also particularly high (OECD, 2019). The demographic and economic effects of this evolution has already started to be felt in the workforce crisis and the decrease of the pupils/students population. According to Population Division World Population Prospects 2019[95], the demographic trends calculated in various scenarios envisaged a decrease of the population to just above *15 million by 2050 in the case of zero migration and constant mortality/ constant fertility*.

This will entail changes in the various sub-populations (school population, population of childbearing age, working age population).

3.7 Regional disparities

The country is formally divided into 8 'development regions' (eight NUTS2 level) and four macro-regions (NUTS1), however with purely administrative responsibilities.

There are **significant disparities between the 8 NUTS2 regions in terms of wealth, RDI facilities, education support and performance.** The level of polarization at the territorial level has not significantly diminished in the last 21 years.

The city of Bucharest is the main pole of economic power, concentrating a significant share of the economic activity (in terms of GVA, employees, total assets, etc.).

Two regions (compared to three in 2016), North-East and South-West Oltenia, have in 2017 GDP per capita below 50% of the EU average. South Muntenia managed to climb over this threshold in 2017. [96] (34/2019, Eurostat, NewsRelease).

The GDP (PPS per inhabitant)[97] in Bucharest–Ilfov region (**43,200 pps/inhabitant),** followed by the West (20,000) and Center, is almost four times (3.7) higher than the GDP/inhabitant in the Region North East (11,600). The share of early leavers from education is the highest in Macroregion 2 (NUTS1). There are significant disparities also regarding unemployment, South-West (9.9%), South (8.9%) and South-East showing the highest rates. The share of people at risk of poverty or social exclusion in N-E (44.7%), S-E(40.3%), and S-W Oltenia (42.2%) is significantly higher than in Bucharest (21.4%), N-W (22.3). (EUROSTAT, 2019)

In terms of **turnover from innovation** as % of total turnover, South Region Muntenia dominates the ranking, with a value significantly higher compared to the other regions. Major companies, such as Dacia - Renault (Pitesti - Arges), Pitesti Nuclear Fuel Factory (FCN Pitesti), OMV Petrom, Petrobrazi refinery and Petrotel - Lukoil Ploiești, are in this region. According to the analysis of the Regional Development Plan (RDP) 2014-2020, a special feature of the region's economy is that almost all branches of industry are represented in the region.

[95] https://population.un.org/wpp/Download/Standard/Population/

[96] https://ec.europa.eu/eurostat/documents/2995521/8700651/1-28022018-BP-EN/15f5fd90-ce8b-4927-9a3b-07dc255dc42a
https://ec.europa.eu/eurostat/documents/2995521/9618249/1-26022019-AP-EN.pdf/f765d183-c3d2-4e2f-9256-cc6665909c80

[97] Gross domestic product (GDP) is a measure for the economic activity. It is defined as the value of all goods and services produced less the value of any goods or services used in their creation. The volume index of GDP per capita in Purchasing Power Standards (PPS) is expressed in relation to the European Union (EU28) average set to equal 100

	Turnover from innovation as % of total turnover by economic sector (%)					
Region	**2006**	**2008**	**2010**	**2012**	**2014**	**2016**
North West	19.1	15.3	21.7	4.33	2.19	1.57
Center	13.4	17.5	12.6	5.02	5.99	6.64
North East	20.3	9	8.1	2.84	2.42	1.81
South-East	31.5	11.2	12.2	2.86	3.9	1.5
South-MUNTENIA	25.6	23.8	24	5.75	21.7	20.56
South-East Oltenia	21.1	9.4	14.9	0.90	0.66	0.25
West	10.1	8.9	9.4	3.37	4.92	1.24
BUCURESTI – ILFOV	16.4	15.3	12.7	3.37	5.62	3.16

Table 3 Turnover from innovation as % of total turnover by economic sector (%) in NUTS 2 Regions (INS, 2019)

Further information regarding the regional disparities is provided under relevant subsection.

3.8 Firm organisation

Capacity to innovate, ability to engage, absorb and disseminate knowledge depends also on the size of the business. Therefore, this section will analyse the share of SME, large companies, multinationals, start-ups, business demography, aiming to map the characteristics that may have an impact on the capacity to innovate.

Large companies/multinationals. A significant share of the Romanian industry consists of branch plants of foreign firms, particularly for the production of automotive components, heavy machinery and equipment for the extraction of oil and gas. The economy is dominated by multinationals, active in Automobile and automotive components, Banking and finance, ICT, Manufacturing, Retail chains, Consumer products, hotels.

Foreign Direct Investments (FDI). The number of companies with foreign capital participation reached **224,682** by the end of **July 2019**, with a social capital of 48595786 mil Euro (data from the National Registry of Commerce, 2019).[98] The major sectors for FDI by social capital are: (1) the wholesale and retail trade repair of automotive industry and motorcycles (48%), mining and extraction (32%), banking and finance (10.7%). The Netherlands, Spain, Germany, Cyprus, Austria and Italy are among the main investors in RO (August 2019, National Registry of Commerce).

To be noted that "*Firms with domestic majority capital, although dominant in number, have a declining economic strength relative to firms with foreign majority capital.*" Excerpt From: BNR. "Notebooks, No. 42. "iBook.

[98] http://www.onrc.ro/index.php/ro/statistici?id=254

Small Medium Enterprises (SME). The SMEs in Romania provide 67.5 % of total employment, slightly more than the EU average and for half of the value added (49.9%) of GDP. The number of SMEs, **29 per 1,000 inhabitants** (of 15 years or above) compared to 57 in the EU28) is one of the lowest positions in EU (EC, 2018: Annual report on European SMEs 2017/2018, EC, 2018).

Out of **824817** companies active in industry, construction and services (except insurance), **382800** were companies with **0 employees**, **330205 with 1 to 4 employees**, 55205 with 5 to 9 employees, and 56207 with more than 10 employees.

In **terms of NACE,** the highest share was in (1) wholesale and retail trade, repair of motorcycle (274560), followed by manufacturing (71441) and ICT (37000). (EUROSTAT, 2019)

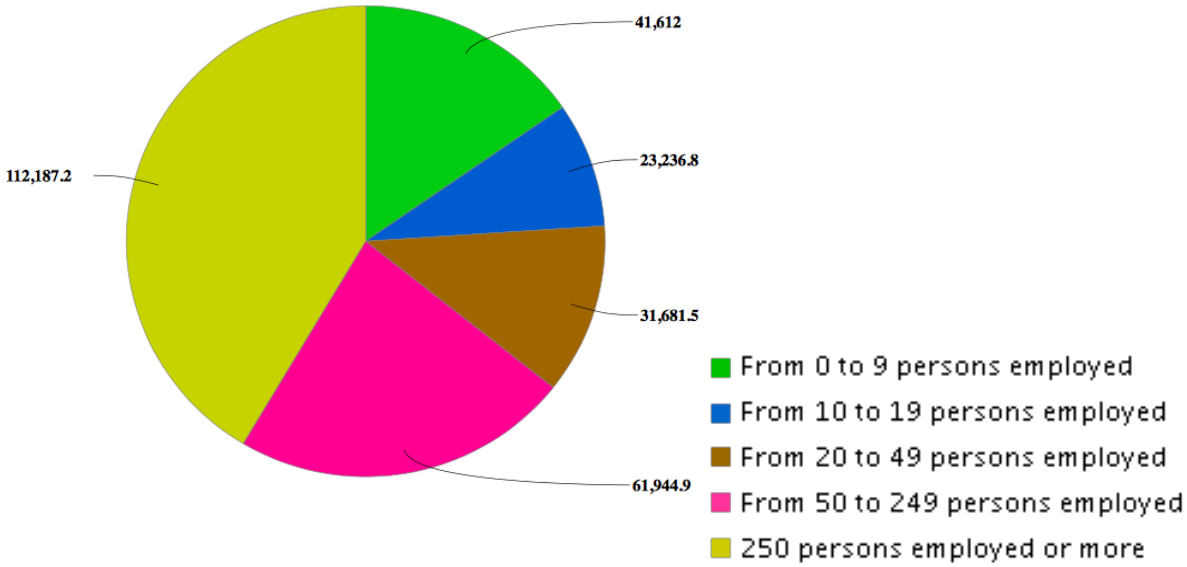

Figure 12 Turnover of the non-financial business economy by size class of employment, 2017 (Source: Eurostat)

Three atypical typologies exist in the Romanian economy: **(i) companies that report a number of employees equal to zero. (ii) companies that report a turnover equal to zero and (iii) companies that have negative equity** (almost half of companies, in December 2014) (*BNR. "Notebooks, No. 42. "iBooks. "Labor taxation, more difficult entry and exit of the market and less friendly behavior of tax authorities")*

3.9 Business environment

	2014	2015	2016	2017	2018	2019	2020	EU28
Country position in Doing Business (Ease of doing business index WB)(1=most business-friendly regulations)	37	37	36	36	45	52	55	30.75 (2015)
Ease of getting credit (WB GII) (Score)	85	85	85					
Ease of getting credit (WB GII) (Rank)	7	7	7					
% of SMEs that indicated access to finance as the most important problem		0.11	0.09					0.1
Innovative enterprises as a share of total number of enterprises (CIS data) (%)	12.8		10.2					50.6 (2016)
EC Digital Economy & Society Index (DESI) (Rank)	29	29	29	29	28	28		
GEDI Global Entrepreneurship Index (2018) (rank)[99]						40		
EC Digital Economy & Society Index (DESI) (Value)	0.25	0.27	0.3	0.32	0.35	0.37		

Table 4 Main business environment indicators – Romania (based on EC-JRC, RIO data)

Romania stands on position **52**, in the ease of doing business ranking of 189 economies. It has a higher position than HU, HR, BG but lower than PL, SK, CZ, for example (Doing Business, 2019).[100] It has a stable position (52) compared to 2017, in the Global Competitiveness Index 4.0 2018[101] ranking of 140 economies. The lowest scores are in '*efficiency of legal framework in challenging regulations'* dimension. Most of dimensions have deteriorated since 2015.

Bucharest demonstrates the potential for dealing efficiently with high demand for business services, while Oradea outperforms in registering property and Timisoara in contract enforcement (Doing Business 2018, Regional Reports).

Topics	DB 2018 Rank	DB 2016 Rank	DB 2015 Rank
Starting a business	111	45	37
Dealing with construction permits	146	105	101
Getting electricity	154	133	132
Registering property	44	64	63
Getting credit	22	7	6
Protecting minority investors	64	57	54
Paying taxes	49	55	53
Trading across borders	1	1	1
Enforcing contracts	17	34	33
Resolving insolvency	52	46	46

Table 5. DB Ranking (Source: WB Doing Business Ranking 2015, 2016 and 2018)

[99] GEDI Global Entrepreneurship Index 2019
[100] http://www.doingbusiness.org/
[101] Global Competitiveness Index 4.0 2018, available at: http://www3.weforum.org/docs/GCR2018/05FullReport/TheGlobalCompetitivenessReport2018.pdf

Business demography

The **net business population growth** shows an **increase** from 0.89% in 2014 to 2.29% in 2017, fluctuating during this period. The rates of births and deaths of Romanian companies indicate a rather high dynamism and instability. Both the number of firms' births and firms deaths increased during this period (EUROSTAT). The highest increase is in the number of enterprises with 1 to 4 employees (from 251810 to 301573).

More than one quarter (26.1%) of young population expected to start a business between 2012 and 2016. This could be explained partly by the high youth unemployment rate and the increase of entrepreneurship mind set and support for starting a business (16.6%).[102]The **Start-Up Nation** programme[103] has offered generous support to entrepreneurs. However, the descriptive statistics, in the absence of programme impact evaluation, may indicate just an opportunistic attitude of the applicants. Author's analysis of the National Registry of Trade (ONR - Oficiul National de Comert) data shows that in the last two years, the volume of new firm creation increases significantly during the time window of the calls for Start-up Nation programme. To be noticed that '**start-up'** in the definition of the programme does not draw on all three criteria commonly used in EC definition of start-up: *younger than 10 years, highly innovative technologies or business models, aim to grow* (European Start-up Monitor[104]).

According to an analysis published in July 2019 by the Sierra Quadrant, the number of de-registrations of companies and PFAs[105] reached 62530 in the first 5 months of this year, 75% more than previous year.

The 2019 report prepared by the National Council of the SME (Consiliul National al Intreprinderilor Private Mici si Mijlocii din Romania - **CNIPMMR**), during November 2018-February 2019, analysing the typology of the beneficiaries of the Start-up Nation 2017 (that uses as definition of start-up: 'company created in 2017') shows that 68.9% of start-ups created in the frame of the programme, have activity in production, followed by creative industries (25.2%), IT (3.2% and Services (2.6%). **A large share (81.6%) are not VAT payers** (indicating the low turnover). 55.8% of the founders have a degree, 48.5% have a background in economics and only 19% a technical background. Only 15.8% had a previous entrepreneurial experience and a large majority had priory an experience in a distinct field than in the one they have received funding (CNIPMMR, 2019)[106]. Most of these start-ups by definition, and as CNIPMMR study shows, do not have an innovative component.

The **Startup Investment & Innovation in Emerging Europe report 2018** identifies around 3,700 tech startups (or start-up projects), and 200-300 new startups or startup projects newly arising each year. The vast majority develops SaaS technologies. "*To a large extent, this is due to the lack of venture capital with entrepreneurs looking for business models and types of applications which can be monetized very quickly, which is often the case with SaaS solutions*." (East-West Digital News, 2018). Romania has some good start-ups (complying to the EC definition) in cyber security, robotics, payments, artificial intelligence, and agritech In the StartupBlink ranking,[107] **Romania ranks 38 globally** among 202 countries, based on the strength of **its start-up ecosystem.** The cities with the most vibrant startup ecosystems are Bucharest, Cluj-Napoca and Iași.

[102] https://www.oecd-ilibrary.org/docserver/9789264283602-en.pdf?expires=1563486764&id=id&accname=guest&checksum=C99BEC7713C81466A0408E97B93ABCE3
[103] https://start-upnation.ro
[104] https://europeanstartupmonitor.com
[105] Authorised Physical Person = Persoana Fizica Autorizata = taxpayers who obtain income from self-employment
[106] http://cnipmmr.ro/wp-content/uploads/2019/05/CATALOG-INTERIOR.pdf
[107] https://www.startupblink.com/startups/industry/mobile

Romanian start-ups face a low survival rate beyond the five-year period. Factors that influence this state are often the lack of space for doing business, the lack of B2B support services (legal advice, accounting), the lack of access to the necessary financing for business development, lengthy and complex administrative procedures, unpredictability of the legal framework, blurred responsibility of the public authorities, red tape, lack of adequate corporate governance, lack of solid business models, managerial expertise. (EU Start-up Monitor, 2015)[108].

There are no studies related to national scale-ups. Since the beginning of 2019, in Romania, only 3 companies have registered investments over 1 million euros: FintechOS, TypingDNA and Elrond.[109]

Following UiPath's success, reaching the unicorn status in 2018, other start-ups grew rapidly, or show the potential to scale up. **UiPath**, the world leader provider of Robotic Process Automation (RPA) and AI software worldwide, is the **first unicorn of the Romanian economy.** The company grew from around $1 million to over $100 million in revenue in less than 21 months.

Most of the scale-ups, showing impressive growth over a short period of time operates in Robotic Process Automation (RPA), AI softwares, cybersecurity, mobile applications, online applications.

Romanian Entrepreneurial Ecosystem Index

The „Romanian Entrepreneurial Ecosystem Index" (REEI)[110] was created by UEFISCDI. It was based on the methodology provided by Endeavor Insight[111], a non-profit organization dedicated to high-impact entrepreneurship. The index is a cumulated measure of the achievements of 5 key-measures: 'inspiration', 'consultancy', 'work experience as an employee', 'mentorship' and 'investment'. In order to better understand the entrepreneurial environment the REEI was divided into two components: the input component, consisting of inspiration, consultancy and work experience and the output or impact component, which consists of mentorship and investment. The value of the Romanian Entrepreneurial Ecosystem Index is 4.5 on a scale from 0 to 10, and has its maximum at 8. It suggests that the Romanian Entrepreneurial Ecosystem is very weakly developed. The networks established among entrepreneurs are not strong enough to lead to a self-sustaining environment

Source: M Mitroi - UEFISCDI

The report of the Policy Support Facility (PSF) panel of experts under the PSF Specific Support for Romania[112], which has been carried out from July 2016 to December 2017 outlines that a key factor to scaling up Romania's growing technology start-up scene consists in developing a robust ecosystem that nurtures Romanian innovation and entrepreneurship. The analysis of the European experts exposes the need for smarter legislative and financial instruments and incentives to nurture Romania's innovators and entrepreneurs. In the report, the country's innovation and entrepreneurial ecosystem is described as having a lot of potential but being still at the "early stage" of development. It highlights the need to improve the country's "dynamics of change" towards a more innovative digital economy. The report mentions that the biggest barriers hindering development are a "**lack of trust, predictability and transparency**", as well as access to finance for innovative enterprises and the limited capacity of higher education

[108] European Startup Monitor 2015 https://europeanstartupmonitor.com/fileadmin/presse/download/ESM_Presentation_Brussels.pdf
[109] https://eytechblog.eyromania.ro/ey-tech-blog/astzi-startup-maine-scaleup/
[110] http://ree.uefiscdi.ro/entrepreneurship-in-romania/romanian-entrepreneurial-ecosystem-index/
[111] https://endeavor.org/impact/insight/
[112] https://rio.jrc.ec.europa.eu/en/policy-support-facility/specific-support-romania

institutions to play a more active role in the entrepreneurial ecosystem. The recommendations provided highlight that Romania should have an entrepreneurship ecosystem that empowers entrepreneurs and provides stability. More predictability – the legal, political and business framework – backed up by better market conditions and access to financial and non-financial support schemes are a corollary of this, giving venture capitalists, business angels and innovative entrepreneurs the impetus to start and scale up their businesses.[113]

4 RDI SYSTEM

4.1 RDI governance

In November 2019, a new government entered office. The government reshuffle led to another institutional reorganisation. The Ministry of Research and Innovation and the Ministry of Education were reorganised as Ministry of Education and Research (MEC). The former Ministry for Research and Innovation (Ministerul Cercetarii si Inovarii - MCI), was established in January 2017, through the split of the Ministry of National Education and Research in two distinct ministries with their specific responsibilities ((a) Ministry of National Education and (b) Ministry of Research and Innovation) and through the restructuring of the National Authority for Scientific Research and Innovation (Autoritatea Nationala pentru Cercetare Stiintifica si Inovare - ANCSI), previously responsible for RDI policy. The Ministry, by law, is responsible for the design, implementation, coordination, monitoring and evaluation of the research and innovation policies and of the national RDI system. According to its mission, as presented on the official Ministry Homepage, MEC has among the most important responsibilities, the following:[114]

- to establish and maintain strategic objectives implemented by the National Plan for RDI and other tools for implementation of the National Strategy in line with the priorities of the Government's economic and social policies;
- develop the National Plan for RDI on multi-annual periods, assess the programs, make their annual breakdown and inform on their implementation;
- forecast, plan and implement, as appropriate, the budget for R&D and innovation. included in the state budget. and financial resources needed to carry out policies in its field of competence;
- approve and **finance NUCLEU programs** (Programul Nucleu), develop sectoral R&D plan and approves its own R&D sectoral plans of other authorities;
- ensure institutional development of institutes and research units subordinate. coordination and under authority.

For the current policy cycle, 2014-2020, MEC is responsible for the overall implementation of the two main funding instruments of the National RDI Strategy: the National Plan for RDI 2015-2020 (PN3) and the Competitiveness Operational Programme (Programul Operational Competitivitate - POC), Priority Axis 1, for which acts as intermediary body.

[113] The report is the result of the request of the Romanian government for Specific Support to Romania under the Horizon 2020 Policy Support Facility (PSF). The assessment exercise included two fact-finding visits to Romania and consultations with over 50 stakeholders. The panel included experts from Finland. France. Poland and Portugal. The Horizon 2020 Policy Support Facility provides expertise and operational support to Member States in designing. implementing and evaluating national research and innovation policies. including country Peer Reviews and Specific Support to policy reforms. as well as thematic Mutual Learning Exercises to improve policy-making practice through exchanges among several countries.

[114] the full list of responsabilities is available on the MEC website http://www.research.gov.ro/ro/articol/980/despre-ancs-prezentare

The Romanian Government approves every year, in the State Budget Law, the public R&D budget, **Romanian Academy having** a distinct budgetary line. Generally. this initial planning is followed by budget rectifications, which most often has revised the R&D budget negatively (see Table R&D Budget). MEC in line with its legal responsibilities, decides on the way funds are allocated to different budgetary chapters.

The responsibility for the PN3 administration is split between MEC and three funding bodies: the Executive Agency for Funding Higher Education, Research, Development and Innovation or (Unitatea Executiva pentru Finantarea Invatamantului Superior. a Cercetarii. Dezvoltarii si Inovarii UEFISCDI), the Romanian Space Agency (ROSA) and the Institute for Atomic Physics (IFA). UEFISCDI administrates the largest share (around 70%) of PN3 project based competitive funding. Since 2014, UEFISCDI has managed around 30% of the national public funds allocated to the RDI activity.

Various Councils[115] and **Consultative Bodies,** the **Romanian Academy** and its branches provide policy support and case by case policy advice. **In January 2017**, the **four RDI advisory councils** which had just started their activity after a lengthy and open selection process were suspended by the new government, reorganized and reactivated with different members in April 2017. The academic community, the Ad-Astra association and the European University Association (EUA) reacted with concern to the controversy related to the dismissal of the councils and of the foreign evaluators.[116, 117]

UEFISCDI is a public institution established by Government Ordinance no. 62/1999 approved with amendments by Law no. 150/2000, and subsequently amended and supplemented, by OG 74/2010[118], under the authority of the Ministry of Education and Research (MEC), In line with the legal provisions, among its main responsabilities are evidence base studies for the allocation of national state funds for universities and the coordination from an administrative point of view, monitoring and evaluation, of **specific** programs and subprograms of the National Plan for Research, Development Innovation[119]. UEFISCDI, as a research funding agency, organizes competitions and subsequently monitors the implementation of projects accepted for funding. In its role of policy support, UEFISCDI plays a policy support role. The second role developed by UEFISCDI and recognized by the policy makers, academic and research communities is of policy advice providing services as "governmental" foresight hub, developing tools and methodology (as Entrepreneurial Development Process), implementing foresight for higher education, science and innovation. Through specific projects has provided support to the Ministry in charge in developing strategic documents (such as the National Strategy for RDI, National Plan for RDI). MEC is the main authority, deciding the final form of all strategic documents and the relevant implementation instruments.

Each NUTS 2 region has a **Regional Development Agency** (ADR - Agentie de Dezvoltare Regionala)[120] which elaborates the Regional Development Plan and ensures the technical management of funding. The agencies are diverse in organisation, number of staff, culture, expertise. Six of the eight ADRs elaborated between 2005 – 2008, their

[115] http://www.research.gov.ro/ro/categorie/967/despre-ancs-organizare-organe-consultative-4-consiliul-pentru-inovare
[116] http://civitas.dogaru.net/nu-reorganizarii-organismele-consultative-ale-ministerului-cercetarii-si-inovarii/
[117] http://www.eua.be/activities-services/news/newsitem/2017/05/30/eua-statement-on-the-recent-developments-in-romania-regarding-the-research-policy-framework
[118] http://legislatie.just.ro/Public/DetaliiDocumentAfis/120010
[119] P1-Development of the national CD system; P2-Increasing the competitiveness of the Romanian economy through RDI. P3 - European and international cooperation. P4 - Fundamental and frontier research
[120] The role of each Regional Development Agency is to contribute to sustainable and equitable development by removing disparities and imbalances among areas within the region. Established by Law 151/1998, the Regional Development Agencies currently operate under Law 315/2004 on regional development in Romania.

Regional Innovation Strategies 2008 – 2013, financed through the Framework Program 7 of the European Commission. All seven 'less developed regions' finalised in 2017 the design of the Smart Specialisation Strategies, responding to the EC request to all EU MS to fulfill the ex-ante conditionality on the RDI area, which specifies the existence of smart specialisation strategies at national/regional level (as further detailed in section RDI Policy).

The **National Committee for Coordination of the Smart Specialisation** was established in August 2019, through Ministry Order no. 458 / 31.07.2019. It includes representatives from various ministries and the eight Regional Development Agencies. From September 2019, regular consultations on the committee will take place. In line with this Order, MEC, through the Directorate of the RDI Policies and Programmes ensures the institutional governance for the management of the National Strategy for Smart Specialisation.

Outstanding issues

"*A genuine regionalisation process still remains uncertain in Romania. The topic has been intermittently on the top of the public agenda, but controversies regarding the appropriate depth and breadth of regionalization have determined the delay of any firm decision."* (Chioncel, M. RIO 2017, Gheorghiu, R EW 2015). As far **October 2019,** the development regions, in line with the relevant laws, **are not administrative-territorial units / legal entities** (Law 315/2004[121], Romanian Constitution). Both types of regions exist primarily for the purpose of coordinating development projects.

4.2 The RDI performers

According to INS data, in 2017 there were 713 units with R&D activity: **276** public RDI (out of which 86 HEIs-public and private) and **437** belong to the private sector (414 business sector and 23 private non-profit). The total number of R&D units dropped to **571** (256 public and 315 private) by the end of 2018 due to the particularly high decrease of the number of business R&D centres (from 414 to 298).

Sectors of performance	Year 2017 Number	Year 2018 Number
Total	**713**	**571**
Public sector	**276**	**256**
Government sector	190	171
Higher education sector	86	85
Private sector	**437**	**315**
Business sector	**414**	**298**
Private non-profit sector	23	17

Table 6 Number of units with R&D activity (source: INS).

The R&D system of **national interest**[122] includes the following categories of legal entities, governed by the Law. 324/2003 regarding the approval of the Government Ordinance no. 57/2002 on Scientific Research and Technological Development:

- National Research and Development Institutes (Institute Nationale de Cercetare si Dezvoltare INCD);

[121] LEGE nr. 315 din 28 iunie 2004
[122] http://www.research.gov.ro/ro/articol/1315/sistemul-national-de-cercetare-dezvoltare

- institutes, centers or research stations of the Romanian Academy and of the branch academies;
- accredited higher education institutes or their structures;
- national companies, institutes or research-development centers organized within the national companies.

According to the official information provided by MEC[123]. the national R&D system comprises '*about 600 enterprises,* ***56 authorized public universities,*** **46 National Research and Development Institutes** (**INCD** - Institute Nationale de C&D), of which 43 are coordinated by MEC and 65 are research institutions and centers of the **Romanian Academy** and other entities.

The **INCDs** are national legal entities organised since 1995, initially as a distinct category of autonomous companies. Currently they are organized according to Law no. 324/2003. They operate on the basis of economic and financial autonomy and have their own patrimony.

The **Romanian Academy** is organised in line with the law regarding the organisation and functioning of the Romanian Academy.[124] According to the law, the Romanian Academy is 'a legal entity, which performs research in fundamental science and culture and independent in its work'. In line with this status, the RA has its own budget chapter in the state budget.

The **University autonomy** is guaranteed by the provisions of Romanian Constitution (art.32 (6)) and those of the Law of Education (2011), with all the later amendments and additions. The whole set of rights and obligations as well as the norms underlying the life of the university community are found in the **University Charta** designed in line with the provisions of the Law of Education. The universities have in theory the right to have their own Research Strategy but this is hardly feasible in the absence of R&D institutional funds for HEIs. Analysis of the University Charta of the main national universities shows that they are similar content wise, prevailing uniformity in the definition of the academic autonomy, governance. **The similarity is mainly grounded in the current legislation which guarantees the academic autonomy, but also significantly limits it**.

The **National Network for Innovation and Technology Transfer** (ReNITT) '*includes 50 specific organizations: technology transfer centers. technology information centers. technology and business incubators. 4 science and technology parks*.

4.3 Human capital for RDI

To be noted that the figures in this section, as provided by the INS statistics, give the total number of employees who, ***at a certain point, directly or indirectly,*** *participate in the the activity of R&D units and are paid for the services performed. Therefore these figures are significantly higher compared to those providing data regardinf Full Time Equivalent (FTE) employees in R&D/ researchers, as detailed in other sections. The definition of employees in R&D[125] and researchers[126] is detailed in the footnote.*

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[124] https://acad.ro/acteNormative/doc2010/MO-0617StatutulAR.pdf

[125] *Employees in R&D are broken down by the following activities: (1)* ***researchers*** *= personnel involved in R&D activity - the personnel that directly participates in such an activity and the personnel that provides services which are directly linked to this activity; (2) personnel involved in the production activity, (3) personnel performing activities auxillary to R&D.*

[126] In the **Researchers** category are included scientific researchers, teaching and research staff in higher education involved in the research, leadership and administrators, carrying out planning and management of the scientific and tehnical aspects of research, as well as doctorate students

At the end of 2018, there were 44733 employees with R&D activity. **More than half of the R&D employees are concentrated in Bucharest-Ilfov Region**. The analysis of the researchers by scientific field shows the dominance of researchers in S&T sciences (47%), followed by natural sciences (22%) and medical sciences.

Employees from research-development activity by occupation	Year 2018 Number of persons
Total	**44733**
Researchers	27471
Technicians and assimilated	6670
Other categories of employees	10592

Table 7. Employees in research-development activity by occupation (source: INS)

NUTS 2 Region	Year 2018	
	Number of persons	% of total
TOTAL	**44733**	**100,0**
NORTH - WEST	3484	7.8
CENTER	4140	9.3
NORTH - EAST	3821	8.5
SOUTH - EAST	2479	5.5
SOUTH - MUNTENIA	2631	5.9
BUCHAREST - ILFOV	**23095**	**51.6**
SOUTH - WEST OLTENIA	1464	3.3
WEST	3619	8.1

Table 8 Employees in research-development activity by NUTS2 region (source: INS)

Researchers by scientific field	Year 2018	
	Number of persons	%
Researchers - total	**27471**	**100.0**
Researchers - in scientific natural and exact sciences	5953	21.7
Researchers - in scientific engineering and technological sciences	12817	46.7
Researchers - in scientific medical sciences	4014	14.6
Researchers - in scientific agricultural sciences	1502	5.5
Researchers - in scientific social sciences	1687	6.1
Researchers - in scientific humanities	1498	5.5

Table 9 Researchers by scientific field in 2018 (source: INS)

involved in research projects. By convention, any member of the armed forces running R & D activities and scientific researchers similar qualifications should be included in this category.

The share and the number of researchers by scientific field and per field have fluctuated. By the end of 2018, it can be observed an increase of the number of researchers in natural sciences (from 4032 to 5953).

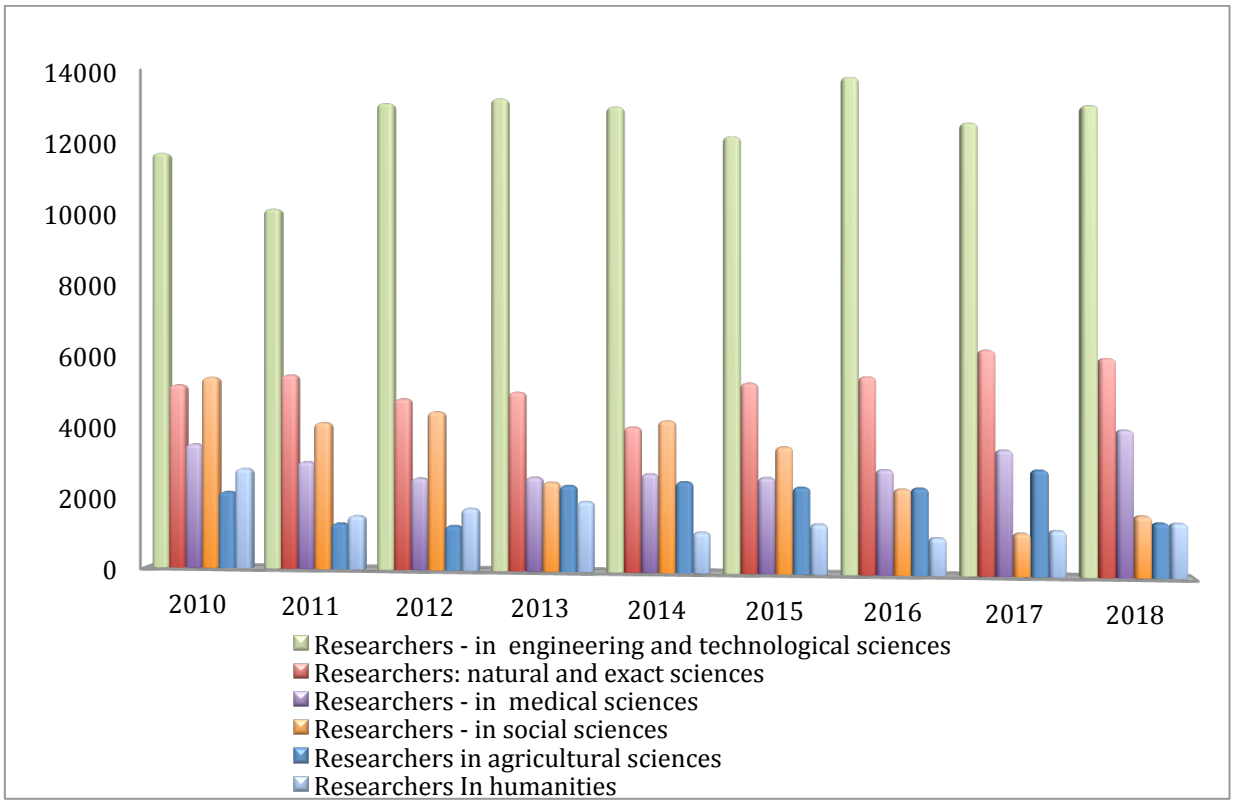


Figure 13. Researchers by scientific field (Source:INS)

4.4 R&D funding

It should be noticed that the budget line in the Annual State Budget dedicated to RDI is labeled 'R&D budget" (and not RDI budget). Therefore, while the activities and the implementation instruments target the broader innovation ecosystem herein the budget will be referred to as the R&D budget, in line with the national legislation. However, innovation is funded from many different public sources.

4.4.1 R&D funding. Time trend

	2014	2015	2016	2017	2018	EU28
GERD (as % of GDP)	0.38	0.49	0.48	0.5	0.5	2.12 (2018)
GERD (million EUR)	575	782	818	945		
GERD funded by BES (million EUR)	189	292	404	514		
GERD funded by GOV (million EUR)	279	326	324	340		
GERD funded by HES (million EUR)	8	13	9	16		
GERD by Private non-profit (million EUR)	1	1	0	0		
GERD funded by Abroad (million EUR)	98	150	81	75		

Table 10. GERD (volume and intensity). Romania: time evolution 2014-2018. EU 28

Romania allocated in 2017, 2018 the lowest GERD per capita in EU28 (48 EUR per capita, compared to 619 EUR the EU28, respectively 52.5 compared to 661). In 2019, the public intensity for RDI was around 0.15% (vs 1% target of public investement in R&D by 2020). However, it should be noted as stated in table 10 (GERD volume and intensity) that the nominal GERD (in million euros) has increased and the declining trend of the intensity of GERD is due to the GDP increase. The R&D funded by BES showed a significant volume increase in 2016. The government support for R&D after an increase in 2015&2016 dropped to 0.18% in 2018 and 2019.

The cohesion funds for the thematic priority Research&Innovation was **1174,629,463 EUR**. By December 2019, **only 34% of this budget has been spent and 57% decided**. (DG-Regio data).[127]

127 https://cohesiondata.ec.europa.eu/themes/1

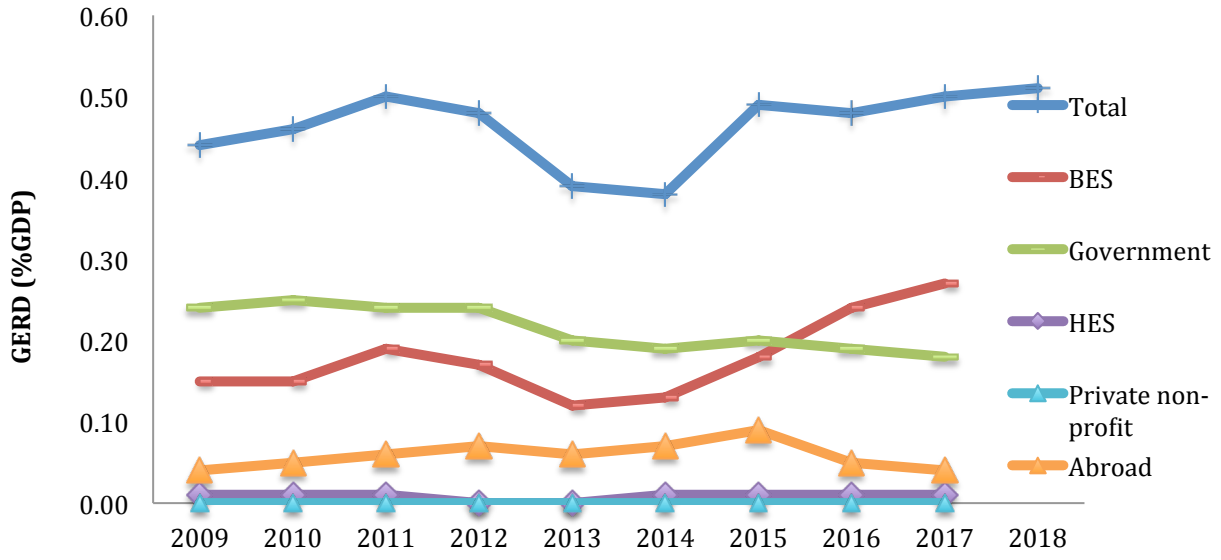


Figure 14. Time evolution of total GERD (% of GDP) and by source of funding, (source: EUROSTAT)

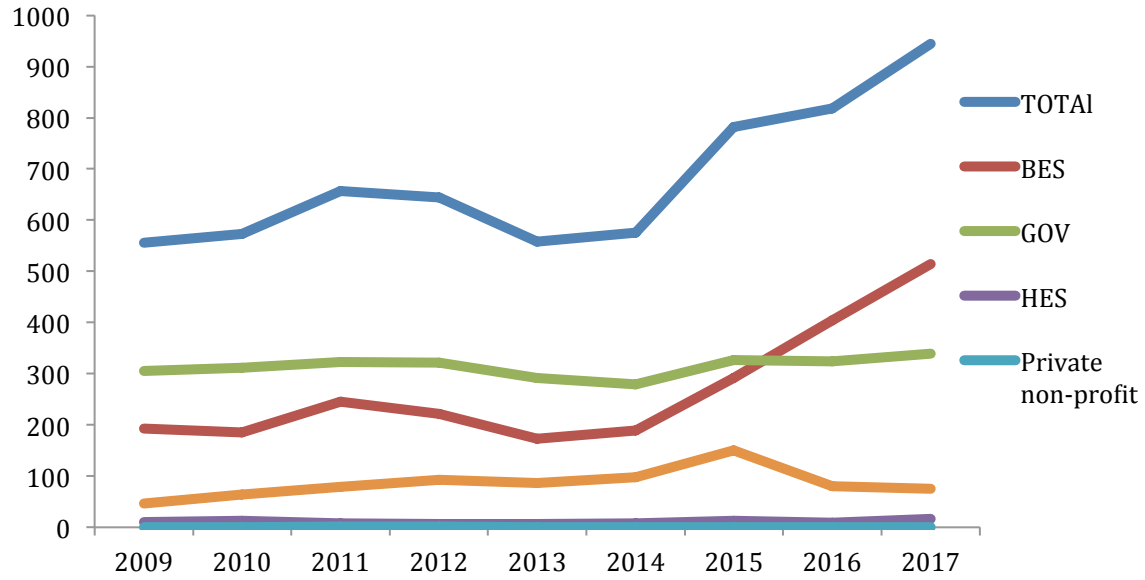


Figure 15. Time trend of total GERD volume (million RON), over the period 2009-2017

Multi-annual planning. According to the National Strategy for RDI and Smart Specialisation the allocation of funds is based on multi-annual planning. However, the RDI annual budget allocations/ executions do not comply to the targets assumed. In addition, the budgets approved by the State Budget Law are followed by a revision (generally downwards).

Year	Initial Budget (thousands RON)	Revised budget (thousands RON)	Final Budget (%initial budget)
2011	1509000	1209181	80,13
2012	1483895	1196403	80,63
2013	1672042	1139261	68,14
2014	1487308	1270633	85,43
2015	1469499	1597759	108,73
2016	2136394	1847083	86,46
2017	1725470	1419251	82,25
2018	1637754	1423778	86,93
2019	1781524	1350000	75,78

Table 11. Initial and revised R&D budget during 2011-2019

4.4.2 R&D funding by funders

	2014	2015	2016	2017	2018	EU28
GBAORD (Million units of national currency)	1420.971	1836.1	2137.29	1610.2	1637.4	
GBAORD (as % of GDP)	0.21	0.26	0.28	0.19	**0.17**	**0.64** (2017)
R&D funded by GOV (% of GDP)	0.19	0.2	0.19	0.18	0.17	**0.61** (2017)
R&D funded by BES (% of GDP)	0.13	0.18	0.24	0.27	0.29	**1.21**
R&D funded by abroad (as % of GDP)	0.07	0.09	0.05	0.04	0.05	**0.2**
R&D funded by EC (% of GDP)	0.04	0.06	0.04	0.04	0.05	

Table 12. Main indicators: R&D funding by performers

The graphics below show the evolution of funds and their distribution across the performance sectors during 2014-2020. Although the GERD volume increased during this period, GERD intensity decreased due to the GDP increase.

The main contributor to GERD is BES.

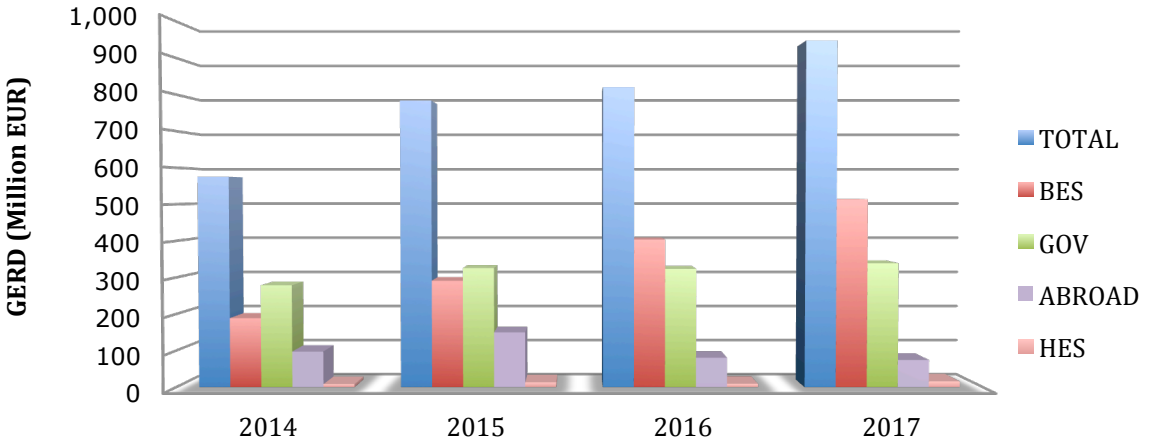


Figure 16. Time evolution of nominal GERD in Romania (mil EURO) by funders (data source: EUROSTAT)

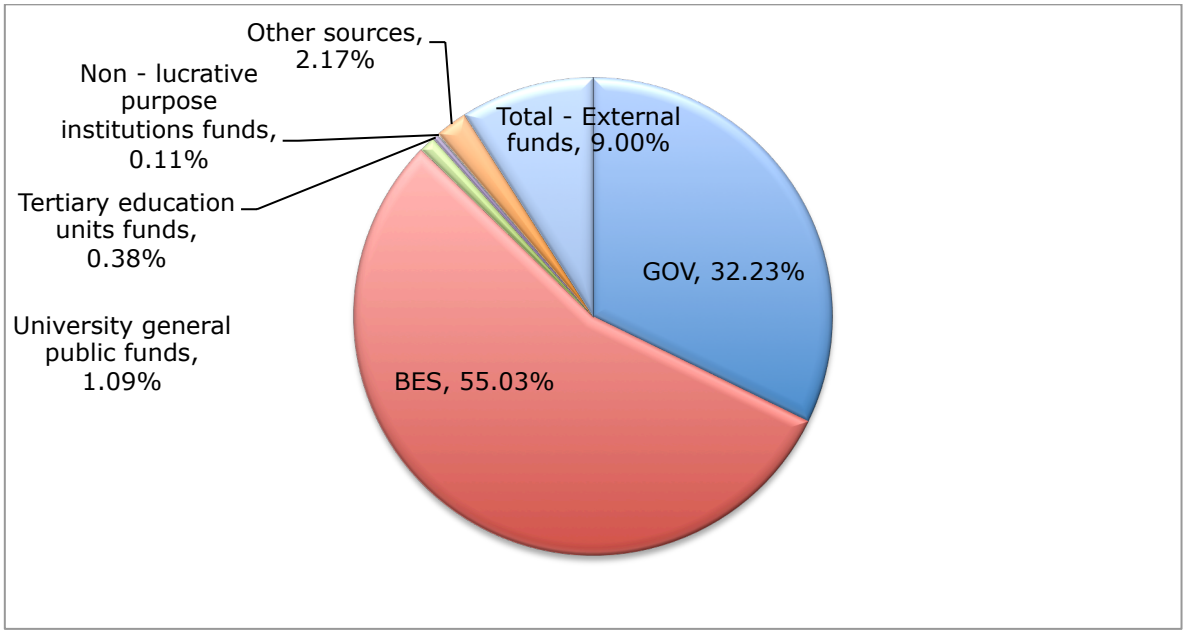


Figure 17. Total R&D expenditures by funders in 2018 (Author's analysis INS data)

4.4.3 R&D funds by performers

	2014	2015	2016	2017	2018	EU28
R&D performed by HES (% of GDP)	0.06	0.09	0.05	0.05	**0.05**	**0.46 (2018)**
R&D performed by HES and funded by public (GOV) (% of GDP)	0.03	0.05	0.04	0.03	0.04	**0.35 (2017)**
R&D performed by HES and funded by private(BES and PNP) (% of GDP)	0	0	0	0		0.05
R&D performed by GOV (% of GDP)	0.16	0.19	0.16	0.16	**0.15**	**0.23 (2018)**
Percentage of scientific publications among the top 10% most cited publications worldwide as % of total scientific publications of the country	3.35	3.5	4.22	n.a	n.a	n.a
ERC success rate (granted over evaluated)	0.02	0.05	n.a	n.a	n.a	n.a
Number of international scientific co-publications per million population	229.54	239.06	252.15	255.32	257.63	n.a
BERD (% of GDP)	0.16	0.21	0.27	0.29	**0.3**	**1,37**
BERD funded by the government	0.03	0.03	0.03	0.02	0.01	0.07

Table 13. Main indicators R&D funding by performers

The **GOV sector** (GOV=INCD and Romanian Academy (Academia Romana) + other public R&D centers) performs the highest share of the public budget allocation (**around 70% of the public GERD compared to around 32%, the EU28 average**). **Research performed by tertiary education counts to around 18% of total GERD** (compared to the EU28 average of 57%).

Block funding for public universities = Higher Education Sector (HES) is provided only for education activities, through contracts between the Ministry in charge of Education and the individual HEIs. HEIs obtain funding for RDI activities only through project based competitive funding, open to all R&I actors. The institutional funds for HEIs are only for educational purposes and the largest share (around 75% in 2018) is based on the average cost per equivalent student per domain, per study cycle and per teaching languages. The financing arrangement has been criticized for dissipating funds among too many universities, in the absence of appropriate mechanisms for rewarding the quality of teaching and research or responding to societal needs. (Andreescu L., et al, 2015).[128]

[128] L Andreescu, R Gheorghiu, A Irimia, A Curaj - Mergers and Alliances in Higher Education, 2015 https://www.oapen.org/download?type=document&docid=1001969#page=53

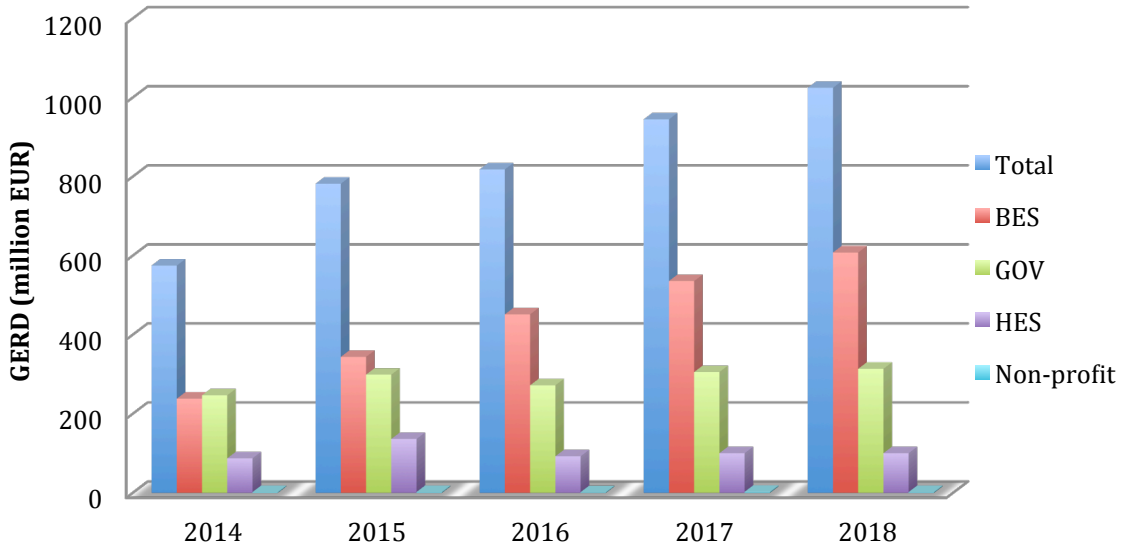


Figure 18. RO GERD by performers: 2014-2018 (data source: EUROSTAT)

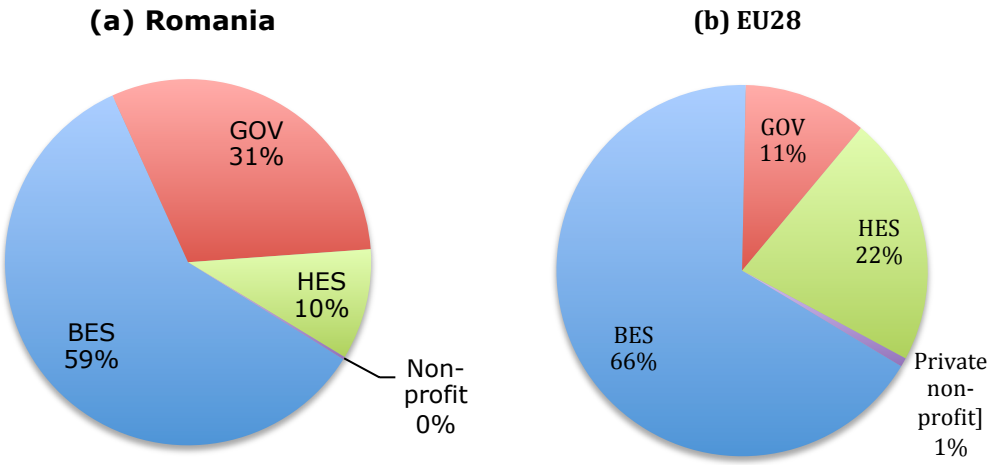


Figure 19. 2018 GERD by sectors of performance in RO and EU28 (Source: Eurostat)

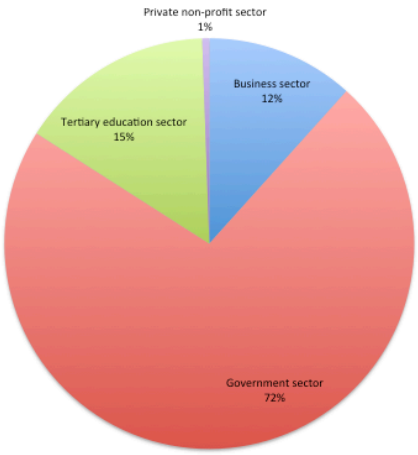


Figure 20. 2017 public R&D funds by sector of performance (Source: Eurostat)

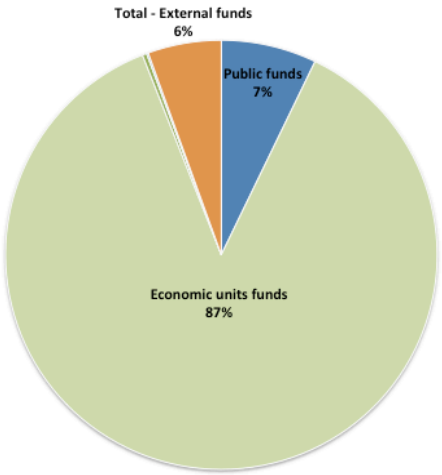


Figure 21. 2017 RDI performed by BES by source of funding (Source: INS)

4.4.4 R&D expenses by category of costs

The figure below shows the time trend during 2014-2020 of the R&D expenditures by category of expenses. The highest increase is in **staff** expenditure. It should be noted that the number of Human Resources in Science and Technology (HRST)/ and researchers did not follow a similar increasing trend.

In Romania, the distribution of R&D expenses by type of costs is similar to that in EU2 average. However, RO spends significantly less in all types of costs (i.e in 2017, the EU28 average labour cost is around 286 EUR per head compared to 24 EUR in RO; EU28 spends around 24.1 EUR per head for equipments, while in RO spends 2.7 EUR). (EUROSTAT).

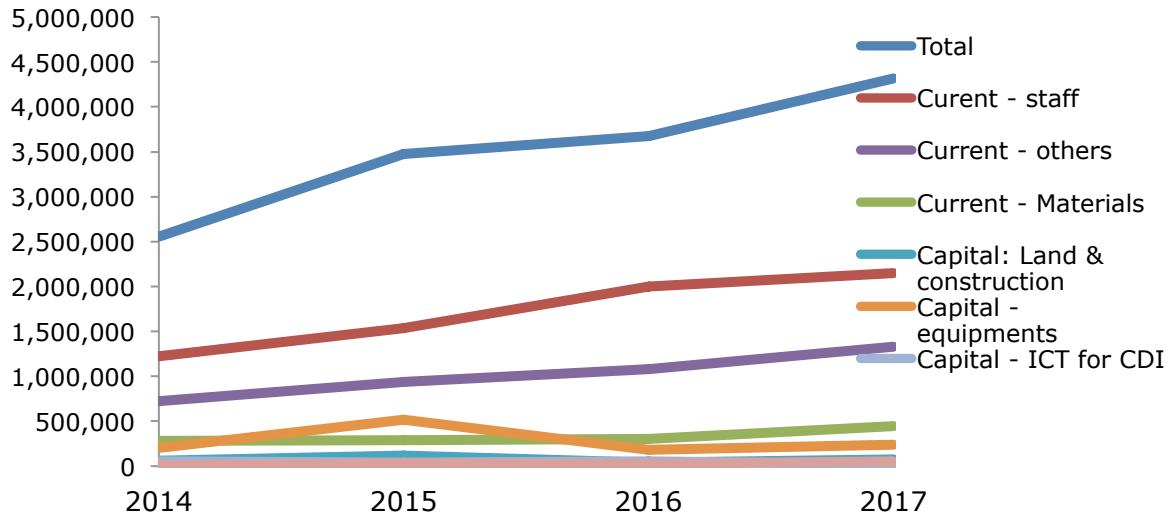


Figure 22. GERD. GERD by category of expenses (thousands RON)

4.4.5 R&D expenditures by type of research

The calculations and the comparative analysis RO – EU28 were perfomed on 2017 EUROSTAT data (the most complete series). No data regarding R&D funders and the type of research perfomed are available. EUROSTAT does not provide data broken down on performers and type of research for Germany, Sweden, Finland (which have large contribution from BES; these data in the statistics would probably increase the share of experimental development).

The time evolution analysis of funds by type and research and performers in RO is based on INS data.

Based on the 2017 data, Romania allocates compared to EU average a lower share to basic research (18% vs 24%), a higher share for applied research (64% vs 42%) and a significantly lower share to experimental development research (19% vs 40%).

Since 2014, the share of GERD allocated to **basic research** decreased gradually from 36% to 18.5% in 2018 (see figure 23). The share of funds performed by all the three main performers (BES, GOV, HES) in basic research decreased from 2014 to 2018, however at different rates and levels. The allocation of BES funds for basic research decreased from 17% in 2014 to 3.7% in 2018. The GOV sector perfomed 36.5% of its funds in 2018 basic reseach compared to 46.14% in 2014, while the HES performed 58% in 2014 compared to 53% in 2014.

The share decrease of basic research performed by BES was complemented by an increase of the funds allocated to **applied research** (from 56% in 2014 to 82.3% in 2018) but suprisingly also by a decrease of the share allocated to **experimental development** (from 26.9% to 13.9%).

Romania allocates a significantly lower share compared to EU28 to **experimental development research (**19% vs 40%) due to the low in house R&D by BES and the higher share invested by BES in applied research. The share of R&D funds performed by Romanian BES for experimental development research counts to 18% of total R&D budget performed by BES compared to the 52% EU average.

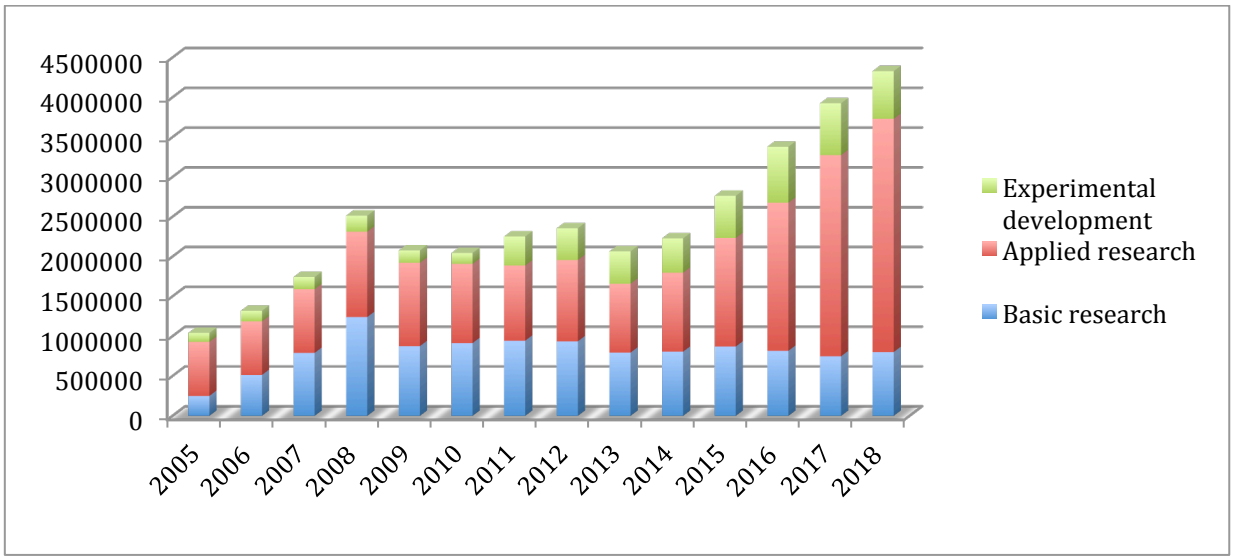


Figure 23. Time evolution of total GERD in Romania (thousand RON) by type of research activity (source: INSSE)

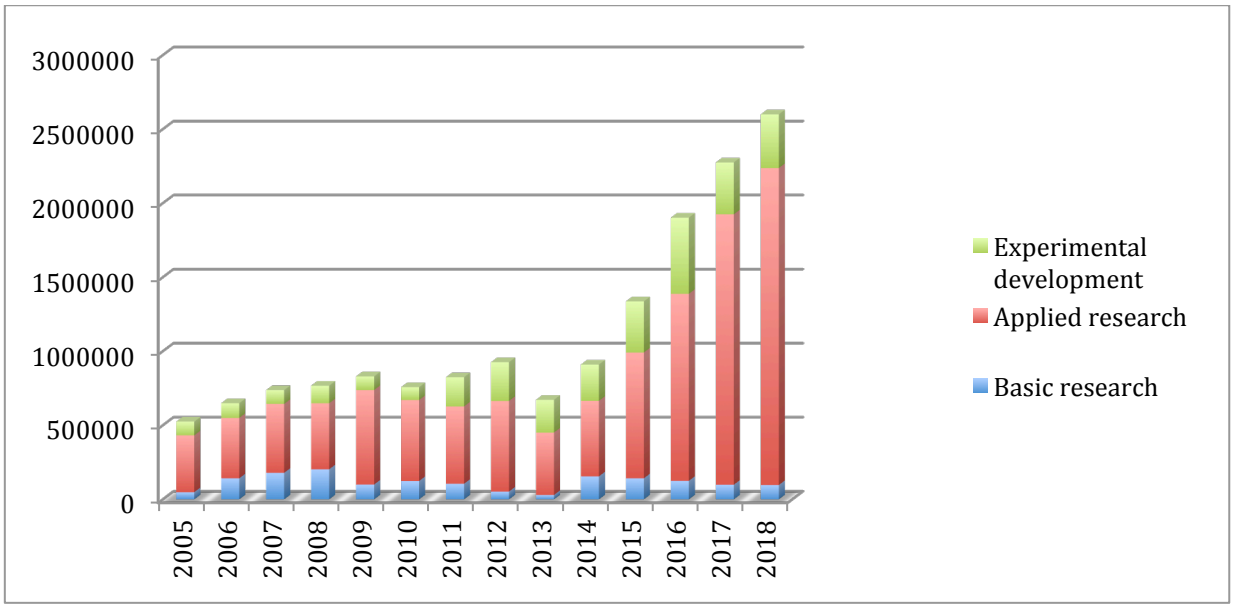


Figure 24. Evolution of GERD performed in Romania by BES (thousand RON) by type of research activity

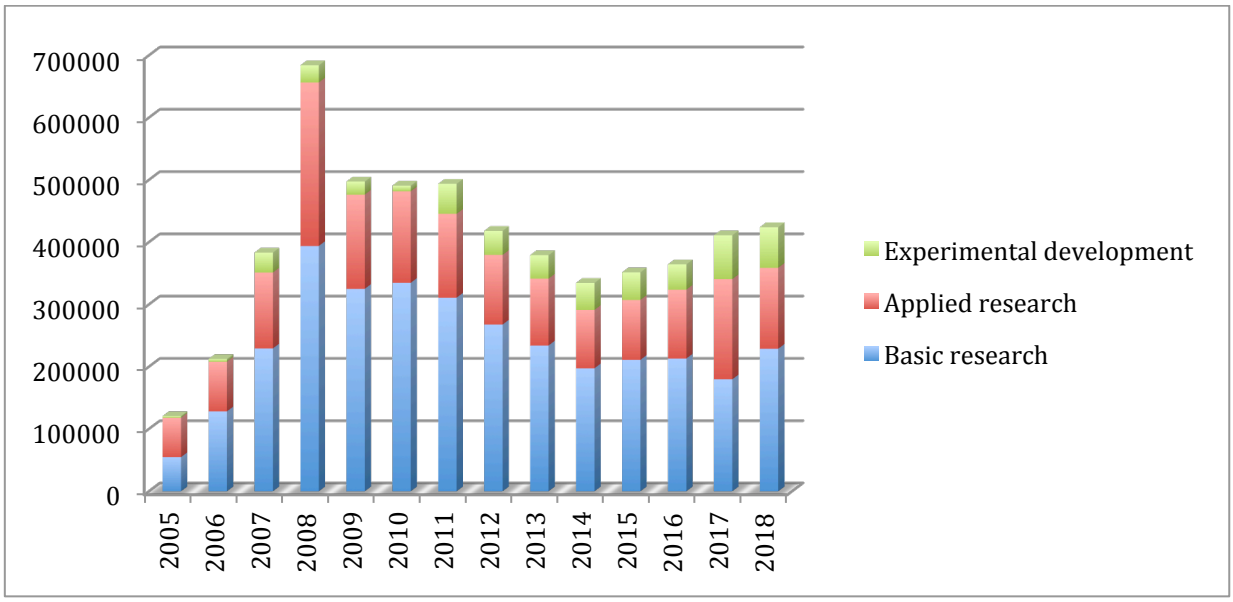


Figure 25. Evolution of GERD performed in Romania by HES (thousand RON) by type of research activity

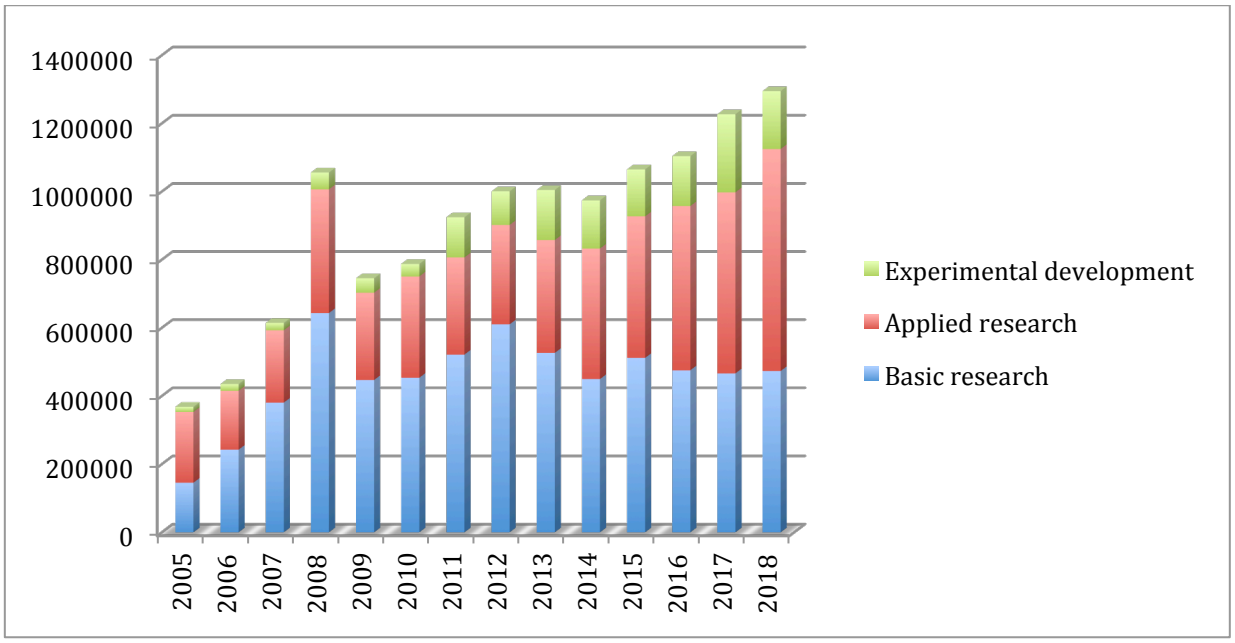


Figure 26. Evolution of GERD performed by GOV (thousand RON) by type of research activity

4.4.6 R&D expenditures by regions

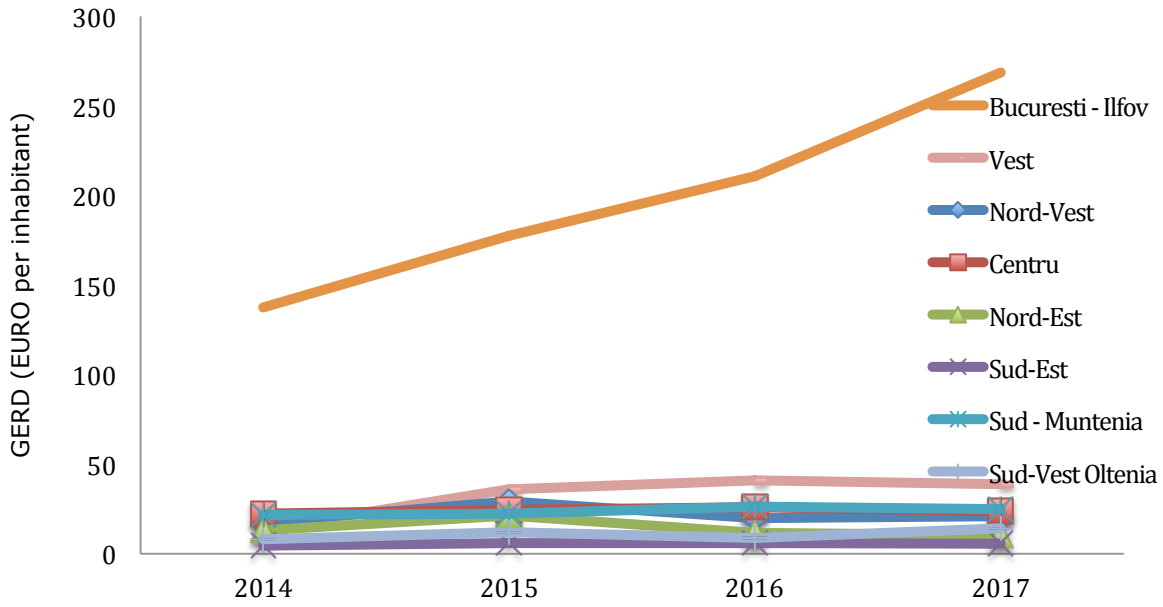


Figure 27. Time evolution of GERD (per capita) in NUTS2 regions (source: EUROSTAT)

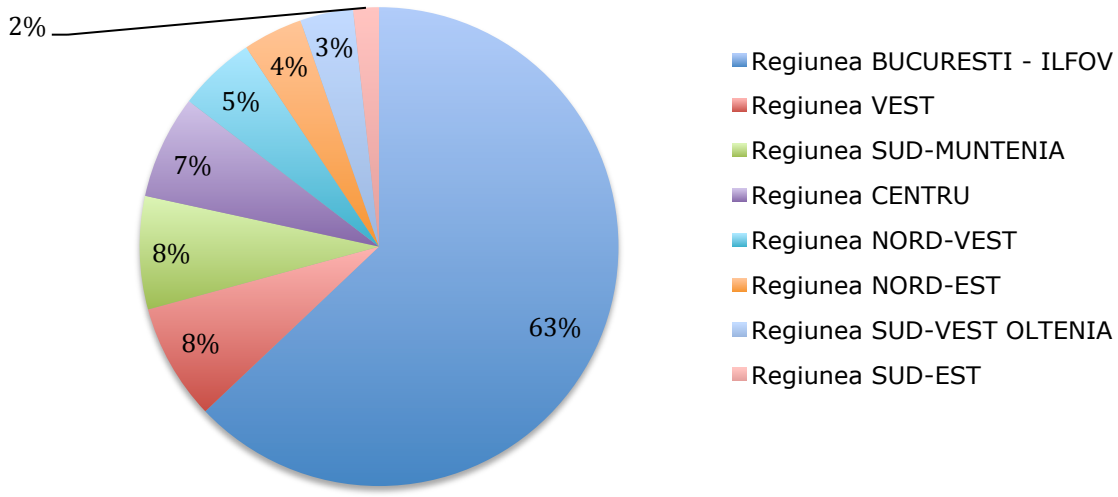


Figure 28. 2017 GERD share by NUTS2 regions (source: EUROSTAT)

There are high disparities between regions in terms of R&D expenditures. Bucharest-Ilfov concentrates more than 60% of the funds, while 40% are distributed across the other seven regions. The same heterogeneity is observed in terms of distribution of HRST/researchers across regions.

Any R&D planning should carefully consider these regional disparities and appropriately design strategies to address them.

4.4.7 R&D funding by smart specialisation domains

According to the latest data available the highest share of project based funding, within the programmes explicitly targeting the smart specialisation domains was allocated to the ICT, space and security, followed by advanced materials, bioeconomy, energy and health.

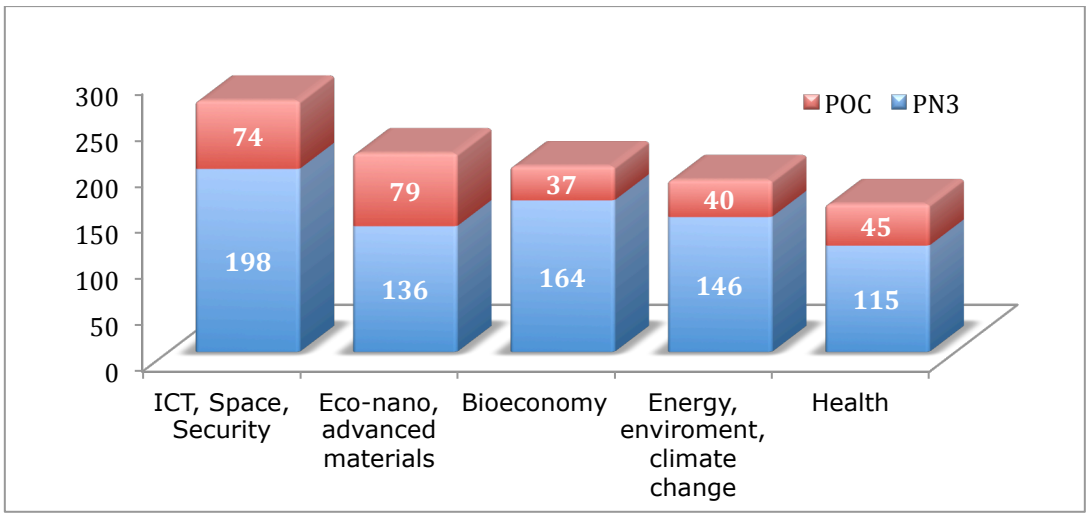


Figure 29. Funds allocated by PN3 and POC programmes to the four smart specialisation domains (and health)

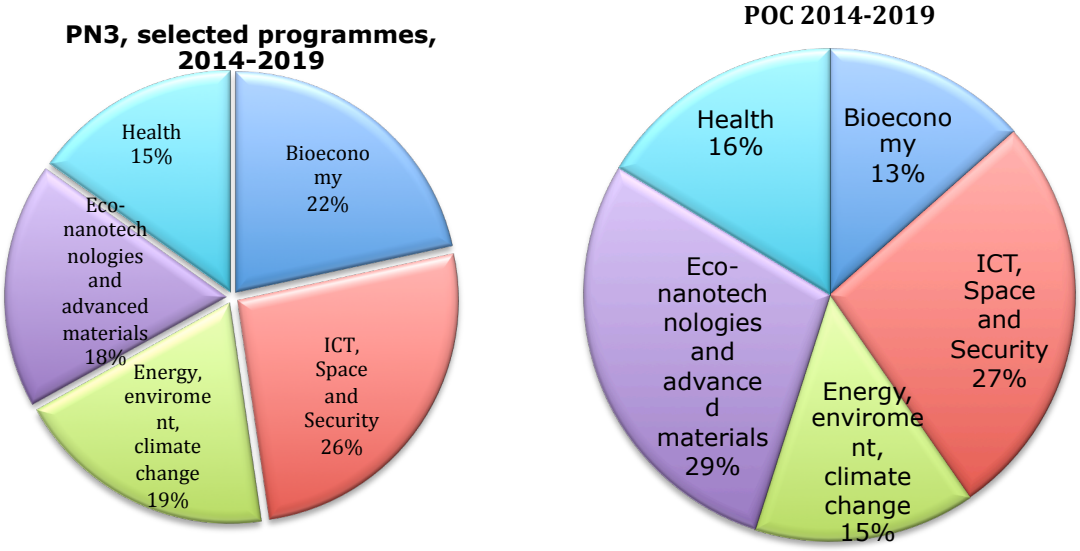


Figure 30. (a) PN3 allocation by smart specialisation domains; (b) POC allocation by smart specialisation domains

4.4.8 Business expenditure in R&D by NACE

The national business expenditure in R&D is low in EU28 comparison, although it showed a sharp increase during the last years. Romania invested in 2017, 0.27% of GDP compared to EU28 which invested 1.21 % of GDP.

The figure below reveals the time trends and the dominance of some NACE fields. The graph does not displays the NACE sectors with very low expenditure. It can be observed that the R&D expenditure has significantly decreased (although the bioeconomy was a smart specialisation domain) and the R&D expenditure is concentrated in professional, scientific and technical activities, ICT and manufacturing.

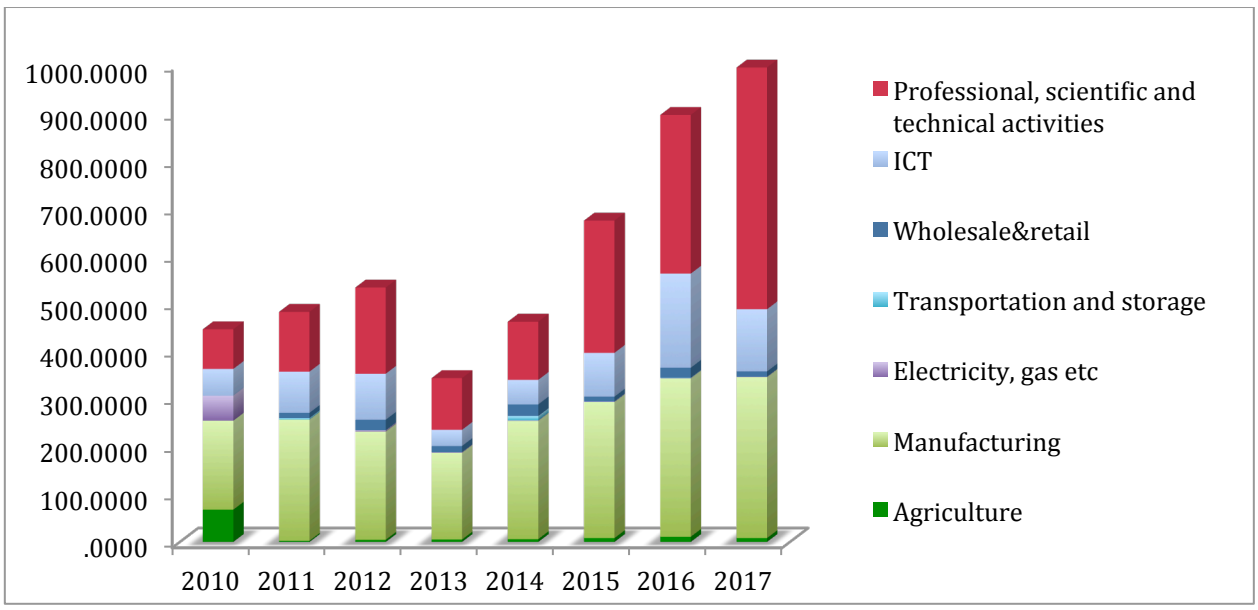


Figure 31. Business expenditure on R&D (BERD) by NACE Rev. 2 activity in Million purchasing power standards (PPS)

4.5 RDI Policy and main funding strategic programmes

The main National Strategies during the 2014-2020 policy cycle with an impact on the long-term development of SMEs, particularly through innovation, are the **National Strategy of Research, Development and Innovation and Smart Specialisatio**n (SNCDI) 2014 –2020 and the **National Strategy for Competitiveness (SNC) 2015-2020.** The SNC defines five strategic priorities, related to improving the regulatory environment of the business environment, supporting public private partnerships, improving the ICT skills of the population, promoting the economic sectors potentially competitive and increasing the standard of living.

The SNCDI 2014-2020 was adopted on 21 October 2014 and focuses on S&T priorities selected on an evidence-based, smart specialisation aware foresight exercise.

The four smart specialisations priorities (S2) aggregated at national level are: bio economy (based on the agricultural potential of the country), ICT (currently the most dynamic RDI sector in Romania), energy and environment (related to the challenges of energy efficiency, water resources and substitution of critical materials) and eco-technologies (focused on new-generation vehicles and equipment, the generation of bio resources, depolluting and waste reuse) and Health as a priority of national interest. The set of specialisations was subsequently expanded by political decision in the adopted form of the NS 2020 to include: space and security, energy production and new materials, culture and heritage as priority of national interest.

The National Plan for RDI 2015-2020 (National Plan 3 /Planul National 3 - PN3), was approved by HG 583/2015 in July 2015, with a total budget of maximum RON 15,000 million (more than €3,300 million). This amount is based on the target of 1% public investement for R&D by 2020, assumed by Romania as one of the targets for Europe 2020 and the forecast of GDP growth. The implementation period is from the date of approval to 31.12.2020, payments continuing to be dispersed until the end of 2023; the effective implementation started in 2016 when the first calls were launched. The responsibility for its management and execution belongs to MCI, which outsourced the management for most of the programmes.

The **Competitiveness Operational Program (Programul Operational Competitivitate, POC),** with a total budget of €1,583 million (EU contribution: €1,329 million), funded through European Regional Funds and managed by the Management Authority (MA) of the European Fund is distributed across two priority axis (PA) out of which PA1. Research, development and innovation supporting economic competitiveness and the development of businesses with a total budget € 952.57 million support RDI.

The Operational Programme Regional Development (Programul Operational Regional POR) 2014-2020, Priority Axis 1, 'Technology transfer', with a €206.5 million fund, aims to support the "creation, modernization and extension of the innovation transfer infrastructure".[129] The ROP is coordinated by the Ministry of Regional Development and Public Administration.

Other funding lines which allocate public funds for R&D are:

- The ***Nucleu programme*** (programul Nucleu);
- The *sectorial plans* of various branch ministries;
- The *Research Plan of the Romanian Academy* and its institutes;

[129] Ministry of Regional Development and Public Administration, Presentation on Regional OP (2014), available at http://goo.gl/JfgxCP.

- The component '*Investment in agriculture and rural development'* of the *Operational Programme Rural Development* allocates a budget of €88 million mainly for support action in R&D agriculture;
- Other sectorial policies;
- Contribution to international organisations;
- Funding of RI of national interest;
- Cross-border, transnational and interregional co-operation, among which the most notable are the Interreg Danube and Interreg Europe..

The draft versions of the PN3 and the POC, AP1 were elaborated in the same process as SNCDI 2014-2020. The POC was adopted relatively swiftly, while the PN3 followed almost one year after the adoption of the Strategy, subsequent to consultations and controversies related to the authority ensuring the administration of the programmes. The policy dialogue period was too long putting under risk the implementatiuon of PN3. Four smart specialisations priorities (S2), defined at national level, were aggregated through the foresight-based process, but subsequently expanded by political decision and lobbying pressure to include Space and security, energy production and new materials (Gheorghiu R., ERAWATCH Report 2014).

The three main RDI funding instruments (1) POC/Priority Axis 1, (2) POR/Priority Axis 1, Technology transfer and (3) the PN3 address the smart specialisation (S2) domains. The two OPs funding RDI target exclusively the S2 domains (POC at national level, ROP at regional level). Most of the PN3 provide support for excellence, implicitly, but not exclusively targeting the S2 areas.

Regional Innovation Smart Specialisation Strategies (RIS3). With the aim to support the preparation of the calls under Regional Operational Programmes, Priority Axis 1, 'Technology transfer', all seven regions eligible for cohesion funds had to develop by March 2017 a concept note which provides a detailed explanation regarding the economic sectors and type of services for which the Technologic Transfer Offices (TTO) could be funded and the SMEs which may implement results of the TT regional smart specialisation areas. For the regions which did not have RIS3 at that time, the concept note had to identify also the S2 priorities. In this process, the regions updated the economic specialisation profiles, undertook a SWOT economic and innovation potential analysis and identified the regional RDI niches with the support of entrepreneurial discovery workshops. The North East and North West Regions benefited from the support provided by EC, DG-JRC through the "Lagging Regions" pilot project[130]. Currently (September 2019), Bucharest-Ilfov Region, the only region without a RIS3 Strategy is in process of finalising it. The complementarities and matching between the regional and national smart specialisation fields are summarised in the relevant Annex.

One of the important outcomes was the start of the dialogue with the RDI actors, particularly with the business sector in a participatory manner, but also the beginning of the start of the collaboration between the central governing authority for R&D, ADRs and EC (Chioncel, M., del Rio 2017).

[130] The project aims to provide support for a coherent, coordinated approach for the RIS3 design, develop and enhance engagement of relevant stakeholders

4.5.1 Policy MIX

Various other strategies elaborated by the Romanian Government for the period 2014-2020, can influence or directly contribute to the achievement of SNCDI objectives, as further detailed in Annex "Policy Mix. Strategies & Legislation"

- The strategy of the Romanian Academy for the period 2014-2020, whose priority directions are connected with SNCDI;
- The EU Macro-regional strategy Danube Delta[131], and Integrated Territorial Investments - Danube Delta;
- The National Strategy for Lifelong Learning 2015-2020 has as strategic objectives the increase of participation in lifelong learning and the increase of the relevance of education and vocational training systems for the labor market;
- The Strategy of Education and Vocational Training 2016-2020 envisages the development of competences regarding innovation, creativity and entrepreneurship within the vocational training programs (implementing through Programme Human Capacity (POCU) and ROP);
- The National Export Strategy (SNE) 2014-2020;
- The National Health Strategy 2014-2020;
- National Strategy for Tertiary Education 2015-2020;
- The National Strategy for Sustainable Development Strategia de Dezvoltare Rurală 2014-2020;
- The governmental strategy for developing the sector of small and medium enterprises and improving the business environment in Romania - horizon 2020
- The Energy Strategy of Romania 2016-2030;
- National Strategy on Climate Change 2013-2020;
- The Digital Agenda;
- The National Strategy for Regional Development.

Various other programmes, while not targeting explicitly the innovation, can impact the innovation performance in general and of the private sector, in particular:

- The *Operational Program "SME Initiative"* with an allocation of €100 million of the European Regional Development Fund (ERDF) and managed by the MA ROP - Ministry of Regional Development and Public Administration, will facilitate the access to finance for the Romanian SMEs.
- The Large Infrastructure Operational Program (LIOP) aiming at promoting sustainable economic growth and efficient use of natural resources can improve the overall framework for business given that one of the main hampering factors in doing business is the access to road infrastructures.

Romania adopted a set of strategies setting out a broad range of research, innovation, entrepreneurship, business objectives. A coordination mechanism with structures on three levels (strategic committee, thematic inter-institutional, operational) was supposed to ensure the coherence of the interventions, complementarities and synergies in the programming and implementation. The coordination mechanism was aimed to function in parallel with the institutional framework designed for implementation. However, this coordination mechanism was not functional.

[131] https://ec.europa.eu/regional_policy/en/policy/cooperation/macro-regional-strategies/danube/

4.5.2 Legislation

Various national laws and regulation related to research, education, researchers, academic staff, researchers, ethics of research, labor market, taxation strongly affect the innovation ecosystem. **Most of the relevant legislation/regulation is prior to Romania's accession to EU although it underwent revisions, additions. However, revision is still required to align it with EU policies and recommandations (as** The European Charter & Code for Researchers)

and avoid contradictions . This affects the decision process, the RDI governing and even the scope of the research activity, as defined by law.

In principle, the University autonomy is guaranteed by the provisions of Romanian Constitution (art.32 (6)) and those of the Law of Education (2011), with all the later amendments and additions and all the relevant legal documents in the field of education and research. The whole set of rights and obligations as well as the norms underlying the life of the university community are found in the University Charta designed in line with the provisions of the Law of Education, adopted by the individual academic senates after consultation with the relevant academic community, and approved by the Ministry in charge of Education.

As commonly defined by the University Charta, and as stipulated by the Law of education 2011, the autonomy focuses on '*leadership, structure, management, scientific research, administration and financing and relies on the right of the university community to its own leadership/self governing and on its right to benefit from academic freedom without any political or religious intrusion…*'.

Analysis of the University Charta of the main national universities shows that they are similar content wise, prevailing uniformity in the definition of the academic autonomy, governance. **The similarity is mainly grounded in the current legislation which guarantees the academic autonomy, but also defines its boundary**. (Chioncel M, 2016, 2017)).

Below, few of the most important laws with RDI relevance. The complete list is provided in Appendix: Legislation.

- **Law of Education**[132] *no1/2011, Art 306 -326* - Provides the principles governing the conduct in RDI activities performed in HEIs and the penalties thereof, the regulatory framework for the functioning and responsibilities of the Ethics Committee in each HEI and for the National Council of Ethics in RDI
- **Law 206/2004**[133] on the appropriate conduct in scientific research, development and innovation: Set of common principles and standards for responsible conduct of research across research fields. The rules envisage the RDI, evaluation, monitoring activities, management in research, publications and commercialization of research results but also the protection of human integrity, animal and environment protection. Aimed at both public and private research institutions, including universities, the research council system, foundations and enterprises.
- **Law 319/2003**[134] regarding the RDI staff. Provides the common framework defining the responsibilities and the rights of the staff involved in RDI, the set of principles and standards for the selection, career progress of the RDI staff and the Code of Ethics and Professional deontology of the RDI staff Conduct for Research Integrity, Adopted 2003

[132] http://cne.ancs.ro/wp-content/uploads/2012/03/len-etica.pdf
[133] http://cne.ancs.ro/wp-content/uploads/cne/2016/lege-nr-206_27-05-2014.pdf
[134] http://www.upt.ro/pdf/infopublic/L319_2003.pdf

5 DRIVERS/BARRIERS FOR INNOVATION

Economic growth is based on three main components: capital accumulation - including investments in real estate, equipment and human resources, population growth (and, consequently, labor force), and (3) technological progress (*Todaro, M. P (1997 Economic Development 6th Edition, New York).* According to the exogenous growth model, the technological progress is perceived as an external element, sustained only by the natural elapse of the time, the emphasis being placed on the intensity of capital accumulation (Robert M. Solow, Nobel prize winner). On the other side, in the theory of endogenous growth model, the technological progress is considered the driver of economic growth. The theory builds on the idea that growth takes place in the context of investments directed in a concerted manner towards technology and RDI (Paul Romer)[135]. In this context, investments in technology as well as in RDI expenditures lead to increased productivity.

While the EU28 innovation performance improved since 2008, Romania showed the highest negative trend[136] and the lowest performance in 2018, with an aggregated score of 34.13. According to EIS 2019, one of the country lowest performance is in Human capital & research.[137] The main obstacles to innovation identified for the period 2014-2016 were the high innovation costs (5.8%), followed by the lack of internal funding for innovation (4.9%), too much competition on the market (3.8%) and the lack of credit or private capital (3.7%). (INSSE, 2018)[138]

The share of innovative enterprises decreased in all enterprise size classes. The top major obstacles for SMEs are the bureaucracy (first place), excessive taxation and unfair competition (SIPOCA 5 report, 2018). These obstacles are also among the main obstacle faced by EU SMEs. However, some obstacles are specific to Romania, such as excessive controls performed by public authorities, increase of the wages, hiring, training and retaining of the human capital, inflation, delays of payments, low quality of the infrastructure.

While the relative importance of these obstacle varies with the size of the business, the bureaucracy, corruption and excessive taxation are among the first three for all size business. The national entrepreneurs feel that they are under a permanent threat. Through the state they nominated both public administration institutions, legislation, government, parliament: "*nobody does anything for us*", "*there is no interest in developing business*", "*have other interests and we do not count*", '*unclear legislation and excessive bureaucracy allow the authorities to control certain socio-professional categories*". Respondents expressed the opinion that the legislation is sometimes contradictory, in a permanent change. Lending costs, banking procedures are considered to be large and difficult, however for many, the only form of financing is accepted with resignation. (Sipoca 5 Report)

[135] Romer, P. M. (1990). Endogenous technological change. Journal of political Economy, 98 (5, Part 2), S71-S102.
[136] European Innovation Scoreboard, (2016), European Commission, http://ec.europa.eu/growth/industry/innovation/facts-figures/scoreboards_es
[137] the weakest sub-pillars expenditure on education as % GDP and per pupil
[138] http://www.insse.ro/cms/ro/content/inovaţia-în-întreprinderile-din-mediul-de-afaceri, INNOVATION IN BUSINESS ENTERPRISES D U R I N G 2 0 1 4 - 2 0 1 6

5.1 SYSTEMIC CHALLENGE (SOCIAL SYSTEM)

5.1.1 Socio-demographic problems disrupting the labor market

Romania's population has been in a continuous decline, from 22.4 million to 19.5 million between 2000 and 2018. **There is a negative natural increase** (INSSE, 2019 Romania in Figures). On the short and medium term, mortality is not expected to contribute significantly to reducing the demographic decline in Romania. The birth rate and measures to reduce the emigration remain the components on which it could be acted with efficient outcomes (INSSE, 2019 – Romania in Figures).[139]

According to a recently released OECD study (July 2019), **Romanian diaspora is the fifth largest in the world** (after Mexico, China, India and Poland) and has faced the **highest growth rate** in recent years. In 2015/16, around **3.6 million**, 17% of all people born in Romania, were living in OECD countries. Between 2009 and 2018, more than a fourth (26%) of Romanians living in Romania expressed a desire to permanently settle abroad if they had the opportunity,(OECD, 2019).

Companies try to adapt in searching for talents from university, developing fully paid internship, policies regarding employees motivation, regular in class and online courses for professional improvement (MCR 2018).

Opportunity. While the workforce crisis is very deep and based on the demographic forecast may further exacerbate, it "*may create the opportunity for Romanian companies to shift the focus from competitive cost to extra value creation". If one of the country advantages was until recently the low cost base, investing in developing talents can create value added* (MCR (2018), Interview Managing Partner Romania & Global AMROP University Lead).

5.1.2 Lack of predictability of the legal framework. Risky business environment

Groupama Asigurari's Risk Assessment which analysed the risk perception among 1500 Romanian managers identifies that the unpredictability of the legal framework, the unstable legislation, regulation and competition are cross-cutting factors that strongly affect the business environment (Major Romanian Companies, 2018).

The National Council for Small and Medium Private Enterprises in Romania (CNIPMMR) analysed the changes made by the government **in 2017** to the legislative framework and concluded that **1,388 normative acts were adopted**, respectively 278 laws, 117 ordinances of emergency, 30 simple ordinances and 963 Government decisions. To these are added the 3,344 orders issued by the Minister of Finance and 1,907 orders issued by the Minister of Labor."[140] These practices increase bureaucracy and cause additional pressure particularly on small businesses, who have limited capacity to manage bureaucratic procedures and adapt to frequent legislative changes.

[139] INSSE, 2019, Romania in Figures
[140] POCA project Creșterea capacității administrative a Ministerului pentruMediul de Afaceri, Comerț și Antreprenoriat de dezvoltare și implementare a sistemului de politici publice bazate pe dovezi"code SIPOCA 5
https://www.digi24.ro/stiri/actualitate/politica/consiliul-imm-urilor-in-2017-290-de-modificari-la-codul-fiscal-861338

A stable and predictable legal framework, reduction of the bureaucracy and of the tax burden are key elements to ensuring a competitive business environment. Ensure legislative stability and improve predictability support business and investment planning. **Legislation has been constantly highlighted by the business community as a hindrance to the development of the current activity or in making new investments**. This limits the companies' capacity to focus on development and innovation.

Taxation

The predictability and the transparency of the taxation system in Romania remain a significant problem. In the last 10 years, good progress has been made in this direction – the number of adjustments and amendments of the tax legislation has decreased. The hope is that this number will go further down in the next years and that any changes will be announced with more time in advance, so that taxpayers may adjust their expectations, business models and plans in due time.

The Romanian economy has been the subject of a major tax cut in 2015. The VAT decrease from 24% to 9% for food and non-alcoholic drinks led to retail prices dropping and therefore contributed to the consumption. Smaller taxes mean more money to reinvest that can be beneficial to the economy overall. However, there is concern that even apparently good decisions are taken without prior impact assessment and this may mean unsustainable decisions on long term that can induce new wave of instability.

In the CIS 2016 study, while a minor share of enterprises declared that tax regulation stimulate the innovation (4%), **a large share (31.3%, second largest in EU)** considered that it creates uncertainty.[141] A higher share of SME compared to large companies (>250 employees) perceive taxation as the major factor hindering innovation.

Concerns regarding the fiscal developments are usually strongly correlated to the fundamentals of the Romanian economy, its strengths and weaknesses (like reliance on consumption), the nature and sustainability of the current GDP growth, the increased volatility.

5.1.3 High and complex administrative bureaucracy

Excessive bureaucracy suffocates small entrepreneurs: they do not have the time, human and financial resources to go through the procedures required for licensing, authorization, filing of statements etc. The reduced digitization of all operations carried out by companies in relation to public authorities, many redundant documents requested by public authorities, and frequent declarations to be submitted to ANAF limit the companies' capacity to devote time and resources to business development.

Overly cautious or burdensome regulations affect the innovation. Many studies lead to the same observation: main challenges for Romanians entrepreneurs remain bureaucracy, excessive taxation, excessive controls performed rather in a punitive manner. Access to, and implementation of projects funded through public funds, particularly structural funds and those for public authorities have the disadvantages of cumbersome and time-consuming procurement process and heavy bureaucracy in proposal preparation and project implementation. Entrepreneurs do not have the education and knowledge they need to apply for the funding offered through various schemes, funded either by national or ERDF money. Excessive bureaucracy related to

[141] https://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do Innovative enterprises whose innovation activities have been affected by legislation or regulations by subject of the regulation/legislation, type of effect, NACE Rev. 2 activity and size class

project implementation, lack of the knowledge required to write a proposal, the high costs required by consulting firms are barriers to access such funds by small entrepreneurs.

5.1.4 Low Quality of Large Infrastructures (Roads, Railways).

The low quality of the large infrastructure (transport in particular, telecommunications, energy) etc. is listed also as one of the **top ten major challenges** faced by SMEs in The White Book of SMEs (2019).[142]

5.2 EDUCATION AND TRAINING

A significant share of 18 years population will not reach the baccalaureate level[143][144] (UEFISCDI, 2018), and even when succeeding the quality of the potential students will not be high. Early school leaving is overwhelmingly a rural problem in Romania: the dropout rate was about 1.5 higher in rural secondary schools than in urban ones. PISA 2015 showed that almost 40 % of Romanian 15 year-olds do not have a minimum level of basic skills, while socio-economic background significantly affects students' performance.[145] Students in Romania scored lower than the OECD average in reading, mathematics and science. **In 2018**, a smaller proportion of students in Romania compared to the OECD average, performed at the highest levels of proficiency (Level 5 or 6) in at least one subject; at the same time a smaller proportion of students achieved a minimum level of proficiency (Level 2 or higher) in at least one subject.[146]

The speed at which society evolves now comes with the concept of "life-long learning". Both children and young people, as well as adults, need to learn new concepts in order to be well integrated into society. Yet, Romania has the lowest level In EU in life-long learning.

The Ministry for National Education **has had over 27 education ministers since 1989**. Political change at the ministerial level is often mirrored by institutional re-organisations and policy changes. Although a Coalition for Education was signed by all the parties, there was no coherence and consistency in policy making. Frequent changes further deepened the low funding problem.

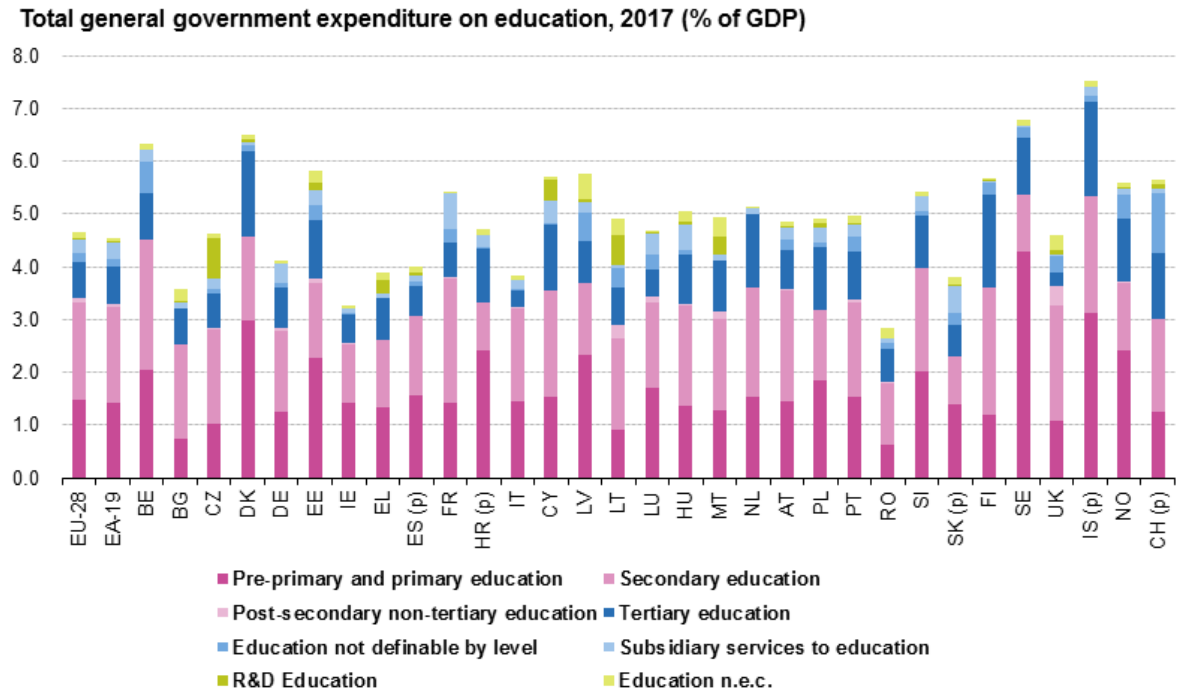
5.2.1 Low level and low efficiency of the Funding

The **underfunding of the education system** and the inefficient allocation of the low funds hold likely the most severe long term consequences on the whole society. In 2016, Romania invested 2.58% of GDP in education (EUROSTAT, 2019), significantly below the level (6%) stated by the national law of education.

[142] http://cnipmmr.ro/wp-content/uploads/2019/07/Prezentare-Ovidiu-Nicolescu.pdf
[143] UEFISCDI, 2018 Policy brief - Analysis of statistical data on the access of baccalaureate graduates from 2015 in higher education (RO), No.3
[144] UEFISCDI, 2018 Policy brief - Analysis of statistical data on access and results of candidates who participated in the two baccalaureate sessions - 2017, (RO), No.2
[145] https://ec.europa.eu/education/sites/education/files/document-library-docs/et-monitor-report-2018-romania_en_0.pdf
[146] https://www.oecd.org/pisa/publications/PISA2018_CN_ROU.pdf

Education in Romania is chronically underfunded, with spending per student in primary and lower secondary education less than one-third of the EU average (Eurostat, 2019). In 2016 (the latest EUROSTAT data available), the allocation per student in tertiary education (levels 5-8) was 2,330 EURO, the second lowest budget in EU (EUROSTAT, 2019). The expenditure has decreased in the 2006-16 period (0.08% and 0.05%), significantly below the EU28 average (0.47%) in 2016. The negative impact on the quality of education was demonstrated, among others, by poor results in PISA surveys (EUROSTAT, 2019).

Figure 32. Total general government expenditure on Education, 2017 (Source: EUROSTAT)



Many schools in urban area are overcrowded, particularly those having a good reputation according to the results in the national examinations, while a significant share (60%) are underutilised (especially in rural areas).

School transportation services are overall insufficient and inadequate, while accessibility worsens as students advance through the school system. 38% of schools in rural areas have outside toilets, without running water or sewage (7 % in urban areas) and only 20% have a library (60 % in urban areas). (EC, Education and Training Monitor, 2018)[147]

Positive change will also require adequate funding.

5.2.2 Traditional and rigid system

5.2.2.1 Pre-university system

The challenges for the Romanian pre-university education system are the early school leaving rates and limited vocational training, reflected in the high number of young people who are not in education, employment or training. Dropout rates are high, especially in rural areas, and one in five students fail to make the transition to upper

[147] https://ec.europa.eu/education/sites/education/files/document-library-docs/et-monitor-report-2018-romania_en_0.pdf

secondary education, recognised by many EU countries as the minimum level of attainment needed in a knowledge economy. (OECD, 2018).

The rate (18.1 % in 2017) of early leavers from education and training (ages 18-24) remains one of the highest in the EU, significantly above the EU average (10.6 %) and the national target for 2020 (11.3 %)[148]

Romania currently enables only a minority of its students to excel. And the high achievers, in the recent years are candidates for universities abroad and most often do not return.

International surveys point to severe deficiencies in basic skills among Romanian teenagers (EUROSTAT, 2019 – PISA RESULTS). The proportion of 15 years old underachieving is high: in reading around 38.7% (compared to 19.7% EU average), in math 39.9%, in science (38.5%)

The evaluation system put pressure on teachers to "teach to perform best in the test", which limits learning opportunities and narrows the curriculum and often penalise students' creativity. The desire to perform well in assessments (the national wide at the 8th and 12th grade) is a strong determinant of teaching and learning practice. Pupils are less focused on learning, and more on achieving high scores in the relevant subjects. '*The range of competencies and domains assessed does not provide for a rounded assessment of student learning, neither encourage learning across the breadth of the curriculum'* (OECD, 2018).

5.2.2.2 HE system

Romania faces important challenges regarding the decreasing number of students in tertiary education. The upward trend in student population during the period 1990 and 2008 started reversing from the 2009/10 academic year onward. **The number of students enrolled for bachelor's degree has sharply decreased by more than half in the 2009-2017 period**. The trend which is expected to continue in line with the decrease in the general population (INS, 2016).

The sharp decrease in tertiary education, particularly in private universities and in the fields of social sciences, business and law, is mainly explained by stricter quality assurance mechanisms, which resulted in fewer private university programmes, lower passing rates at the baccalaureate and the high levels of emigration. It also reflects the demographic trend, the decreasing number of high school graduates who pass the baccalaureate exam and the reduction in years of study (the effects of the Bologna process implementation started showing after 2008/09). Other possible causes leading to a drastic decrease in the number of students include the high early-leaving rate in the pre-university education system and the phenomenon of emigration, which affects the size of the cohort that can reach this educational level.

The Romania Secondary Education Project (R.O.S.E) implemented by World Bank, aims to improve the transition from upper secondary into tertiary education and increase the retention in the first year of tertiary education in project-supported education institutions.

The analysis of the evolution of pupils enrolled in first year of school in 2003/2004, up to year one in HE, shows that only 27% of the cohort reached the higher education, and only about 20% completed the first year of university studies. (UEFISCDI, 2018)[149]. Losses appear at every stage of the education:

[148] https://ec.europa.eu/education/sites/education/files/document-library-docs/et-monitor-report-2018-romania_en_0.pdf
[149] UEFISCDi, 2018 Analiza datelor statistice privind accesul absolvenților de bacalaureat din 2015 în învățământul superior (RO), No.3, 2018

- 17.64% of the students of the first class of the 2003/2004 academic year did not reach the eighth grade in 2010/2011 (repetition, dropout, migration, deaths);
- 4% of those enrolled in the eighth grade did not complete the secondary education and 6% of those who completed secondary education did not participate in the national assessment;
- 28.5% of those who participated in the national assessment in 2010/2011 did not complete high school education (12th grade);
- 28% of those who completed high school (12th grade) did not pass the baccalaureate exam;
- 29.3% of those who passed the baccalaureate exam in 2014/2015 did not enroll in the Romanian higher education in the 2015/2016 academic year;
- 21% of those with 10, and around 15% of those with mark 9-10 were not registered in the national higher education system;
- 25% of first year students failed to promote in the second year of study.

In **2015/2016**, 42.22% of the first-year students were enrolled in social sciences fields. Out of these, 36.37% were enrolled in public universities and 79.63% in private universities.

HES performance

A university does not merely prepare young people for the wide variety of roles in an innovative economy. its higher mission is to "discover and invent the future." The culture of a university influences its success in producing innovation and can influence the culture of a region. Public investments are essential if universities are to fulfill these missions**.**

The Romanian **HE landscape** remains quite homogenous three decades after the change of the political system, although in some dimensions appears increasingly diverse. After 1989, the system expanded, many new public and private universities were established, although the public funding remained low. In 2018, there were 93 accredited Higher Education Institutions (HEIs) (55 public universities). Although diverse as size and coverage of specialties, the universities are almost identical in their organizational structures and have very similar programs in the same subject, partly due to overly prescriptive accreditation regulations. They offer "Bologna-type" bachelor degree, master and PhD programs – and little beyond this. Romania has very low engagement in lifelong learning, far below the EU average and the 'distance' or "open" education programs are limited as numbers and questionable as quality (Andreescu L., et al, 2015).

The universities have in theory full freedom to manage their research budget and design research agendas, however, this in practice is limited due to budget constraints. The allocation of funds is not based on performance criteria, although the system is highly polarised, with few universities pooling most of the research results (see 4 top Universities).

Disconnection from labour market

The higher education is disconnected from the labour market (according to interviews with stakeholders from private sector). There are **14.4 graduates in STEM** for every 1000 people aged 20-29, compared to an EU average of **19.1**. The number of new graduates in science and engineering for every 1000 people aged 25-34 is decreasing. Employers report that students and graduates entering the labour market often lack key socio-emotional skills and possess sufficient, though overly theoretical, academic skills

(WB, 2018)[150]. The supply of skills is not keeping up with the needs of the economy. Low attainment levels in basic skills and digital skills have an adverse impact on competitiveness, employment and convergence (EC, 2018 Country Specific Recommendations).

The structure by specialization groups of students enrolled in higher education (bachelor's, master's, doctoral, postgraduate or postdoctoral programs), in the academic year 2017/2018, shows that most students were in: (1) business, administration and legal studies (23.8%), (2) engineering, processing and construction (21.0%), (3) health, social assistance (13.8%). In the private sector, the highest percentage was in business, administration and law (57.0%). (INS, 2018)[151]

Biological sciences&biomedicals studies, mathematics and natural sciences (the two groups gathering also students with the highest scores in baccalaureate) and engineering students **are outnumbered by the students in socials sciences and humanist science** and arts (54142 vs 64047). These figures are an indication of the alignment between smart specialisation domain and the human resources supply.

Regarding the **quality of the students**, two important aspects must be considered: (a) a significant share of the best performers in baccalaureate (21% of those with 10, and around 15% of those with passing mark 9-10) were not registered in the national higher education system; (b) 25% of first year students fail to succeed to the second year of study. No additional data are available regarding the number of those who finalise the studies vs the number of those registered in the first year. Many of the top performers go abroad. While per se, this could be a strength, it changes into a weakness since the large majority does not return.

The low quality of training for applied research of young graduates is highlighted also by the Mid term evaluation of SNCDI 2020 *"The lack of alignment at a strategic level of the competences and skills that are increasingly demanded on the market should be covered both by the education system and by a strong public-private partnership".*

The faculties have the right to propose study programmes, the language of instructions and number of students, but these must be approved by the Ministry of Education. However, the number of state funded places is not determined by labour market forecast studies but rather follow an inherited pattern, associated to the number of staff. The students' demands for certain degrees is not necessarily determined by realistic possibilities of working in the chosen field.

The supply of PhD holders does not match the absorption capacity of the RDI labour market. The number of new doctorate graduates has varied, increasing significantly in line with the implementation of PhD doctoral programmes funded through ERDF during 2007-2013. However, the increase over that period of the number of PhD holders was not reflected in a in increased number of researchers/ HRST. The quality of the PhD theses has been under significant debate given the famous, past plagiarism cases.

Curriculum in HE

The interviews performed with relevant stakeholders (SIPOCA 27 survey conducted by UEFISCDI) highlight that there is an acute shortage of workforce in general, and even more of well-trained workforce/ with relevant research skills. The curriculum is outdated and does not match the market needs (as highlighted by many of the stakeholders): "*The school is disconnected from industry*." At the same time, the respondents also observe that '*the attitude and the theoretical background were better before. Young*

[150] WB (2018), From Uneven Growth to Inclusive Development Romania's Path to SharedProsperity, Romania Systematic Country Diagnostic.Systematic Country Diagnostic, Washington, https://openknowledge.worldbank.org/bitstream/handle/10986/29864/9781464813177.pdf?sequence=2&isAllowed=y

[151] INSE, 2018. Romania in figures

people are missing that drive and passion. It is very important to develop partnerships to work together and inspire the passion for knowledge."

Law 258/2007 on the industrial internship for students stipulates the framework and the obligation to carry out the training. The lack of financial instruments to cover the usage of the equipment and the time allotted by the private sector staff to the training activities affect the quality of these training stages.

The accreditation of the undergraduate study programmes is based on the evaluation performed by ARACIS, or any other agency registered in the European register for the quality assurance in Higher Education. The long procedures for accreditation, the underfunding of the system (lack of infrastructures and often of interest given the scarcity of funds), the lack of collaboration between HEIs and private sector in designing training agenda led to misalignment between the skills acquired in universities and those requested by private sectors. Often the innovative sectors (i.e. IT) develop faster than the curriculum given the slow accreditation process. RDI centers have modern technologies on which graduates do not have hands on experience.

5.2.3 Regional disparities

Low skills and early school leaving are concentrated among students from socio-economically disadvantaged backgrounds. With 70% of the poorest population living in rural areas, educational inequities in Romania are closely associated with disparities between rural and urban areas. As students' progress through the education system, the significant underrepresentation on of rural youth worsens (National Strategy for Higher Education (NSHE, 2018))**.** Roughly 45% of all Romanian youth live in rural areas, but only 24% of students in tertiary education come from rural areas.

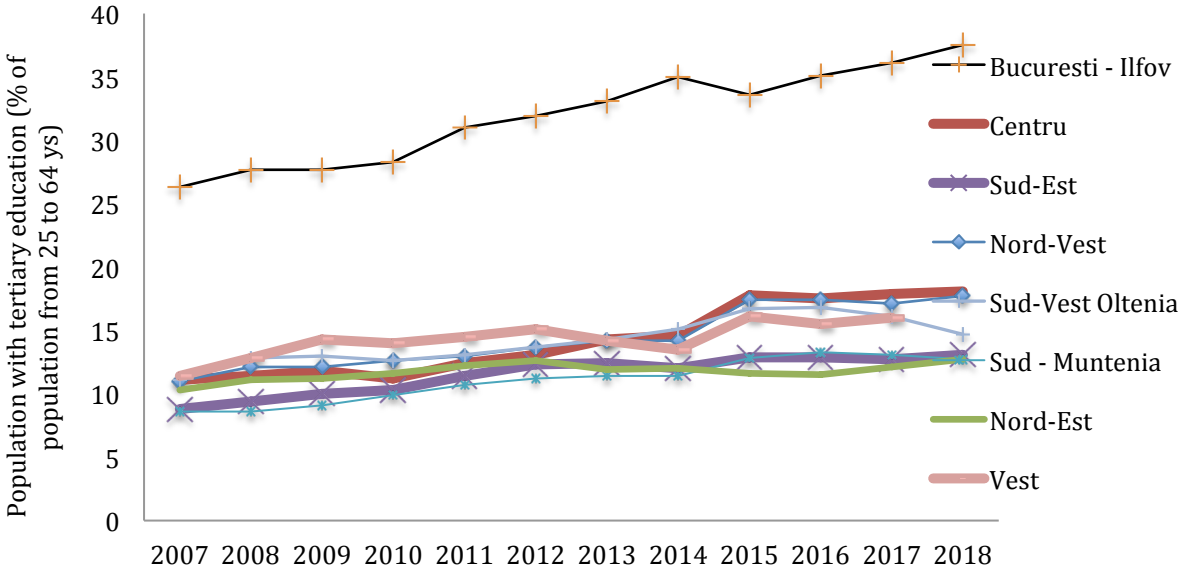


Figure 33. Time evolution of tertiary educational attainment, age group 25-64 by NUTS 2 region (Source: Eurostat)

If the share of early leavers is 8% in Bucharest (2018), this increases to 21.3% in South East, 19.5% N-E, and 18.8% Centru Region, closely related to the level of poverty.

5.2.4 Limited vocational training and life long training

The participation in long life training is very low (EUROSTAT, 2019). The labour market relevance of vocational education and training (VET) is still a challenge (EC, 2018). Romania's participation in continuing vocational training (CVT) courses as a percentage of persons employed in all companies is of 21%, below the EU28 average of 41%. The limited availability of vocational and life long training is also highlighted by companies, which often try to compensate the limited public support (MCR 2016, 2017, 2018). In the search of adequate skills and human resources, the companies which can afford this, started offering more competitive packages, that include in-house training.

Recently, legislative measures have been implemented to support dual education and lifelong learning.

The Emergency Order no 81/2016 regarding the revision of the Education Law no.1/2011 provides the legal framework for the professional and technical education, including the dual one (Romanian Government, November 2016), while the Law no. 176/2018 provides the framework for internships. Based on the data transmitted to the National Authority for Initial Vocational Training in Romania (ANFPISDR), at present, at national level there are 177 units of dual education (compared with 73 school units in 2017)[152]. In 2019, more than 500 economic operators were involved in the dual system.

The recent implementation of the vocational training may release some of the labour skills shortage. However, the early school leaving rates and limited vocational training remain, despite recent efforts, significant challenges of the Romanian pre-university education system.

[152] http://adev.ro/pzg4z9

5.3 RESOURCE MOBILISATION. LOW R&D FUNDING

The government has many ways of stimulating investments in innovation. This include direct support for research and development, but also taxation, regulation, and trade policies.

5.3.1 Low level of direct funding for RDI

Expenditures on RDI activities are an indicator of a country's efforts in the direction of driving innovation (*OECD Factbook 2013, Science and Technology, OECD, 2013).* The innovation leaders in EU are that MS with the highest RDI investments (SE, DK, Fi, DE). The correlation is evident also for modest innovators: RO has had one of (if not) the lowest GERD and has had one of the lowest innovation performances in the recent years.

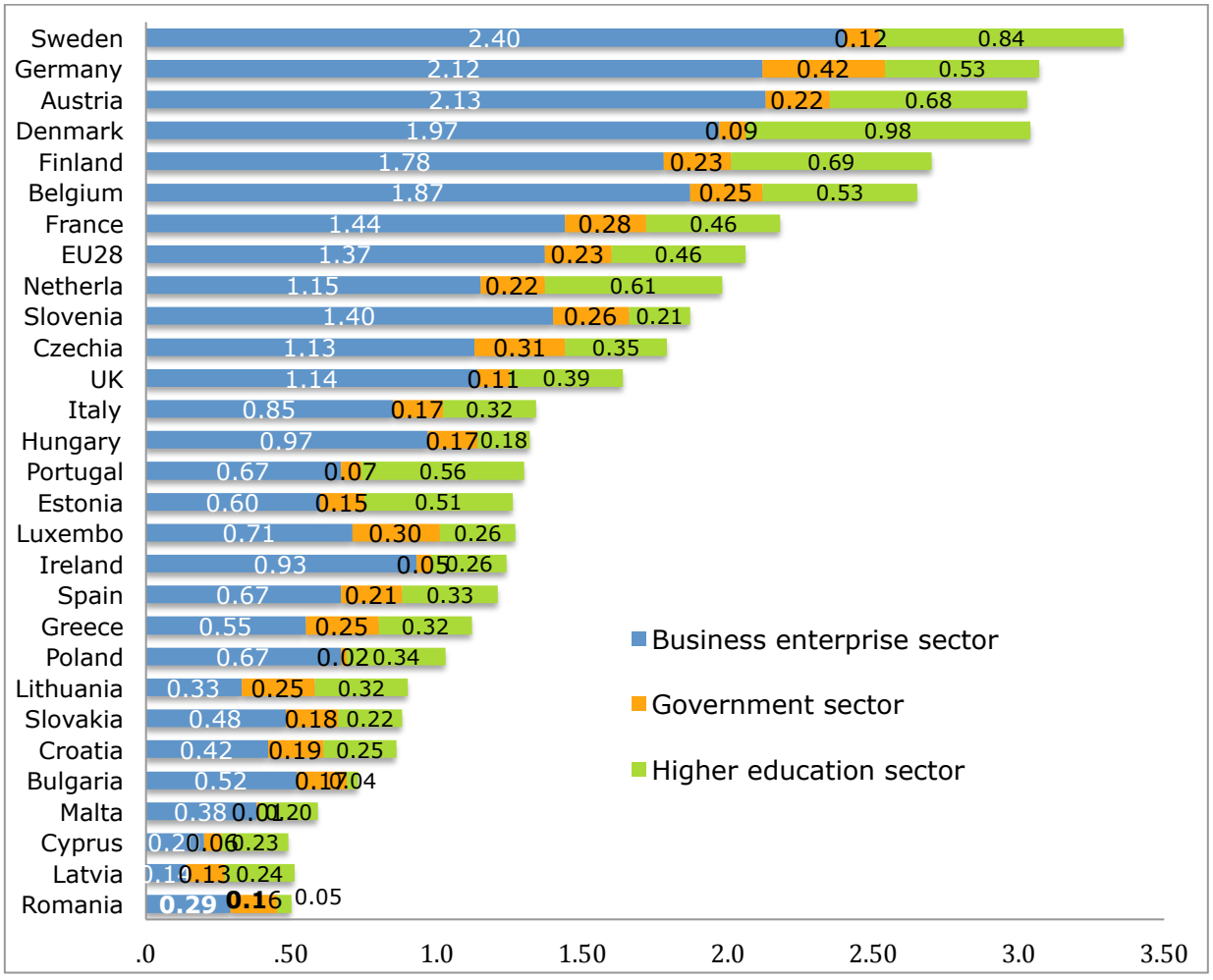


Figure 34. 2018 GERD by performers in EU MS (Source: EUROSTAT)

The R&I system is chronically underfunded. The budget allocation is well below the targets assumed by the national strategic documents , and in comparison to EU28. The GERD intensity showed a minor increase from 0.48 (2016) to 0.5 (2017), reflected in a larger nominal GERD due the GDP growth. Romania, allocated in 2017 the lowest GERD

per capita in EU28 (48 EUR per capita, compared to 619 EUR the EU28 average) (Eurostat, 2019). In 2019, the public intensity for RDI was around 0.17% (vs 1% target of public investment in R&D by 2020).

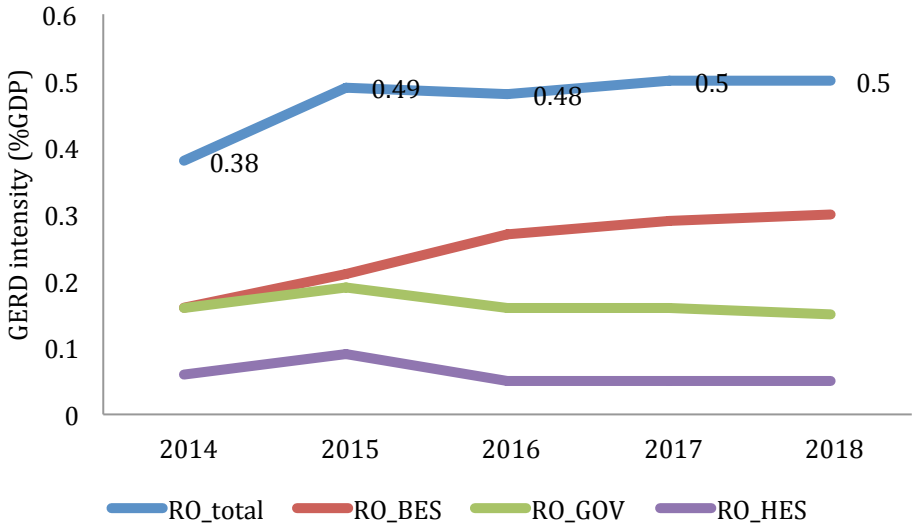


Figure 35. Romania: GERD Intensity (% GDP) time evolution 2014-2018. Total and by sector of performance

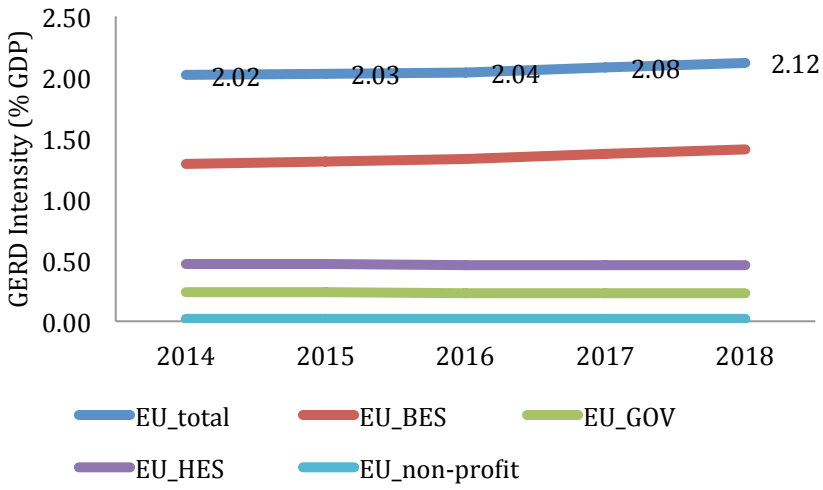


Figure 36 EU28: GERD Intensity (% GDP) time evolution 2014-2018. Total and by sector of performance

The GERD intensity for most **EU28 countries has increased, while for RO has stagnated/decreased**. This has further widened the gap. In 2017, the EU28 average is 656 euros per inhabitant, compared to 52 euros in Romania.

The R&I system is **chronically underfunded**. Romania, allocated in 2017 the lowest GERD per capita in EU28 (52.5 EUR per capita, compared to 656.8 EUR the EU28 average). In 2019, the public intensity for RDI was around 0.12% (vs the target of public investment in R&D of 1% by 2020).

The **National Strategy for RDI (SNCDI) 2014-2020, is, in theory, based on multi-annual planning.** The R&D investment **target is 2%** by 2020 (1% public+1% private). All national governments committed in strategic documents to the GERD targets, but this has remained rather **political rhetoric.** The **lack of science awareness** increases the vulnerability of the national R&D budget.

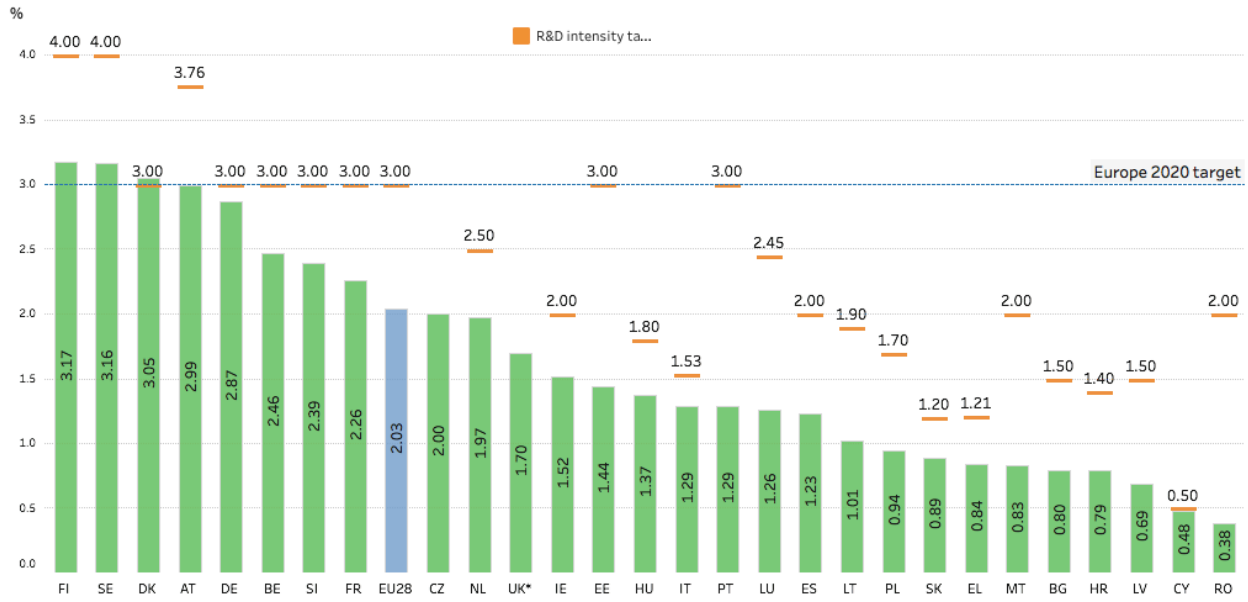


Figure 37. Progress made by EU28 Member States towards the R&R intensity targets (Source: DG-JRC, RIO)

The low importance of R&D in the political agenda is demonstrated also by **the low share of cohesion funds allocated for the thematic objective 'Research&Innovation**" in the current policy cycle. Romania has t**he lowest share of ESIF allocated for R&I** for 2014-2020 **in the region** (Curaj A, 2015). If Romania has the 6th total ESIF budget allocation among the EU countries, it drops to the 13th position for the thematic area R&I (Chioncel M, 2017). In 2014-2020 in RO has one of the lowest shares, around 3.2% of the total cohesion funds (the 9th) in the total budget (the third the lowest after ICT and efficient public administration), while in the EU28 is the fifth largest share. [153]

The cohesion funds allocated for the thematic objective Research innovation amounts 1,174,645,269 EUR, around 3,2% of the total cohesion funds allocated to Romania.[154] (for comparison HU allocated 8.7%, BG 5.3%).

153 https://cohesiondata.ec.europa.eu/2014-2020/ESIF-2014-2020-Fin-Implementation-total-costs-by-T/vyjd-jfhd

154 https://cohesiondata.ec.europa.eu/countries/RO

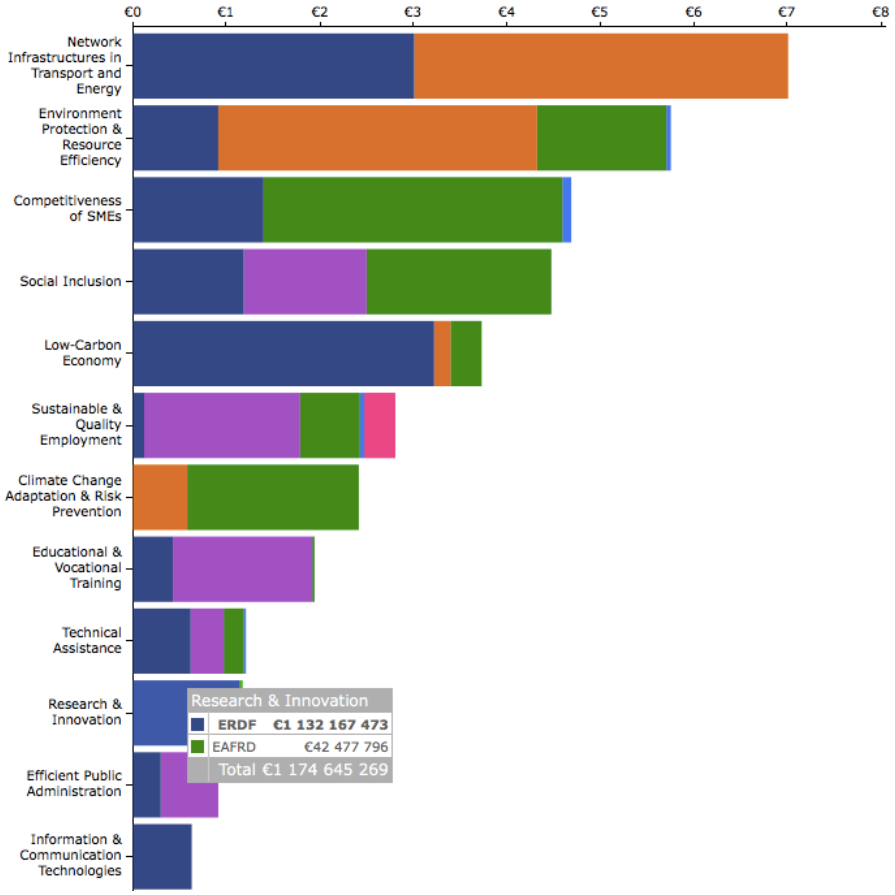


Figure 38. Romania. ESIF allocation during 2014-2020 policy cycle by theme (Source: Cohesion data[155]

BERD intensity in Romania is very low, however showing a light revival starting 2015 (increasing from 0.16% of GDP in 2014 to 0.29% in 2017. However, it remains significantly lower than the EU28 average BES investement in R&D (1.3%). Tax credits available for organizations and persons for RDI projects may have fueled the visibility and increase of BERD due to reporting rules. The increase of the private investement in RDI (from simple to double) is not reflected in a similar increase of the human resources in RDI in the private sector.

T**he number of researchers in BES, holding a doctorate, has decreased to half from 2017 to 2018**. This may be generated by the finalisation of programmes supporting researchers working in BES of different reporting in the national statistics. No further information is available.

In the period 2017-2019, Romania **does not have any company in the top 1000 EU R&D** investors, 2016 being the year in which Romania entered the top, with only one company. (EC-JRC, 2016-2019 reports, EU Industrial R&D Investment Scoreboard).

The lack of financial resources to perform RDI is highlighted by small and large companies altogether: "*an innovative idea requires huge initial investments".*

[155] https://cohesiondata.ec.europa.eu/countries/RO

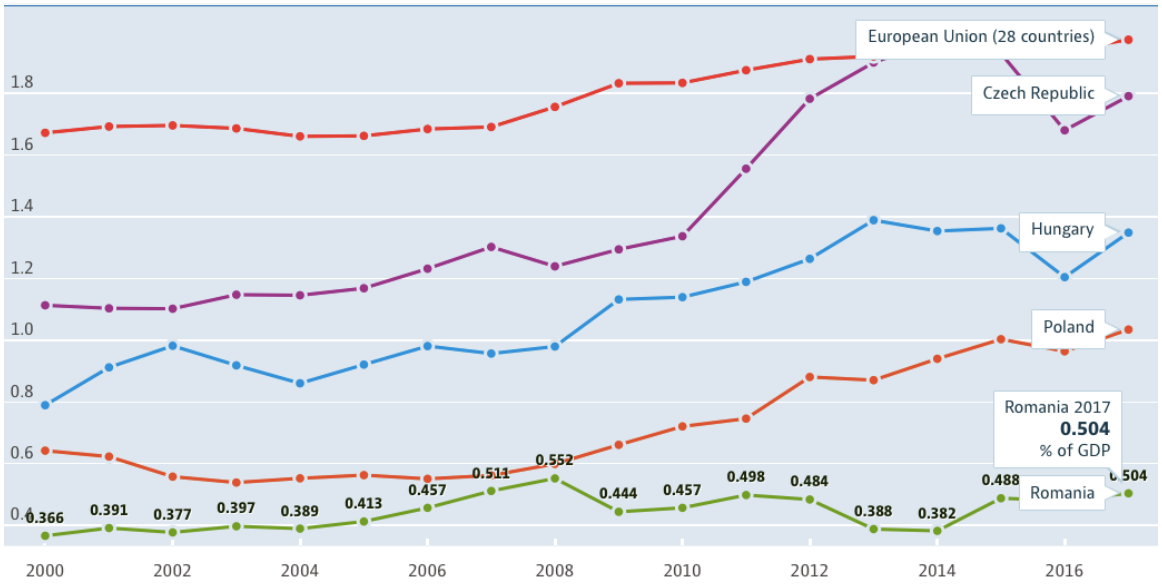


Figure 39. Gross domestic spending on R&D in selected countries (Source: OECD, doi: 10.1787/d8b068b4-en)

The reduced and unpredictable funding, the lack of compliance to the initial planning. do not allow the RDI units to establish an institutional strategy. The lack of predictability of funding affects both the capacity of the RDI institutes to develop the existing infrastructure, to attract and retain the human resource, as well as to maximize the accumulations of knowledge (SIPOCA 27, Mid Term evaluation of SNCDI).

BERD intensity in Romania is very low, however showing a light revival starting 2015 (increasing from 0.16% of GDP in 2014 to 0.29% in 2017. This shows **the weak innovation activities of Romanian** firms. The lack of financial resources to perform RDI is highlighted by small and large companies: "*an innovative idea requires huge initial investments".*

Given the scarcity of the public funds and their unpredictable allocation due to the lack of commitment to the targets assumed, there is high competition, a certain level of frustration given the limited funds, the time invested in applications and the low success rate. Even when successful, budget cuts can occur during the implementation phase, the reimbursement of the amounts stipulated by contracts is difficult and not within the agreed deadlines.

The respondents complaining about the insufficient public funding for RDI refer to the fact that "*it is difficult to access the public funds", "the funds for R&D projects are limited", many "have applied for RDI funding several times, but were not successful*", *„the companies "have been involved in many RDI projects in past, but at present there is no funding available" etc.*

The lack of predictability of the public funding for RDI is particularly emphasized by the respondents from the (public) research organisations: "*there is no reliable source of funding for research activity from the state budget*", "*the RDI allocations are insufficient for salaries and research activities*" (SE, R&D Centre), "*public funding for RDI is unpredictable*".

5.3.2 Limited usage of fiscal incentives for R&D

The investment in RDI is risky: it may or may not lead to results in improved products that may bring value added to the investing companies. Also, the economic exploitation of ideas is generally exposed to a degree of rivalry. *'A user's willingness to pay for an idea may decrease directly proportionally to the level of public dissemination of that idea' (*Iancu, V (2014*).* **To mitigate these hindering factors, governments are increasingly allocating more public resources in the form of grants or fiscal incentives.**

Several fiscal incentives are currently available in Romania. The first concrete step towards encouraging R&D through fiscal incentives for R&D was realized in 2008, when introduced into national law, with applications of January 1, 2009, tax facilities regarding tax on profit, specific to this area -the additional deduction when calculating the tax on profit of 20% of R&D expenses (subsequently increased to 50% from 1 February 2013) and the application of the method of accelerated damping for R&D equipment.

Delloite 2014 study indicates that while 62% of the companies knew about the accelerated depreciation of assets used in R&D, over 50% of respondents were familiar with other incentives, less than half of them had actually used these benefits (Delloite, 2014).

The Government Ordinance OUG 32/2016 amends the Tax Code, introducing a fiscal stimulus for R&I activities. This ordinance stipulates an exemption for personnel income resulting from R&I activities. The companies which conducts exclusively RDI activities should be excepted from paying corporate tax for ten years (starting January 2017). The final form of the methodology for granting the fiscal incentives for RDI was approved in august 2017. This was vital as a secondary legislation, filling the legislative gap. (Joint order Ministry of Public Finances 2326, MCI 2855/29.08.2017).

However, **while fiscal incentives exist, they have limited impact**. According to the KPMG study[156], the following issues create difficulties and uncertainty regarding the application of the income tax exemption for R&D:

- The way to define the eligible activities for the tax exception is very general; it generates uncertainty.
- The administrative effort for drawing up the documentation required by law is high, especially if a significant number of RDI projects is performed in one year.
- The time and financial effort to change the salary calculation can be significant for companies whose employees work in the same month in several eligible projects.

In addition to the level of facilities offered, the clarity and ease of application of legislative norms, and the width of the sphere of the eligible activities are important. Overall, companies take limited advantage of these facilities.

While entrepreneurs appreciate the fiscal facilities for RDI granted in recent years, they criticize the methodology for the implementation of the legal provisions. The additional deduction for the calculation of the taxable profit on the expenses eligible for the RDI - is considered as "*a benefic measure, but not very widely applied - because of the National Agency for Fiscal Administration controls – whose employees are not specialists in RDI but must validate the RDI activities'*. '*The tax deduction for R&D activities is welcome, but the conditions of application are very difficult, it is impossible to meet all the conditions*. *The tax exemption on income from salaries for the RDI employees* - as emphasised by one of the respondents - "*was initially adopted in a totally unacceptable form: we were somehow forced to hire an accountant for each R&D employee/ engineer*

[156] KPMG, Cercetare, dezvoltare, inovare Stimulentele fiscale și creștereaeconomică în România

to calculate how many square meters of his office are used for research, how much energy he uses and so on." (SW, Automotive). The opinion is also shared by another entrepreneur: "*The result was that at least in the Automotive field it did not apply. You cannot say in a company that you will only do one thing, you have to do everything you are asked for in the job description*" (SM, Automotive).

While companies' perception is that the ambiguous methodology restrict the larger usage, the limited usage of the fiscal deductions could be also explained by the fact that the majority of SMEs do not have the capacity to create an RDI department and to demonstrate the R&D activity as required by the methodology. "*Applying the deductions requires an organizational framework (a group, department formally devoted to R&D activities), an R&D project (defined as such in line with the principles of project management), and accordingly recording the timesheets. In general, everything that companies need to be able to prove that staff performs R&D is identified in the methodology of the fiscal deductions. For a small company, this task becomes relevant if there is a relatively large number of employees who perform R&D (at least three persons) and the work performed does address, at least one of the following situations:(a) an internal development project (new product, service, etc.)- "organic growth"; (b) participation in an ERA or National R&D project; (c) an external request for R&D services. When the actual R&D project work is missing, it will be very difficult for an SME to quantify the success of the research through an "innovative" product". (interview, O Buiu - IMT, Honeywell).*[157]

Companies **feel** uncertain about the methodology for tax deduction for R&D activities and find difficult to identify which R&D projects are eligible for deductions. While this may be triggered by the limited capacity of companies to perform R&D, further attention should be devoted to the analysis of the fiscal incentives.

5.3.3 Fragmentation of the RDI system

"*The system remains underfunded and highly polarised, with a limited number of actors concentrating the output. Its performance is low and the research is not aligned to the economic needs. The number of ISI publications has increased gradually, however, indicators of excellence*[158] *show that the research may be disconnected from the international research trends. SNCDI 2014-2020 stipulates that performance principles will apply for institutional funding. However, the prospects of implementation and its relevance to funding to date are not clear. The higher education (HE) financing arrangement has been criticized for dissipating funds among too many universities, in the absence of appropriate mechanisms for rewarding the quality of teaching and research" (Chioncel, M, 2017).*

The 2018 ERA Progress Report observes that in the recent years, many EU28 countries started reforms to reduce the number of PROs. It is expected that these changes might encourage cooperation between PROs but also increase their competitiveness in national and international competition.[159]

[157] deputy scientific director at IMT Bucharest (1994-1997), Portfolio Manager and Senior Technology Manager at Honeywell Romania – Advanced Technology (2007-2017, respectively). Currently, he is a scientific researcher in IMT Bucharest; he is also co-founder and CEO of BIS INNOVATION DEVELOPMENT

[158] such as the percentage of scientific publications among the top most cited publications worldwide, participation in FP7/H2020

[159] https://ec.europa.eu/info/sites/info/files/research_and_innovation/era/era_progress_report_2018-technical.pdf

While the number of researchers has reduced more than half (from 38612 to around 17,000) from 1995 to 2017, over the same period the total number of R&D centers has increased.

5.3.4 Limited competitive funding based on rigorous institutional evaluation

The allocation of R&D national funds, over the period 2014-2020 is detailed in the table below.

The National Plan for RDI 2 (for which payment continued until 2017), PN3 and POC-AP1 allocate project based funding. Most of the POC-AP1 and PN2 and PN3 programmes are open for all RDI performers (HEIs and PROs, as well as for private, for or not for profit). Payments under PN2 continued to be made until 2017, while project contracting under PN3 started in 2016.

There are **two institutional/block funding mechanisms**: **NUCLEU**[160] (allocates funds to INCD) and the funds allocated to **Romanian Academy**, through the relevant chapter in the State Budget Law. Several ministries manage their separate sectorial R&D plans. These include funds for research in agriculture, studies on economics, medical research, market forecasts, labour market, etc.

Based on the table below, a large share of the national public R&D budget is allocated to public research organisations (INCD+Romanian Academy), through mechanisms which arguably are rather block funding mechanisms, insensitive to excellence (input-oriented, e.g based on number of staff etc) rather than institutional competitive funding.

In the calculations are included only the data available. The **sectorial plans** are managed by line Ministries. The budget data are available just for some sectorial plans; based on data provided by MEC, these R&D plans, over the whole period 2014-2019 count to around 170 mil RON.

The two funding mechanism, Nucleu and AR, have been subject to significant controversy and scientific community debate[161,162] **. The author, in the absence of any solid evaluation of these (any!) programme, just raises the attention to way the institutional funding mechanisms are decided/managed, the relevant restrictions regarding the beneficiaries, the lack of transparency.**

[160] http://www.research.gov.ro/ro/articol/3768/programe-na-ionale-programe-nucleu
[161] https://mic-mic-anc.ro/tag/buget-cercetare/
[162] https://mic-mic-anc.ro/tag/bugetul-cercetarii-2020/

	2014	2015	2016	2017	2018	2019	2020	Eligible entities
NUCLEU (mill RON)	287	316	375	353	512	488	418	INCD
PN3 (mill RON)	0	0	84	413	538	552	620	PROs+BES +HES
PN2(mill RON)	515	515	539	175	-	-	-	PROs+BES +HES
Contribution to large international RI(mill RON)	144	166	168	111	101	141	n.a	
Academia Romana[163](mill RON)	247[164]	334[165]	327[166]	270[167]	312[168]	515[169]	566	Romanian Academy
Sectorial Plans*	n.a for all the ministeries							
IOSIN (national RI) (mill RON)			97	88	107	101		PROs+HES

Table 14. The 2014-2019 budget allocated through NUCLEU, PN2, PN3, contribution to international research organization, national research infrastructures. of the Ministry of Research and Innovation [170] (Source: MCI/MEC), The sectorial plans acount to around 163 thousands RON

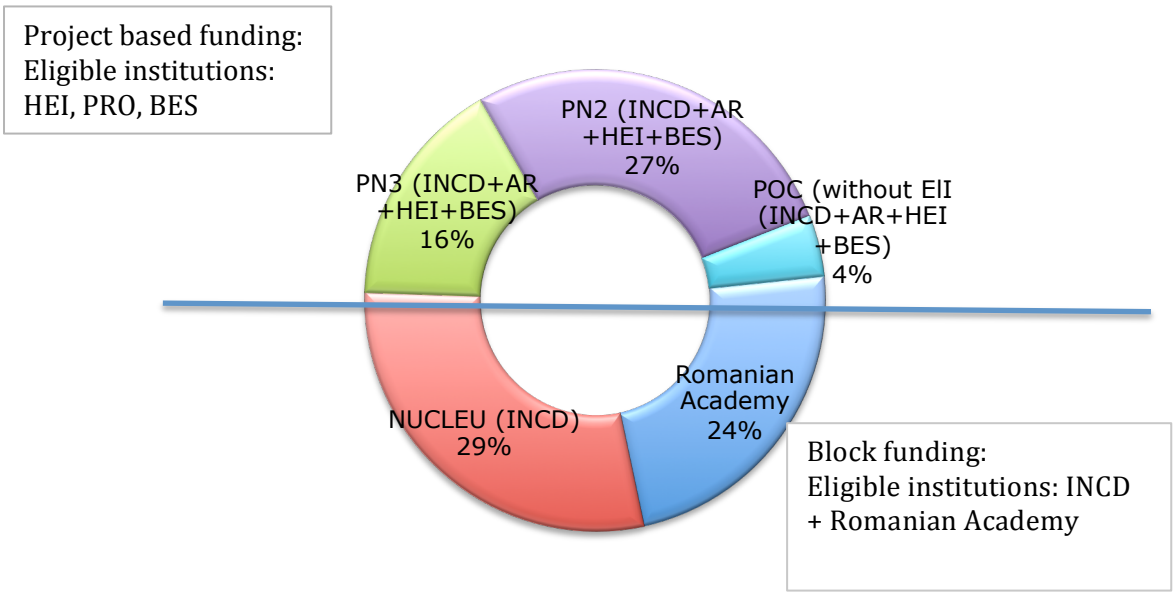


Figure 40. Distribution of public national by block and project based funding

[163] To be noted, that herein is included the whole AR budget
[164] https://www.mfinante.gov.ro/static/10/Mfp/proiect_buget2015/Academia_Romana.pdf
[165] https://www.senat.ro/legis/PDF/2017/17L010B337.pdf
[166] https://www.mediafax.ro/cultura-media/bugetul-academiei-romane-marit-cu-1-milion-de-lei-viorel-stefan-am-facut-si-noi-ceva-pentru-natie-14917587
[167] http://www.cdep.ro/pdfs/buget/2020/anexa3/Academia%20Romana.pdf
[168] http://www.cdep.ro/pdfs/buget/2020/anexa3/Academia%20Romana.pdfhttp://www.cdep.ro/pdfs/buget/2020/anexa3/Academia%20Romana.pdf
[169] http://www.cdep.ro/pdfs/buget/2020/anexa3/Academia%20Romana.pdf
[170] Thomson Reuters, Unitatea Executiva pentru Finantarea Invatamantului Superior, a Cercetarii, Dezvoltarii si Inovarii, 2015 - Bibliometric Analysis of Romania's Research Output, 2005-2014 availble at https://uefiscdi.gov.ro/scientometrie-baze-de-date

The distribution of competitive allocation of POC- AP1 by category of beneficiaries, is represented in the figure below. The top beneficiaries are the public HEI, followed by INCD and small enterprises.

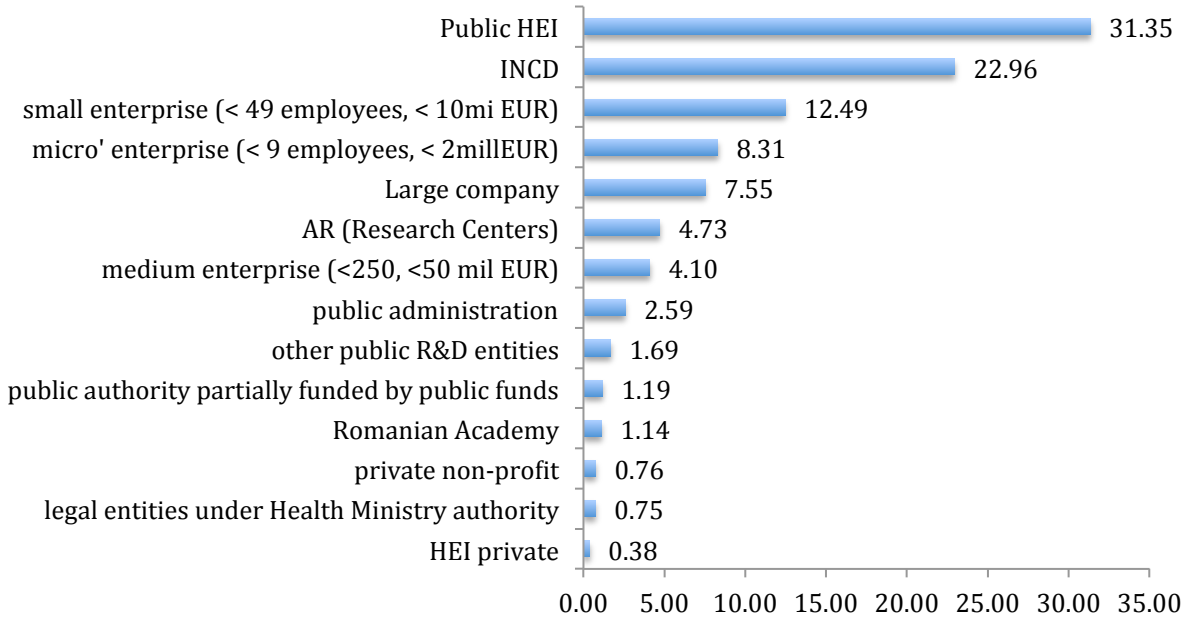


Figure 41. Distribution (% of total POC funds: 2014-2019) across categories of beneficiaries

Institutional evaluation has been discussed extensively in Romania.

Evaluation and funding of HEIs. **HEIs do NOT have and have never had block funding for research** activity. A share of the activity (salaries) of the academic staff, which depends on the academic position, is formally devoted to research activity.

The financing arrangement for HEIs had been criticized for dissipating funds among too many universities, in the absence of appropriate mechanisms for rewarding the quality of teaching and research or responding to societal needs (Andreescu et al., 2012). This inefficient allocation of public money 'complement' the chronic underfunding of the HEIs.

Universities went through a classification exercise. The first stage, primary evaluation and ranking of programme studies undertaken by the Association of European Universities in 2011.The classification in research-intensive, research-and-education and teaching-intensive was designed to be tied to specific funding lines available to the best performers and the right to organise doctoral and master studies. The second stage, institutional evaluation, undertaken by the EUA, independently by the IEP (Institutional Evaluation Programme), 2012-2014. The overall evaluation exercise was however heavily contested and just one year later, the newly appointed government decided through the Emergency Order 21/2012, that allocation of public funds to HEIs in the academic year 2012-2013 will **be independent of the evaluation and ranking.**

The National Higher Education Funding Council, CNFIS, proposed methodologies for an 'Institutional Development Fund' for universities to be granted to the highest-scoring HEIs. Call for projects under specific themes were finally opened in 2016.

According to the Law of Education, the HEIs should be evaluated regularly, using various benchmarking and ranking tools. HEIs are evaluated according to specific methodologies and applied by the Romanian Agency for Quality Assurance in Higher Education (ARACIS).

EVALUATION of the national R&D institutes

An evaluation procedure for PROs – INCD entities part of the national R&I system was adopted under Government Decision 1062/2011, replaced by Government Decision HG nr. 477/2019.

All entities of the public RDI system should produce annual self-evaluation reports. The reports, in theory, should involve benchmarking and all sorts of comparative analysis as analytical tools. Nevertheless, given that most of the institutions do not have dedicated staff (as time allocation, knowledge and expertise) and data repositories, these reports are mainly a list of achievements. *The reports vary in extent and substance, but generally they list activities and accomplishments.*

5.4 LIMITED EVIDENCE BASED POLICY DESIGN, FRAGMENTATION, LACK OF COORDINATION

The national policies relevant for the innovation ecosystem have some particularities:

- They generally target short-term results, overlapping with budget cycles. Some areas need long term strategies, which should transcend the political changes and interference.
- There have been many strategies, policies, interlinked, managed by distinct public institutions, with different institutional cultures. There is a significant degree of fragmentation, lack of coordination and communication.
- The policies often do not take into account the needs of business.
- While in theory, many Strategies complement the SNCDI in creating a sound policy mix, there is no evidence of their impact. Sometimes there is significant discrepancy between these strategies and their implementation. This occurs either due to the inadequate design or the absence of the implementing actions (therefore the strategies remaining just rhetoric), the low funding or inefficient management of the funds.
- The policies with economic impact are based on figures at macroeconomic level, which are generated by a small number of companies. "*The Romanian economy is highly polarized and heterogeneous. In this context, translating the favorable or unfavorable effects reported by the macro figures to the individual companies may not be so relevant.* ***The overwhelming majority of companies in the economy achieve significantly different results from the average values*** *expressed by macro figures. The trends at the aggregate level were generated by a small number of companies*" Excerpt From: BNR. "Notebooks, No. 42.

5.4.1 Fragmentation of governance&policies, lack of efficient coordination

Various Strategies, **at different governance levels** were designed and implemented during 2014-2020 policy cycles. These deploy various funding instruments which were not necessarily designed/nor implemented in a coordinated and integrated manner. This brings an additional layer of complexity which the beneficiaries face in accessing information, additional efforts to understand and comply to criteria, implementation and reporting procedures.

The R&I governance is characterised by excessive and burdensome bureaucracy, predisposition to over-regulation, frequent legislative and institutional changes, lack of human resources.

The governance of the RDI is also hindered by a fragmentation amongst Ministries and Agencies responsible for research, economic development, education and regional development, with distinct institutional settings and culture, with different procedures during the projects' life cycle (calls, evaluation, implementation, reporting), M&E (distinct monitoring indicators and systems, evaluation procedures and timings). This was signaled a significant drawback by the Mid Term evaluation of the impact of the SNCDI on the S2 domains.

While coordination mechanism was in theory designed in SNCDI 2014-2020, there is no evidence that they were functional/operational for 2014-2020. Since August 2019, a Committee for the Coordination of the Smart Specialisation was established through a

Minister's Order but for the next programming period, 2021-2027. There has not been an overarching strategy/governance to provide direction and purpose to the policy mix.

The midterm evaluation of the SNCDI 2007-2013 and NP2007-2013 highlights that '*little is said about the actors that should employ and implement these tools and particularly their qualification and readiness, hence the functioning of ministries, agencies, advisory bodies. research institutions, particularly universities, the National Institutes, not least the Romanian Academy*.' (Technopolis, 2012). More or less it applies for the current period. To date, such an **evaluation of the whole RDI governance**, at national and regional level, to the best of author's knowledge **has not been performed**. There is no visible evidence of the reform of public administration, which should provide for an administrative apparatus, restructured to include expertise and activities which are strongly needed for policy design, e.g. foresight studies, evaluation exercises.

The EC Recommendations since 2013 (including in 2017) reinforce that the **weak capacity of the public administration to develop and implement policie**s remains a core challenge for Romania. "*Romania's administrative and policy-making capacity has been suffering from opaque processes and decision-making, little recourse to quality evidence, weak coordination across sectorial policies and widespread corruption" (*EC, 2017).

The lack of coherence of the policies is also an important weaknesses of the Romanian cluster landscape. While the Ministry of Economy is the main actor responsible for the cluster policy, funds are only available under the ERDF Competitiveness Programme, managed by the Ministry of European Funds (Management Authority) and the Ministry of Innovation and Research (Intermediate Body). Furthermore, content of the calls does not match real needs of clusters, nor do they come in time. In that regard, the launching of a small cluster support scheme in the frame of the National RDI Programme in 2017 is to be seen as a temporary yet salutary solution. (*Source: Daniel Cosnita: Romanian Clusters).*

5.4.2 Limited evidence based policy making

There is limited practice of evidence-based policy making. This is largely the result of the lack of sound evaluation of policies/programmes, lack of data and studies, lack of policy development capacity.

5.4.2.1 Lessons learned 2007-2013

The ex-post impact evaluation of the National Plan II for RDI (PN2), neither of the POS-CCE programme, were not perfomed. There were two intermediary evaluations of the SOP-IEC – Sectoral Operational Programme on Increasing Economic Competitiveness 2007-2013. It had been concluded that the evaluation of the impact could not constitute a basis for the impact evaluation of the OPC 2015-2020. (RO Government, 2016)

A mid-term evaluation of **National Strategy for RDI 2007–2013 (SNCDI 2007–2013)** was published in 2012, but there was no ex post evaluation. The review report highlighted the improvements in project evaluation and assessed that while the strategy identified tools, good practices, benchmarking mechanisms, the information regarding the readiness and capacity of institutions to deploy all these tools is rather vague.(Technopolis, 2012) [171]

[171] Technopolis Group, GEA Consulting, FMMC, Mid-Term Evaluation of the National Strategy and of the National RD&I Plan 2007-13, 2012.

The initial targets of the SNCDI 2007-2013 were correlated with a planned budget three times larger than the final allocation. The budget cuts affected unevenly the funding instruments. While the funds for the National RDI Plan 2007-2013 were reduced greatly, the funds dedicated for the Programmes "Nucleu" and those of the Romanian Academy were kept. This shows a preferential reduction of the competitive funding in favour of less transparent non-competitive institutional funding (Zulean, 2015).

The analysis of the evaluation and monitoring (M&E) implemented during 2007-2013 showed that the monitoring component is weakly developed, the results being presented in an aggregated form in annual reports. The Nucleu and Romanian Academy Programme are less transparent in both components – evaluation and monitoring. The competitive based financing instruments PNII, POSDRU, POSCCE appear to have a higher degree of transparency in comparison with the block funding (Zulean, 2015).

5.4.2.2 Lessons learned 2013-2020

The Project "*Development of the Administrative Capacity of the Ministry of Research and Innovation for the implementation of actions set out in the National Strategy for Research, Technological Development and Innovation 2014-2020 (code SIPOCA 27*[172]*)"* provided for the implementation of a monitoring and evaluation mechanism (main beneficiary MCI). Within the project, methodologies for the evaluation of the impact of the National Strategy at aggregated level and on the four smart specialisation domains and Health were developed. Six midterm evaluation reports were finalised in July 2019 and are available on the official webpage of the project. [173]

The analysis builds on surveys covering firms, HE and INRDIs, and five thematic focus groups. The evaluation covers **four PN3 programmes** (582 projects finalised by March 2019) targeting explicitly the smart specialisation areas and having projects finalised by December 2018 ((1) *Bridge Grant, (2) Experimental Demonstrative Project (Proiect experimental demonstrative PET, (3) Transfer to the economic operator (4) Innovation voucher (cec de inovare)*.

Within the POC, AP1 (2014-2020), around 220 projects were contracted until the end of 2018, with a total value of RON 3.08 billion. Of these, however, only 21% (**46 projects**) were completed at the time of the "Mid Term Impact Evaluation" (March 2019), with a total budget value of about RON 259 million. Aggregated data on these 46 projects were provided for the evaluation by the responsible OI for POC, AP. The information was not structured on instruments.

To be noted that a Mid Term Evaluation has a **'formative'** and not '**summative'** role. Therefore any impact evaluation should be performed ex-post. Qualitative and quantitative methods were applied (including an attempt of counterfactual impact evaluation). Given the short time between finalisation of the projects and the evaluation, the low RDI investement/number of projects in a specific domain, the lack of integrated approach in measuring the impact of all RDI instruments on a specific smart specialisation domain, the lack of clear baseline indicators, the difficulties in avoiding the bias of selection of the entities in the non-beneficiaries group, the results of the quantitative analysis should be treated with caution. Bearing this in mind, the evaluation shows a positive, yet modest (given the low funding) impact of all instruments evaluated at micro level, contributing to the general objectives of SNCDI 2014-2020. Dominance of some sub-field were identified. The design of the programmes and the mix of the programmes were assessed mainly as appropriate.

[172] http://sipoca27.ro
[173] The methodologies and the reports are available at http://sipoca27.ro/rezultate/

The main problems highlighted by the RDI performers were related to the low funding, high competition, lack of continuity of the competitive funding which created problems particularly in retaining temporary research staff and affecting the continuity of the research activities, and also limited the capacity to access external funding. The lack of multiannual planning of competitions and funds, including annual calendars, lack of predictability represents a hindrance in establishing partnerships with large companies, which establish their development strategies generally 12 months in advance.

The institutional framework of governance did not integrate all the relevant stakeholders. The lack of the essential structure for coordination – The Council for ST&I (Consiliul National Politici Stiinta Tehnologie Inovare) at the center of government, envisaged by SNCDI 2020, has generated major negative consequences.

Other obstacles relate to heavy and complex bureaucracy related to programmes implemented through structural funds. In some situations, the evaluation process was assessed as too long and subjective, further delayed by the long period between results of the evaluation and the contracting phase. The evaluation indicates a need to align output/outcome indicators to specific needs: business is not interested in ISI papers as academics & researchers are.

Among the positive aspects: the support/guidance received from the UEFISCDI monitoring teams, the on-line platform UEFISCDI has developed for the whole funding cycle of RDI projects.

The project also made operational a platform integrating the Romanian Registry of Researchers, including more than 37,000 profiles with the Registry of Research Results [174], and the National Registry of Research Infrastructures[175].

5.4.3 Limited evaluation of the RDI strategic programmes

Competitiveness Operational Program (Programul Operational Competitivitate POC), Priority Axis 1 - POC, AP1

By September 2019, according to the information publicly available, within POC, AP1, 221 projects were contracted, counting to 667,415,917 Euro (1 euro=4.6531 RON), representing approx. 70% of the total of the budget allocated to this PA.[176]

Major delays in the implementation of POC, AP1 put at risk the efficiency of the SNCDI. The reasons triggering these delays are related to the significant delays in evaluation. In some cases, this led to 2-3 years delay from the launch of the call to the contracting phase. These delays are linked to the nomination of evaluators. Romanian experts have good experience in peer review and are searchable in Brainmap platform. BrainMap platform provides access to more than 20000 Romanian and foreign experts, who have agreed at different moments in time to performe as evaluators for different RDI funding competitions. As a rule, the evaluation activity was paid. However, given a controversy related to the selection of the evaluators, in May 2018[177], MCI officially requested experts/institutions to support the technical-financial evaluation of proposals submitted under specific funding instruments POC, AP1 (see complete list in the footnote)[178], in pro-

[174] www.brainmap.ro
[175] www.erris.gov.ro
[176] http://mfe.gov.ro/wp-content/uploads/2019/06/10ce91d94af809a60b4ba4adc7fa3e71.pdf
[177] http://www.poc.research.gov.ro/ro/articol/4234/despre-oi-cercetare-comunicare-axa-1-poc-anunt-pentru-experti-evaluatori
[178] POC/62/1/3/Stimularea cererii întreprinderilor pentru inovare prin proiecte CDI derulate de întreprinderi individual sau în parteneriat cu institute de CD si universitați, în scopul inovarii de procese si de produse în sectoarele economice care prezinta potențial de crestere- SECTIUNEA C

bono regime. Eventually, in September 2018, MCI opened a request for service consultation[179] for the evaluation. The evaluation was outsourced to private companies, with a very limited number of experts, nominated before publicly at the tender, before the evaluation. This had put under doubts the confidentiality of the evaluation process.

On the official website, **Annual POC implementation Reports** are available (https://www.fonduri-ue.ro/poc-2014#rezultate-implementare). The 2018 Annual Report *highlighted that 'due to the delays in the process of purchasing the evaluation services, no evaluation reports were prepared during the reference period*." At the end of 2018, in terms of financial progress, 133% and 441% of the target budget was achieved for less developed, respectively more developed regions. These POC-AP1 annual reports, signal the following implementation problems for POC, AP1:

- The mismatch between the provisions of the OP and the reality arising from the implementation (including technological progress);
- Delays in the evaluation process;
- Delays in the implementation of the major ELI NP project;
- The calculation mode / the erroneous reporting of the project indicators;
- Difficult setting up of the reimbursement / request for payment files and the purchase file;
- The impossibility to carry out transfers from the research organizations to the companies with which they signed subsidiary contracts;
- Uncertainties related to filling-in the reimbursement / pre-financing applications.
- Difficulties in updating data in the electronic system MySMIS.

According to the Plan of the Evaluation of POC[180], to date, several evaluations should have been finalised:

- The evaluation of the impact POC actions on the RDI capacities in the smart specialisation domains and Health (first semester 2019);
- Evaluations of the POC actions regarding private investments in RDI (first semester 2019)
- Two evaluations of the POC actions regarding the knowledge, technological and human resources transfer, between public and private (2017 and 2019)

No additional public data are available on the official website regarding these evaluations. To the author's best knowledge, the evaluations have not yet been performed.

National Plan for Research, Development and Innovation (PN3)

The implementation of the National Plan for RDI (PN3) started with two years delay, in 2016. Additional delays were caused by the political change in January 2017, leading to dismissal of the four RDI advisory councils, changes in priority actions of SNCDI, the exclusion of the foreign expert evaluators.[181, 182]

POC/77/1/2/Crearea de sinergii cu acțiunile de CDI ale programului-cadru ORIZONT 2020 al Uniunii Europene și alte programe CDI internaționale- RO-EIT
POC/78/1/2/Crearea de sinergii cu acțiunile de CDI ale programului-cadru ORIZONT 2020 al Uniunii Europene și alte programe CDI internaționale- ESFRI-ERIC
POC/80/1/2/Crearea de sinergii cu acțiunile de CDI ale programului-cadru ORIZONT 2020 al Uniunii Europene și alte programe CDI internaționale- CENTRE SUPORT
POC/81/1/2/Crearea de sinergii cu acțiunile de CDI ale programului-cadru ORIZONT 2020 al Uniunii Europene și alte programe CDI internaționale- CATEDRE

[179] https://infocentrum.ro/Servicii_de_consultanta_pentru_evaluarea_proiectelor_primite_in_cadrul_Axei_Prioritare_1_POC-217283-1.html

[180] http://www.fonduri-ue.ro/images/files/programe/COMPETITIVITATE/POC/Plan.Evaluare.POC.pdf

[181] http://civitas.dogaru.net/nu-reorganizarii-organismele-consultative-ale-ministerului-cercetarii-si-inovarii/

[182] http://www.eua.be/activities-services/news/newsitem/2017/05/30/eua-statement-on-the-recent-developments-in-romania-regarding-the-research-policy-framework

All the information regarding the guidelines, evaluation process and results and a summary of the funding, including descriptive statistics (distribution by region/ domain) of the instruments funded by PN3 and managed by the Executive Agency for Higher Education, Research, Development and Innovation Funding (UEFISCDI) is available on the agency website and BrainMap. There is a one-stop-shop platform https://uefiscdi-direct.ro, with all the upcoming, open, closed calls. The Agency also makes available Annual Reports[183] that provides descriptive statistics regarding the implementation evaluation, analysis of the results of all the programmes under its management. The information is provided in a structured, transparent manner per instrument/aggregated, per year.

The presentation of all the relevant information in a structured, easily searchable way, the availability of annual reports recommends the UEFISCDI as an example of good practice.

In line with its official responsibilities, the body responsible for the evaluation of PN3 is MCI. Besides the evaluation performed within SIPOCA27 project, no other PN3 evaluations are available.

NUCLEU programme

A significant share of the state R&D funds is allocated through NUCLEU Programme. The eligible benficiaries are the National R&D Institutes.

No evaluation reports of the programme, neither any descriptive statistics (per domain, type of RDI activity, etc.) are available.[184] The evaluation highlights the lack of information related to Nucleu Programme in a comprehensive format (Zulean et al, 2015)[185]. The situation persists in the current policy cycle. There is no evidence of evaluation; results and impact of the programme are still missing a transparent, compressive format. The NUCLEU programme has raised significant concern [186] regarding the lack of transparency, '*the obscure spiral through which is circulated a third of the MCI budge*t", the opening of calls over short period of times, often during holiday period.

The author, based on the evidence publicly available (or better said its absence) can just observe the lack of coherent, consistent evidence regarding the impact of the funds' allocation.

Regional Operational Programme – Priority Axis 1 (POR, AP1)

The guidelines for POR, AP1 (Technological Transfer) were opened for public consultation in June 2017. The competition was launched in February 2018.[187] 66,000,000 EUR were devoted to this funding action. The first evaluation for POR, AP1 (technological Transfer) is scheduled for 2019, third semester.

The information regarding the funded projects by ROP is not available per funding instrument/ AP. No annual reports regarding the implementation, descriptive statistics, funds allocation per region, smart specialisation domain could be found on the official website of the Ministry in charge (October 2019). The site provides just a list of approved financing.[188, 189]

[183] https://uefiscdi.gov.ro/rapoarte-de-activitate
[184] http://www.research.gov.ro/ro/articol/3768/programe-na-ionale-programe-nucleu
[185] Zulean, M., Ionita, I., Viiu, G.A. (2015), Raport de evaluare a guvernantei sistemului public de cercetare, dezvoltare si inovare din Romania, 2007-2013 (Assessment of the governance of the RDI system in Romania 2007-2013)
[186] https://mic-mic-anc.ro/2018/02/14/spirala-obscura-prin-care-circula-o-treime-din-bugetul-public-al-ministerului-cercetarii-si-inovarii/
[187] http://www.fonduri-ue.ro/calendar-lansari
[188] https://www.mdrap.ro/dezvoltare-regionala/-4970/-7166
[189] http://www.inforegio.ro/ro/implementare/stadiul-implementarii-financiare

5.5 LOW level of HRST/Researchers

	2014	2015	2016	2017	2018	2019	EU28 (latest available)
New doctorate graduates per 1000 population aged 25-34	0.3	0.35	0.19	0.16			1.07 (2014)
New graduates in science, math., computing, engineering, manufacturing, construction per 1000 population	2.15	1.9	1.77	1.8			2.32 (2018)
Number of researchers per thousand of population	1.38	1.37	1.41	1.39			6,07 (2018)
Public expenditure on education (% GDP)	3	3.1	3.3	2.8	3.2		4.7
Public expenditure on tertiary education (% GDP)	0.6	0.8	0.7	0.6	0.7		0,7
Population age 25-34 having completed tertiary education (ISCED 5-8) (%)	25.4	25.5	24.8				38.2 (2016)
Employment rates of population age 25-64, having completed tertiary education (%)	86	86.9	87.8	89.2	89.7	90.5	85.3 (2018)
Share of employees age 25-64 having completed tertiary education (%)	25.9	27.6	27.2	26.8	26.6	27.1	35.9 (2018)
Share of tertiary degree mobile graduates from abroad (%)	2.4	3.2	3.6	4.2			
Share of scientists and engineers in the age group 25-64 as % of active population (%)	5.9	6.1	6.4	6.4	6.6	6.7	7.8 (2018)
Share of female researchers	46	46.2	45.8	46.7			32.8

Table 15. Supply of human resources. Romania and European Union (Source: https://rio.jrc.ec.europa.eu/stats/country-based-indicators)

5.5.1 HRST/Researchers. Time trends

Human capital is the essential factor of competitiveness in a knowledge society, the main driver of development and economic growth and strongly influences the innovation level of society knowledge.

The share of researchers in the total working population is strongly correlated with the production of innovative solutions. Countries with high share tend to be also leaders in innovation.[190]

In Romania, the share of Human resources in science and technology (HRST) in 2018 was 27.9%, **the lowest in EU** (compared to 47.5 in EU) (EUROSTAT, 2019). The number of researchers per 1000 employees in Romania in 2018 was 1.99, compared to 8.71 in EU28 (OECD). In the 2019 European Innovation Scoreboard, one of the weakest

[190] Science, Research and Innovation performance of the EU, (2016) European Commission.

innovation dimensions is the Human resources and one of Romania's lowest indicator scores are on Lifelong learning. [191]

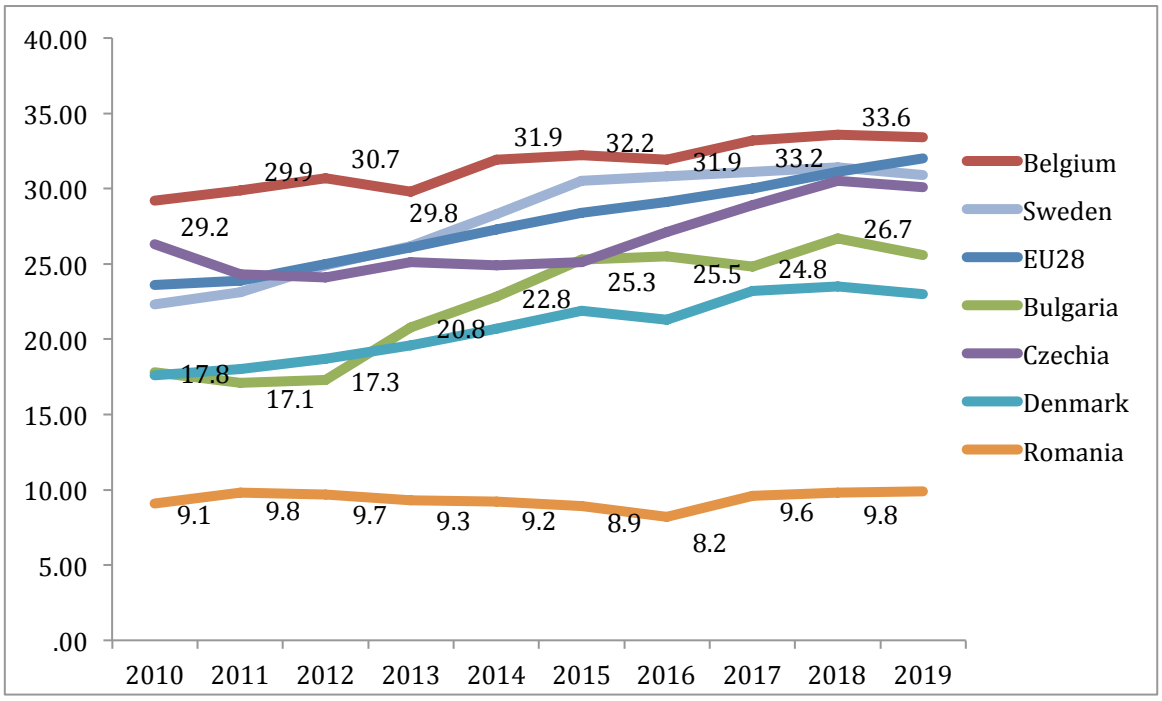


Figure. Time evolution in selected countries of HRST (Persons with tertiary education (ISCED) and/or employed in science and technology)

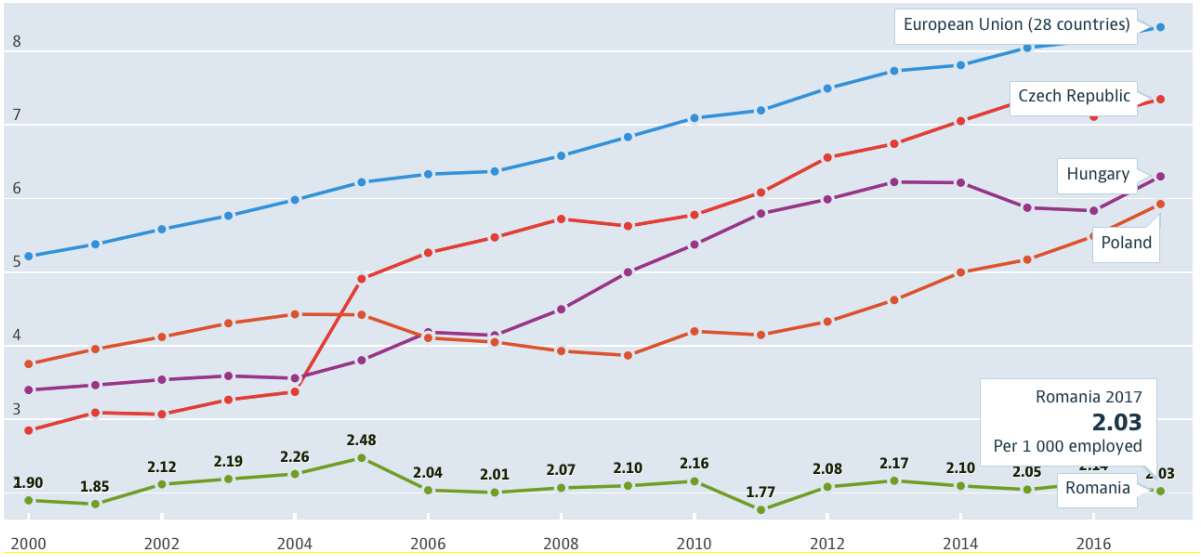


Figure 42. Time evolution in selected countries, over the period 2000-2017, of the number of researchers per 1000 employees (Source: OECD. doi: 10.1787/20ddfb0f-en)

[191] the weakest sub-pillars expenditure on education as % GDP and per pupil

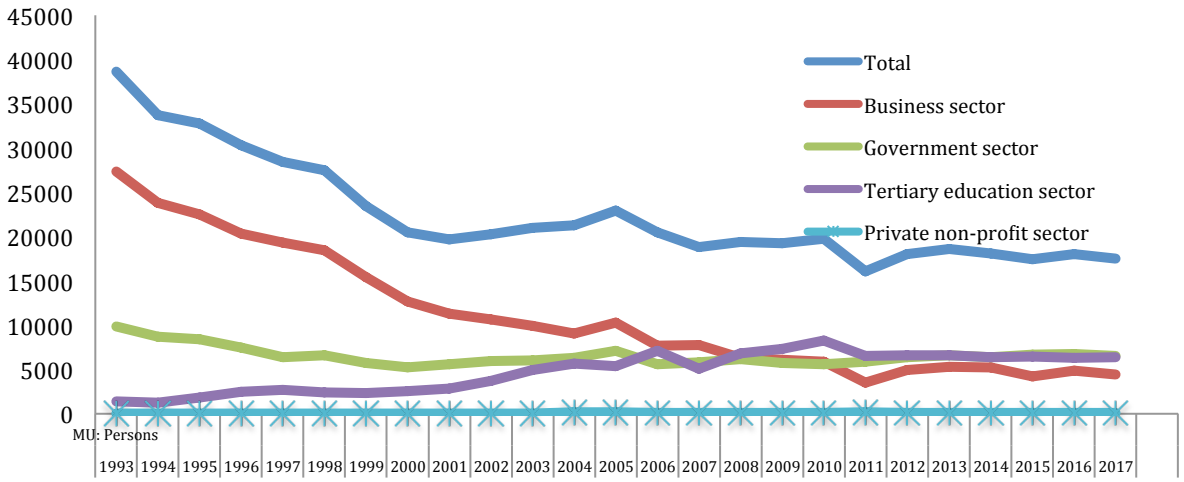


Figure 43 Romania: time evolution of the number of researchers, full-time employed[192] during 1993-2017 (source: INS).

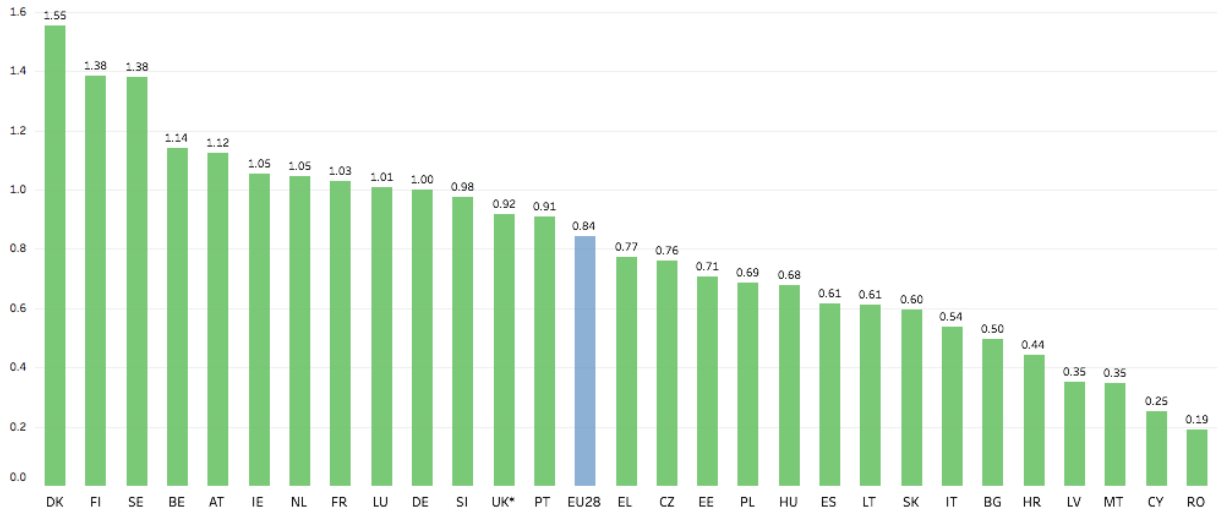


Figure 44. EU28 MS. Number of researchers (FTE as percentage of the active population) in 2018

[192] The employees from the R&D activity are expressed not only as a physical number of persons, but also in a conventional measurement unit called full-time equivalent, which is based on the evaluation unit representing a person who works full time during a certain period and on the conversion of the number of part-time workers in a full-time workers equivalent, taking into account the hours of work dedicated to the R&D activity. The evaluation of human resources was performed as follows: - persons working full time in the research-development sector (90% of time or more). - persons mainly working in the research-development sector (50-90% of the time). - persons working part time in the research-development sector (less than 50% of the time).

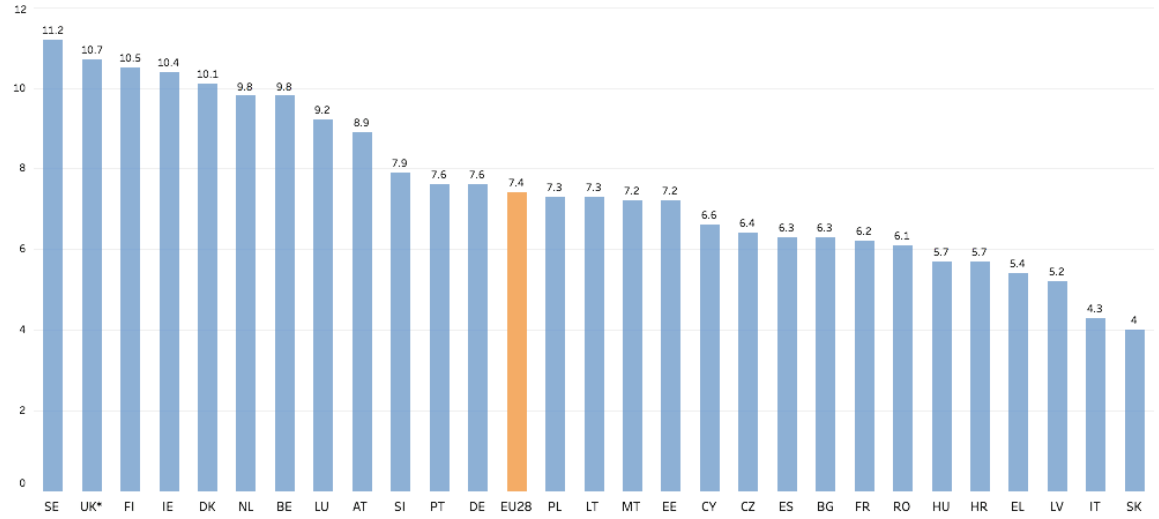


Figure 45. Scientists and engineers as % of active population: EU28 MS, 2018 (Source, DG-JRC, RIO)

As can be seen in the graphs above, Romania HRST has showed over the last 20 years a descending trend and is on the lowest positions as % of active population in almost all categories (except scientist&engineers). The majority of EU MS invested in R&D the time evolution of the number of researchers is increasing, widening the gap.

5.5.2 Brain Drain

Around **760,000** (22% of the total national emigrants) highly educated Romanians live in OECD countries, In 2015/2016 Romania has the **highest emigration rate of highly educated. This increased more rapidly than the number of tertiary graduates in RO**. (OECD, 2019)

The number of physicians is low compared to EU averages: 2.8 doctors per 1 000 population compared to 3.5 in the EU. Although the number of nursing graduates and medical graduates steadily increased, there was also a high rate of emigrating health workers over the past years.

The brain drain is driven by many factors that are not necessarily related to the design of the strategic RDI policy. The brain drain cannot be reversed without a coherent approach to tackle this phenomenon. The recent reform of the public wages attempts to tackle the most common causes of dissatisfaction, such as low salaries as well as low social status and recognition. However, these measures should be complemented by a consistent reform, tackling other reasons such as limited career development opportunities and the poor working conditions, the lack of equipment and supplies.

While the reversal and the control of the brain drain needs a consistent and coherent process, reflected in many policies, the RDI policy can take advantage of the Romanian diaspora. This can bring knowledge, expertise, can support networking.

Conference "Diaspora in Scientific Research and Higher Education Romania - Diaspora and friends" 2008, 2010, 2012, 2016

The Conferences tried to bring together Romanians residents and from abroad. Several editions had been organised. The conference is organised by UEFISCDI in partnership with ministries, agencies, private organisations, NGOs and brought together more than 4000 Romanians, most of them top professionals in their field. The Conference creates the space for dialogue and cooperation, a framework for discussing ways of making collaboration more effective and fit for purpose.

5.5.3 Supply – demand

While Romania has a clear deficit in terms of HRST, any measure to increase the number of the researchers has to consider the supply capacity of the system and measures should be formulated accordingly.

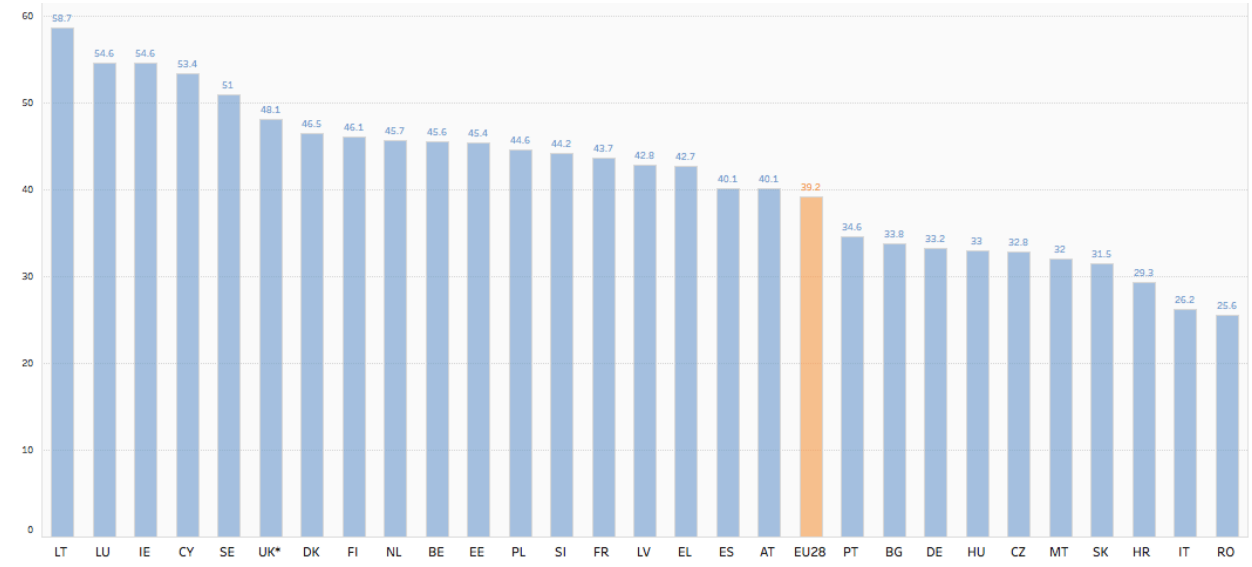


Figure 46. Percentage of the population aged 30-34 who has successfully completed tertiary education

Tertiary educational attainment (age 30-34) in 2017 was 26.3 % compared to 40.6% EU28.

In Romania graduates in tertiary education per 1 000 population, aged 20-29 in STEM-related fields have decreased, from 17.6% to 14.4% in a short period of time (2013-16). The trend is consistent with the overall declining trend of the number of students enrolled in the tertiary education (OECD, 2019 (c)). In 2015/2016, 42.22% of the first year students were enrolled in social sciences fields. Out of these, 36.37% were enrolled in public universities and 79.63% in private universities.

No studies are available regarding the employability in the relevant field of the studies.

The main factors which must be considered to understand this situation are:

- The demographic decline of the relevant student sub-population;
- The high drop-out levels;

- The cohort of pupils underachieving is high ((EC, Country Report 2017. EUROSTAT, 2019 – PISA RESULTS). Many pupils will not reach or pass the baccalaureate. 25% of first year students registered in the HES failed to promote in the second year of study. A higher drop-out is observed until the end of the studies.
- The high achievers (21% of those with 10, and around 15% of those with mark 9-10) were not registered in the national HES and most likely enrolled in HE abroad;

The time **trend of PhD graduates** f**ollowed an increasing trend until 2014, similar for example to BE, ES.** In 2013, the number of doctorate graduates reached 1.1 per 1000 population of 25-24 (similar for these countries). While the time trend of doctorate holders for other EU countries show a consistent trend (increasing, stable), in Romania the number of PhD dropped significantly from **1.1 in 2013 to 0.3 in 2014** and stabilises at this value afterwards.

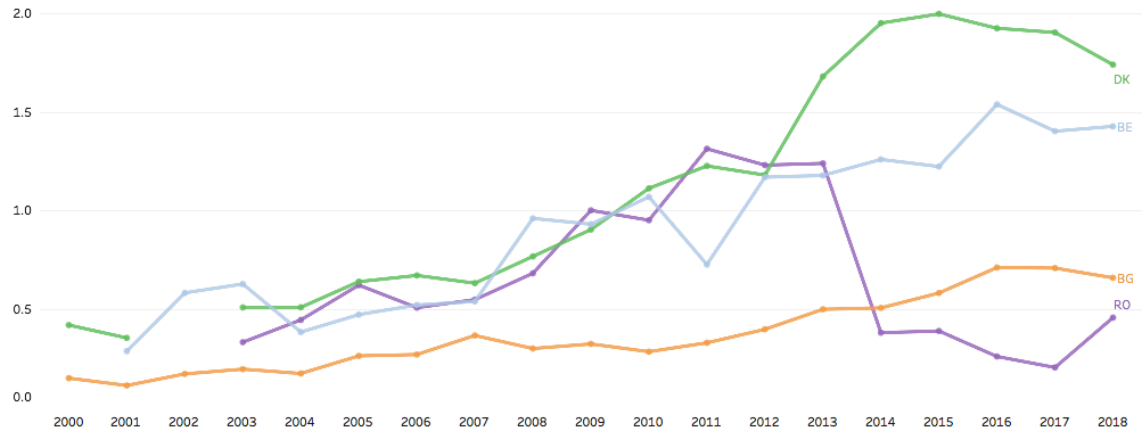


Figure 47. New doctoral graduates per thousands population aged 25-34: RO, BG, BE, DK

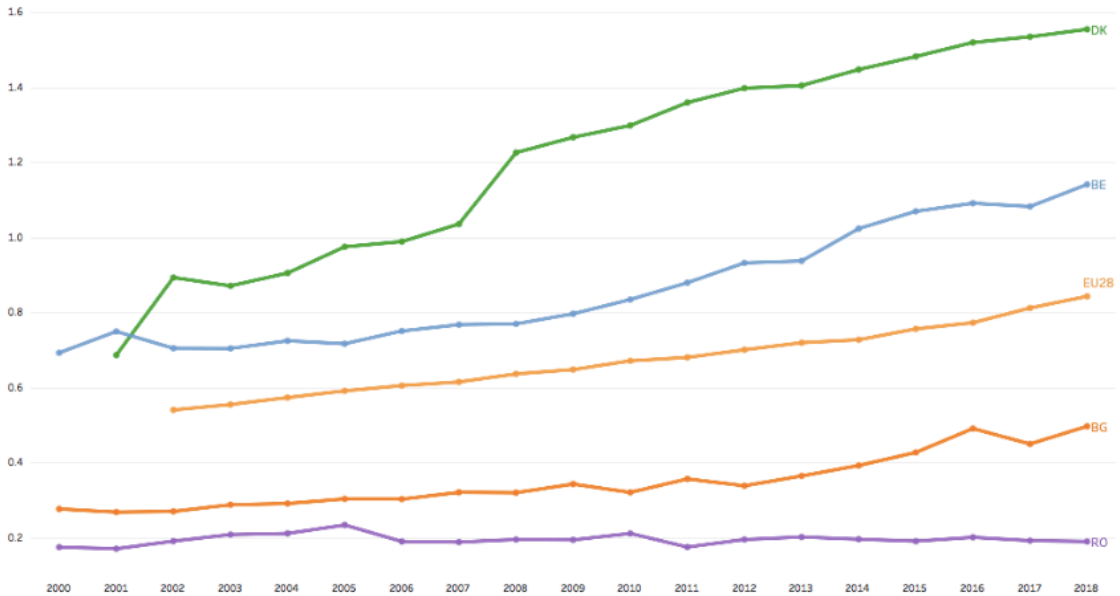


Figure 48. Total number of researchers. Time evolution: RO, BG, EU28, BE, DK (Source DG-JRC, RIO)

Countries with a similar increasing trend of the PhD graduates show also an increasing trend of the number of researchers. This did not happen in Romania, indicating that the supply was not tailored to the demand. During that period, also the attention was raised

by the academic community that while the plagiarism PhD cases of various politicians were exposed to the media, these were just the tip of the iceberg.

All these aspects indicate the lack of integrated long term strategic (either in design or implementation) approach of the quadruple helices of the innovation system.

5.5.4 Attractiveness of scientific careers in public system

To the best of authors' knowledge, there are no publicly available studies assessing on a rigorous methodology the attractiveness and the satisfaction of the academic and scientific staff in Romania. Nevertheless, some aspects should be considered.

In the context of significant reduction of the number of students due to the demographic decline, the decrease of the cohort passing the baccalaureate and the high number of Romanians studying abroad (to which still adds the long term effects of the Bologna restructuring), in many S&T fields the academic staff schemes are frozen, with low chances of new openings or career progression. Advancing to a higher academic position is not a promotion based on the mere fulfillment of the performance requirements and depends on the number of teaching available.

Given the lack of predictability of the R&D funding, HEIs and PROS can not design long term institutional research strategies. This limit the capacity to retain young staff.

The input to the system is the lowest in EU28, yet according to some studies the scientific performance for career progression in many fields is evaluated against criteria 'to which academics in top world ranked universities may not comply'. The frequent changes of the regulation generated a system extremely heterogeneous across fields, academic positions, many of the current highly rank academic staff being below the criteria against they evaluate their younger colleagues or compared to peers from other fields (Chioncel M, 2017).

A large share of the staff in HEIs, education, research and medical system remains underpaid, when comparing with the staff in other EU28 MS and other national professionals in the public system (justice system, local administration, police). The salaries are prescribed in bands, with low flexibility for merit-based deviation, therefore the financial capacity to reward the individuals is limited.

5.5.5 Regional disparities

Romania's prosperity is not equally shared. A large **population (around 40%)** is disconnected from the drivers of growth. '*Around half of it does not work, while other remains engaged in subsistence agriculture*" (World Bank, 2018). Most of these people live in poor rural areas, with very few job options, highly unskilled and own small areas of arable land, usually used just to cultivate their own food.[193]

Romania has at the same time substantial unused labour potential, and several groups such as young people, Roma, the long- term unemployed and people with disabilities have difficulties in accessing the labour market. (EC 2018 Country Specific Recommendation).[194]

[193] The latest official data
[194] http://data.consilium.europa.eu/doc/document/ST-9448-2018-INIT/en/pdf

Despite the emerging of a severe workforce crisis, governments have never designed effective policies/strategies to make these people interested in taking real jobs. **The lack of opportunities is not compensated by labor force mobility**. "*Low internal mobility further reinforces Romania's dual development challenge – less than 2 percent of the population reports having moved in the past five years, implying that structural constraints inhibit internal mobility toward economic opportunities*," World Bank experts point out.[195]

5.6 INEFFICIENT USAGE OF RIS

An exercise in mapping the infrastructures and research equipment and services existing in Romania and their use has been performed, and the data and information are available through the ERRIS portal ("Engage in Romanian Research Infrastructures System", https://erris.ro/index.php?. The platform evidences the high number of research equipments. In August 2019, ERRIS registered 1,439 research infrastructures with at least one associated research equipment and service (www.erris.gov.ro). In total, they had 8,885 services and 22,131 associated equipment. Approximately 54% were purchased in the period 2010-2019, and 40% in the period 2000-2009. Most of these infrastructures are concentrated in universities and INCDs, those owned by the private sector accounting for about 10%. A blockchain layer, for smart contracts, is to be developed as a reputation mechanism as well as for easing the contracts for services.

Romanian private companies do not have the financial resources to invest in research, and their access to public RDI infrastructure is difficult (ESFRI, 2018).

While recent investments in RIs increased the quality of infrastructures, often the investments were made for the 'sake of investing/ additional income'. Often the investment in research infrastructures did not respond to national strategic priorities, or have been duplicated at territorial level, underused due to the lack of adequate skilled human resources and subsequent funds for maintenance and for relevant research activities (Curaj, A 2015). Both, public and private RDI sectors, observe that graduates lack hands-on experience in state-of-art technologies, their training requiring significant resources.

[195] http://business-review.eu/business/hidden-workforce-almost-1-in-4-romanians-works-in-agriculture-the-highest-share-in-the-eu-202120.

5.7 LOW KNOWLEDGE PRODUCTION

	2014	2015	2016	2017	2018	2019
Scimago country ranking	38	38	39	42	43	40
Scimago total documents	15123	15425	15398	16381	15227	
Scimago non-cited	5286	5629	6344	8708	11944	
Triadic patents number	8.7	12.7	13.8	11.4	n.a	n.a
OSIM patents granted	952	980	1005	1098	1110	888

Table 16. Data on patents and publication. 2014-2019

This report defines R&D as a "*creative and systematic work undertaken in order to increase the stock of knowledge including knowledge of humankind, culture and society, and to devise new applications of available knowledge*", in line with OECD Frascati Manual (2015). For an activity to be an *R&D activity, it must satisfy five core criteria: the activity must be novel, creative, uncertain, systematic, and transferable and/or reproducible.*

Studies show that the countries **scoring low on research excellence are also those that spend less on R&I, a 'critical mass' 1.5 % of GDP being needed to achieve excellence** (S Hardeman et al, 2013). **Romania is well below this threshold level, stagnating for many years among the lowest GERD levels in EU.**

Indicators on scientific publications among the top 10% most cited publications, research excellence composite indicator and the ERC success rate show that **Romania underperforms in most areas of research**. Romania has one of the lowest Adjusted Research Excellence scores[196] (in 2016, 16.8 compared to 16.6 BG, and 16.7 in LT) (Vertesy, D, 2018).

The analysis provided below is just an attempt of providing directions for further, detailed analysis, highlights the patterns and correlate them with statistical data, provides a proxy for understanding the statistical data. To date, to the author knowledge, such thorough analysis has not been performed and it is far beyond the limits of this report.

[196] The Research Excellence index is a composite of four components: share of top 10% most highly cited publications per total publications (data source: CWTS); PCT patent applications per population (OECD, World Bank); Participation in Marie Skłodowska-Curie Actions (DG-EAC); ERC grants per public R&D (DG-RTD, Eurostat, OECD).

5.7.1 Scientific publications

Region, country	2013			2014			2015			2016		
	Top 1%	Top 5%	Top 10%	Top 1%	Top 5%	Top 10%	Top 1%	Top 5%	Top 10%	Top 1%	Top 5%	Top 10%
World	1,00	5,00	10,00	1,00	5,00	10,00	1,00	5,00	10,00	1,00	5,00	10,00
EU	1,27	6,13	12,14	1,29	6,12	12,08	1,29	6,17	12,13	1,30	6,28	12,32
RO	**0,89**	**3,60**	**6,84**	**1,02**	**3,86**	**6,84**	**0,98**	**3,92**	**6,93**	**1,16**	**4,22**	**7,60**

Table 17. Share of S&E publications in the top 1%, 5%, and 10% most-cited articles in the Scopus database, 2013–2016 (source: NSF/SEI[197]

In SCIMAGO[198] country&journal global ranking, Romania with 198390 documents over the period 1996-2018, is on the **40th global position and drops to position 44 in the citation ranking**.

The author has performed analysis of the SCOPUS and WoS. WoS and Scopus use different metrics, have distinct advantages/ disadvantages, but both index journals with high scientific credibility. While ISI, due to its much longer history may be still more popular worldwide, some countries measure the scientific progress by the number of papers published in Scopus. Also, NSF switched from WoS to Scopus for reporting citation metrics. For the IT field, the Romanian University Consortium (that includes the informatics faculties of the four big university centers Iasi, Cluj, Timisoara, Bucharest) recommends to take into account for conferences the Australian Ranking. The aim was to increase the quality of publications and to eliminate "ISI" commercial magazines / conferences.

Beside these aspects, the author is fully aware by the limitation of the analysis. A solid analysis should consider also the journals (impact factor) in which the papers are published, the number of citations, the number of authors, the number of papers with the first author from a specific institution. Bearing these in mind, the analysis herein provided barely provides a proxy and suggests further directions for analysis.

The total publication output **increased since 2005** (the number of ISI publications increased from 3003 to 9821 in 2018, while the number of SCOPUS publications over the same period increased from 4743 to 15997), partially as a pressure of the academic evaluations but also due to the access of the HEIs to competitive funding. Nevertheless, around **30% of publications** as counted in Scimago are non-cited. Author's analysis of the SCOPUS publications with Romanian authors indicates that the highest share of publications was produced by universities.

Romania out of more **100000 WoS documents** produced during **2014-2020**, **has only 665 highly cited documents (0.66% of the total)** and 56 hot papers. The distribution by institution/field is detailed in the section top performers. The large majority (if not all) are written in collaboration with top world universities/research institutes. **This emphasize the need to be connected to the international trends and research leaders in the field**.

According to the 2020 NSF/SEI report, the number of scientific articles (from Scopus, using the fractional method) with country affiliation Romania, increased f**rom 2601 in 2003 to 11061 in 2012**, fluctuating around this value afterwards. Only **7.6% of the articles are among the 10% most cited**, placing Romania on the second lowest

[197] [SEI2020S5a-35] - https://ncses.nsf.gov/pubs/nsb20206/data#supplemental-tables
[198] The SCImago Institutions Rankings (SIR) is a classification of academic and research-related institutions ranked by a composite indicator that combines three different sets of indicators based on research performance, innovation outputs and societal impact measured by their web visibility.

position in EU (**EU average: 12.32%)**[199].

During **2014-2019**, Romania produced **0.44%** of the total number of articles (20.07 million), in the Web of Science categories. Romania's normalised citation impact, while remaining below world average citation impact between 2005 and 2013, managed to climb above that threshold in 2014.[200]

As observed in the *Annex "Number of Publications and Open Access (OA)'*, the share of the open access of Romanian ISI papers increased from 9.85% (2005) to 29.60% (2018), reaching a value above the share of world OA ISI papers (24.74%) (*based on Analysis of WoS & Scopus databases - by Victor Velter, UEFISCDI*).

Analysis of SCOPUS publication by funding institution shows that the funding is spread among many funders. UEFISCDI is the top funding institution **(around 9% of SCOPUS publications been funded by UEFISCDI).** The SCOPUS analysis tool, clusters under a separate funder CNCS, wrongly associated to Corporation for National and Community Service, the documents funded by CNCS–UEFISCDI, National Plan 2 or National Plan 3 (author's analysis). The funding of a significant share of the publications is distributed among other organisations.

To be noted that beyond this formal acknowledgement of the funder, the PN3 '**Award' of the research results**[201] funding scheme managed by UEFISCDI has offered financial rewards for Romanian authors, with Romanian affiliation, of selected scientific publications and patents after **these have been published/awarded**. The reward takes in consideration the prestige of the Journal, the number of Romanian authors, the type of the patent. Thus, these papers although have benefited from the programme can NOT acknowledge the funder.

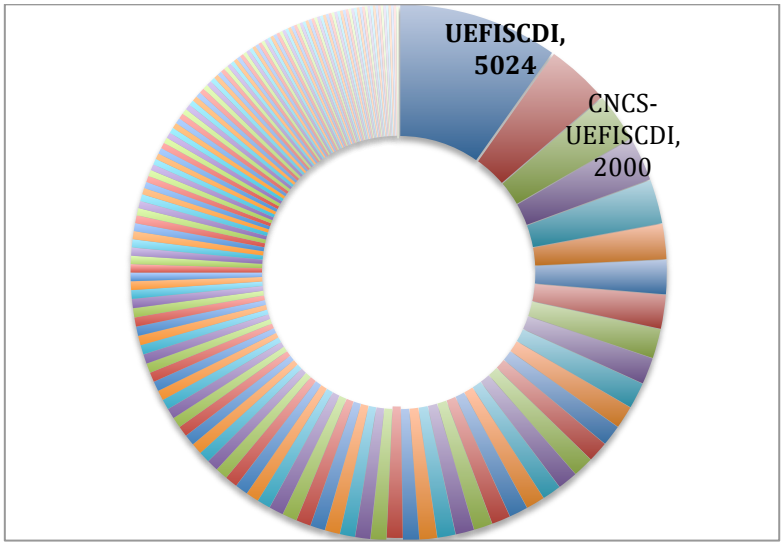


Table 18. Distribution of SCOPUS publications by funding agency (2014-2020)

[199] [SEI2020S5a-35] - https://ncses.nsf.gov/pubs/nsb20206/data#supplemental-tables
[200] Thomson Reuters&UEFISCD (2015) Bibliometric Analysis of Romania's Research Output, 2005-2014
[201] https://uefiscdi.gov.ro/premierea-rezultatelor-cercetarii-brevete

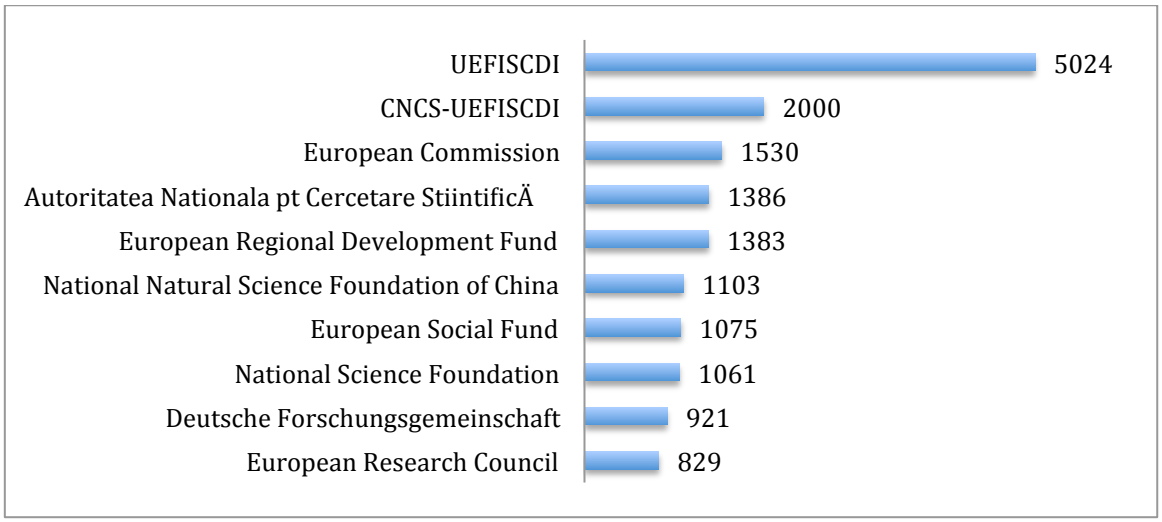


Figure 49. SCOPUS publication by funders (% of total). Top 10 funders (2014-2020)

While as any other SCOPUS, WoS analysis these data can be considered only as proxy, it must be noted that around 14% of the total papers are funded by UEFISCDI-CNCS.

The way the funding agency is identified by the analysis tools of the databases also signals the need for proper, detailed and consistent acknowledgment of the funding.

5.7.2 PATENT/TRADEMARKS

'IP is protected in law by, for example, patents, copyright and trademarks, which enable people to earn recognition or financial benefit from what they invent or create. By striking the right balance between the interests of innovators and the wider public interest, the IP system aims to foster an environment in which creativity and innovation can flourish"

The patent activity is particularly modest. In EIS 2019, R**O has the lowest position in terms of patent application** (scoring 5.95 compared to 212 of Sweden).[202]

EPO, USPTO, Triadic patents, worldwide

During the period **2009-2014**, 37% of all 'Romanian' inventions were owned by 'academic & government' entities, closely followed by individuals (35%) and, at some distance, by business (28%) (Thomson Reuters Romanian Research Output: IP Analysis prepared for UEFISCDI (2015).[203]

Analysis of PATSTAT database using the search query RO inventor, 2014-2019 returns more than 7400 patent applications worldwide, out of which 1395 were granted. Less than half (603) are patents with RO inventor and RO applicant.

The author's analysis of EPO and USPTO databases shows the dominance of companies in terms of patent activity,

The USPTO search using the search query **RO Inventor, RO Applicant returns 393 applications, while** using the search query **RO Inventor returns 1446 applications. This once again that while Romanian inventors are active, the invention may not be owned by Romania.**

[202] https://interactivetool.eu/EIS/EIS_2.html
[203] https://uefiscdi.gov.ro/scientometrie-baze-de-date

Authors' analysis of the USPTO database, using the search query: **RO Inventor, RO Applicant, RO Assignee** returns **30 granted USPTO patents** over the whole period covered by the database (1978-2020). This result search shows that the earliest patent application is dated 2006, with the large majority having the filling date after 2009. The main contribution comes from two companies: **Honeywell s.r.l and Softwin**. During 2014-2019, the search returns **eleven patent applications** using the search query Ro inventor&RO applicant. There are **two applications by HEI,** both belonging to Politehnica Timisoara and **three by distinct INCD** (Institutul National de Cercetare Dezvoltare pentru Fizica Tehnica Iasi, Institutul de Chimie Macromoleculara Petru Poni, Institutul National de Cercetare-Dezvoltare pentru Microtechnologie-IMT).

The Scopus analysis of patents for the period 2014-2020, returns 47 results:

- 19 EPO and 17 USPTO.
- Seven patent applications UK
- Four WIPO patent applications
- Out of 36 EPO+USPTO, 21 belong to Honeywell, seven to SOFTWIN and three to University Stefan cel Mare, three to Hella and two to Continental s.rl. To be noted that this search does not fully match the results identified in USPTO database
- Further analysis shows that out of 36 patents, 11 USPTO and 11 EPO were granted (10 to Honeywell s.r.l and 1 to Hella).

The total number of patent applications[204] to the European patent office (EPO) was **estimated** as 99 in 2017 (EUROSTAT data). **Author's analysis** of the **PATSTAT** database identifies around 14oo patents with a Romanian inventor, awarded worldwide. There are around **251 EPO** applications, with **RO inventor&RO applicant** during the period 2014-2020 and around less than 20 EPO granted.

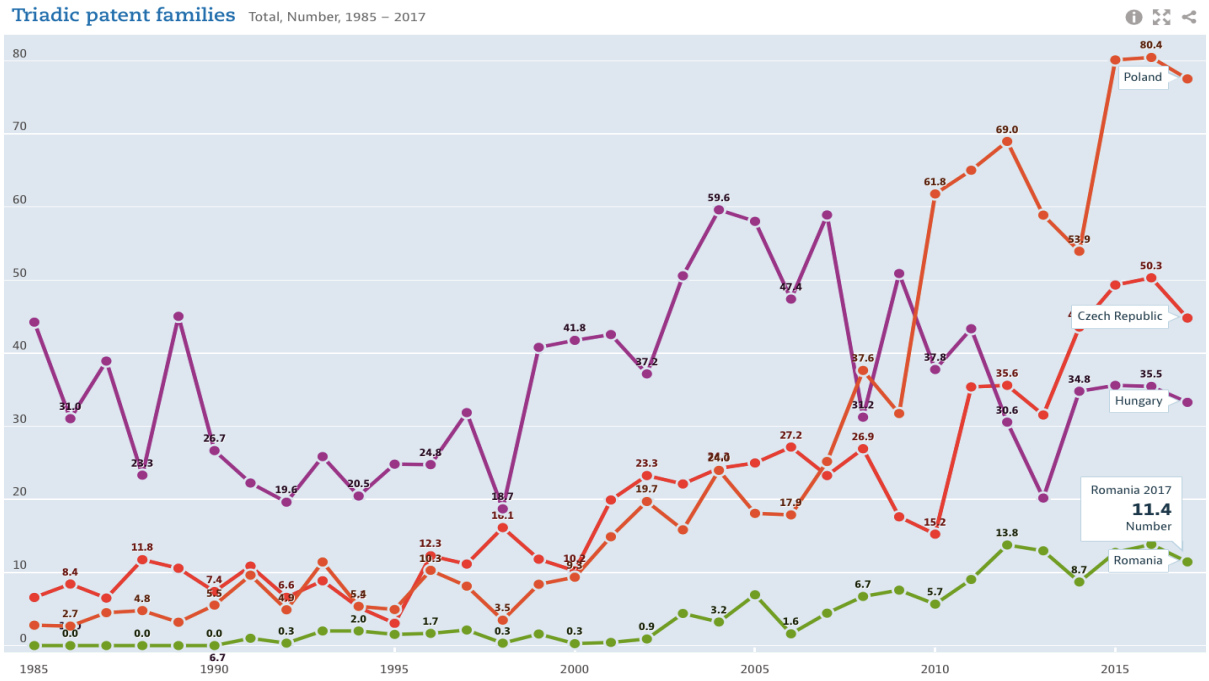


Figure 50 Triadic patents 1985-2015. Source: OECD, Triadic patent families (indicator). doi: 10.1787/6a8d10f4-en

[204] The total European patent applications refer to requests for protection of an invention directed either directly to the European Patent Office (EPO) or filed under the Patent Cooperation Treaty and designating the EPO (Euro-PCT), regardless of whether they are granted or not. The data shows the total number of applications per country. If one application has more than one inventor, the application is divided equally among all of them and subsequently among their countries of residence, thus avoiding double counting.

It is very important to note that while the majority of business patents in the EU are owned by a company located in the country where inventors are, **Romania is the only exception: German companies own about 51% of the patents invented by Romanians**. (Hernández, H. et al, 2018)[205]

	2014	2015	2016	2017
World	54144	53773	53676	54505
EU28 Total	13637	13159	13316	13106
RO (number)	8.7	12.7	13.8	11.4
RO (share of EU total)	0,06	0,10	0,10	0,09

Table 19. Triadic patents over the period 2014-2019 (author's analysis: source OECD)

The Romanian contribution counts to around **0.09% of EU28 total of triadic patents during,** the 2014-2019 period (author's calculation, based on OECD data).

OSIM

The graph below shows the time evolution of the patent applications by Romanians at the **National Office for Inventions and Trademarks (OSIM).** The number had a sharp decline in 2012, followed by fluctuating values, around 1000-1100.

To be noted that the cost for OSIM patent applications is not high (less than the cost of participation in international conference). Thus, OSIM patent application can be a good **practice in artificially producing good output indicators. The analysis should go further, analysing the economic impact of these patents.**

During **2014-2019**, the **National Office for Inventions and Trademarks** (Oficiul de Stat pentru Inventii si Marci OSIM) registered **6416 patent applications** by Romanians, out of which **around 2092 (32.6%)** were granted.[206]

[205] Hernández, H. et al, 2018) Grassano, N., Tübke, A., Potters, L., Gkotsis, P., and Vezzani, A.: The 2018 EU Industrial R&D Investment Scoreboard; EUR 29450 EN; Publications Office of the European Union, Luxembourg, 2018, ISBN 978-92-79-97293-5, doi:10.2760/131813, JRC113807.
[206] https://osim.ro/despre-osim/statistici-publicate-in-2020/

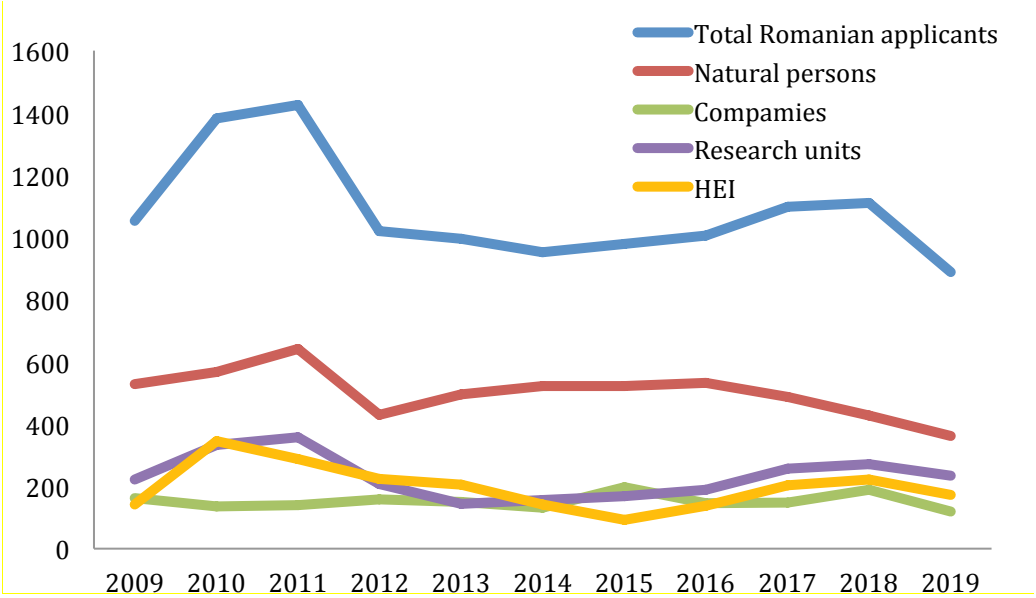


Figure 51. Number of patent applications at OSIM by Romanian applicants, during 2009-2019 (Data source: OSIM)

The highest share of patent applications belong to natural persons (47%), around **21% were made by PROs**, **16% by HEIs** and **16%** by companies.(author's calculation based on OSIM data).

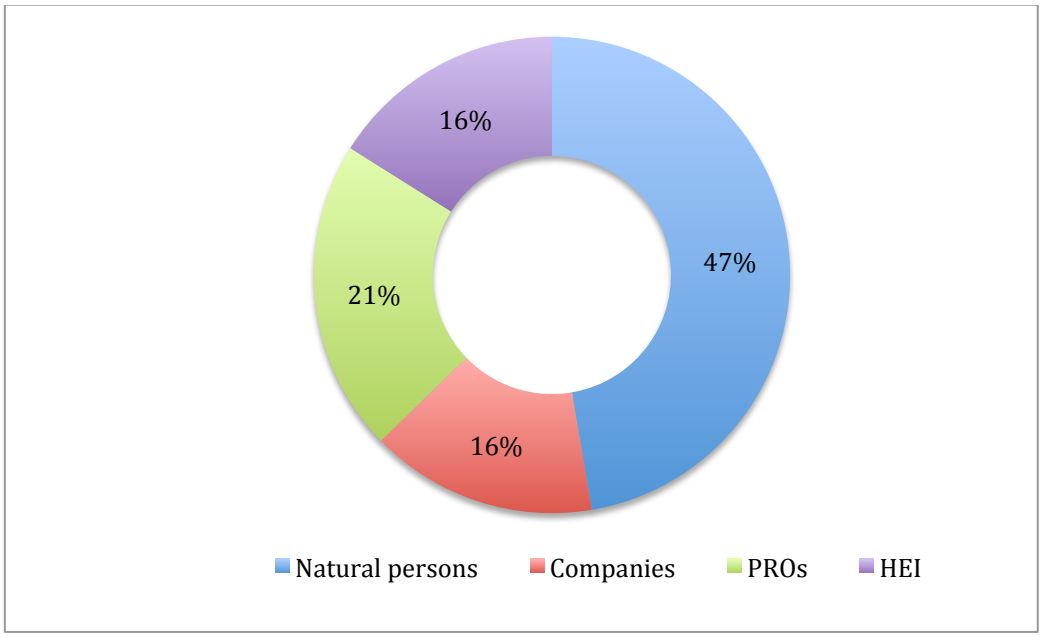


Figure 52. OSIM patent applications during 2014-2019 by category of applicants

The **number of applications for EU trademarks** per 1 billion euros PPS GDP, has increased significantly in recent years - from 2.09 in 2014 to 2.58 in 2018. However, Romania is still significantly below the EU average (EU28: 7.9 in 2018).

5.7.3 Factors that hinder the patent/trademark activity

Romania had one of the **highest ratio of articles per triadic patent** (Corlan A, 2015)[207]. In 2010, RO had around 0.16 triadic patents per million inhabitants (compared to a world average of 7.32). Since then, the number of publications has increased, while the number of patents stagnated. This may (among other aspects) indicate that the **public research is disconnected from economic needs**.

Various other elements affect the low patent activity: **high patenting costs**, the **long 'time to patent'** periods which discourage the HEIs/PROs/SMEs to patent the innovation, while the multinationals prefer to transfer the intellectual property to the headquarters.

The IP regulations favored the individuals until 2014, when the amendments of the law governing patents were introduced. The Law no. 83/2014 regarding service inventions, regulates the status of inventions created by an individual/group of inventors when the individual inventor or at least one member of the inventors' group is employed by a legal entity in Romania. The law aims to stimulate technological innovation in Romania.

According to Start-up Nation study prepared by CNIPMMR 2019[208] **a large majority (around 97.4%) of the companies do not have a form of protection of the IP**.

Entrepreneurs who considers IPR a barrier highlight the high patenting costs, the "*lack of support for the preparation and filing of patents by the Romanian State Office for Inventions and Trademarks*" (C, Pharma) or "*the low capacity to exploit the patent to its real value*" (SE, Biotechnology).

Pharmaceuticals poses specific difficulties since it takes a long time for innovations to reach the market. RDI stakeholders in the field complain that public support for RDI is provided just for initial phases of the research. Most often the research results do not reach even the first stage of trials given the lack of funding.

Another specific problem was identified in the **ICT sector**. **OSIM** does not accept patents on Software. The IT Faculties from Universities that create software cannot patent their invention in the country, while patenting abroad (EPO/USPTO) is too expensive. Only the strong IT companies can eventually afford to patent the software in the USA or Europe (Interview L Alboaie, Univ Iasi).

The MNCs usually move the IP to the country where they have their headquarters. There is no real incentive to maintain IP in Romania.[209] ICT and automotive industries, in particular, comment that the *R&D results in MNCs are transferred as intellectual property to the headquarters and highlight the need for a solution to incentivize to keep the IP rights in Romania*" (C, Automotive).

'The majority of the most prolific – patents wise – Romanian branches of MNC are associated – historically, with high-level investments made by the MNCs (Continental, Renault Technologies, Honeywell, Infineon etc.) across the country in terms of manufacturing, and R&D and Engineering groups. There are other MNCs – active in terms of patent applications – who either do not have a manufacturing site in Romania (i.e NXP

[207] Corlan, A (2015), România în "Science & Engineering Indicators 2014".I. Statistica Descriptiv˘a a Indicatorilor s¸i Ratelor. (Romania in "Science & Engineering Indicators 2014".I. Descriptive Statistics of Indicators and Rates) REVISTA DE POLITICA STIINTEI SI SCIENTOMETRIE, Vol. 4, No. 2, iunie 2015, p. 110–123, available at: http://rpss.inoe.ro/articles/205/file

[208] http://cnipmmr.ro/wp-content/uploads/2019/05/CATALOG-INTERIOR.pdf

[209] Manual of good practices for applying the s on service inventions (UEFISCDI 2015) can offer some support

Semiconductors, *GE) or they do not need one (Adobe). Running a research research department, within a legal structure which does manufacturing, sales, customer support, etc., which is run, overall, as a profit center, implies additional costs, that include – in a first instance - those related to the preparation of the patent application and the application itself.*

The green light for proceeding with patent applications – usually, as part of ongoing internal, multi-sites, research projects – is, first of all a business decision (i.e., will represent a valuable asset for a new product/service to be made available on the market). The costs associated must be "covered" from projects/resources that do not affect the profit of the "hosting site", Romanian legal entity. If registered within the Romanian legal entity, as intangible assets in the additional costs, related to the management of the IP (financial, legal) will occur over the years and these will have to be absorbed by the research group, leading – overall – to a raise of the costs.

Due to the overall costs and business considerations, most of the MNCs will choose as an "assignee" a company from the group which is dedicated to act as a repository for all the patents in the MNC (for example Honeywell International) To note that the practice of designating an outside-Romania company, as an assignee for the patents, was adopted also by one of the most successful Romanian IT companies (Bitdefender).

Must be noted, as a good practice, that MNCs involved in EU and/or structural funds projects, had associated the EU patents developed to the legal entity which was part of the project' (interview with O Buiu - IMT, Hoeywell).[210]

Motivational factors act mainly as disincentives for potential inventors. *The inventors are generally rewarded a fixed, capped, "one-off" award (300-350 USD), regardless the added value that the invention brings to the company. Romanian researchers cannot patent as natural person due to the employment contract. Even when fired ("with the agreement of the parties"), some very strict restrictions still apply.*

The PN3 funding scheme '**award' of the research results**[211] managed by UEFISCDI has offered generous financial rewards for the Romanian authors of the scientific publications and patents.

While the patent activity counts in the career progression evaluation, it is still more rewarding on long term a publication in a top journal given that the number of citations will raise the overall scores.

Starting 2018, the national statistics includes in the expenses categories those **related to IPR** (as shown in figure below). The statistics shows that HES spends 27% of the total IPR budget, compared to GOV which spends significantly less (6%).

[210] deputy scientific director at IMT Bucharest (1994-1997), Portfolio Manager and Senior Technology Manager at Honeywell Romania – Advanced Technology (2007-2014 and 2014-2017, respectively). Currently he is a scientific researcher in IMT Bucharest; he is also co-founder and CEO of BIS INNOVATION DEVELOPMENT

[211] https://uefiscdi.gov.ro/premierea-rezultatelor-cercetarii-brevete

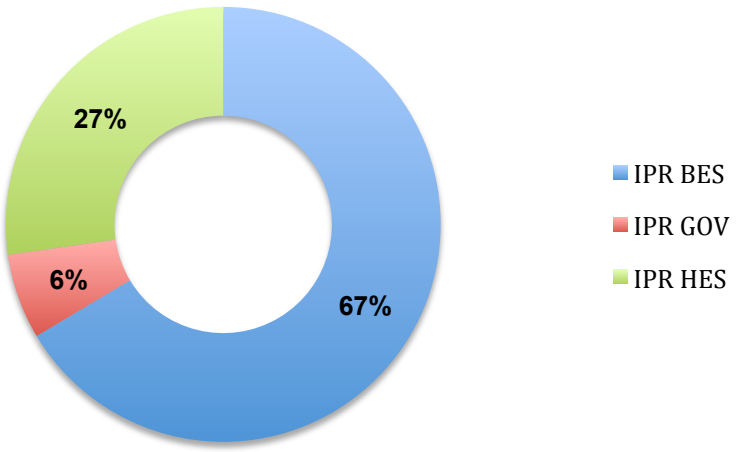


Figure 53. 2018 expenses for IPR by sector of performance

Product certification and approvals, as well as conformity of production pose additional challenges to the innovative entrepreneurs: "*the whole process is expensive. the cost of all certifications and approvals for a new cosmetic is about 800 euro*" (NE, Pharma), "*we do not have the necessary time and money to go through the certification process*" (NE, Biotechnology), "*for financial reasons, a large number of new biological creations were not certified and patented. in time, they have been lost or were "adopted" by the competing companies from abroad. the Romanian market is now "invaded" by seeds produced by private companies that use our creation under other names, thus infringing the copyright law*." (SE, R&D Centre).

5.7.4 TOP PERFORMERS

From the author's perspective the rankings of the **institutions** are meaningful in the policy design only when the champions are analysed as good practice or/and if associated with statistical data (as detailed below), to identify patterns/trends/ as proxy of the global position.

None of the Romanian university has ever been included in the Shanghai top 500[212]. The ranking uses six objective indicators to rank world universities, including the number of alumni and staff winning Nobel Prizes and Fields Medals, number of highly cited researchers selected by Clarivate Analytics, number of articles published in journals of Nature and Science, number of articles indexed in Science Citation Index - Expanded and Social Sciences Citation Index, and per capita performance of a university. More than 1800 universities are actually ranked by ARWU every year and the best 1000 are published.

In 2018, two universities entered the Shanghai top 1000. The poor standing of Romanian HEIs in international rankings signals the low research productivity in international comparison, partially caused by the chronic underfunding and lack of block funding for research (since 1996), high fragmentation of the HES.

[212] http://www.shanghairanking.com

In 2019, Romania has only two universities in the **top 1000 Shanghai Academic Ranking of World Universities:**

- **Babeș-Bolyai University Cluj** (700-800) and
- the **University of Bucharest** (900-1000).

Several universities are in **the 2019 Shanghai ranking on S&T fields**:

- **Clinical Medicine**: (200-300) Carol Davila University of Medicine Bucharest, (400-500) Iuliu Hatieganu University of Medicine and Pharmacy Cluj-Napoca and Victor Babeș University of Medicine and Pharmacy, Timisoara
- **Mathematics** (300-400) Babeș-Bolyai University, University of Bucharest
- **Physics:** (400-500) Babeș-Bolyai University, Polytechnic University of Bucharest
- **Electrical and electronic engineering** (401-500) Polytechnic University of Bucharest
- **Chemical Engineering** (301-400) Gh. Asach Technical University of Iasi
- **Economic**s: (201-300) Bucharest Academy of Economic Studies
- **Business Administration:** (201-300): Academy of Economic Studies
- **Public Affairs Administration** (151-200): Babeș-Bolyai Cluj University of Cluj

In 2019, four universities were listed in the 1000 Top QS[213]**. University of Bucharest is the only RO university in the top 500 employability ranking.**[214]

Top performers in the private sector

In the period 2017-2019, Romania does not have any company in the top 1000 EU R&D investors, 2016 being the year in which Romania entered the top, with only one company. (EC-JRC, EU Industrial R&D Investment Scoreboard, 2016, 2017, 2018, 2019 reports).

HGIE. Scale-ups. Over **20 Romanian companies** entered the Deloitte's 2018 Technology competition that recognizes the most dynamic technology companies in Central Europe. Most of them are in IT, software solutions for automation. Two of the **Trencadis** and **Mondly** have made it to Deloitte's 2018 Technology Fast 50 Central Europe, in the main category, Technology Fast 50 ranking, respectively in the Rising Stars category. (Deloitte[215]). Most of the **HGIE**, showing impressive growth over a short period of time operates in Robotic Process Automation (RPA), AI software, cybersecurity, mobile applications, online applications. In 2019, three companies were identified as raising more than $1 million: **FintechOS, TypingDNA and Elrond**.[216]

UiPath, First Romanian Unicorn

UiPath, the global leading provider of Robotic Process Automation (RPA) and AI software worldwide, the winner of the Most Disruptive Innovation Award of the 2017 Central European Deloitte Technology Fast 50 ranking, is the **first unicorn of the Romanian economy.** DeskOver was founded in 2005 aiming to offer solutions for automatization of repetitive administrative business tasks. In 2015, DeskOver becomes UiPath, after Earlybird Digital East Fund organized a consortium for the first seed funding round. At that time, the company consisted of 10 people operating from an apartment in Bucharest. Over the next years, $400M investment by partners as Accel, CapitalG, Kleiner Perkins, Sequoia[217] supported the entrepreneurial team in building a global business, extended currently to more than 2,000 staff across 31 offices in 14 countries. The

[213] https://www.topuniversities.com/university-rankings/world-university-rankings/2019
[214] https://www.topuniversities.com/university-rankings/employability-rankings/2019
[215] https://www2.deloitte.com/ro/en/pages/about-deloitte/articles/two-romanian-companies-in-deloitte-2018-ranking-fast-50-in-central-europe.html
[216] https://www.zf.ro/business-hi-tech/anuntam-o-revolutie-tehnologica-start-up-ul-fintechos-atrage-o-noua-finantare-de-1-1-milioane-de-euro-condusa-de-gapminder-18129533
[217] https://www.uipath.com/company/investors

company is the fastest **growing enterprise software company** ever, growing at more than 10x per annum from 2015-18, currently reaching more than 2000 customers worldwide. The company raised more than $1B from top-tier venture capital firm and has annual revenues higher than $100m. UiPath raised a €500m in 2019, valuing the business at more than €6bn.[218]

In 2018, 60% of patents invented are owned by only three companies Continental (DE), Renault (FR), Honeywell International (US). (Hernández, H. et al, 2018)[219]

Author's analysis show that over the whole period covered by EPO, the ranking is dominated by some strong companies. As with the publications, while more than 90 entities appear in the ranking, the first 15 top entities concentrates around 63% of the total patent activity.

To be noted that companies as Continental (Continental automotive and Conti) and Honeywell (International and Honeywell s.r.l) appear with two distinct names. The patents resulted from projects funded by public funds have been assigned to the Romanian branch.

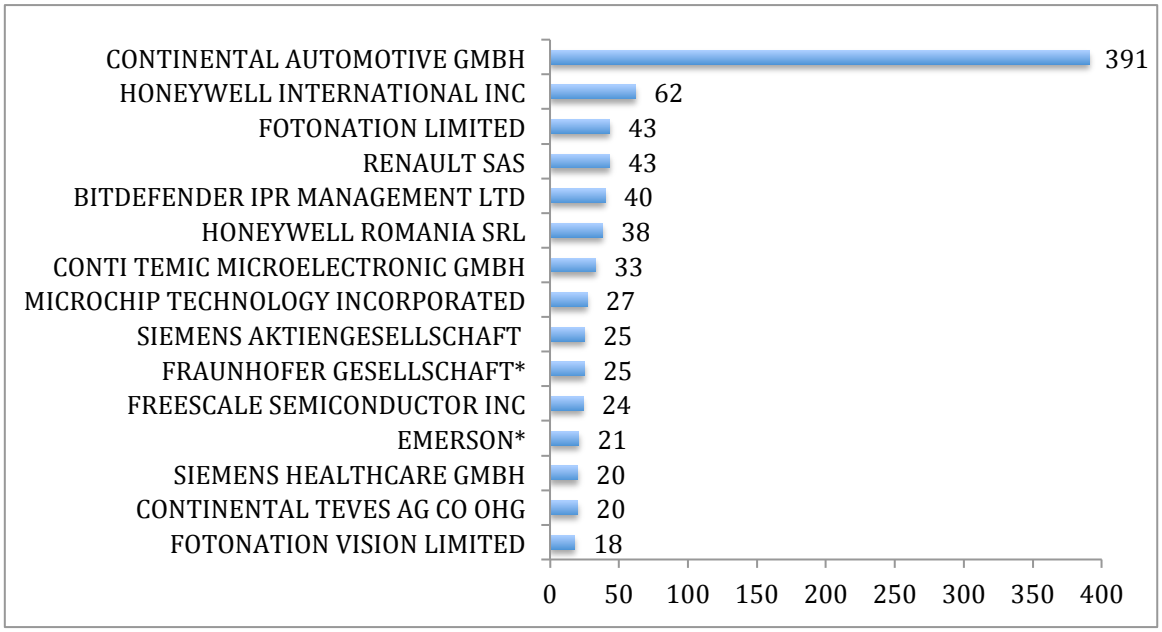


Figure 54. Top 15 entities with EPO patents (Source Patstat. Search query: Romanian inventor, Romanian applicant, 1979-2020)

Fraunhofer=FRAUNHOFER GESELLSCHAFT ZUR FORDERUNG DER ANGEWANDTEN FORSCHUNG EV; Emerson* = EMERSON PROCESS MANAGEMENT REGULATOR TECHNOLOGIES INC*

Analysis of the EPO database indicate that the automotive, IT and automatisation are the sectors with higher patent activity. Besides the national advantage in ICT, this may be also generated by the short product lifecycle and the effort to control the sector. Also, the national inventors in the ICT sectors are forced to patent their activity abroad since the OSIM accept applications only for those ICT inventions which involves also hardware development.

[218] https://www.investeurope.eu/about-private-equity/private-equity-in-action/case-studies/uipath/

[219] Hernández, H. et al, 2018) Grassano, N., Tübke, A., Potters, L., Gkotsis, P., and Vezzani, A.: The 2018 EU Industrial R&D Investment Scoreboard; EUR 29450 EN; Publications Office of the European Union, Luxembourg, 2018, ISBN 978-92-79-97293-5, doi:10.2760/131813, JRC113807.

Top performers: scientific publications

The evaluation and classification of **Scimago Institution Rankings** is based on a composite indicator that combines three distinct sets of indicators: (1) research performance (50% of the final score; based on Scopus data), (2) innovation efficiency (30% of the score) and (3) the impact on society taking into account research institutions around the world, both public and private.

Rank	Global Rank	East Europe Rank	Research rank	Innovation Rank	Societal Rank	Institution	Sector
1	671	68	301	540	236	Institute for Space Sciences	GOV
2	676	70	375	485	223	Romanian Academy *	GOV
3	696	86	380	504	219	Babes-Bolyai University	HEI
4	699	89	403	490	212	Politehnica University of Bucharest	HEI
5	707	94	399	490	225	Iuliu Hatieganu University of Medicine and Pharmacy Cluj Napoca	HEI
6	722	106	410	484	235	University of Agricultural Sciences and Veterinary Medicine of Cluj-Napoca	HEI
7	724	108	471	425	235	Institute of Macromolecular Chemistry Petru Poni Romanian Academy	GOV
8	737	120	425	497	222	Carol Davila University of Medicine and Pharmacy	HEI
9	740	123	420	506	221	University of Bucharest	HEI
10	747	128	415	525	215	Institute of Atomic Physics *	GOV
11	760	140	451	483	232	Technical University of Cluj-Napoca	HEI
12	760	140	420	523	224	Alexandru Ioan Cuza University	HEI
13	761	141	444	492	232	National Institute for Research and Development of Isotopic and Molecular Technologies	GOV
14	766	146	412	539	222	Horia Hulubei National Institute of Physics and Nuclear Engineering	GOV
15	766	146	461	479	233	Politehnica University of Timisoara	HEI

Table 20. Top 15 performers in SCIMAGO Institutions Ranking[220]

To be noted that the Romanian Academy has 65 research centers and the **Institute of Macromolecular Chemistry Petru Poni** belongs to the Academy. Thus, apparently is included also in the Romanian Academy.

The ranking in terms of total number of SCOPUS publications by institution is dominated by universities. **The ranking does not reflect the number of SCOPUS publications per head, neither per euro invested, nor top cited publications**. The universities have also a large number of staff. Yet, only a share of the work of the academic staff (the level depends on the academic position) is formally devoted to research. Few notable Institutes polarise the publication output in terms of quantity and quality.

However, it should be considered that during the period 2014-2018, the HES has performed an average of 0.06% of GERD, compared to GOV sector which performs 0.164%.

[220] https://www.scimagoir.com/rankings.php?country=ROU

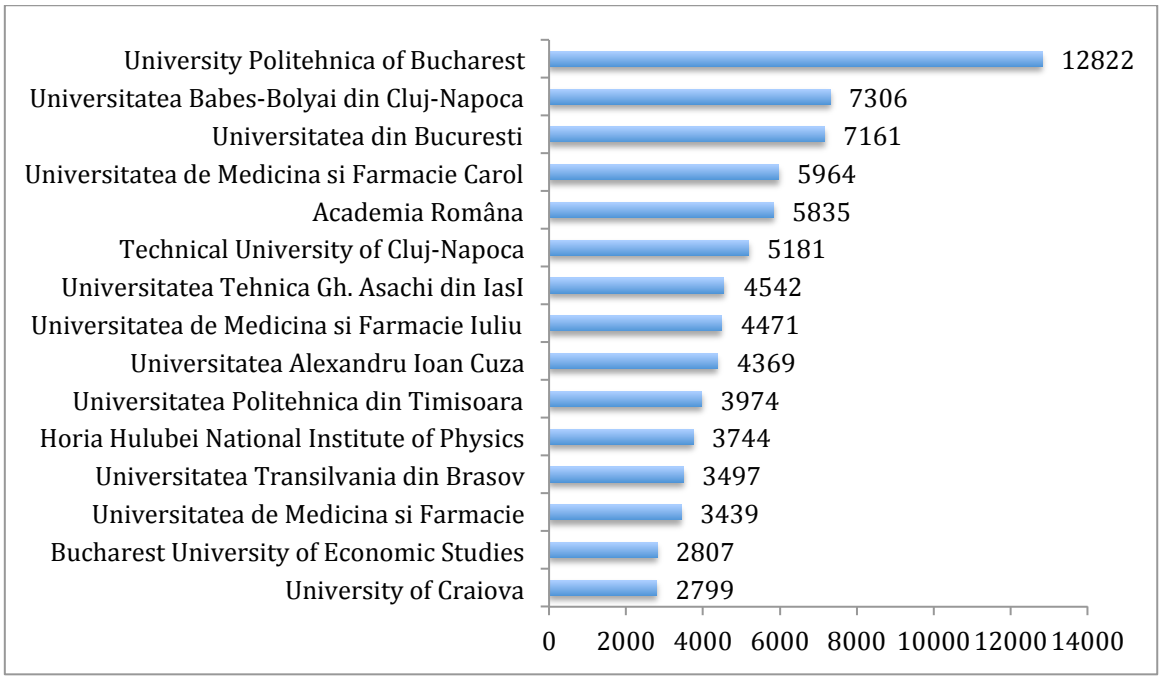


Figure 55. Top 15 Romanian institutions in term of total number of SCOPUS publications (2014-2020)

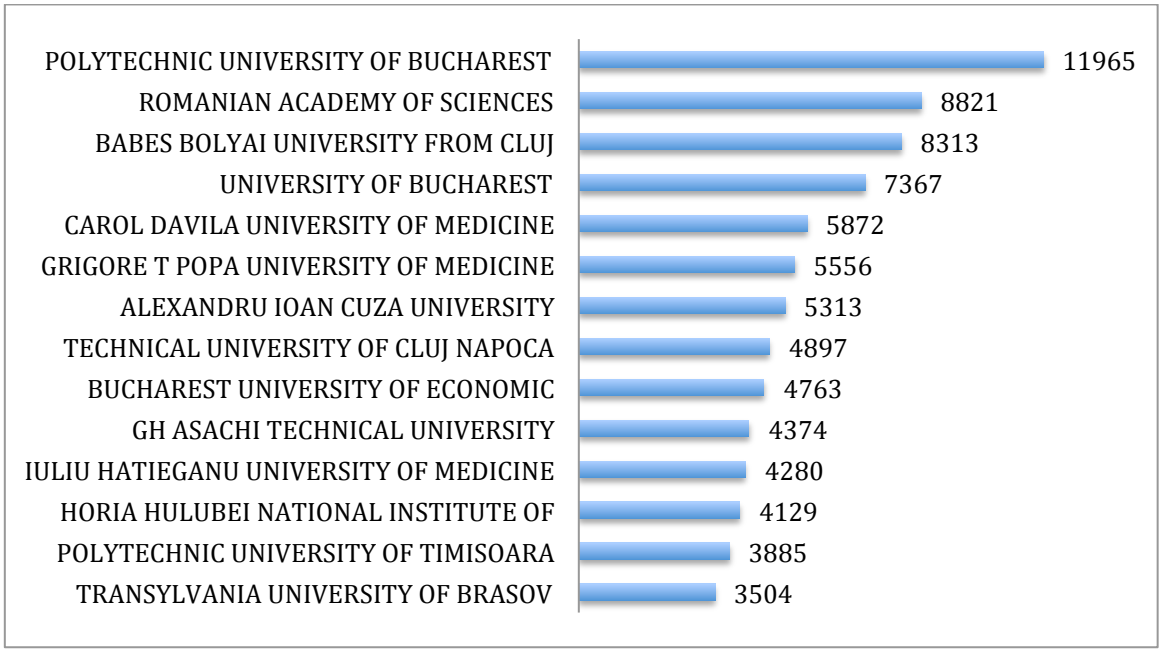


Figure 56. TOP 15 Institution in terms of total number of WoS documents

The highest numbers of SCOPUS publications are in engineering, materials science, physics and astronomy, medicine and computer science. It should be also noted that the highest number of papers is in Romanian journals (i.e. Revista de Chimie) and **37718** documents are published in Proceedings of Conferences.

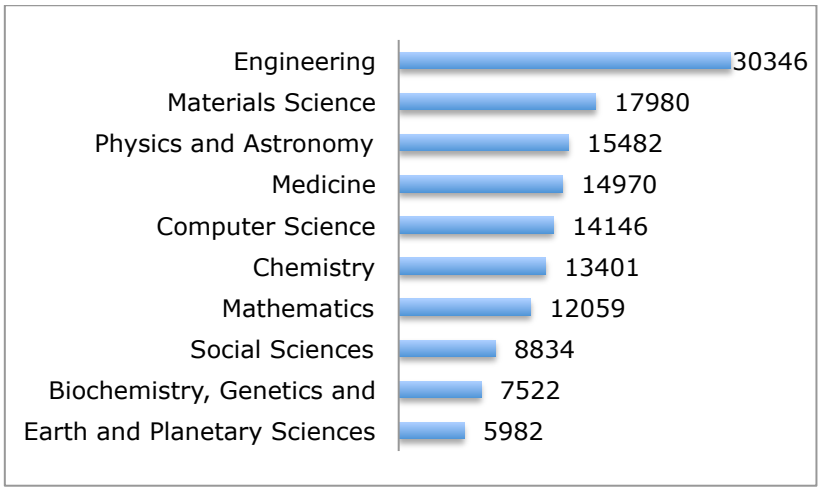


Figure 57. TOP 10 S&T fields by number of SCOPUS documents (2014-2020)

Romania had during **2014-2020** only **665 highly cited and 54 hot papers. The largest majority are papers in collaboration with top universities/ research institutes.** The top performers appear also in the ranking of highly cited papers, with couple of INCD standing out for quality rather than quantity. As mentioned above already, **few very notable R&D Institutes polarise the publication output in terms of quantity and quality**.

The largest share of these highly cited papers are in **physics, mathematics and medicine**. Some of the papers in physics and medicine have a very high number of authors and are a result of large collaborations. **To be noted also that for these highly cited& hot papers, the main funding agency is the European Commission**.

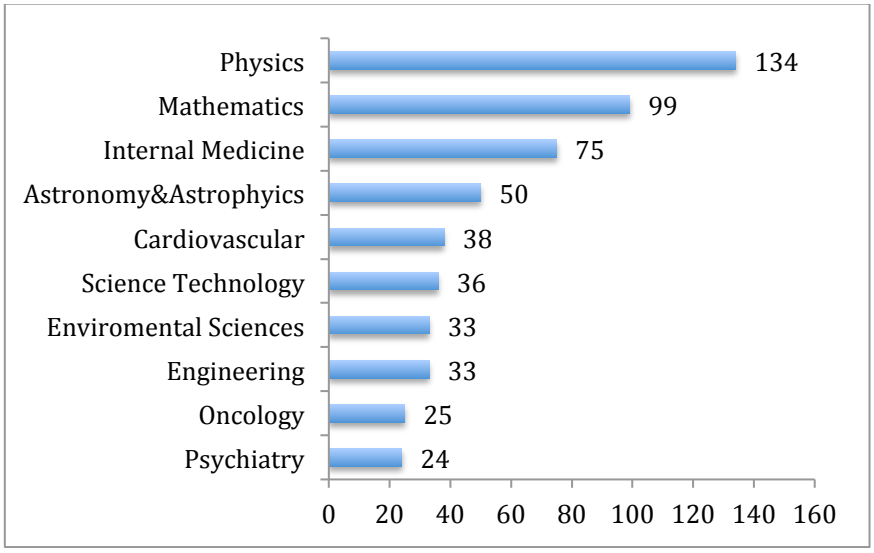


Figure 58. Top 10 S&T fields of highly cited papers (WoS). 2014-2020

Romania is on the 40th position in the overall SCIMAGO world ranking. It has a relative advantage in the following S&T fields: **chemistry, materials science, mathematics, physics, engineering, computer science, health**. Specific sub-fields are better positioned in the ranking.

Chemistry	28
Materials Science	29
Arts	30
Mathematics	31
Engineering	32
Physics	33
Business	35
Computer science	35
Decision science	36
Health	37

Table 21. Top 10 fields in the SCIMAGO ranking

Participation in H2020

Romania has 702 signed H2020 grants (2.57% of H2020) counting to a total of 186 Million EUR H2020 Net contribution (0.37%).

	Legal Name	**H2020 Net EU Contribution**
1	CLARIANT PRODUCTS RO SRL	€ 20.583.325
2	SIVECO ROMANIA SA	€ 13.099.584
3	Unitatea Executiva pentru Finantarea Invatamantului Superior, a Cercetarii, Dezvoltarii si Inovarii	€ 11.081.679
4	UNIVERSITATEA POLITEHNICA DIN BUCURESTI	€ 10.126.818
5	ROMAERO SA	€ 5.161.469
6	INSTITUTUL NATIONAL DE CERCETARE-DEZVOLTARE AEROSPATIALA "ELIE CARAFOLI"- INCAS BUCURESTI	€ 5.055.563
7	UNIVERSITATEA TEHNICA CLUJ-NAPOCA	€ 4.987.861
8	CENTRUL ROMAN AL ENERGIEI - CRE	€ 3.409.026
9	INSTITUTUL NATIONAL DE CERCETARE DEZVOLTARE PENTRU FIZICA LASERILOR PLASMEI SI RADIATIEI	€ 3.298.105
10	UNIVERSITATEA DIN BUCURESTI	€ 3.289.982

Table 22. TOP 10 Romanian legal entities in terms of net contribution from H2020

The two top beneficiaries in terms of EU net contribution are CLARIANT and SIVECO (followed by UEFISCDI)[221]. The top performer in terms of **number of projects** is UEFISCDI (with EUR 9.33 Million). The top three Universities as number of participants are University Polytechnics Bucharest, University of Bucharest, Technical University Cluj (TUC). In terms of EU net contribution, the ranking change: UPB is still leading the ranking, followed by TUC and UB.

[221] https://webgate.ec.europa.eu/dashboard/sense/app/a976d168-2023-41d8-acec-e77640154726/sheet/0c8af38b-b73c-4da2-ba41-73ea34ab7ac4/state/analysis/select/Country/Romania

	Legal Name	Nr proiects
1	Unitatea Executiva pentru Finantarea Invatamantului Superior, a Cercetarii, Dezvoltarii si Inovarii	58
2	UNIVERSITATEA POLITEHNICA DIN BUCURESTI	42
3	SIVECO ROMANIA SA	31
4	UNIVERSITATEA DIN BUCURESTI	25
5	UNIVERSITATEA TEHNICA CLUJ-NAPOCA	22
6	INSTITUTUL NATIONAL DE CERCETARE -DEZVOLTARE PENTRU FIZICA SI INGINERIE NUCLEARA "HORIA HULUBEI" (IFIN-HH)	16
7	INSTITUTUL NATIONAL DE CERCETARE-DEZVOLTARE PENTRU GEOLOGIE SI GEOECOLOGIE MARINA-GEOECOMAR	14
8	NATIONAL INSTITUTE OF RESEARCH AND DEVELOPMENT FOR OPTOELECTRONICS	13
9	INSTITUTUL NATIONAL DE CERCETARE-DEZVOLTARE AEROSPATIALA "ELIE CARAFOLI"- INCAS BUCURESTI	12
10	UNIVERSITATEA BABES BOLYAI	12

Table 23. Top 10 legal entities in terms of number of projects financed by H2020

5.7.5 NOTABLE ASPECTS

As already mentioned, from the author's perspective the rankings of the **institutions** are meaningful in the policy design only when the champions are analysed as good practice or/and if associated with statistical data (as detailed below), to identify patterns/trends/ as proxy of the global position. However, **significant cautious should be devoted when analysing the top S&T fields that may lead to budget prioritisation.**

- The author has performed a comparative analysis of SCOPUS, WoS, Scimago. Many aspects as papers/per euro/per staff, number of hot papers/highly cited papers, papers with the first author affiliated to a Romanian institution, number of authors, the impact factor of the journal should be considered in a **rigorous scientometric analysis**, which is well below this study. However, **comparative analysis of searches with different criteria show the same pattern.** Same institutions appear in the first 15-20 positions (with a notable exception the "Institute for Space Sciences" whose output shows quality but ranks lower in terms of share of total output).
- Author's analysis of SCOPUS and WoS database, shows that during 2014-2020, the ranking by number of documents **is dominated by HEIs**. Overall, the HEIs produce more than 85% of the scientific publications, but performs only 0.05% of GDP (compared to 0.15% by GOV). In the **top SCIMAGO institution ranking** (which considers three distinct criteria) out of 38 Romanian institutions 28 are HEIs and 10 PROs (among them Academia Romana, which includes 60 research centers and also one of the Institutes which appears also separately in the ranking).
- This also triggers attention to the **effect of fragmentation.** The **first 10 top institutions in terms of number of publication concentrate more than 50% of the total number.**

- Romania out of more 100000 WoS documents produced during 2014-2020, has only **665 highly cited documents** (**0.66%** of the total) and 54 hot paper. The large majority (if not all) are written in collaboration with top world universities/research institutes. **This emphasize the need to be connected to the international trends and research leaders in the field**.
- The number of **EPO/USPTO/triadic patents is particularly low.** There are various reasons that may trigger this situation, not all related to the quality of research or the limited relevance for economy of the research performed: low IPR awareness, limited incentives for patent activity (for researchers/institutions), patenting costs etc.
- While MNCs generally, try to optimise their benefits, and delegate one central branch to deal with all patents the fact that Romania is the EU country with the largest share of inventions owned by a foreign country trigger the need for further analysis and appropriately tailored incentives.

5.8 LOW LEVEL OF COLLABORATION (PUBLIC-PRIVATE, PRIVATE-PRIVATE, INTERNATIONAL)

5.8.1 Current state

Public R&D funded by business rank	16
Public R&D funded by business (%)	7.9% GOV 1.2% HES (2017 data)
Enterprises co-operating with universities or other higher education institutions	n.a
Enterprises co-operating with Government, public or private research institutes	n.a
Enterprises engaged in any type of co-operation	n.a
International scientific co-publications	28
Innovative SMEs collaborating with others **(Rank)**	28
Public-private co-publications per million population EU28 rank	26
Public-private co-publications per million population value	3.7
Job-to-job mobility of HRST	2% (vs 7.8% EU28)
Scientific publications among top 10% most cited EU28, rank	26

Table 24.Main indicators for R&D collaboration.
Source: https://interactivetool.eu/EIS/EIS_2.html and EUROSTAT

The knowledge is the most important 'commodity' in the quintuple helix, and the circulation of knowledge continually stimulates new knowledge. All helices in the quintuple helix influence each other with knowledge, in order to promote sustainability through new, advanced and pioneering innovations.

In the EIS 2019[222], Romania has the fourth worst score in linkages but drops to the **lowest position in the dimension 'innovative SMEs collaborating with others'**.

The ranking significantly improves when assessing the **private co-funding of RDI public investment**s, likely due to the co-funding shares imposed in the projects funded by structural funds. However, the number of public-private collaboration papers per capita is 3.7, a 9% fraction of the EU28 average (40.9 papers per capita)[223], value which places RO on the lowest position.

The Romanian business, historically, has low engagement with academia and public research organisations. The SMEs do not know the rules and means of engagement and most often lack the resources to pursue RDI activity and collaboration. On the other side, the financial returns available to universities and research institutes from working with small businesses are often not sufficient to justify significant engagement. The government can facilitate and support such collaborations, through funding of collaborative projects, advisory support, collaborative platforms, events and connecting hubs that can bring the entrepreneurs and innovators together.

The research intensive HEIs stipulate in their strategies the mission to support through the research performed the progress of the society and economy, by actively collaborating with the innovative companies. However, such collaborations remain limited

[222] https://interactivetool.eu/EIS/EIS_2.html
[223] https://ec.europa.eu/info/sites/info/files/research_and_innovation/era/era-2018_country_profile_ro.pdf

to the public funded partnership public-private projects, within the overall context of low tradition of public-private collaboration and low interest of private sector to invest in RDI.

Products developed by the Romanian RDI sector are poorly capitalized on the market. Many foreign companies are present on the Romanian market, but they are not interested in patenting the activity in the country. On the other side, the domestic companies most often do not have the strength needed to impose themselves on the market, so they generally follow market trends, without generally having the capacity to influence it.

Most SMEs do not have an R&D department. PN3 Programmes, under the SNCDI 2014-2020 aimed to mitigate the lack of capacity/expertise, by supporting the adoption of innovation patented by a public organisation and to further develop/implement it to proof of concept/ experimental model.

5.8.2 Low level, unpredictable public funding of the public-private collaboration

Various schemes under PN3 and POC offered support to RDI public-private collaboration, either through collaborative research or research performed by HEIs and PROs for enterprises. However, the level of financing is low in the overall context of underfunded RDI system. Sometimes, such collaborations were implemented rather in an opportunistic approach driven by eligibility criteria, which required a private-industrial partner since the eligibility criteria required a private partner in the consortium, but with no real collaboration implemented. Nevertheless, such projects may foster the possibility for future collaborations.

Lack of predictability for R&D funding. There are funding instruments supporting collaborative projects. In theory multi-annual funding is ensured through the SNCDI. However, the allocation of funds well below the committed budgets generated discontinuities in funding, significant unpredictability and very high competition with an painfully low success rate, sometimes of 5%. While for the public RDI sector, this funding, however difficult to access, is the main source of funding, the business sector has other priorities. For business, the complexity of bureaucracy procedures related to programmes financed by structural funds, the high competition and the time required for the preparation of proposals may deem such efforts too high.

Good Practice. Experimental demonstration project

Biomaterials functionalized for implants for total arthroplasty

The aim of the BioArt project is to demonstrate the feasibility and applicability of a new TRL4 level technological chain, used to obtain new innovative biomaterials for implants used in total hip, knee and shoulder arthroplasty, by developing new synthesis and thermo-mechanical processing technologies. alloy and for the functionalization of its surface and by coating with two different types of thin layers, using PVD deposition techniques. It aims to achieve functionalized biomaterials, based on the knowledge already acquired by the team (TRL3). Starting from the current state of knowledge, we propose the complete development of a set of biomaterials for total hip / knee / shoulder arthroplasty, to solve the following undesirable issues: i) reduction of bone tissue density at the place of implantation, due to the lack of mechanical stresses, which increases the risk of bone fractures. ii) excessive wear of the movable components of the joints, or even fractures arising from the use of oxidized materials, which limit the size of the femoral head and cause metallosis or inflammation due to the particles generated by the wear.iii) metallosis, osteolysis and reduced osteoconductive properties of the metallic components of the metal rods inserted in the bone tissue in case of total arthroplasty interventions without cementation.

The objective of the project is to demonstrate the feasibility at the TRL4 level of the technologies to obtain: a new Ti-based bioalloy with superior mechanical properties (low elasticity mode, high wear and corrosion resistance, breaking and hardness resistance), covered with thin layers based on biocompatible multicomponent carbonitrides with reduced wear, rubbing and corrosion rate (for mobile joints) and doped hydroxyapatite for rapid implant Osseo integration in bone tissue.

Results: 1 patent. 3 publications. 7 conferences. 21 products and technologies

Source: Nicoleta Dumitrache, UEFISCDI

5.8.3 Limited willingness to collaborate

In addition to scarce funding and missing intermediating structure, the evidence indicates that the lack of willingness to collaborate represents a significant barrier. Interesting to observe that both sides (public and private) highlight the lack of willingness of the other side, while correctly identifying the lack of collaboration as a significant weakness.

There is a weak collaborative culture amongst SMEs firms, and a reluctance to engage with partners who are external to the firm or social networks. This is partially the result of a traditional pattern of a culture lacking such collaboration and the mutual trust and inertia/ fear for change. On the other side, the RDI system does not still facilitate optimally the connection/communication of public research to the economic environment. Many academics/researchers lack the individual contacts to develop connections with the private sector, while the administrative structures within the HEIs/PROs have limited capacity or willingness to develop such collaborations.

While all strategic documents, either national or EU, acknowledge the need of research to be connected to economic needs, the two sectors, RDI public and the business sector, function under distinct constraining factors. On one side, the business needs to compete with large international players, within a rather unpredictable regulatory framework, most SME focus on survival and do not have the means, the capacity or the will to plan growth based on innovation. If innovation happens, the business sector interest is to transfer this in a new product, technology, or service. On the other side, the academic&research staff undergoes annual evaluations, against high performance criteria mainly focusing on scientific output (‘*publish or perish*’), regardless the very scarce or absent budget for research. Some academics have high teaching loads, which limit their ability to undertake research. Both sides function in silos and in the absence of appropriate regulation to mitigate the pressure resulted from distinct needs, in the absence of connecting hubs, events communication is difficult to happen.

5.8.4 Limited level of Knowledge transfer

The innovation and technology transfer infrastructure in Romania has developed in the last years to some, yet limited extent. Recent national policy efforts have been concentrated in facilitating the transfer by creating **structures that can mediate the transfer** (i.e., “Knowledge Transfer Offices” - KTOs).

According to the legislation, the technology transfer organizations (KTOs) are accredited by ANCS / MCI/ MENC according to GD 406/2003, respectively OG 14/2002, The KTOs (EITT=entitati de inovare si transfer tehnologic) form the ReNITT network (*Reteaua Nationala pentru Inovare si Transfer Tehnologic*), whose foundation was put during 2004-2007, by INFRATECH program. In June 2019, there were 49 EITT certified, with 237 full time equivalent staff: **28** KTOs (CTT=centru transfer tehnologic), **six** incubators for innovative business, **nine** offices for technological information, **one** offices to maintain the relation with industry and **five** Scientific and Technological Parks. (Cosnita, D. et al, 2019). The majority (43) are departments within the host organisation and are not individual legal entities. Over the period 2016-2018, 120 techonlogical transfers are reported.

The POR, AP1 aims to support KTOs, but the implementation of the accepted projects has been significantly delayed.

Many HEIs and PROs have in theory dedicated KTOs, however there is no evidence of their activity, efficiency, impact. Generally, these offices have scarce budgetary and human resources and lack dedicated staff with relevant expertise.

Some progress has been made. The statistical evidence shows that there is still much space for improvement. Studies/ surveys identifies the limited availability of KT support. In the N-E region, there are five ReNITT entities certified provisionally for TT. Yet, survey and analysis of responses identify a strong and diversified demand for Innovation and Technology Transfer support (Loeffler, J, 2017). Expert analysis (Alboaie, L, 2020) shows that in 2020 out of five KTOs, three do not have a website, and they have provisional accreditation (one can not be contacted/do not have site).

The communication networks are still weak. Some SME/start-up are notably outperforming in innovation. However, MNC are the main innovators. There is **no evidence of a common practice (rather exception) of technology transfer occurring from MNC to local companies**. There are **weak heterophilic** relations between the **innovators and laggards**.

Renault could be identified that through networking, collaboration with local companies and imposing standards, has supported such transfer, allowed his is the advantage of a well standardized industry. Other good practices may exist (i.e. Continental), yet they are not well documented. The clusters may also play a potential framework for this.

Fostering technology transfer between large companies and SMEs in clusters

The takeover of the Romanian car manufacturer Dacia by Renault in 1999 created competitiveness problems at the level of Romanian subcontractors as RDI effort has been pushed upstream on the value chain. In order to tackle the problems, several research centers have been created at the level of the automotive cluster **SPRINT** led by the Romanian Car Manufacturers' Association. The Research centers involved Dacia-Renault, some subcontracting SMEs, the University of Pitesti and other Romanian RDI organisations which received funding through FP6 Project "SPRINT" (2006-2007).
The cooperation was taken to a higher level in the frame of the **Automotive Competitiveness Pole**, which was funded 15 Million EUR under the Competitiveness Operational Programme 2007-2013. The Pole clustered together Renault and 25 SMEs, resulting in joint investments and research projects.
The cooperation is an on-going process; the "**Mechatrec**" Mechatronics Clusters delivers testing & control equipment for the French Romanian OEM.

https://cordis.europa.eu/project/id/15802/reporting
http://acarom.ro/wp-content/uploads/2018/01/PolAM.pdf
http://www.clustermechatrec.ro/documents/

The innovation process requires specialized managers in the field, i.e. innovation managers, combining management, marketing, RDI expertise and knowledge. All these skills should be acquired through a complementary scientific, technical and economic university training and professional experience.

Evidence (author's analysis of the vacancies on the about market) indicates very low demand from companies for such profile. SMEs and mainly micro and small companies do not have the financial capacity to develop in house RDI departments. Specialised promoters of innovation and technological transfer, having the capacity to identify those

patents, inventions, know-how, innovative solutions that can be implemented in the company, can mitigate this weakness.

Science and technology expertise alone is not enough to ensure innovation. Additional skills in finance, business development, production, and management are much needed. Recent efforts were considered to embed entrepreneurship in STEM education. However, the lack of specialised trainers deem to limited desired results.

5.8.5 Limited job-to-job mobility of HRST

Knowledge transfer does not generally take place from one institution to another. Rather, people are transferred, and they circulate ideas and use experience. In Romania, **the job-to-job mobility of HRST is the lowest in EU** (**2% compared to 7.8% in EU**). Romanian HEIs and PROs systems **remain traditional, rather closed systems**, tending to penalise rather than support mobility.

Few programmes encourage such type of knowledge flow (i.e., PN3 programmes, Bridge Grant). However, their impact in the context of low funding and in the absence of solid programme evaluation is difficult to be documented.

5.8.6 Low integration in ERA. Disconnection from international RDI trends

To date (October 2019), Romania with 673 signed contracts (representing 2.97% of the total number of Horizon 2020 funded projects) and amounting to EUR 183,3 Million (0.45% of EU total), has a low share of the H2020 funding. The success rate is around 11.96%, but the number of applications is very low (7060 applications, representing 1.12% of the total number of applications), which denotes the lack of interest in applying.

Romania has only six ERC grants (0.13% of the total), 105 MSCA (0.55%) and three EIC participations (0.18%).

The private sector, with 293 beneficiaries (of 75,42 Million Euro) has the highest participation (41.2%) among the RO beneficiaries of H2020 programmes in terms of the net EU contribution. It is followed by Public Research organisations (23%), HEIs (16,5%) and public body (8.6%).

5.8.7 Limited and fragmented support to clusters[224]

Clusters are drivers of competitiveness based on innovation and internationalisation. At the end of July 2019, **74** cluster initiatives were registered at the Ministry of Economy, Trade and Business Environment, body which is responsible for the cluster development as part of the industrial policy. Out of them, **42 clusters** are members of the Romanian Cluster Association – CLUSTERO**,** the representative body at national, European and international level (www.clustero.eu).

Romanian clusters are generated according to the so called "4 leaves clover" model, a quadruple helix, which in addition to industry, academia and policy, emphasis the role of catalyst institutions such as technology transfer centers, chambers of commerce, consultants etc.

[224] This section was developed based on the information received from Daniel Cosnita – President of Romanian Cluster Association

Romanian clusters rank on top position in EU when it comes to cluster excellence, as assessed by the European Secretariat for Cluster Analysis. Over the past 6 years (60 Romanian clusters have been awarded 20 bronze label (as of July 2019), 14 silver label (6 valid as of July 2019) and 3 gold label. However, the presence of Romanian clusters in the Strategic Partnerships of European Clusters (ESCP), launched and supported by the EC through the COSME program, is reduced; thus, Romania is represented in **two of the nine partnerships** for smart specialization and only in four of the over 40 partnerships for internationalization.

In the absence of a coherent cluster policy, Romanian clusters have developed sustainable business models of various types ranging from clusters strongly supported by public regional actors (as it is the case of IMAGO MOL and Euronest, of which the management in embedded in the ADR North East and, respectively, the County Council of Iasi) to research driven clusters (as it is the case of IMDAGRO POL, of which the management is ensured by the National R&D Institute for Agricultural Machinery – INMA) up to **industry driven** clusters, which represent the majority.

The financing support schemes for clusters have been set in place since 2010 but the financing has been characterised by incoherence and mismatch with the real cluster needs. In the current policy cycle only two schemes:

- **2015**, Innovative Clusters, POC 2014-2020. Very few projects submitted largely due to the huge financing effort and the much too high minimum value of the project
- **2018**: Innovation Clusters, PN3 National RDI Programme (Scheme elaborated in cooperation between the Ministry for Innovation and Research, the RDI Financing Agency (UEFISCDI) and CLUSTERO)
- **2019**: Innovative Clusters, POC 2014-2020 - expected to be launched.

Development of VCs must entail actions to speed up cross-sectorial and cross-regional flow of knowledge and information.

Good Practice. Romanian Textile Concept

In order to enhance the level of innovation and internationalization of SME clusters, CLUSTERO has started a close cooperation with the management of Romanian Textile Concept. The methodology follows a 3 step "funnel "approach: 1) a presentation seminar where benefits of cluster membership, available financial and non-financial instruments for SME development and international best practice are presented 2) first company visits together with the cluster manager where an innovation audit or business review is performed, followed by recommendations accompanied by proposed measures and according deadlines. The recommendations include orientation towards specific financial (Structural Funds, Horizon 2020, SME Instrument, INTERREG programmes) and non-financial support services (EEN, Senior Expert Services, etc.).

Output and results

Output: 18 cluster SMEs participating to the information seminar, 2 innovation audits and 5 business reviews performed, 1 enhanced innovation audit performed (Improve methodology), 1 RO-BG CBC Project submitted,1 new innovative start up. As a result, 1 international Commercial PA has been already achieved so far. Furthermore, Romanian Textile Concept obtained silver label for cluster excellence. Source: *Interview Daniel Cosnita - "Romanian Clusters"*

Cluj IT Cluster

One of the most known and successful concerted effort to create an ecosystem to spawn innovative companies is the "Cluj IT Cluster" (CITC) (www.clujit.ro/en/), a cluster of organizations active in the field of ICT. Romanian IT, launched by a group of Romanian IT specialists from Paris, aims to create a network of centers that bring together the national IT professionals entrepreneurs from the country and from abroad.

5.8.8 Incipient stage of Regional concentration.

Proximity matters: innovation can be facilitated by a concentration of talent that increases the rate of interaction. Physical proximity between venture capitalists and entrepreneurs is often critical. The symbiotic relationship between research parks and the surrounding region is crucial to the innovation ecosystem.

"Science parks have the role to create an environment that encourages innovation, offer industry access for faculty and students, and serve as a landing pad for industry recruitment." Research parks are where academic culture meets corporate culture" [225]. Science parks can facilitate networking, cultural exchange and the movement of personnel. They can also function as clusters of capacity/knowledge that can attract businesses to a region.

The Science and Technology Parks are authorized based on the provisions of OG no. 14/2002, approved with amendments and completions by Law no. 50/2003, and in accordance with O.M. no. 4940/2006 on the approval of the Methodology for authorization, suspension and cancellation of the authorization for operation of the science and technology park. Five S&T parks are reported (Cosnita, D. et al 2019).

However, their S&T activity is not well documented:

- **S&T Tehnopolis Park,** N-E Region. https://tehnopol-is.ro The website offers information regarding the availability of space and land for rent; there is no information regarding the S&T activity.
- Technological Park, **Parc de Soft, Galati** https://www.softwarepark-galati.ro The park offers various services, marketing, support. There is no information regarding the S&T research activity. According to various media sources *"its activity is in free fall. It has been reduced by around 80%, and only six companies are currently active in the park.'* (Viata Libera, 2019, 2020)226,227
- S&T Minatech, Bucharest–Ilfov. https://www.minatech.ro/en/ **MINATECH-RO** was created and received institutional funding during 2004-2005 through the national INFRATECH Programme. According to the website its essential function is incubation and spaces for equipment requiring special working conditions. There is no information regarding the research activity/research results. The latest updates are dated 2008.
- TimScience Parc, https://www.incemc.ro/index.php?page=tsp.html was established at the joint venture initiative in The fields of activity are: chemistry, electrochemistry, environmental protection, physics, welding, computers, automatic management of technological systems, economics, marketing. This is the only S&T park which provides information related to the scientific activity. The last self-evaluation report is dated 2007.
- Tetapolis Park, Cluj. Although announced since 2016 with a 50 million EUR investement and listed as ReNITT entity, to date has not been approved[228]

The existance of strong, functional Science Parks, as locus where entrepreneurs, researchers and innovators work together could benefit the flow of idea.

[225] The Role of Research Parks." National Academy of Sciences, National Academy of Engineering, and Institute of Medicine. 2013. Trends in the Innovation Ecosystem: Can Past Successes Help Inform Future Strategies? Summary of Two Workshops. Washington, DC: The National Academies Press. doi: 10.17226/18509 https://www.nap.edu/read/18509/chapter/7#38)
[226] https://www.viata-libera.ro/economie/143004-cronica-unui-declin-anuntat-parcul-de-soft-mai-are-doar-sase-firme
[227] https://www.viata-libera.ro/prima-pagina/135899-parcul-de-soft-in-moarte-clinica
[228] https://www.clujmanifest.ro/administrativ/parc-stiintific-tetapolis/

5.8.9 Limited sharing knowledge platforms/collaborative spaces

The Startup Barometer 2019 shows the importance of sharing knowledge/communities platforms as the most important source of interaction and inspiration.[229] While many recent initiatives try to provide the right context for open dialogue, communication, as observed by respondents in the UEFISCDI interviews: "*today, there is no connected community, but several disparate communities doing good things, but who do not know how to connect*".

BrainMap

Brainmap (https://www.brainmap.ro) is an online platform, connecting more than 28800 researchers, innovators, technicians and entrepreneurs. Besides a connecting hub, it also presents a searchable platform for expertise required for example in proposals' evaluation, projects.

However, the recent activity, related to technology start-ups, internet-related technology, entrepreneurial hubs, clusters signals the potential beginning of a new period of innovation.

The innovative initiatives emerged primarily in the field of ICT (e.g., How to Web, Innovation Labs, RICAP) and in major urban areas such as Bucharest, Cluj, Timisoara, Iaşi or Braşov.[230]

Innovation Café (Cafeneaua de Inovare)

Cafeneaua de Inovare (Innovation Café) is an event happening at least twice a year, aiming to facilitate and promote a collaborative framework between the actors supporting the innovation environment in Romania in discussions about innovative ideas and proposals to develop the innovation ecosystem. It represents a flexible networking framework facilitating the exchange of experience and know-how among innovative entrepreneurs, investors, venture capitalists, innovators, NGOs and policy makers, contributing to the development of new partnerships between them.

The Innovation Café offers a tested model for long term quadruple helix cooperation and engagement. It is an open format event addressing the most challenging innovation topics at national level, trying to involve all active players in the ecosystem in an informal debate about the future of innovation, contributing to the pool of evidences for public policies recommendations.

Cafeneaua de Inovare (Innovation Café) is a registered trademark of (UEFISCDI). It was acknowledged as a good practice by the European experts in 2016 under the aegis of H2020 Policy Support Facility for Romania[231] as well as inside the Interreg Europe project[232] Mainstreaming Responsible Innovation in European S3. www.cafeneauadeinovare.ro

[229] https://www.impacthub.ro/barometrul-startup-urilor-2019/
[230] See, for example, the distribution by city of the approx.. 300 tech start-ups on Romanian Startups, probably the most important platform for tech startups in the country (http://goo.gl/on850J).
[231] https://rio.jrc.ec.europa.eu/en/policy-support-facility/specific-support-romania
[232] https://www.interregeurope.eu/marie/

Online platform RePatriot

The 'Repatriation through Entrepreneurship' (RePatriot) action aims to bring national entrepreneurs around the world together, to share ideas and search for solutions. RePatriot addresses the Romanians from the Diaspora who want to reconnect with the country, to invest in Romania and / or to relocate home and rebuild their life and career here. The online website offer information about the opportunities to be an entrepreneur in Romania, success stories of entrepreneurs who have managed to build their businesses, guides for entrepreneurs, the funding and sponsorship opportunities, and information about starting a business in Romania.

RomanianStartups.com

RomanianStartups.com platform brings together Romanian technology and Internet related startups, founders, accelerators/incubators, events, co-working spaces, mentors, investors and makes it a one-stop-shop for all the information needed to get an overall view of what is happening in the Romanian tech field. The locations are irrelevant, the condition imposed being at least one of these entities' co-founder is Romanian.

Techsylvania

Techsylvania (https://techsylvania.com) is one of the leading technology event that gathers tech enthusiasts, business people and developers each year. During the Startup Avalanche which takes during Techsylvania with the support of Spherik Accelerator, the seed-stage startups are challenged in a competition to showcase their business for awareness and reward. Over 3.000 engineers, founders, investors, executives and CEOs of IT & digital companies, banks and pioneers of growing start-ups from across the world meet at Techsylvania, in the heart of Transylvania, for inspiration and networking. Attendees from 27 countries, mainly European, come to Techsylvania which is the gateway to Eastern Europe tech ecosystem.

Innovation Labs

The Innovation Lab is an accelerating and mentoring program anchored in 11 prestigious universities in Bucharest, Cluj-Napoca, Iasi, Sibiu, Timisoara and Tel Aviv in the ICT field. In March 2019, over 480 young people enrolled in the five national Hackathon Innovation Labs, proposing over 160 digital product ideas. In the Hackathons, 111 teams entered, developing their ideas in prototypes with mentors, during 24 hours of fire. The TechHub Bucharest demo night is another event dedicated to early stage startups. https://www.innovationlabs.ro/

Rubik Hub Piatra Neamt

Rubik Hub, Piatra Neamt is a private initiative of North-East ADR that established a business incubator & coworking space in 2016. Its mission is to develop and connect communities, to educate and accelerate startups and create global successful businesses. Today with the support of private an academia partners the following programs are available: (1) Bootcamp is a 3-day intensive program which offers the basic tools and knowledge to start a startup or a project. (2) Rubik Garage is a pre-accelerator for early-stage start-ups. It is a free program with the aim to provide support to startup to overcome any bottlenecks and identify the development needs. In 6 months support programme a personalized roadmap for the startup is designed (3) Office Hours by Rubik gives access to free session with a mentor for feedback, validation, a deadlock, another perspective helpful for you to take the project to the next level.https://rubikhub.ro/ourstory/

Startup Spinner Makeathon

This is an event dedicated to startup founders, helping them to move to a higher level, Each team will be assigned a mentor along with whom they will work intensively throughout the event to identify bottlenecks, solve problems and set short or long term goals. In addition to the working hours spent with dedicated mentors, they will also have the opportunity to learn how to work on specific tools (Business Model Canvas, Team Mission Fit, Business Idea Canvas), each presented in a workshop.

5.9 LOW KNOWLEDGE DEMAND

Romania's competitiveness is affected by a weak R&I capacity doubled by the low demand for R&I due to structural factors.

5.9.1 Economic specialisation

Romania is specialised in labour-intensive, capital-driven and marketing-driven industries. The agriculture and manufacturing play a stronger role compared to other EU28 countries.

Wood & Furniture, Textiles and AgroFood play a major role in the national economy in terms of contribution to GDP, employment, exports. However, they are "low skilled – low tech" sectors based on competitive advantages such as massive production capacities or low wages.

The population working in agriculture is aging, the training level is very low, while the farm structure is dominated by subsistence and semi-subsistence farms lacking modern fixed and financial capital. (Popescu A, 2013 (a), (b)). The sector in terms of value added is dominated by multinationals. **The country is a net provider of unprocessed agricultural products, requiring know-how, technology, innovation to become a producer of processed and value-added product**s. R&D in Romania cannot assure more than 15% of the required vegetable seeds on the market, and this opens the way to FDI in agriculture. However, given the subsistence farming structure, the low training and technical endowment, lack of risk management strategies, further exacerbated by the recent extreme weather events frame agriculture as a sector with high potential for growth, but mainly unable to do the shift due to the above underlined features.

The R&D investments are concentrated in high, medium technology, accounting only for a small share of the total private companies. The innovative and knowledge-based development (high-tech and knowledge-intensive services sectors) in Romania has been relatively modest. According to the report "Analysis regarding the evolution and current state of the SME sector and business environment" [233] (Analiză cu privire la evoluția și situația actuală a sectorului IMM și a mediului de afaceri din România. http://imm.gov.ro/wp-content/uploads/2018/11/Sipoca5-R1.1.pdf), the time evolution of the SME industrial structure is not very favourable. **The share of SMEs using advanced technology is low, decreasing from 2.7% in 2008 to 2.02% in 2017**. The group of SMEs using advanced medium technology has increased its share from 6.94% in 2008 to 7.27% in 2017. Overall, these two groups shows a slight cumulated increase of 0.08%.

The business environment has not succeeded to trigger the increase of the share of companies with high potential to create added value.

5.9.2 Size of the business

The potential for innovation of the private sector is related also to the business size structure.

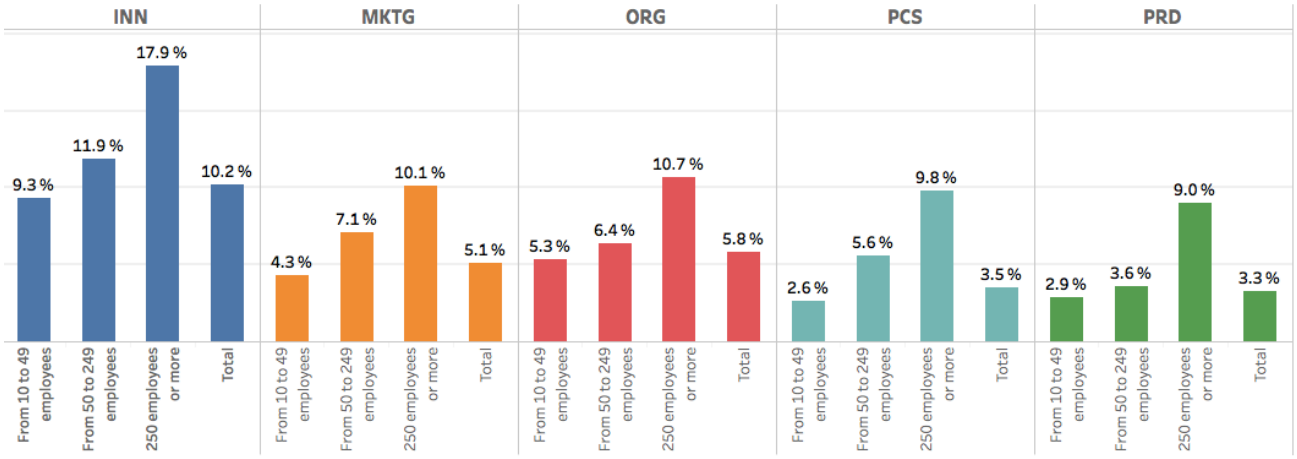
The Romanian SMEs show very low innovation activity, with low, to null performance in all the components (product/process. marketing/organizational, innovating in house) (EIS, 2019).

On one side, **SMEs** and mainly micro and small companies do not have the financial

[233] POCA project Creșterea capacității administrative a Ministerului pentruMediul de Afaceri, Comerț și Antreprenoriat de dezvoltare și implementare a sistemului de politici publice bazate pe dovezi"code SIPOCA 5, http://imm.gov.ro/wp-content/uploads/2018/11/Sipoca5-R1.1.pdf

strength to support and develop RDI department / activity for product/process innovation. Innovation requires also market research: it has to respond to a demand to create a new or improved product/ process. This requires competences and capacity in performing research on retails markets, partnership with major industry events, sophisticated market strategies. Many SMEs do not have the capacity to develop and implement these useful tools, particularly in the context of other significant pressures as the volatile legal framework, strive to find and retain employees.

On the other side, multinationals (MNCs), given the IPR provisions transfer the RDI results to the headquarters. '*Often the innovative projects are taken over by the large foreign companies, which bring them back to the Romanian market at much higher prices." (BI, ICT).*



INN: Enterprises that have either introduced an innovation or have any kind of innovation activity (including enterprises with abandoned/suspended or on-going innovation activities)

MKTG: Marketing innovative enterprises (regardless of any other type of innovation)

ORG: Organisation innovative enterprises (regardless of any other type of innovation)

PCS: Process innovative enterprises (regardless of any other type of innovation)

PRD: Product innovative enterprises (regardless of any other type of innovation)

Figure 59. Innovative enterprises as share of total enterprises (EC-RIO based on Eurostat, CIS 2016)

5.9.3 Position in the value chain

The Romanian companies are mainly producers, with no significant roles in the other value chain segments. The concept design takes place elsewhere, the national enterprises being involved just in their execution.

Romania has a growing automotive industry, with a network of suppliers and components manufacturers. Most of the Romanian suppliers work in Joint Ventures with foreign partners, in which the Romanian party provides production facilities, utilities and engineering services, whilst the international car manufacturers bring in their brand, knowhow and services. The respondents of the SIPOCA survey highlight that: "*The RDI activity in the production of harnesses is concentrated within few global companies. None of the wiring developers in Romania develops new products but works according to the clients' design plans*." (SM, Automotive). Same idea is emphasised by the shipbuilding

industry *"the RDI activities take place in the concept design, in which Romanian companies are not yet involved*." (SE, Shipbuilding). The ICT sector has a similar perspective: "*The national software development market is dominated by execution of projects from abroad and less by the generation of new products." (V, ICT*). The same "monopoly of multinationals" is noticed also in agri-food. The Romanian market is very attractive, given that "*at present, R&D in Romania cannot assure more than 15% of the required vegetable seeds on the market - and this opens the way to foreign agricultural inputs*" (SE, Agriculture).

5.9.4 Market/business competition

Most CEOs, from large companies/multinational (as resulted from analysis of MCRs reports) and SMEs (as resulted from the interviews performed by UEFISCDI) underline the impact of a highly competitive business environment. Competition although can be a driver for growth, if adequate and fair competitive framework environment is not provided, it can inhibit the development of newly arising companies, which may not have the force to compete with well-established enterprises, particularly in the context of the workforce crisis and fluctuating legislation.

SMEs cannot compete with the wages offered by MNCs, and MNCs and SMEs altogether, find a strong competitor in the public administration, since the recent salaries increase in this sector. Often SMEs invest significant time and money in training young graduates but fail to have a good long-term staff retention rate, due to the fact that "*it is very difficult to maintain wages at a competitive level compared to large companies*" (C, ITC). The issue of the competitiveness of the salaries in relation to big companies is felt especially among the respondents from the ICT sector.

MNCs have the financial strength and why not say the know-how, capacity in planning long term strategy and in providing competitive advantages to their employees. In the context of the workforce crisis, particularly from this segment of large companies, there has been an increasing trend of competitive packages including wellbeing of the employees, looking beyond wages: flexible working arrangements, medical support, in house training, access to sport facilities. It can be seen as a positive shift, however slow, towards quality of life in broader terms.

"The macro economic success of Romania relies heavily on how successful Romanian companies are at microeconomic level. Companies these days have to perform in a ***very complicated and unpredictable environment****. This* ***requires a highly competent and sophisticated corporate governance which not so many Romanian companies have used so far****. Confronted with the scarcity of the domestic capital, Romanian companies have no other choice but to compensate for this by having a state of- the-art corporate governance which would help them utilize, in the most efficient way, the available resources for maximum res*ults. (*statement of Craciun A,* MCR)

From SMEs' perspective, the MNCs "*inhibit entrepreneurship" (BI, ICT),* because they have much higher financial strengths*: "The salaries are above average in multinationals, the working conditions are very good and those who have entrepreneurial "spirit" prefer not to go on their own*" (W, Automotive). Under these circumstances, the conclusion of an entrepreneur is that "*the tendency is to transfer the High-Tech activities to companies with foreign capita*l." (SW, Electronics - UEFISCDI survey).

5.10 LIMITED Financial support for business investment

A business incubator is an organization designed to accelerate the growth and success of entrepreneurial companies through an array of business support resources and services that could include physical space, capital, coaching, common services, and networking connections

The prevalence of venture deals reflects both the availability of, and demand for, funding for SMEs aiming to grow. The OECD (2014) emphasizes the importance of venture funds not only as a source of funding, but also in stimulating entrepreneurship, supporting young companies and replacing or complementing traditional bank finance. Businesses have little motivation to invest in R&I, most of them neither have the financial strength to invest in RDI, preferring to import technology. While the private sector is in general reluctant in taking financial risks, which arise from R&I, financial services and instruments to mitigate the risk have been hardly available in Romania. (Chioncel M, 2017).

In Romania, access to financing for SMEs is limited due to both supply- and demand-side constraints, the SMEs being perceived as risky for banks due to their high share of non-performing loans.

The **venture capital** (VC) market is at incipient stage, with few visible venture capital providers on the market. In 2018, in Romania, the venture capital investments intensity, less than 0.001% of GDP, was the lowest in EU28. RO ranks slightly better in terms of aggregate deal value (the 26th position) and number of deals (the 24th position) (EC 2018, Annual Report on European SMEs 2017/2018**)**. Financing (VC, business angels etc.) is available mainly for pre-seed and seed stages via EIF-backed funds. As the advantage of low labour cost is fading out, there is a risk that some companies (particularly ICT) will disappear. These companies need to develop new business models, integrating innovation and should have access to business angels funding.

Business Angels, allocate, on average, between €10,000 and €200,000 in companies in ICT, innovative technologies under predefined conditions, and taking a high degree of risk. In 2016, the IT & C sector remained the main economic sector beneficiary of these types of funding, being closely followed by the medical and media field. These Business Angels have not benefited from benefits tax for any gains generated by such investments. [234]

Although the RO market for **corporate venture capital** (CVC) is still in its early stage, the national startup ecosystem is beginning to become more attractive to such complex investors.

There are a number of domestic **crowd funding platforms**.[235] However, most projects raise minor amounts. According to the Statista portal[236] , the transaction value in the "Crowdfunding" segment amounts to US$0.9m in 2019.

Access to both early stage and later stage funding, as well as to venture capital are among the challenges to innovation identified by the companies participating in the UEFISCDI survey ("*the investors for the 10-100,000 Euro market are missing*" while other respondents point to the fact that "*there are no business angels in the area, no persons or financial entities to appreciate if an idea is good and could generate high revenues at a later stage and to invest in it.*"

[234] http://www.revistadestatistica.ro/supliment/wp-content/uploads/2018/02/RRSS_02_2018_A4_EN.pdf
[235] http://crestemidei.ro. http://multifinantare.ro, http://www.wearehere.ro, http://potsieu.ro. http://www.kazuu.ro/. https://www.sprijina.ro
[236] https://www.statista.com/outlook/335/148/crowdfunding/romania#

5.11 Low culture for innovation

Innovation tends to take place in an environment characterized by an entrepreneurial spirit, a variety of supporting institutions, adequate funding, and the creation and exchange of ideas. Openness to new ideas and tolerance for failure are important features of a culture stimulating innovation. "*The lack of education of the entrepreneurs in the industry and the mentality of many to make a quick profit, the resistance in adopting new technologies and the lack of knowledge in the field is observed in the large number of bankruptcies" (MCR, 2019).*

Bringing innovative ideas to market takes time, requires a culture that supports innovative ideas and people. Innovation requires also educated customers: poorly educated clients prefer to copy existing concepts. The ability of a community to take risks is crucial to innovation.

There is a reduced demand for new and innovative products and services, due to the lack of market maturity. Not only that the national clients may lack sophistication, and are less receptive to new ideas, domestic companies consider that the purchase power of the Romanian customers is low, often preferring cheaper but less quality products from import. *Customers are perceived by the innovative entrepreneurs as "poorly educated", "reluctant", "lacking openness to new concepts", "having unrealistic expectations" and "adversity at risk", "high appetite for imported products" and "lack of interest for innovative products*" (UEFISCDI survey)

The 2019 Startup Barometer[237] gives solid evidence that one of the main obstacles of the ecosystem is the fear of failure.

Analysing the drivers for innovation as identified in the NESTA study (Hughes et al. 2011),[238] the national innovation culture can be assessed as weak, the working environment in the public system remains rigid, lacking openness for new ideas and incentives to support them. This is the mixed result of rigid mentalities, scarce financial, time and human resources, very rigid administrative frameworks that hamper the creative thinking, little awareness of the value of innovation, lack of strong leaders who can induce the cultural shift, all of these resulting in apathy and indifference.

Neither the education system, both at pre-university and university levels, creates a good seeding environment for innovative behaviour and creative ideas. The system has remained very traditional and rigid, the curricula focusing on memorisation, extensive extra-schoolwork and lacks the creativity component. The heavy weight of national examinations leaves little space to more individualised approaches to learning. Often creativity is penalised rather than encouraged. The system remains heavy and rigid, creative thinking being rather penalised by the rigid evaluation system, a system which can not put the seeds for the shift required for a culture for innovation.

The entrepreneurial education/activity is still at incipient stages, yet more developed in Technical Universities, mainly due to their training orientation, providing education to the future engineers/managers/entrepreneurs. Although some universities may claim that they integrate the entrepreneurial education, the extent is limited due to lack of tradition and availability of human resources.

The barriers regarding the entrepreneurial culture are generated, from the perspective of the respondents of the UEFISCDI survey, *especially by the education environment, the absence of a ‚culture of failure' and "the fear of starting the development of a product because it costs money and time*".

[237] https://www.impacthub.ro/barometrul-startup-urilor-2019/

[238] Open culture, staff share experiences, Managers prioritize innovation, Managers support testing of new ideas, Staff understand the value of innovation, Space for creative thinking, Ability to operate independently as a team, Allow time for projects, Dedicate funds Allocate the right people.

6 DIGITIZATION

6.1 PERFORMENCE

Enhancing digital literacy, digital skills, connectivity, and the usage of online commerce, services by the business, public and users community, the adoption of digital technologies are important drivers in generating jobs, labour productivity growth and the overall development of a digital economy. Romania, with an overall Digital Economies and Society Index DESI[239] score of 36.5 (compared to 52.5 of EU), is part of catching up cluster, ranking the second lowest in EU28. The performance has slightly improved in almost all of the DESI dimensions, but the progress is slow (Digital Economy and Society Index (DESI, 2019)) and the growth rate is lower than in other EU countries. Only a fraction (42%) of businesses is digitally active, and only 33% Romanian workers use a computer in their daily activities, while the number of Romanian businesses that sell products online is even lower (7%).

Human capital. More than one fifth of Romanians have never used the internet, partially due also to the low share of people with at least basic digital skills (DESI 2019). Only 29% of people aged between 16 and 74 have basic digital skills (compared to EU28 average of 57%) and 10% have advanced digital skills (against an EU average of 31 %). Romania also has the lowest ICT usage rates amongst the internet users in employment. Across competence dimensions, the largest skills deficit, both among the active labour force and the population at large, relates to the use of software for content manipulation. In 2018, Romania has also one of the lowest shares of ICT specialists in total employment (2.1 %). The ranking improves to 16th position, with regards female ICT specialists in total employment (1.3 % of women in employment, slightly below the EU average of 1.4 %) and has the third highest share of women among all ICT specialists.

Connectivity. Romania performs best in the Connectivity dimension (ranking on the 22nd position), due to the wide availability of fast and ultrafast fixed broadband networks, however with a strong urban-rural divide. Although the coverage with fixed lines (89%) and mobile (63%) is below the EU average, 70% of the connections are fast and the costs are low. A significantly higher ratio of homes (55%) subscribe to fast broadband than the EU average (41 %).

Use of Internet. Romania continues to be on the lowest position in EU: 21 % of individuals aged 16-74 have never used the internet (compared to the EU average of 11%). Yet, it is on the top position when it comes to use of social networks (86 % of internet users compared to 65 % in the EU28). Romanians used video calls (51 %) also above the EU average (49 %). However, the use of banking, shopping as well as music, videos and games (10 %, 26 % and 63 % respectively) is below the EU average.

Integration of digital technology. Romania did not improve in this dimension in the last two years. In 2018, Romania is placed on the 27th position in the EU28 ranking, well below the EU average. Only 9 % of Romanian enterprises are using social media (compared to 21 % EU average), 7% use the cloud services (compared to 18% inEU28). A larger share uses big data analysis (11 % versus 12 % EU average), where the country ranks 14th. In 2018, only 8 % of total SMEs are selling online (against an EU average of

[239] The Digital Economy and Society Index (DESI) is a composite index developed by the European Commission (DG CNECT) to assess the development of EU countries towards a digital economy and society, aggregating a set of relevant indicators structured around 5 dimensions: Connectivity, Human Capital, Use of Internet, Integration of Digital Technology and Digital Public Services.

17%) and even less (2 %) of them are selling online cross-border (8% EU average). The e-commerce turnover is also low (5% against 10% in EU28). In 2018, e-commerce in Romania grew 30%, reaching a total of €3.5 billion. This represents the highest growth in Europe for the second consecutive year, demonstrating the huge potential for developing online stores in the country. [240]

Digital public services. Romania's rank decreased each year one position since 2016, dropping to the lowest position in 2018. Certain indicators, as the interaction between public authorities and citizens, are better. With 82 % of internet users versus 64 % EU average, Romania ranks seventh regarding e-government users. This contrasts with the low scores for pre-filled forms and online service completion, which could indicate a systemic problem with the quality and usability of the services offered. Although the use of medical data exchange is low (19 % of general practitioners versus 43 % EU average), but e-prescription services are more widespread (39 % versus 50 % EU average). Romania is just slightly below the EU average as regards open data policy and the national open data portal (62 % versus 64 %).

According to Barometer of digitization in Romania 2018, things are improving. In 2018, 46% of companies, compared to 60% in 2017, did not make digital transformation the central part of their business strategy. In 2018, 60% of companies vs. 37% in 2017 of the responding companies say that they have taken advantage of the digitization to have a competitive advantage. 50% (2018) vs. 46% (2017) say that reducing costs and simplifying processes are the benefits of integrating the digitization process. A large share of companies say that the main obstacle to digitization is the fact that they do not have 'digital' consumers (40% in 2018 vs. 55% in 2017).[241]

6.2 Obstacles for digitization

Romanian ITs are employed in top tech companies, high school pupils are among the best performers in international IT competitions and are accepted in top IT universities. But RO ranks on the 27th position among the EU28 MS as aggregated DESI score. The paradox of the RO economy.

Romania adopted its National Strategy on the Digital Agenda for Romania for 2020 (SNADR) in February 2015. The SNADR is the steering document for all digital matters, including digital skills. The strategy focuses on: providing ICT infrastructure in schools. developing pupils' and teachers' digital skills. using ICT in the learning process and in lifelong learning, updating the ICT skills of public administration staff, and ensuring e-inclusion by developing digital skills and e-skills. In 2018, the Romanian Government launched the tender for a project entitled 'Wireless Campus' - a national integrated platform that will provide wireless internet in 4,500 state-run schools. The project will get a RON 117 million (EUR 25 million) financing from the ERDF and RON 32.8 million (EUR 7 million) from the state budget. All are recent developments, the implementation and the impact still to be observed over time.

Barriers in Human capital dimension. The country has **very good IT specialists**, **but they are too few**. The country ranking in terms of graduates (17th) decreases to 27th in the number of employees. Many of the best go abroad.

An important share of its student population still does not reach basic levels of competence and leave school before graduating from upper secondary education. One of

[240] https://www.eu-startups.com/2019/07/romanian-startup-blugento-raises-e1-million-to-scale-its-e-commerce-solutions-internationally/
[241] Barometrul digitizarii, available at https://valoria.ro/portfolio/barometrul-digitalizarii-companiile-din-romania-2018/

the specialisation in high schools is mathematics-informatics. Some of the high schools have a very strong reputation in international IT competitions. Yet, this represents a small share, and the human capital is lost for the country since most of these graduates go to study abroad and do not return. As with the rest of education, while the top students in Romania have high performance, a large bulk of them in the context of heavy curricula, lack of interest from teachers and students altogether, lack of school IT resources, will not acquire the basic competences in general, and IT skills in particular. If to this, we add the high drop out share, the results are not positive despite the good fame of the national IT school.

A 2016 study for the Orange Foundation showed that almost all rural schools have a minimal technological endowment (internet, computers).The report also showed that most of the students already have access to the internet at home and the main problem is related to the lack of trained teachers who can use the internet in the act of teaching. "*The new technologies are used at a relatively limited time. there is a need for training in the digital area*".[242]

Opening Opportunities

This is a mentorship program, in which IT experts mentor teams of high school pupils in computer science, product development, and team work in less -developed regions in Romania. The program is developed by Asociatia Techsoup, in which enthusiast professionals, support teams of high schoolers in developing tech products and learning what team work is all about.

The program creates the context for a meaningful first-time interaction with app building, with mentors from the IT industry as main drivers of inspiration. It was created for students aged 15-18 who don't share the same opportunities of becoming creators of technology as others.

https://www.openingopportunities.ro

The number of ICT places in public universities is limited and there is a lack of ICT graduates. Several Romanian universities have started offering online courses (MOOC), while several private companies investing in digital skills, offer IT specialisation programmes. There are several initiatives from the private sector.

Google Digital Workshop hub[243]

In October 2018, the University of Bucharest, together with Google Romania, launched an innovation hub for digital skills, the Google Digital Workshop hub.

Google partnership with the University of Bucharest, the Technical University of Cluj-Napoca and the Polytechnic University of Timișoara will evolve into two directions: free programming classes (Java, Android – beginners, Android – advanced).

[242] https://www.edupedu.ro/guvernul-pregateste-mega-contractul-de-209-milioane-de-lei-pentru-wireless-in-scoli/
[243] https://unibuc.ro/free-programming-classes-and-support-for-startup-development-offered-to-the-students-of-the-university-of-bucharest-in-the-new-hub-google-digital-workshop/?lang=en

The tax exemption provided for IT professionals in the country aims to retain the ICT specialists. There is an overall low level of life-long learning that could help many adults to gain the relevant digital skills. .

The low GDP per capita, the level of attainment in education ("*the main obstacle to digitization is the fact that they do not have 'digital' consumers*"), the poverty level, particularly in rural areas, significant regional disparities in GDP per capita, insufficient implementation of the SNADR, all are factors that affect the RO digital economy.

"Digitalisation and open data are key drivers of innovation today. We highly recommend that the Romanian government builds its entrepreneurial ecosystem based on e-government and support for digital start-ups, induces transparency by opening access to data it owns, and stimulates digital transformation at all levels of education," (Daria Tataj, H2020 PSF expert)[244].

Connectivity

This is the only major criterion in the DESI index that Romania is not in last is connectivity. Romania has the highest share of ultrafast broadband subscriptions– approximately 1.7 times the average for Digital Frontrunners, according to McKinsey study.[245]

Yet, 10% of the population of Romania does not have access to internet connections, largely because their connection is not economically viable. For a faster transition to a digital society, the government must develop policies to cover these areas (the RO-NET project being one of them. the project supports deployment of backhaul networks in 'white areas' and was granted ERDF financing of EUR 45 million). A new grant scheme for next-generation networks (NGN) deployment, with a total estimated budget of EUR 64 million, was set up to provide support to private operators deploying backhaul and last-mile access infrastructure for additional localities in underserved (white) areas. The first call of the project was launched in October 2018.[246]

Use of Internet

89% of the population of Romania has Internet access. Efforts to reduce costs and make the Internet accessible (Romanians pay 1.1% of their income for the Internet) have led to an increase in education and consumption of digital products.

There is a need to consolidate the trust in digital services. To do this, standards should be established and information provided. The users should know what (especially from a legal point of view) what means issuing an electronic invoice, signing an electronic contract, the legal value of a digital signature, the rights and obligations of data processing with personal character.

Integration of digital technology.

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[244] https://rio.jrc.ec.europa.eu/en/file/12145/download?token=0n9R0Eb9

[245] The Rise of Digital Challengers, McKinsey (2019)

[246] To address the urban-rural digital divide, under the 2014-2020 financial framework, the Romanian Operational Programme for Competitiveness has earmarked EUR 100 million from the European Regional Development Fund (ERDF), while the 2014-2020 Rural Development Operational Programme had initially foreseen an indicative amount of EUR 25 million from the European Agricultural Fund for Rural Development (EAFRD) under LEADER4, out of which less than EUR 2 million were effectively allocated to broadband infrastructure measures. The RoNet project to support deployment of backhaul networks in 'white areas' was granted ERDF financing of EUR 45 million, to finalise the intended coverage in the current financing period, ensuring broadband backhaul infrastructure for a target of 721 localities.

Digitalization can be an extraordinary source of optimization of business processes, leading to cost savings. The business environment must always aim to be more advanced than the public administration in terms of digitization. Yet, companies operating in Romania are reluctant to adopt new technologies, highlighting as one major obstacle to digitization the lack of 'digital' consumers. The loops again close in education system.

Digital public services

The national administration's IT system is fragmented, with a **low level of interoperability, as each public institution focused on its own digital public service**. This generates a significant administrative burden for citizens and businesses. A significant number of papers are still required by the administration, even if/when electronic systems in theory exist. Authorities need to be pushed to increasingly use digital technologies.

The high salaries for the IT specialists in the private sector, complemented by the tax exemption, make this category of professionals among the top paid jobs. However, the **salaries in the public IT sector are not correlated with the market**. The public sector, where is a significant need of IT specialists in order to ensure implementation and functioning of digital services can not compete with the wages in the IT private sector. Those who take positions in the public sector are often disconnected from innovation.

The doctors remain under a significant burden to fill in papers and do not benefit by centralised registries for epidemiological studies. The medical ID card had created significant problems in periods when the system failed to respond.

7 CONCLUSIONS

Innovation is critical in the modern economy. The economic growth can be decomposed into three elements: (1) growth in labour force, (2) growth in physical and natural capital inputs, and (3) total factor productivity growth (TFP), the "unexplained part" of GDP growth, such as technological progress, human capital, and institutional and cultural factors (OECD, 2011). TFP growth is considered the best predictor of cross-country variations in living standards, while innovative activity has been considered most important component of long-term economic growth.[247] Economists have calculated that approximately 50% of U.S. annual GDP growth is attributed to increases in innovation. As the relative national advantage of cheap labour force errodes, there is a need to shift attention towards innovation driven economic growth.

A strong innovation ecosystem requires macroeconomic stability, strong institutions, good infrastructure, ICT readiness, stable regulatory frameworks and a market that is receptive to new ideas. **Investing in people (education, health, wellbeing) is a fundamental building block of growth**. There is need also for strong entrepreneurial culture, companies embracing disruptive ideas, multistakeholder collaboration, critical thinking, meritocracy, social trust, a strong entrepreneurial culture and innovation capability.

The digitalization affects not only the industry but also the customers' needs. '*With the right skills, workers can become the actors of the economic transformation rather than becoming victims of it*.' (Global Competitiveness Report, 2018)

Social system challenges. These affect significantly the capacity of potential adopters to consider undertaking research and innovation activities. Skills and human resources shortages (declining demographic trend, high levels of emigration, failure of the education system to provide a solid education to the bulk of the pupils), lack of legal predictability are the main factors which limit the capacity of SME to get involved in risky and time demanding RDI.

Actions should be taken at all levels of the diffusion of innovation/ knowledge domains and in the larger social system. The innovation ecosystem must function in a new paradigm, allowing transparency, accountability, efficiency, monitoring and evaluation. More funds will not simply make the change.

Various type of actions must be considered: funding instruments, principles for RDI funding, revision of legislation and regulations, transparency, monitoring and evaluation, increasing the RDI administrative capacity, support to stakeholders to optimally use the measures and from them in the RDI policy co-creation.

Relative importance of the volume of funding should be correlated to the characteristics / the needs of the system. In a flexible, progressive manner this should allow the positive change to occur across the entire chain of knowledge diffusion.

- **increase the level and quality of knowledge production** addressing the economic and societal needs. This implies significant changes in education and research system +++++
- in parallel, **prepare the potential adopters** to make the behavioral change ++
- and with appropriate measures support the **innovators and early adopters** ++

247 https://www.brookings.edu/wp-content/uploads/2016/06/08_innovation_greenstone_looney.pdf

- while **ensuring the communication among all stakeholders which allow to bridge distinct communities; support heterophilic relations** as diffusion requires a certain degree of heterophily to introduce new ideas.++

All these activities should be performed within a framework that enforces **transparency, efficiency of funds allocation, monitoring, evaluation and mechanisms of corrections.**

This section includes *some suggestions,* based on the conclusions of the report***, without any intention to cover exhaustively all the barriers and the directions of action, neither to impose any action. They represent some of the author's opinion based on the conclusions of the report and are just aspect for further reflection.***

RDI System and Policy

- There is an impetuous need of tackling the demographic problems and the high emigration: provide systemic support to retain and attract the high professionals
- The national education and RDI system should perform in a stable framework, based on multi-annual budgets and strategic priorities, regardless the political changes.
- Invest in building administrative capacity of the public authority designated to coordinate the RDI strategic processes, to ensure correlation between sectorial and territorial policies (strategies, plans and programs, national and regional) and their management bodies, to develop and promote an unitary framework for RDI policy implementation, monitoring and evaluation.
- There is need of evidence-based policy making, proper monitoring and evaluation mechanisms.
- All relevant stakeholders should be involved in RDI policy making process (smart specialization governance and entrepreneurial discovery process)
- Strategies require realistic targets, in line with the political will.
- Distinct strategies targeting explicitly or implicitly the innovation system should be designed and implemented in a coordinated manner. The strategies should be linked to the implementation plan, funding sources and sound management system.
- Embed monitoring and evaluation mechanisms in the strategies, performed in an integrated approach, with coordinated planning, avoiding duplication of financial and administrative efforts and reasons for not performing a sound evaluation.
- Design the policy instruments/input, output, outcome indicators based on the intervention logic.
- Ensure periodic evaluations and flexible funding for national RDI funding schemes to allow corrections.
- Develop "Stairway to excellence" programs, to qualify for financing, eligible projects submitted in the Horizon Europe calls
- Introduce selection system for RDI projects based on relevance and estimated impact qualification criteria
- Create a national "one stop shop" for RDI funding programs with unitary communication system for the presentation of the calls and capacity to support development of RDI and TT project.
- Academic/research staff have conflicts of interest/commitments that need to be understood and properly managed.
- There are several fiscal incentives for RDI. There is a need for clear, unambiguous guidelines for their implementation.
- Normative acts are needed to support innovation with all that it entails (i.e. Advantageous rules on "private use" of research facilities etc.)

- Formulate and promote regulatory initiatives to encourage research activities, support access to public research infrastructures, valorise research results, encourage innovation and digitalisation in SMEs
- In order to mitigate the high migration of highly qualified personnel, creation of legal framework for freelancing collaboration in research projects funded by public funds.
- Ensure stable legal framework, taxation. Ensure digital processing of the bureaucracy workload related to project design and implementation.
- Expand the research and development RDI tax reduction to provide some benefit to companies collaborating with HEIs/PROs.
- Create favorable rules on "private use" of research facilities.
- Develop legal framework/ design funding instruments that consider the specificities of the innovative companies.
- Provide incentives for MNC to maintain IP in Romania.

RDI funding

- Increase RDI funding and its efficiency. Invest more and invest wisely ! Ensure multi-annual, predictable funding. Ensure budget allocation based on transparent, rigorous, periodic (strategic, funding programs and institutional) performance evaluation mechanisms
- Develop funding programs for public RDI organisations, based on institutional performance basement system, to ensure the relevance of the research to the societal challenges and economic needs, and alignment to the international trends
- Promote firstly the consolidation of the science base, support knowledge production aligned to societal challenges, economic needs and international trends. Support excellence in research, collaborative research, business incubations and technology transfer.
- Develop smart specialization funding programs (grants and financing instruments) capable to cover the entire life cycle of research and innovation, especially invest in programs dedicated to research to market, research societal challenges oriented, applied research, collaborative research-industry programs, start-ups' incubation and acceleration.
- Invest in developing RDI and TT intermediaries, their capacity to align industry demand with research and education offer, to ensure transfer of know how and technology uptake in areas with potential for smart specialization.
- Invest in developing networking and cooperation among RDI performers, to encourage transfer of know-how, promote joint national and transnational investments in early product validation, commercialization and patenting in areas with potential for smart specialization
- Development of actions that speed up cross-sectorial and cross- regional connectivity, including clusters support.
- Invest in developing industrial activities in specific value chains with potential of smart specialization and cross sectorial spillover effects.
- Invest in developing DIHs and innovative clusters in areas with potential for smart specialization.
- Invest in propagation of digitalisation in all areas of activity
- Invest in increasing interoperability of IT national system
- Increase and review public funding for RD structures to introduce multiannual funding and institutional performance assessment system.
- Encourage risk-taking: provide venture capital support schemes for innovation, support risk-sharing through joint-ventures; support business angels through fiscal incentives.
- Integrate urban innovation districts in urban growth poles, based on integrated urban development strategy.

- Create cluster knowledge including in rural and peri-urban towns to facilitate networking and exchange of knowledge and establishment of sustainable innovative environments for entrepreneurial discoveries
- Focus on champions/ quasi champions (start-ups/SME) that have the potential and the desire to innovate and grow. Identify High Growth Innovative Enterprises, their needs. Create funding instruments for HGIE.
- Design instruments for all stages of innovative start-ups (Seed Stage, Startup Stage, Growth Stage, Later Stage and Steady Stage).
- Provide support for patenting.
- Provide support for scaling up innovative companies.
- Provide support to companies that have taken steps towards developing services and products on external sales market

Education

- Increase the investment in Education, Health. Economic growth has not been reflected in an improved quality of life. There has been and it is going to be a high outward flow of Romanians, seeking better lives, careers in the context of low quality of life and lack of career prospects.
- While tertiary education may seem more important for innovation, the systemic problems of the entire education system should be considered. Regardless the level of the education, its quality affects the society as a whole, its ability to perform towards a sustainable growth. An education system is also a strong component of the quality of life – employees and employers want for their families access to a good education, health, social security system.
- There is a need to correlate the number of state funded places in public HEIs to the labour market demand.
- The university curricula should be correlated to the demand of specialists from the market. This involves also a more flexible studies recognition regulation/process.
- Invest in supporting the innovation culture – education at all levels, vocational training and specialization programs, including mobility of students, master, PhD students and teachers.
- Reform the Education System – to be more focused on student learning/ reach achievements and not on subjective evaluations.
- Support the education system, create a favorable environment able to retain quality staff, to provide for their continuous training.
- Review institutional assessment system of HEIS to support high quality standards, to attract students and researchers in areas with potential for smart specialization and technology development.
- Provide the regulatory framework and financial support for in house training programmes for Master and PhD students, internships. Develop and sustain incentives for the HEIs and VETs that align their education offer with the market needs.
- Invest in developing the strategic management capacity of the public universities and VET schools.
- Provide support for training and research networks similar to Marie Curie Schemes with dual aim: training and research.
- Invest in increasing competences of local public authorities to administrate digital public services.

ABBREVIATIONS

ADR	Regional Development Agency (Agentia de Dezvoltare Regionala)
AR	Romanian Academy (Academia Romana)
ARACIS	Romanian Agency for Quality Assurance in Higher Education
BERD	Business expenditure on R&D
BES	Business Enterprise Sector
CNFIS	The National Higher Education Funding Council
CNIPMMR	National Council for Small and Medium Private Enterprises in Romania
COP /POC	Competitiveness Operational Programme (Programul Operational Competitivitate)
DESI	Digital Economies and Society Index
EDP	Entrepreneurial Discovery Process
EIF	European Investment Fund
EIS	Eurpean Innovation Scoreboard
ELI-NP	Extreme Light Infrastructure
EPO	European Patent Office
ERDF	European Regional Development Fund
ERRIS	Engage in the Romanian Research Infrastructure System (platform)
ESIF	European Structural and Investment funds
EU28	The 28 Member States of the EU
FDI	Foreign Direct Investment
FTE	Full-time equivalent (researchers)
GCI	Global Competitiveness Index
GD	Governmental Decision
GDP	Gross Domestic Product
GERD	Gross domestic expenditure on R&D
GOV	Government Sector (from statistical point of view, when discussing R&D perfomance this means PROs)
GVA	Gross Value Added
HEIs	Higher Education Institutions
HES	Higher Education
HGE	High growth enterprises
HGIE	High growth innovative enterprises
HRS	Human Resources in Science and Technology
HRST	Human Resources in Science and Technology
ICT	Information Communication Technology
IDF	Institutional Development Fund
INCD	Institute Nationale de Cercetare, Dezvoltare

KT	Knowledge transfer
KTO	Knowledge Transfer Offices
MCI	Ministry of Research and Innovation (Ministerul Cercetarii si Dezvoltarii)
MEC	Ministry of Education and Research (Ministerul Educatiei si Cercetarii)
MNC	Multinational company
MNE	Ministry of National Education
MNER	Ministry of National Education and Research (Ministerul Educatiei Nationale si Cercetarii)
NASRI	National Authority for Scientific Research and Innovation (Autoritatea Nationala pentru Cercetare Stiintifica si Inovare)
NCIE	National Council for Innovation and Entrepreneurship (Consiliului Naţional pentru Inovare şi Antreprenoriat – CNIA,
NCSTIP	National Council for Science, Technology and Innovation Policy (Consiliul National pentru Cercetare, Tehnologie si Inovare)
NES	National Strategy for Export
NRT	National registry of Trade (Oficiul Roman de Comert)
NS	National Strategy
OECD	The Organisation for Economic Co-operation and Development
OP	Operational programme
OSIM	National Office for Inventions and Trademarks (Oficiul de Stat pentru Inventii si Marci OSIM
PATSTAT	Worldwide Statistical Patent Database
PISA	Programme for International Student Assessment
PN3	National Plan for Research, Development, and Innovation, 2015-2020 Planul National pentru Cercetare, Dezvoltare, Inovare 3
R&D	Research and development
R&I	Research and innovation
ReNITT	Romanian network for innovation and technological transfer (Reteaua Nationala pentru Inovare si Transfer Tehnologic)
RI	Research infrastructure
RIS3	Regional Innovation Smart Specialisation Strategies
ROP POR	Regional Operational Programme Programul Operational regional
S2E	Stairway to Excellence
SF	Structural Funds
SME	Small, Medium Enterprises
SNARD	National Strategy on the Digital Agenda for Romania
SNCDI	National Strategy for Research, Development, and Innovation, 2014-2020 (Strategia Nationala pentru CDI)
UEFISCDI	Executive Agency for Higher Education, Research, Development and Innovation Funding (Unitatea Executiva pentru Finantarea Invatamantului Superior, a Cercetarii, Dezvoltarii si Inovarii)

USPTO	United States Patent and Trademark Office
VAT	Value Added Tax
VC	Venture capital
WoS	Web of Science

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APPENDIX 1. COVID 2019. World Bank forecast

TABLE 2 **Romania** / Macro poverty outlook baseline scenario (annual percent change unless indicated otherwise)

	2017	2018	2019 e	2020 f	2021 f	2022 f
Real GDP growth, at constant market prices	7.1	4.4	4.1	0.3	4.4	3.9
Private Consumption	9.6	6.5	5.9	2.9	5.2	5.1
Government Consumption	4.6	4.5	12.8	15.4	3.1	3.0
Gross Fixed Capital Investment	3.3	-1.2	17.8	-0.4	4.2	4.1
Exports, Goods and Services	9.7	6.2	3.5	2.1	3.7	3.7
Imports, Goods and Services	11.3	9.1	7.2	4.3	4.6	4.8
Real GDP growth, at constant factor prices	7.6	3.9	3.5	0.3	4.4	3.9
Agriculture	14.5	10.8	-3.2	8.9	1.0	1.0
Industry	4.7	4.4	-1.5	-1.3	3.1	3.1
Services	8.4	2.9	6.9	0.2	5.4	4.6
Inflation (Consumer Price Index)	1.3	4.6	3.8	3.5	3.4	3.1
Current Account Balance (% of GDP)	-3.2	-4.4	-4.7	-5.2	-4.7	-4.8
Net Foreign Direct Investment (% of GDP)	2.6	2.2	2.3	1.3	2.2	2.2
Fiscal Balance (% of GDP)	-2.8	-2.9	-4.6	-5.5	-3.9	-3.3
Debt (% of GDP)	36.8	36.3	37.6	39.3	39.6	41.0
Primary Balance (% of GDP)	-1.6	-1.6	-3.4	-4.2	-2.5	-1.8
International poverty rate ($1.9 in 2011 PPP)[a,b]	3.8	3.7	3.6	3.6	3.5	3.4
Lower middle-income poverty rate ($3.2 in 2011 PPP)[a,b]	7.2	6.9	6.7	7.3	7.1	6.9
Upper middle-income poverty rate ($5.5 in 2011 PPP)[a,b]	15.8	14.9	14.2	17.0	16.2	15.5

Source: World Bank, Poverty & Equity and Macroeconomics, Trade & Investment Global Practices.

APPENDIX 2. RDI Programmes

The NPRDI (PN3) 2015-2020 with various project-based funding programmes, aiming to cover the whole spectrum of innovation activities from idea to market and from short to long term has launched many of its financing instruments in 2016. The main programmes and sub-programmes and their specific aims are detailed below:

Programme 1. Development of the national RDI system

- **Sub-programme 1.1 Human Resources** supports doctoral and postdoctoral projects, including a new industrial doctorate, the reintegration of diaspora researchers, for young researcher teams, mobility and rewards for scientific results. projects for young researcher teams. Managed by the Executive Agency for Higher Education, Research, Development and Innovation Funding (UEFISCDI).
- **Sub-programme 1.2 Institutional Performance provides support for strategic development in POR, and research-business cooperation.**
- **Sub-programme 1.3 R&D Infrastructures** supports investments in regional, national and pan-European Ris, connecting the domestic to international RIs**.** This sub-programme is partly managed by The Executive Agency for Higher Education, Research, Development and Innovation Funding (UEFISCDI)
- **Sub-programme 1.4 Support** mainly targets the creation of competence centres and technological services. equipment for RDI policy management. and support for evidence-based policy, access to scientific literature, and science communication. This sub-programme is partly managed by The Executive Agency for Higher Education, Research, Development and Innovation Funding (UEFISCDI)

Programme 2. Increasing the competitiveness of the Romanian economy through RDI

- **Sub-programme 2.1 Competitiveness through RDI** funds experimental demonstration and experimental development projects. technology transfer projects. projects outsourcing research to public R&D partners. innovation vouchers. innovative solutions. the establishment of R&D departments in companies. technological platforms. and the creation of clusters. This sub programme is coordinated by (UEFISCDI).

Programme 3 European and international cooperation. This programme through six distinct sub-programme has the aim to strengthen the RDI national system through international cooperation, increase the international visibility and participation of the RDI system in Horison2020, European Innovation Partnerships (EIP), Joint Programme Initiatives (JPIs), support RO representation in pan-European, international programmes and organisations.

- **Subprogram 3.1. Bilateral / Multilateral** supports the bilateral and multilateral cooperation in RDI through complex projects and mobility. (Bilateral cooperation Romania – France, RO - Community Wallonia-Belgium. Romania – Moldova). Management authority UEFISCDI
- **Subprogram 3.2 Horizon 2020.** Support is provided for national participation in the following EU collaborations (RI-links2. ERA4CS. ACT.ProSafe. NEURON. SYNAMERA. ERA-GAS. Waterworks 2015. ENSUF - ERA-NET co-fund Smart Urban Futures. INNOVOUCHER. Columbus. BSH - Black Sea Horizon. E-Rare 3. ERA-Net Plus Smart Grids. ERA-NET Smart Cities and Communities. Waterworks 2014). Management authority UEFISCDI
- **Subprogram 3.3** European and international initiatives and programs has the aim to 'foster economic and technological performance of Romanian companies by

financing those entities that have the ability to transform ideas into products and innovative technologies with real market potential. provide support to realization of new products and technologies, based on research results showing potential for commercial exploitation. stimulate SMEs to consider innovation as a growth strategy, both by developing their own research capabilities, and by accessing experimental facilities available in research entities in Romania. supporting cooperation between research organizations and industry. (fully coordinated by UEFISCDI)

- **Sub-programme 3.4.** Support to common technological initiatives (JTI, JU)
- **Sub-programme 3.5** Support has the main aims to increase the visibility of RO RDI system are international level, support the sustainability of national participation in the projects funded by H2020 and the capacity of future participation in H2020 competitions**.** The financing is awarded to national institutions which had won a H2020 competition.

Programme 4 Fundamental and frontier research. The program has the aim to support fundamental research in emerging areas in which Romania is interested to conduct frontier scientific research, increase the performance, international visibility of the national RDI in areas holding research potential, adoption of international valuation standards for fundamental research projects.

Programme 5 Research in fields of strategic interest

- **Sub-programme 5.1** supports nuclear physics and high-power lasers research, particularly in connection with the future ELI-NP infrastructure**.**
- **Sub-programme 5.2** supports participation in activities and projects in atomic and subatomic physics (such as EURATOM, CERN, FAIR, CEA, F4E).
- **Sub-programme 5.3** funds the STAR programme for advanced space research and technology.
- **Sub-programme 5.4** supports research in river-delta-sea systems, particularly in connection with the future DANUBIUS-RI infrastructure.

OPERATIONAL PROGRAMME COMPETITIVENESS (POC)

The main objective of POC is to contribute to the increase of the economic competitiveness by investing in RDI and ICT. The main directions of investments aim to stimulate the innovation of the business sector through public support to private RDI and private RI, development of centers of research excellence centers, clusters and networks, stimulate the knowledge transfer The following main action lines are foreseen in POC:

DEVELOP RD&I CAPACITIES INFRASTRUCTURES

Action 1.1.1 : Large RD Infrastructures (€416million, 44% POC)

- Creating new RD investment in public RD institutions.
- Investment for RD departments in enterprises.
- Innovative clusters.
- Support to research pan-European infrastructures (ELI-NP stage II €175 million. and DANUBIUS Centre €47 mil)

DEVELOP RD&I CAPACITIES–SYNERGIES

Action 1.1.2. Development of networks of RDI centres which are nationally coordinated and linked to international related, as well as ensuring researchers' access to scientific publishing and international data

- GRID and RoEduNet
- Facility access to scientific publishing (ANELIS)

Action 1.1.3 : Creating synergies with RD&I actions of Horizon 2020 and other International RD&I programmes: Complement JTI. RO-EIT. RO-ESFRI-ERIC. Finalist-IMM. Centre-support. ERA CHAIRS. Teaming

DEVELOP RD&I CAPACITIES–PEOPLE

Action 1.1.4: Attracting high-skilled personnel from abroad to foster RD capacities.

STRENGTHEN RESEARCH AND INNOVATION CAPACITY IN ENTERPRISES

Action 1.2.1: Stimulating enterprises' demand for innovation through RD&I projects carried out either by the enterprise itself or in partnership with RD institutes and universities, in order to innovate processes and products in economic sectors with growth potential

- Innovative technological projects
- Innovative spin-offs and start-ups
- Innovative newly created enterprises

FINANCIAL INSTRUMENTS FOR INNOVATIVE ENTERPRISES

Action 1.2.2 : Credits, guarantees and risk capital measures for innovative SMEs and research organizations searching for market demands

- Accelerator and seed stage for innovative ideas
- Portfolio Risk Sharing Loan for innovative SMEs and research organizations answering market demands.
- Creating a research and innovation offer on business needs

Action 1.2.3:Knowledge Transfer Partnerships Research organizations' offer shall include 4 categories of R&I activities:

- consultancy and expertise for knowledge transfer
- access to RD&I facilities
- transfer of research skills by providing RD&I services
- collaborative partnerships

APPENDIX 3. Relevant RDI legislation (ad detailed on the MEC website)

General research legislation, as listed on the MEC website: http://www.research.gov.ro/ro/articol/1021/legislatia-sistemului-de-cercetare

National Research, Development and Innovation Strategy 2014-2020 - (GD 929/2014)

Modification and completion of the National Strategy for research, development and innovation 2014 - 2020, approved by GD 929/2014 - (GD 81/2017)

National Education Law - (Law 1/2011)

Government Ordinance 57/2002 on scientific research and technological development - (OG 57/2002)

Law 319/2003 on the Status of research and development staff - (Law 319/2003)

Evaluation and classification in order to certify the institutions from the national research-development system - (GD 1062/2011)

Government Ordinance 41/2015 amending and supplementing Government Ordinance no. 57/2002 on scientific research and technological development - (OG 41/2015)

Law 206/2004 on good conduct in scientific research, technological development and innovation - (Law 206/2004)

Legislation related to the Ministry of Education and Research:

Organization and operation of MEC - (GD 24/2020)

Regulation on the organization and functioning of the MEC - (OM 3390/2020)

UEFISCDI legislation:

Regulation on the organization and functioning of UEFISCDI - (OM 5804/2016)

Government Emergency Ordinance 74/2010 establishing the UEFISCDI - (GEO 74/2010)

Government Ordinance 62/1999 establishing UEFISCSU - (OG 62/1999)

National research-development and innovation plan:

Government Decision no. 8/2018 on amending and supplementing Government Decision no.

583/2015 for the approval of the National Plan for research-development and innovation for the period 2015-2020 (PNCDI III) - (GD 8/2018)

Modification and completion of the National Strategy for research, development and innovation 2014 - 2020, approved by GD 929/2014 - (GD 81/2017)

National research-development and innovation plan for the period 2015 - 2020 (PNCDI III) - (GD 583/2015)

National Research, Development and Innovation Strategy 2014 - 2020 (SN CDI 2020) - (GD 929/2014)

Modification and completion of some normative acts regarding the National Plan for research-development and innovation - (GD 1244/2012)

National research-development and innovation plan for the period 2007 - 2014 (PNCDI II) - (GD 475/2007)

National strategy in the field of research-development and innovation for the period 2007 - 2013 - (GD 217/2007)

Methodological norms regarding the programs, projects and actions included in PNCDI - (GD 1265/2004)

Grants for young researchers KING CAROL I:

Grants program for research and development and innovation "GRANT for young researchers KING CAROL I" - (GD 403/2017)

Secondary legislation related to the research system:

Approval of the National Register of Experts for the certification / expertise of the research-development activity - **MCI Order no. 350 of May 30, 2019** - (Order 350/2019) - 05.06.2019 12:49

Doubling the ceilings for revenues obtained from programs financed from public funds - **Government Decision no. 751/2017 for the amendment of the annex to the Government Decision no. 327/2003 on the ceilings on the basis of which the direct salary costs are calculated for the financing contracts concluded from budgetary funds** - (GD 751/2017)

Tax exemption for all staff involved in RDI activities - Law 136/2017 on the approval of Government Emergency Ordinance no. 32/2016 for the completion of Law no. 227/2015 on the Fiscal Code and the regulation of some financial-fiscal measures (Law 136/2017)

The procedure for applying the tax exemption for the personnel involved in RDI activities - Joint Order MFP / 2326/29 August 2017 - MCI / 2855/29 August 2017 regarding the establishment of the procedure for granting the fiscal facility provided in art. 60 point 3 of Law 227/2015 on the Fiscal Code (Joint Order MFP / 2326 - MCI / 2855/2017)

The norms regarding the deductions for the research-development expenses for the calculation of the fiscal result - (Order 1056-4435 / 2016)

Competition methodology for the position of general director at the national research-development institutes - (GD 576/2016)

Competitive framework methodology for filling vacant teaching and research posts in higher education - (GD 457/2011)

Categories of expenditures for research-development and innovation stimulation activities, financed from the state budget - (GD 134/2011)

Law no. 305/2009 for the amendment of par. (1) in art. 65 of the Government Ordinance no. 57/2002 on scientific research and technological development and for amending and supplementing art. 52 of Law no. 500/2002 on public finances - (Law 305/2009)

Framework Regulation for the organization and operation of INCDs - (GD 637/2003)

Establishment, operation, evaluation, accreditation and support of entities in the infrastructure of innovation and technology transfer - (GD 406/2003)

Legislation of other research bodies:

Law on the organization and functioning of the Romanian Academy - (Law 752/2001)

Statute of the Romanian Academy

Law on the organization and functioning of the "Gheorghe Ionescu-Şişeşti" Academy of Agricultural and Forestry Sciences and of the research and development system in the fields of agriculture, forestry and food industry - (Law 45/2009 - Part I , Part II)

Law on the organization and functioning of the Academy of Medical Sciences - (Law 264/2004)

Statute of the Academy of Medical Sciences - (ASM Decision 1665/2004)

Regulations and composition of the Scientific Councils

National Council for Scientific Research (CNCS)
regulation of organization and functioning and composition

Advisory Board for Research and Development and Innovation (CCCDI)
regulation of organization and functioning and composition

National Council for Technology Transfer and Innovation (CNTTI)
regulation of organization and functioning and composition

National Council for Ethics of Scientific Research, Technological Development and Innovation (CNECSDTI)
regulation of organization and functioning and composition

State aid schemes

Regulation (EC) no. 800/2008 ro en
Structural funds - orders for the approval of state aid and de minimis schemes
PN-CDI II - State aid No N 542/2007

Legislation of the private domain of the state

Minister of Finance no. 668/2014 for the approval of the Specifications regarding the elaboration and updating of the centralized inventory of the real estate privately owned by the state and of the real rights subject to the inventory

Form P4000 on the centralized inventory of state-owned real estate and real rights subject to inventory - updated version 08.01.2015

APPENDIX 4. Policy mix

Politicy Strategia	RDI relevant Directions of implementation	Developed by
Regional Strategies for Smart Specialisation Strategiile de Specializare Inteligentă ale regiunilor(RIS)	RIS 3 North-West RIS 3 Center RIS 3 North-East RIS 3 South-East RIS 3 South- Muntenia ADR South-West Oltenia RIS 3 West ADR Bucharest-Ilfov (in prpgress)	ADR North-West ADR Center ADR North-East ADR South-East ADR South-Muntenia ADR South-West Oltenia ADR West ADR Bucharest-Ilfov
National Strategy for Competitivity 2014-2020	Long-term institutionalization of industrial / technological / CDI foresight centers in public-private collaborative regime Supporting SMEs to launch innovative products or services through venture capital funds, grants, collaborative projects Improving the position of exporter of Romania in 10 economic sectors with potential for intelligent specialization Increasing the attractiveness of investments in the 10 sectors with the potential for intelligent specialization	Ministry of Economy
National Strategy for Export 2014-2020 Strategia Nationala de Export	[Support for enterprises regarding the acquisition, transfer and adaptation of advanced technologies Support for the creation and development of innovative companies, especially in the high-tech fields Stimulating public and private investments in innovative companies Encouraging greater participation of enterprises in publicly funded research, development and innovation programs Direct support for companies for developing in-house research capabilities: hiring staff Territorial economic concentrations - Supporting innovative clusters	Ministry of Economy
NS Health 2014-2020 Strategia Nationala de Sanatate	Promoting R&D in Health Development of research, development, innovation capacity for the health sector aiming at results that could be integrated into practice Development of research in public health and health services, for the development of evidence-based health policies	Ministery of Health
The Strategy for Rural Development 2014-2020 Strategia de Dezvoltare	Encourage innovation, cooperation and the creation of a knowledge base in rural areas Strengthening the links between agriculture, food production and forestry, on the one hand, and research and innovation, on the other, including for better environmental	Ministry of Agriculture and Rural Development

Rurală 2014-2020 prin PNDR 2014-2020 – instrument secundar de implementare a SNCDI	management and improved environmental performance Encourage lifelong learning and vocational training in the agricultural and forestry sectors	Ministerul Agriculturii și Dezvoltării Rurale
NS for Tertiary Education 2015-2020 Strategia Nationala Invatamant Superior	Tertiary education as a driver of growth based on knowledge and high qualification. The investments will be made with priority in areas with growth potential that contributes to increasing the employability of the graduates of higher education in competitive sectors / smart specializations.	Ministerul Educației
National Strategy for life-long Learning SN de Învățare pe Tot Parcursul Vieții 2015-2020, (și prin POCU și POR – instrumente secundare de implementare a SNCDI)	Improving the level of knowledge / skills / aptitudes related to the economic sectors / domains identified by SNC and SNCDI Increasing the number of employees benefiting from tools, methods, practices, etc. standard of human resources management and improved working conditions in order to adapt the activity to the dynamics of the economic sectors with competitive potential identified according by NSC / SNCDI 2014-2020 Diversification of educational offers in tertiary university and non-university technical education organized within accredited higher education institutions correlated with the needs of the labor market in the economic sectors / domains identified by SNC and SNCDI Increasing the number of university and non-tertiary tertiary education graduates who find a job as a result of access to learning activities at a potential job / research / innovation, with an emphasis on the economic sectors with competitive potential identified according to the NSC and SNCDI 2014-2020 Increased participation in on-the-job learning programs of students and apprentices in non-university secondary and tertiary education, with an emphasis on the potentially competitive economic sectors Increasing the number of vocational training programs for the economic sectors with competitive potential	Ministry of National Education Ministerul Educației Ministry of Labour and Social Justice Ministerul Muncii și Justiției Sociale
National Strategy for Regional Development SN pentru Dezvoltare Regională (și prin POR)	[Grow regional economies by developing the specific infrastructure for innovation and research and by stimulating economic competitiveness] Development of research and innovation infrastructure: Development of business incubators, technological, scientific parks, industrial and business parks, competence centers, clusters Development of business networks Support for the development of the economic activity within the specific infrastructure of innovation and research Adopting new technologies Development of innovative systems Increasing the competitiveness of SMEs_: Developing the entrepreneurial spirit, in particular by facilitating the economic exploitation of new ideas and by encouraging the creation of new productive enterprises Developing SMEs, in particular to promote technology transfer	Ministry of Regional Development and Public Administration Ministerul Dezvoltării Regionale și Administrației Publice Regional Development Agencies Agențiile pentru Dezvoltare Regională
National Strategy for Education and Professional	Development of competences regarding innovation, creativity and entrepreneurship within vocational training	Ministry of Education

Development Strategia Educației și Formării Profesionale 2016-2020	programs.	 Ministerul Educației
NS for Digital Agenda 2020 SN privind agenda digitală pentru 2020	[Research and development and innovation in ICT] Promoting innovative groups and competing poles for regional growth Encouraging research on regional infrastructure development. Dissemination of participation in ICT Innovation, Research and Development projects within the framework of initiatives Financing of ICT innovation initiatives in Romania Stimulating national research and development and innovation capabilities in cyber security - Encouraging national research / development / innovation capabilities in cyber security	Ministerul pentru Societatea Informațională
National Strategy for the Development of SMEs and improvement of the business enviroment in Romania - 2020 Horison Strategia guvernamentală pentru dezvoltarea sectorului întreprinderilor mici şi mijlocii şi îmbunătăţirea mediului de afaceri din România – orizont 2020	Encouraging technology transfer Developing a support system for innovation at national level Encouraging the technical-economic cooperation of SMEs with large enterprises, especially in the field of technological and commercial innovation Supporting the exploitation of the competitive advantages of SMEs with extensive development potential and promoting the advantages of obtaining the intellectual / industrial / commercial property right Supporting the connection of SMEs to RDI networks Supporting the activity of scientific research, technological development and innovation in the field of energy. developing public-private partnerships with the energy industry, following best practices. Developing the capacity to attract and use the sources of funding for scientific research, through participation in international consortia, as well as in European and international programs and projects.	Romanian Government Guvernul României – Departamentul pentru IMM-uri, mediu de afaceri și turism
NS for Energy 2016-2030 Strategia Energetică a României 2016-2030, cu perspectiva anului 2050	Supporting the activity of scientific research, technological development and innovation in the field of energy. developing public-private partnerships with the energy industry, following best practices. Developing the capacity to attract and use the sources of funding for scientific research, through participation in international consortia, as well as in European and international programs and projects.	Ministry of Energy Ministerul Energiei
NS regarding the climate change SN a României privind schimbările climatice 2013-2020	Supporting climate change research and creation of a national climate change database	Ministry of Enviroment (Ministerul Mediului)
Fiscal Code Codul Fiscal	(Attracting, maintaining and developing in Romania the highly qualified human resource for carrying out the research-application development and / or technological development activity, as well as for strengthening the research-development system in order to increase the competitiveness of the Romanian economy) The income from the salaries and assimilated to the salaries obtained by the natural persons active in the field of	Ministry of Finance Ministerul Finanțelor

	research and development are exempted from the payment of the income tax. (OUG 32/2016). Exemption from the payment of the tax on the profit of the companies that exclusively carry out the activity of innovation, research and development - Government Emergency Ordinance no. 3/2017 for amending and supplementing Law no. 227/2015 regarding the Fiscal Code, published in the Official Gazette, Part I, no. 16 of January 6, 2017)	

APPENDIX 5. SNCDI 2020. Target indicators

	Valoare de bază (an 2011)	Ţinta 2017	Ţinta 2020
Premise			
Cheltuieli publice cu cercetarea-dezvoltarea (% din PIB)	0,31	0,63	1,0
Număr absolvenţi de doctorat la 1.000 locuitori, cu vârsta de 25-34 ani	1,4	1,5	1,5
Număr de cercetători în sector public (echivalent normă întreagă)	12.409	15.000	17.000
Publicaţii ştiinţifice în top 10% dintre cele mai citate publicaţii din lume (% din totalul publicaţiilor ştiinţifice la nivelul ţării)	3,8	5	7
Co-publicaţii ştiinţifice internaţionale la 1 mil. locuitori	148	200	300
Capital de risc (% din PIB)	0,033	0,06	0,09
Antrenarea sectorului privat			
Cheltuielile de cercetare-dezvoltare ale sectorului de afaceri (% din PIB)	0,17	0,6	1,0
Număr de cercetători în sector privat (echivalent normă întreagă)	3.518	7.000	14.500
Co-publicaţii public-privat (nr./1 milion locuitori)	8,3	12	16
IMM inovative care colaborează cu alţii (%)	2,93	3,5	6
Aplicaţii brevete EPO (nr./an)	40	80	120
Aplicaţii brevete USTPO (nr./an)	17	30	60
Aplicaţii mărci comerciale comunitare (nr./1 mld. euro PIB ajustat la paritatea puterii de cumpărare)	2,14	3	4
Impact economic			
Firme inovative cu creştere rapidă (nr.)	-	50	150
IMM care introduc produse sau servicii inovative(%)	13,17	16	20
Venituri din licenţe şi brevete din străinătate (% din PIB)	0,13	0,15	0,17

APPENDIX 6. Number of CD units over 1995-2017 period (source INS, 2019, tempo online)

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2003	2004	2005
Total	617	591	615	616	645	643	626	601	609	719	753	806
Public sector	157	139	161	161	149	150	153	162	185	206	199	209
Government sector	120	105	120	122	109	114	109	110	116	120	120	124
HES	37	34	41	39	40	36	44	52	69	86	79	85
Private sector	460	452	454	455	496	493	473	439	424	513	554	597
Business sector	460	452	454	455	496	493	473	439	424	488	523	563
Private non-profit sector	:	:	:	:	:	:	:	:	:	25	31	34

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Total	884	787	775	667	660	1166	970	920	773	781	792	713
Public sector	285	251	267	231	231	268	269	273	286	298	293	276
Government sector	177	165	164	134	129	177	174	186	192	204	200	190
HES	108	86	103	97	102	91	95	87	94	94	93	86
Private sector	599	536	508	436	429	898	701	647	487	483	499	437
Business sector	559	506	491	426	410	884	683	623	460	462	476	414
Private non-profit sector	40	30	17	10	19	14	18	24	27	21	23	23

APPENDIX 7. Number of total/open access ISI, SCOPUS worldwide and Romanian publications

Years	ISI Publications	OA	%OA	ISI Romanian	OA Romanian	%OA Romanian
2018	2.338.776	652.348	27,89%	9.821	2.907	29,60%
2017	2.279.672	674.271	29,58%	9.694	2.643	27,26%
2016	2.240.798	648.151	28,93%	9.860	2.314	23,47%
2015	2.151.032	596.543	27,73%	9.918	2.106	21,23%
2014	2.089.917	551.292	26,38%	9.131	1.975	21,63%
2013	2.036.389	514.417	25,26%	9.893	1.891	19,11%
2012	1.943.011	469.367	24,16%	8.740	1.614	18,47%
2011	1.861.376	422.796	22,71%	8.242	1.261	15,30%
2010	1.782.781	383.188	21,49%	8.608	1.152	13,38%
2009	1.736.269	350.471	20,19%	7.738	937	12,11%
2008	1.663.250	310.880	18,69%	6.504	804	12,36%
2007	1.575.007	261.806	16,62%	4.955	488	9,85%
2006	1.503.455	224.466	14,93%	3.601	383	10,64%
2005	1.438.101	204.222	14,20%	3.003	314	10,46%
2004	1.358.512	188.106	13,85%	2.690	241	8,96%
2003	1.270.546	164.645	12,96%	2.517	183	7,27%
2002	1.235.948	137.595	11,13%	2.427	142	5,85%
2001	1.192.289	134.725	11,30%	2.156	146	6,77%
2000	1.206.412	124.763	10,34%	2.111	158	7,48%
Total	32.903.541	7.014.052	21,32%	121.609	21.659	17,81%

Years	SCOPUS Publications	OA	%OA	Romanian	OA Romanian	%OA Romanian
2018	3.151.299	779.785	24,74%	15.997	4.407	27,55%
2017	3.098.431	729.628	23,55%	16.453	4.491	27,30%
2016	2.964.247	659.482	22,25%	15.450	2.893	18,72%
2015	2.878.864	602.781	20,94%	15.503	2.451	15,81%
2014	2.915.469	545.377	18,71%	15.178	2.091	13,78%
2013	2.861.256	480.477	16,79%	15.453	1.934	12,52%
2012	2.748.115	428.230	15,58%	14.618	1.775	12,14%
2011	2.620.454	373.790	14,26%	13.689	1.240	9,06%
2010	2.459.511	314.289	12,78%	13.358	933	6,98%
2009	2.338.241	287.962	12,32%	11.454	722	6,30%
2008	2.228.259	254.756	11,43%	9.051	561	6,20%
2007	2.132.849	219.577	10,30%	6.746	388	5,75%

2006	2.003.260	205.139	10,24%	5.006	295	5,89%
2005	1.914.310	182.428	9,53%	4.743	223	4,70%
2004	1.685.195	162.824	9,66%	3.918	197	5,03%
2003	1.569.977	146.183	9,31%	3.818	181	4,74%
2002	1.487.694	130.242	8,75%	3.325	136	4,09%
2001	1.418.717	120.195	8,47%	3.174	122	3,84%
2000	1.308.935	105.359	8,05%	3.114	103	3,31%
Total	**43.785.083**	**6.728.504**	**15,37 %**	**190.048**	**25.143**	**13,23%**

APPENDIX 8. Top 10 Romanian institutions with the highest publication/ patenting activity , 2005 – 2014

Rank	Institution	City	Number of papers
1	Polytechnic University of Bucharest	Bucharest	7,115
2	University of Bucharest	Bucharest	6,605
3	Babes Bolyai University from Cluj	Cluj-Napoca	6,440
4	Romanian Academy of Sciences	Bucharest	5,195
5	Alexandru Ioan Cuza University	Iasi	3,943
6	GH Asachi Technical University	Iasi	3,119
7	Horia Hulubei National Institute of Physics & Nuclear Engineering	Magurele	2,990
8	Iuliu Hatieganu University of Medicine & Pharmacy	Cluj-Napoca	2,593
9	Carol Davila University of Medicine & Pharmacy	Bucharest	2,451
10	Grigore T Popa University of Medicine & Pharmacy	Iasi	2,310

Source: Thomson Reuters (2015), Bibliometric Analysis of Romania's Research Output, 2005-2014 (funded by UEFISCDI)

Source: Thomson Reuters IP Analytics, (2015): Romanian Research Output: IP Analysis (funded for UEFISCDI)

	Organisation	Number of patents
1	UNIV SUCEAVA STEFAN CEL MARE	328
2	UNIV BRASOV TRANSILVANIA	141
3	INST NAT CERC DEZVOLTARE ELECTROCHIMIE	111
4	CONTINENTAL TEVES & CO OHG AG	111
5	UNIV IASI TEHNICA ASACHI GHEORGHE	110
6	INST NAT CERC DEZVOLTARE MASINI INSTALAT	107
7	UNIV CLUJ-NAPOCA TEHNICA	100
8	UNIV POLITEHNICA DIN BUCURESTI	90
9	INST NAT CERC DEZVOLTARE FIZICA TEHNICA	92
10	INST NAT CERC DEZVOLTARE CHIM FARM	88

Appendix 9 Number of projects funded by PN3 programmes included in the Mid Term Evaluation SNCDI

denumire instrument	total	D1 Bioeconomie	D2 TiC, spatiu, securitate	D3 - Energie, mediu shimbari climatice	D4 - Econano tehnologii si materiale avansate	D5 Sanatate	D6 Patrimoniu, identitate culturala
BG	126	33	27	24	20	19	3
PED	252	48	59	44	48	46	7
PTE	57	12	15	11	15	3	1
Cecuri inovare 2017	147	54	33	29	21	6	4
TOTAL	**582**	**147**	**134**	**108**	**104**	**74**	**15**

Source: Mid Term Evaluation

APPENDIX 10. Match S2 regional/national smart specialisation domains

National	Bio economy	ICT, space, security	Energy, environment, climate change	Eco-nano technologies and advanced materials	Health
1.N-W region[248]					
Agro-food, cosmetics and supplements	x				x
Industry of metals		x	x	x	
Furniture			x	x	
Health					
Paper, plastic	x			x	
Production technologies				x	
ICT		x	x		
2.N-E Region[249]					
Agro-food	x			x	
Bio-technologies	x				
ICT (big data, eHealth, smart cities etc)		x	x		
Energy and environment			x		
Apparel &textile				x	
Health & Tourism	x				x
3.CENTER[250]					
Automotive and mechatronics			x	x	
Aeronautic industry		x		x	
Agro-food	x			x	x
Textile and leather		x		x	
Sustainable construction	x		x	x	
Forestry, wood and furniture	x		x	x	
IT and creative industries		x			
Pharmaceutical industry and health	x			x	x
Balneal tourism	x		x		x
4.South East[251]					
Maritime engineering and transportation			x	x	
Apparel &textile				x	
Agro-food and fishery	x		x		

[248] http://www.nord-vest.ro/s3/
[249] http://adrnordest.ro/user/file/news/17/RIS3_Nord-Est_05_12_2017.pdf
[250] http://www.adrcentru.ro/Document_Files/StrategiaSpecializareInteligenta/00002531/vbp08_1.RIS3_sep_2017.pdf
[251] http://www.adrse.ro/Documente/Planificare/Comunicat_presa_Strategia_Specializare_Inteligenta_Regiunea_SE.pdf

Biotechnologies	x		x		
Eco-technologies			x	x	
Tourism					x
ICT		x			
5. South Muntenia[252]					
Construction of vehicles,			x	x	
Agriculture and food	x				
Tourism and cultural	x				
Bio economy	x		x		
Smart cities			x	x	
High technology products					
6. West					
Automotive industry				x	
Agro food	x				
Construction			x		
ICT		x			
Textile	x				
Tourism	x				x
7. South West Oltenia					
Industrial engineering and	x	x	x	x	
Energy and environment	x	x	x		
Innovative medicine	x	x	x		x
Agriculture and food	x	x	x		
Tourism and cultural heritage		x	x		

[252] http://www.adrmuntenia.ro/strategia-pentru-specializare-inteligenta-a-regiunii-sud-muntenia-pentru-perioad/static/892