Comparative Analysis of Technology Transfer Supply in North-East and North-West Romania

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I. INTRODUCTION AND SCOPE

A European Parliament Preparatory Action (EPPA) centred on enhancing the competitive advantage and the potential for smart specialisation at regional level in Romania was launched in 2016. The project is implemented by the Territorial Development Unit of the European Commission's Joint Research Centre (JRC), in close cooperation with DG REGIO and the regional development agencies of North East and North West Romania, with the support of selected independent experts.

In line with the objectives of the Preparatory Action, support is provided to elaborate and implement the Regional Smart Specialisation Strategy in North-East and North-West Romania with a focus, among others, on supporting the regions in assessing their potential for technology transfer.

This report, building on the evidence provided through [1] and [2], aims to compare the degree of sophistication of the technology transfer approach of the regional higher education institutions and public research organisations in both regions, to quantify the inputs and outputs of ongoing technology transfer processes, and finally, to explain any differences in the enablers, or in the approaches, or in the outputs.

II. METHODOLOGY

According to [3], technology transfer takes place in channels of interaction between research/academia and other stakeholders (firms, public administration, individuals and the society as a whole). Knowledge can be produced, mediated, reproduced, acquired, and transformed in and between the different forms through these channels. The channels themselves can be direct or indirect/mediated. A typical (but not exhaustive) classification of channels includes networks (both formal-between organisations and informal-between individuals), continuous professional development, consultancy, collaborative research, licensing, spin-offs and teaching. Figure 1 describes the typology of knowledge that stems from research, the channels and the beneficiaries of the technology transfer process.

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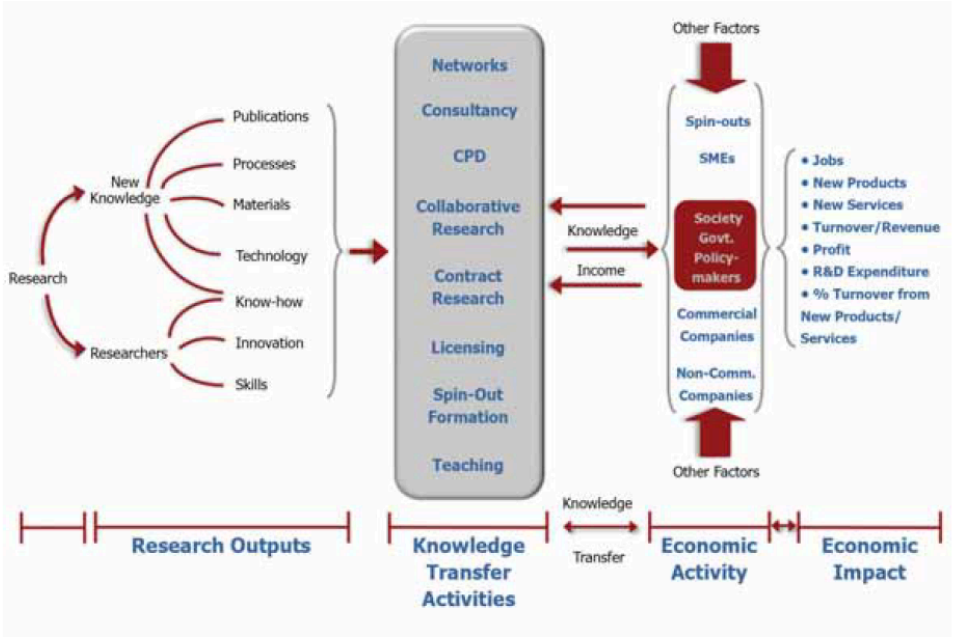

FIGURE 1 MODEL OF TECHNOLOGY TRANSFER WITHIN THE INNOVATION ECOSYSTEM (SOURCE: [4]).

To assess the potential of the supply-side for technology transfer in North West Romania we used the model by Rothaermel *et al*. [5] shown in **Error! Reference source not found.** as the underlying framework of analysis.

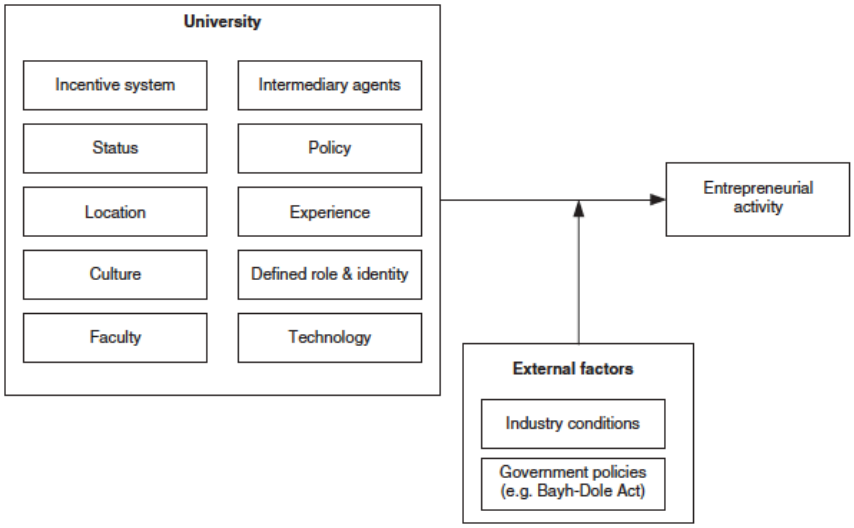

FIGURE 2 THE FRAMEWORK OF ANALYSIS FOR THE SUPPLY-SIDE OF TECHNOLOGY TRANSFER.

This report focuses on quantifying and assessing the supply of HEI/PRO generated knowledge in North-East and North-West Romania and the channels used to diffuse it outside of the research actors. To that end, the following objectives and methodological instruments have been defined:

Objective	*Methodological approach*
1. Identification of regional suppliers of knowledge (HEIs/PROs)	Desk research, data provided by the Regional Development Agencies and data fusion from bibliographical databases (see objective 2).
2. Quantification of the knowledge production by the HEIs/PROs in the region	Bibliometric analysis based on Thompson/Reuters Web of Science data for the period 2012-2016. Measurement and analysis were performed both at the country and at the regional level by searching the database ADDRESS field for all publications with an author from Romania and

	by specifying the county capital cities (i.e., Cluj-Napoca, Oradea, Baia Mare, Iasi, Bacau, Suceava, etc.) respectively. The database RESEARCH AREA field was used to calculate regional scientific specialisation by calculating location quotients and normalising them using the function $n(x) = (x\text{-}1)/(x+1)$. With this selection of the normalisation function, a value of 0 means that the regional location quotient is equal to the national one, values around 0.25 indicate that the regional location quotient is 50% stronger than the national one and values below 0 indicate weaker location quotients.
3. Quantification of the patenting activity by the regional HEI/PROs	Patent search in the European Patent Office database for all patent families having as applicant at least one of the HEI/PROs identified in steps 1 and 2 above and having priority date from 1.1.2007 until 31.12.2016. Data analysis on the extracted record set including descriptive statistics.
4. Assessment of the technology transfer approach and outcomes of the regional suppliers of knowledge and technology (HEIs & PROs)	A questionnaire encompassing two research instruments designed for this purpose, one looking at HEI/PRO approach and another, which was based on [3] aiming to quantify outcomes, was administered, in English and Romanian, through a web survey. The survey collected information on: • Institutional policies on technology transfer and research commercialisation, management of intellectual property rights, balancing stakeholders' interests, incentive systems for faculty and departments, engagement with industry, establishment of spin-offs. • Age, size and maturity of technology transfer offices operating within HEI/PROs. • Scale and intensity of technology transfer interactions with industry in terms of contract research, collaborative research, consulting services and establishment of spin-off companies. • Existing stock of intellectual property rights owned by HEIs and PROs. • HEI/PRO revenues from licensing intellectual property rights.
5. Scale and performance of intermediary agents for technology transfer	A separate research instrument was developed to collect data from intermediate institutions (Technology Transfer or Information Centres, Science Parks) that do not operate within HEI/PROs. Collected data include the type of intermediary institution, the legal framework under which they operate, their age, staff and the expertise and service mix and their contribution to technology transfer from HEI/PROs.
6. Structure of the regional economies.	Official structural business statistics from INSSE, the national Romanian statistics authority for both regions and Romania. Key variables: number of units, employment, turnover. Same approach to calculate regional specialisations as in point 2 above.

III. RESULTS AND DISCUSSION

III.A THE NATIONAL CONTEXT

The public RDI system in Romania consists primarily of national R&D institutes, institutes of the Romanian Academy and branch academies, and universities, which focus on different types of activities, as follows:

- National R&D institutes (NRDIs) carry out activities defined under the broader heading of 'research and development'. There are currently 45 such organisations, of which 43 are coordinated by the Ministry of Research and Innovation (MRI), one by the Ministry of Communications and Information Society, and one by the Ministry of Agriculture and Rural Development[1];

[1] See http://www.research.gov.ro/ro/articol/4514/sistemul-de-cercetare-institute-na-ionale-de-cercetare-dezvoltare-in-coordonare

- The institutes and research centres of the Romanian Academy (RA) carry out activities defined under the broader heading of 'fundamental research', mostly in social sciences and humanities. There are currently 60 institutes and research centres within the Romanian Academy. Branch academies include the Academy of Agricultural Sciences and Forestry (ASAS), which coordinates 4 research institutes, 13 branch institutes, 45 agricultural R&D stations across the country, as well as 3 private research institutes[2], and the Academy of Health Sciences, which, according to its statute (art.19), has several medical research structures in institutes and hospitals[3] .
- Universities, both public and private, have rapidly increased in number since the early 1990s. There are currently 102 accredited higher education institutions (HEIs), including 55 public (48 universities and 7 military higher education institutions), and 47 private ones[4]. Public universities lead in both student enrolments and research production, and are the only ones to enjoy institutional public funding. However, universities are comparatively new players in RDI and have been struggling to adapt to this new section of their mission after 1990. Their ties to industry, although gradually increasing in some aspects, remain weak overall. R&D activities in academia are rather irregular, depending only on project-based funding and on faculty's publishing efforts. Only 'teaching duties' are clearly defined for individual faculty in virtually all Romanian academia, so 'research duties' are more informally set at 25% of the former. For this reason, in official statistics the number of researchers in universities is estimated simply as the equivalent of 25% of all academic staff.

Technology transfer activities undertaken by public bodies in Romania are regulated by Ordinance 57/16.8.2002[5] (Art. 13 and a few others) and the National Education Law 1/2001 (Articles 117 and 131), which specifically includes knowledge transfer in the mission of higher education institutions (HEIs). National policies for technology transfer and innovation are under the responsibility of the Ministry of Research and Innovation, through its specific Directorate General for Innovation and Technology Transfer. The Ministry of Research and Innovation is also in charge of the accreditation of ITT entities, according to a specific procedure.

In 2003, Government Ordinance 406/2003 introduced specific methodological norms for the setup and operation of four specific types of innovation and technology transfer (ITT) infrastructure entities, namely:

- Technology transfer centres
- Technology information centres
- Technology and business incubators
- Liaison offices with industry

One year later, the National Programme INFRATECH "Development of the infrastructure for innovation and technological transfer" was approved through Government Ordinance 128/2004 as an instrument to support the setup and operation of ITT entities (technology transfer centres, technology information centres, technology and business incubators, liaison offices with industry, technology clusters and brokers, and S&T Parks) by a multiannual funding mechanism for the period 2004-2007. It was structured in two sub-programmes, one for the establishment and development of technology transfer centres, technology information centres, industry liaison offices and the like; and one for the establishment and development of S&T Parks and technology and business incubators.

The INFRATECH programme allowed the co-financing (50%) of two types of projects:

a. Institutional building projects that supported the procurement of goods, services and endowments by the technology transfer entity in order to increase its capacity to develop specific technology services;
b. Technological services projects, which supported specific activities of the technology transfer entity, except for S&T Parks, for the purpose of carrying out specialised services.

After the end of the INFRATECH Programme, technology transfer projects have been supported at the national level by the National RDI Plans (PN II 2007-2013, PNIII 2015-2020). Currently, there are 44 ITT entities in Romania (40 accredited and 4 provisionally accredited), which, together with 4 S&T Parks, constitute the *National Network for Technology Transfer and Innovation RENITT*. The network provides different types of specialized services to public and private customers, including:

[2] http://www.asas.ro/wcmqs/academia/despre+noi+-+02+academia+astazi.html
[3] http://www.adsm.ro/media/dms/STATUTUL%20ASM-2004.pdf
[4] https://blog.jorjette.ro/lista-facultati-acreditate/
[5] https://lege5.ro/Gratuit/gm4tioby/ordonanta-nr-57-2002-privind-cercetarea-stiintifica-si-dezvoltarea-tehnologica/5

- assistance for innovation and technology transfer activities, development of experimental models and prototypes, exploitation of intellectual property rights;
- technology information, technology audit, technology forecasting;
- legal advice on legislation at national, European and international level;
- physical or virtual incubation for innovative SMEs.

III.B The Regional Context

III.B.i Tertiary Education

Both Regions have a strong endowment of Higher Education Institutions (HEIs): in 2016, of the 97 HEIs in Romania (56 public/405 faculties, 41 private/155 faculties), 15 were operating in NW (7 public/70 faculties, 8 private/21 faculties) and 12 in NE (7 public/55 faculties, 5 private/11 faculties)[6].

The structure of tertiary education is rather similar, and consists of a top-tier, multi-discipline public HEI (Babes-Bolyai in NW, Al. I. Cuza in NE), a technical university (Cluj-Napoca in NW, Iasi in NE), a university of medicine/pharmacy/dentistry (Cluj-Napoca in NW, Iasi in NE), an agricultural/veterinary university (Cluj-Napoca in NW, Iasi in NE) and several peripheral public universities (e.g., Oradea in NW, Suceava and Bacau in NE).

Regarding student population, in 2016, of the 405 638 students enrolled in bachelor studies in Romania, 70 632 were in NW and 51 134 in NE. The same figures for Masters programmes were 106 794, 17 155 and 13 495, and for PhD programmes 19 154, 3 583 and 2 301, respectively[7].

From a technology transfer perspective, the number of graduates that actually stay and work in the region and become agents for knowledge spill-overs to the society as a whole would be a key variable to monitor. There is no evidence to suggest that regional HEIs track the career paths of their graduates and this, in conjunction with the nation-wide enrolment in the regional HEIs, cannot lead to any estimation of spill-over effects from graduates. An on-going, nation-wide effort to track employment prospects of graduates focuses only on the bachelor degrees[8] and does not track the flow of graduates among development regions.

III.B.ii Public-Sector Research Organisations

In addition to HEIs, there is a strong presence of public-sector research organisations (PROs) in both regions that can be:

(i) either national institutes of research and development located in these regions or subsidiaries of such of institutes headquartered in Bucharest. The first category includes the National Institute for Research and Development of Isotopic and Molecular Technologies (INCDTIM) of Cluj-Napoca (NW) and the National Institute for Research and Development for Technical Physics (INCDTP) of Iasi (NE). The second category includes several branches of National Institutes such as INCDSB (biological sciences), INCERC (construction and building economics), INCD-INOE2000 (analytical instrumentation), IGR (geology and geophysics) and INMA (machinery for agriculture and food industries) in NW and the Institute of Macromolecular Chemistry "Petru Poni" in NE.

(ii) regional branches of the Romanian Academy, which comprise 11 institutes or units in NE and six in NW.

III.B.iii Regional R&D Profiles

A record-set of the scientific publications at a level of geographical granulation can be used to measure the relative weight of a region, the output of researchers, or the dynamics of a scientific field or an institutional sector. Comparisons between regions can also be based on disciplines and regional specialisations can be calculated versus a higher geographical granule (e.g., universities in a region, region in a country) [6]. For the purposes of our analysis, we consider the top-15 research areas by number of publications as an indicator for the existence of a critical mass of researchers working on these research areas within a territorial unit of analysis. Moreover, calculating the regional specialisations helps identify the research areas which, through policy choice or investment or contextual factors, have managed to produce more scientific output than the national average. Our analysis of Thomson/Reuters Web of Science data indicates that

[6] INSSE, Tempo database, tables SCL101A and SCL101E.
[7] ibid, table SCL103H.
[8] See http://www.absolvent-univ.ro/UserFiles/File/rezultate/domeniu%202010.pdf

- In North-East, the top-15 research areas by number of publications were Chemistry, Engineering, Materials Science, Physics, Mathematics, Environmental Sciences-Ecology, Pharmacology-Pharmacy, Biochemistry-Molecular Biology, Polymer Science, Spectroscopy, Computer Science, Crystallography and Agriculture. The top-5 regional research specialisations when compared to Romania were Polymer Science, Crystallography, Urology-Nephrology, Water Resources and Life Sciences [1].
- In North-West the top-15 research areas by number of publications were Chemistry, Mathematics, Physics, Engineering, Materials Science, Environmental Sciences-Ecology, Other Topics in Science & Technology, History, Area Studies, Psychology, Oncology, Pharmacology & Pharmacy and Computer Science, while the top-5 regional research specialisations were History, Area Studies, Psychology, Oncology and Mechanics [2].

Figure 3 presents the normalised location quotients for the 37 research areas with the largest number of publications at the country level in decreasing order. Overall, with the exception of Polymer Science, North-East seems to match the national research profile in terms of publications in the first 15 research areas, while NW seems to be more specialized in social sciences and humanities, medicine (oncology, radiology) and agricultural and veterinary sciences.

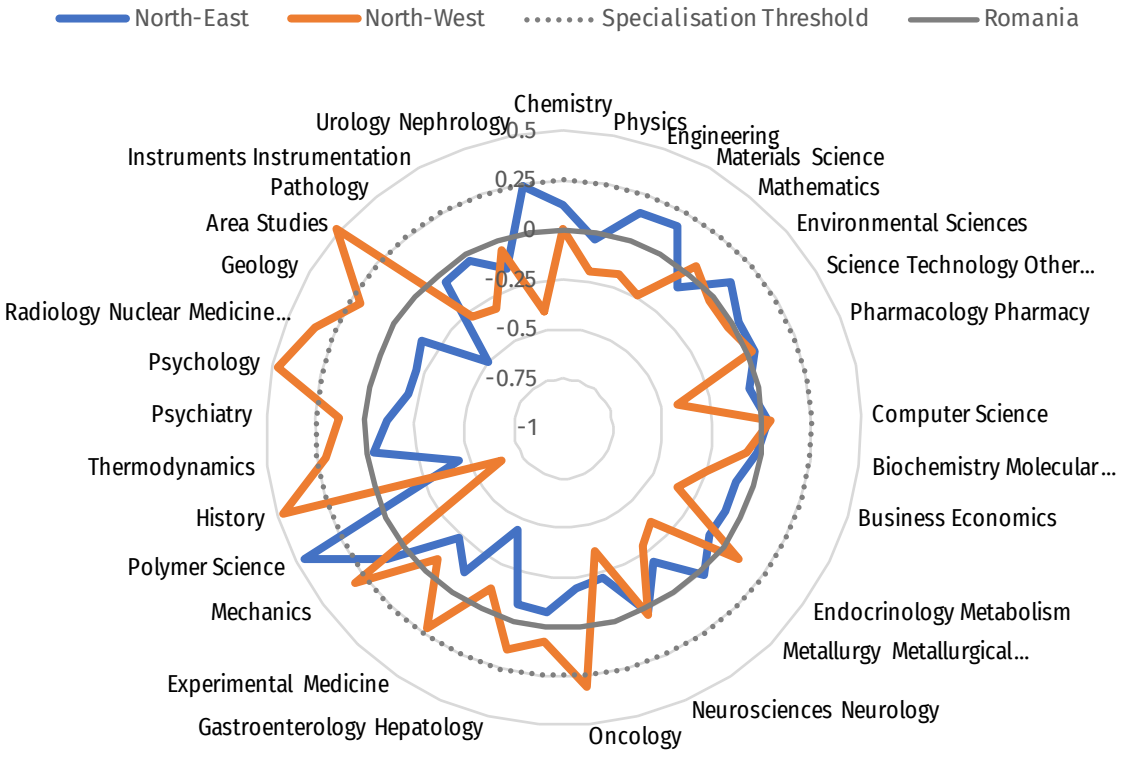

FIGURE 3 REGIONAL RESEARCH PUBLICATION SPECIALISATIONS.

Table 1 presents 3-year trends in three key R&D lead indicators. It is noteworthy that the aggregate number of researchers in HEI and GOV sectors has increased in both regions while R&D expenditure has decreased in both sectors, especially in the North-West. A considerable fluctuation in the number of researchers in the business/enterprise sector is also noticed for both regions, which, if seen together with the R&D spending of this sector can lead to the conclusion that research performance is probably tied to funding from abroad (see Table 3 in [7]).

TABLE 1 TRENDS IN KEY R&D INDICATORS

Indicator	*Sector*	*Geo*	*2012*	*2013*	*2014*
Researchers by sector of performance (Researchers; Headcount)	HEI	NE	2 454	2 487	2 585
		NW	1 269	1 175	1 409
	GOV	NE	494	481	510
		NW	490	493	454
	BES	NE	324	404	237
		NW	545	278	399
Researchers by sector of performance (Researchers; Full time equivalents)	HEI	NE	940	976	1 048
		NW	616	581	777
	GOV	NE	462	451	481
		NW	424	408	362
	BES	NE	265	348	201
		NW	502	238	302
Total intramural R&D expenditure (GERD) by sectors of performance (Percentage of GDP)	HEI	NE	0.13	0.09	0.10
		NW	0.22	0.20	0.12
	GOV	NE	0.17	0.13	0.12
		NW	0.10	0.07	0.06
	BES	NE	0.10	0.08	0.06
		NW	0.13	0.05	0.09

Source: EUROSTAT (updated 20.11.2017).

III.B.iv Technology Transfer Intermediaries

In 2003, Government Ordinance 406/2003 introduced specific methodological norms for the setup and operation of four specific types of innovation and technology transfer (ITT) infrastructure entities, namely technology transfer centres, technology information centres, technology and business incubators and liaison offices with industry. Currently, there are 44 ITT entities in Romania (40 accredited and 4 provisionally accredited), which, together with 4 S&T Parks, constitute the *National Network for Technology Transfer and Innovation RENITT*.

The North–West region hosts 3 technology transfer centres (two operated by HEI/PROs; one privately-held), 2 technology information centres (operated by a HEI and a PRO), and two S&T Parks (one public-sector held and one private). The North-East region hosts an accredited technology information centre operated by the Chamber of Commerce and Industry of Bacau and a S&T Park in Iasi. Our surveys suggest that all ITT infrastructures that are not operated by HEIs or PROs do not play any role in commercialising the outputs of public research.

III.B.v Structure of the Regional Economies

The business structure in North-East is dominated by manufacturing, wholesale and retail trade, construction and transportation-storage. Manufacturing is concentrated on low-skill, low-tech sectors including textiles, food, wood and metal products. Machinery and equipment is the only high-intermediate tech subsector in the region. For the services sector, telecommunications and computing (both high-skills), high tech and real estate, and professional, scientific and technical services (high skills) are the most important subsectors.

The business structure in North-West is dominated by manufacturing, wholesale and retail trade (Low Intermediate skill), construction, transportation and storage. Manufacturing is concentrated on low-skill, low-tech sectors including food, textiles, and wood, leather, and rubber, plastic and metal products. Only the manufacture of motor vehicles within the region can be considered as high intermediate tech. For the services sector, telecommunications and computer programming and related activities which are high-skill/high-tech sectors, while other dominant high-skill sub sectors include real estate, architectural and engineering activities and management consultancy.

The Romanian Cluster Association (RCA) reports that there are four clusters operating in North-East: NewMedia Iasi (est. 2012), the Innovative Regional Molecular and Structural Nuclear Imaging Cluster

(IMAGO-MOL) also in Iasi (est. 2012), the Astrico North-East Cluster working on textiles (est. 2010) and the Tourism Regional Cluster/Bucovina Tourism Association in Suceava (est. 2001). In North-West, five clusters are registered with the RCA, all in Cluj-Napoca: ClujIT (est. 2012), Polaris (also on ICT, est. 2012), Transylvanian Furniture Cluster (est. 2012), iTechSylvania (est. 2012) and AgroTransilvania.
The National Statistics Office reports that in 2014, 444 of Romania's 3645 innovative companies were located in North-East Romania and 401 in North-West. Of the 444 in NE, 308 were small, 299 in industry and 145 in the service sector. The same for NW were 257, 199 and 202, respectively.

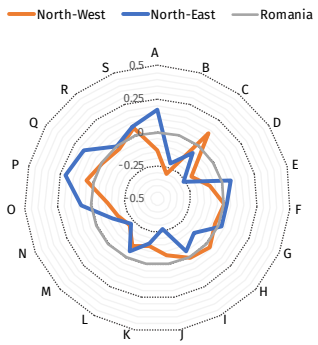

FIGURE 4 NORMALISED LOCATION QUOTIENTS; EMPLOYMENT PER NACEV2 SECTOR ON 31.12.2016. (SOURCE: INSSE TEMPO DATABASE).

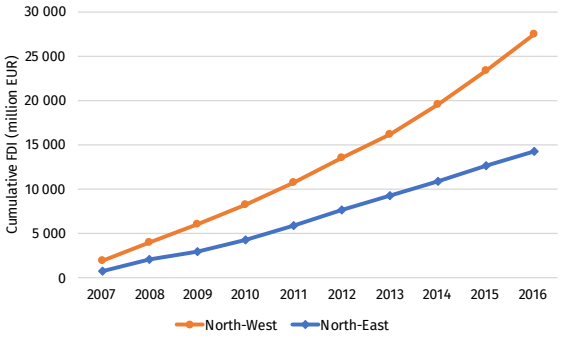

FIGURE 5 CUMULATIVE FOREIGN DIRECT INVESTMENT FLOWS, 2007-16. (SOURCE: NATIONAL BANK OF ROMANIA)

Figure 4 presents the normalised location quotients of employment in all NACEv2 sectors for both regions. It is clear that the share of employment in North-East is stronger than the national share in agriculture (A), public administration (O), education (P) and health (Q), while in North-West manufacturing (C) has the most prominent share of employment, followed to a lesser degree by Hotels/Restaurants (H) and education (P). The strong share of manufacturing jobs in North-West can be attributed to considerably larger foreign direct investments during the last decade in the region, as shown in Figure 5, which has built a considerable and still expanding € 13.2 billion gap in favour of North-West. The reasons for NW being more attractive to FDI have to do among others, with its proximity to central European markets and also the availability of better infrastructure.

III.B.vi Institutional Approaches to Technology Transfer

The first group of questions in our survey aimed to understand the organisations' approach to technology transfer, how it is operationalised and a self-assessment of the effectiveness of this approach.

In North-East, two out of four respondents (50%) reported that they have an explicit technology transfer approach, mentioned in the organisation's mission statement. In North-West five out of nine organisations (55.5%) reported the same. However, the descriptions provided in North-West suggest more of certain aspirations to engage with industry rather than actual ways of achieving that engagement, and unilateral knowledge flows at various geographic levels. Only one respondent explicitly mentioned technology transfer as a source of revenue to further support R&D activities.

Irrespective of the existence (or the completeness) of a technology transfer approach, the survey also aimed to investigate whether the institutions have some common elements in their technology transfer approach. Table 2 summarises the answers from both regions. As expected, the rules for collaboration with the industry and contract research is one of the first issues that have to be set before anything else, and this is verified by the responses in both regions. On the other hand, rules for spin-off creation and for sharing royalty revenues with inventors have not been fully deployed in both regions yet. This absence of rules might be explained by the lack so far of a specific case that would trigger such a discussion and decision-making among the HEI/PRO administration. On the other hand, it could also be seen from the opposite sense, as one factor that prevented the emergence of a specific case of spin-off creation of royalty sharing, or in other words, as an organisational barrier to entrepreneurial faculty members that might otherwise consider starting a spin-off or patent a research outcome having commercial value.

TABLE 2: ATTRIBUTES OF TECHNOLOGY TRANSFER THAT HAVE BEEN ADDRESSED BY HEI/PROS

Attribute of TT Policy that has been addressed	*North-East* *(2 HEI, 2 PRO)*	*North-West* *(5 HEI, 4 PRO)*
Ownership of inventions and supportive technologies	75%	66%
Use of the institution's name and logo	75%	55%
Ownership of copyrights (publications, software, online courses)	75%	55%
Conflict of commitment and outside professional activities by faculty	25%	44%
Open access to research	75%	77%
Revenue sharing with inventors	50%	11%
Spin-off creation & institutional involvement (e.g., equity vs licensing)	50%	11%
Collaboration with industry and contract research	100%	89%

To assess the degree of development and deployment of key processes required to deliver technology transfer outcomes, we asked the organisations if a minimum set of TT-related processes are in place and which organisational unit is responsible for them. Table 3 summarises their responses. With the exception of invention disclosure, all the remaining processes that lead to patent applications seem to be in place, usually carried out through a TTO. The low degree of deployment of drafting equity sharing agreements (which is applicable mainly to spin-offs) is consistent with the responses in Table 2.

TABLE 3 DEPLOYMENT STATISTICS ON KEY TT PROCESSES.

Key process that has been developed and deployed	*North-East* *(2 HEI, 2 PRO)*	*North-West* *(5 HEI, 4 PRO)*
Invention disclosure	75%	55%
Invention assessment	50%	66%
Patent application	50%	66%
Drafting licensing contracts	50%	44%
Drafting equity sharing agreements	50%	0%
Review of joint research contracts	100%	66%
Verification of licencing revenues	75%	33%
Providing information on research outcomes / technologies available for licensing	50%	88%

Almost all of the respondents reported that they provide to any interested party information on opportunities to use research outcomes and technologies available for licensing. In practice, what they provide is unstructured lists of patents without any other navigational aids for search or an indication of the intended business partners.

The annual activity reports seem to be the main vehicle for reporting, among others, their performance in technology transfer. This reporting procedure is regulated by law and the recipient of such reports is the Romanian Ministry of Research and Innovation. A review of four HEI annual reports by the author suggests that the sections on research and technology transfer results are characterised by a lack of a structured approach, very limited adherence to globally accepted indicators and big variability on the details each institution choses to provide. This makes any attempt to benchmark performance virtually impossible.

All the evidence presented above suggests that the regional public-sector knowledge-generating organisations have acknowledged the need for engaging into technology transfer, have transposed it into their latest 5-year development plans and they are active in making it happen. However, it seems that institutions in both regions are still taking their first steps towards developing comprehensive technology transfer policies and in deploying and managing the necessary processes needed to implement them. This, in a context of under-staffed and under-funded public-sector research governed by a legal framework that does not consider technology transfer *outcomes* in the assessment of tenure and promotion, inhibits the potential of otherwise excellent research institutions of becoming the locomotive for the transition of the regional economy towards knowledge-based, high value-added endeavours.

III.B.vii Technology Transfer Performance

Table 4 summarises the aggregate results of two surveys carried out in Spring 2017 in North-East Romania [1, p. 20] and in Autumn 2017 in North-West [2, p. 22]. It should be noted that *these results are not directly*

comparable since the top-tier research university in North-East Romania chose not to participate in the survey and the characteristics of the sample are not similar in both regions. Having this in mind, some qualitative comments can still be made.

TABLE 4 TECHNOLOGY TRANSFER PERFORMANCE INDICATORS. AGGREGATE DATA FOR 2014-2016.

Performance Indicators	*North-East (4 HEI, 2 PRO)*	*North-West (5 HEI, 4 PRO)*
1.1 Number of research agreements	195	1146
with firms in the region	188	849
1.2 Number of collaborative research agreements	93	674
with firms in the region	87	501
1.3 Number of contract research agreements	101	472
with firms in the region	101	348
1.4 Number of consultancy agreements	136	461
with firms in the region	136	286
1.5 Average share of total research expenditure funded by the private sector (%)	8.19	5.79
min/max	[3.18...16.35]	[5.09...6.52]
1.6 Financial value of all research and consultancy agreements (in RON)	14 561 137	49 242 499
with firms in the region	11 095 879	40 382 344
2. Number of invention disclosures received between 2014-2016	155	118
3. Total patent applications filed between 2014-2016	147	104
to the National Office	146	102
to the European Patent Office	1	1
to the USPTO	0	1
4. Total number of new patents granted between 2014-2016	110	59
by the National Office	110	57
by the European Patent Office	0	1
by the USPTO	0	1
5. Total number of licenses executed	3	10
6. Total license income earned (in RON)	0	13 500
7.1 Number of spin-offs established between 2014-2016	0	0
7.2 Number of active spin-offs at the end of 2016	0	0
7.3 Revenues generated from spin-off royalties/profits/equity sales	0	0

The first comment has to do with the intensity of research-industry collaboration (indicators 1.1-1.4 and 1.6) in the two regions. Irrespective of the difference in numbers that can be partially attributed to the sample, it seems that the institutions in NW are more engaged with the industry and also their operation zone exceeds the regional boundaries. Although the higher number of research and consultancy agreements within North-West can be attributed to the considerably higher number of enterprises operating in NW (73860 vs 54132, 8200 vs 6100 in manufacturing in 2015), the out-of-region agreements indicate better relevance of research to industry needs or better promotion of research outcomes in NW.

The average value of all research and consultancy agreements in the reference period (indicator 1.6/(indicator 1.1+indicator 1.4)) is higher in the figures reported from North-East (43 991 RON in NE vs 30 643 RON in NW). In both regions, the range of individual average values calculated per institution is rather wide and the regional average is highly dependent on the number of low performers in the sample.

All the attributes of patenting activity (invention disclosures, patent applications, patents granted) in North-East are better than those in North-West, even if the sample is smaller. As discussed in detail in [1, pp. 12-16], the patenting activity of University of Suceava, the national champion in the number of patent applications to the National Office during the last decade, is the main reason for this. However, after applied the patent quality metrics proposed by OECD ([8], [9, pp. 135-146]), the technological and economic value

of the patent portfolio of the HEI/PROs in both regions was assessed as modest. This assessment is further supported by the evidence regarding the number of licences executed (indicator 5) and the total license income earned (indicator 6), which are low in both regions.

Finally, there seems to be no spin-off activity in both regions (indicators 7.1-7.3). The existence of two spin-off companies was reported in North-East, but they are not counted in the statistics as they don't appear to be genuine spin-offs, since none of them has some type of formal connection to the host organisation through licensing or equity shares.

To put the regional technology transfer performance in perspective, in Table 5 we compare the *per unit* reported indicators from NE and NW Romania for 2014 to those reported from a total of 369 HEI/PROs in Europe (mainly UK, Spain and Italy, but none from Romania) in [10] for the same year. The results are comparable because all three surveys follow the same methodology [3] for data collection and the values reported per indicator are also calculated using the valid answers for each of them.

TABLE 5 TT PERFORMANCE BENCHMARKING: NE AND NW ROMANIA VS EUROPE IN 2014.

Performance Indicators	*North-East (n=6)*	*North-West (n=7)*	*ASPT-PROTON*
1.1 Number of research agreements	10.33	47.57	165.02
1.2 Number of collaborative research agreements	6.16	27.71	40.10
1.3 Number of contract research agreements	4.00	19.86	124.92
1.4 Number of consultancy agreements	5.66	18.57	440.67
1.6 Financial value of all research and consultancy agreements (in EUR)	11 391.31	3 733.00	26 120.00
2. Number of invention disclosures	13.16	5.33	19.31
3. Total patent applications filed	7.00	5.00	11.20
4. Total number of new patents granted	5.50	2.29	7.44
5. Total number of licenses executed	0.00	0.43	68.12
6. Total license income earned (in EUR)	0.00	0.00	n.a.
7.1 Number of spin-offs established	0	0	1.98

Table 5 portrays a significant gap in performance between North-East and North-West Romania and western Europe. The gap is evident in across every dimension. Starting with engagement with the industry, we note that in all attributes except collaborative research agreements the difference is between one (NW) or two (NE) degrees of magnitude. The considerably better performance in collaborative research agreements, which is still below 50% of the European average, is probably driven by the availability of project funding at the national or at the European level. Contract research and consultancy agreements, which are usually funded by firms, are low, being symptoms of either limited relevance to the industry or the prevalence of low-tech industry, or both. North-East's performance in the average value of agreement is noticed, but it might be circumstantial due to the low number of agreements reported.

In terms of patenting activity, North-East leads, being approximately at 66% of the European performance in terms of disclosures, patent applications and patents granted. However, both regions strongly underperform in licensing and in earning income from licensing. Although the ASTP-Proton report for 2014 did not report average licensing revenue per institution, the 2009 one did: it was found to be € 262 300 [11, p. 52].

IV. CONCLUSIONS

The scope of this report was to provide insights regarding the degree of sophistication of the technology transfer-related approaches in public knowledge-generating organisations in two Romanian regions, to quantify the inputs and the outputs of the technology transfer processes in place and finally, to inform the regional smart specialisation strategy and provide the regional stakeholders, the national authorities in Romania, as well as the European Commission with evidence for initiating further actions in order to support technology transfer and technology transfer entities, including those that shall receive financing under Priority Axis 1 of the Regional Operational Programme 2014-2020.

The overarching question in the scope of this report is rather straightforward: *Is there potential, in terms of HEI- and PRO-generated supply, for technology transfer in these two Regions? And if yes, which*

are the policy recommendations that can unleash this potential? In brief, the answer is that both regions have a considerable endowment of knowledge that is relevant for their development. This knowledge has to be unleashed by improving, through policy and appropriate delivery instruments, the exploitation of the knowledge in HEI/PROs for the benefit of the regional economies.

Three key challenges are identified, and they are discussed in conjunction with targeted policy recommendations.

a. How to transform HEI/PRO knowledge into an economic asset for both industry and the institutions themselves? The first step in the right direction will have to deal with the enablers in support of technology transfer. In the ideal approach, the Government would get insights from European or international best practice and carefully adapt them to the national context, thus providing clear rules for ownership of inventions; motives (e.g. promotion and financial criteria) and also conflicts of interest or commitment for public-sector researchers engaging with the industry—including spin-off creation; obtaining equity in spin-offs, providing flexibility for managing revenues from consultancy contracts, licensing and sale of equity stakes. In the absence of government regulation on these, the institutions themselves should consider drafting internal regulations that abide with the law and introducing soft measures (e.g. awards) to stimulate the entrepreneurial attitude of their faculty members. In this attempt, they could benefit from targeted assistance provided by various agencies of the EU, or by collaborating and exchanging best practices at the regional or at the national level.

Mainly the academic and less the research institutions should consider moving from simple, ad hoc contract research or consulting engagements to more relevant, and sometimes interdisciplinary, solutions that would leverage their institutional knowledge bases. This would require a paradigm shift from passive to proactive technology transfer supported by effective TTOs with an improved understanding of the regional enterprise-sector needs and extended interdepartmental cooperation. Given that the supply of mature, close to market IPRs is rather limited and the demand-side has to be educated, support for networks of TTOs to engage in such activities should be of primary importance to the Managing Authorities of all the Operational Programmes that have budgets for thematic objective 1. Such support should be partially *result-oriented*, and results should be monitored using standardised, EU-wide, indicators so that benchmarking can be possible and good performance be rewarded. The key challenge for both the government and the top-tier research universities and centres would be to make a big step forward in areas where no performance is reported (licensing IPR, spin-off creation). Targets need not be audacious: 10% of the reported EU-wide performance would mean one new spin-off every 5 years, 7 licenses of any type and €20 000 of licensing revenue per institution per year. After all, what is the point in investing in technology transfer infrastructure if they cannot achieve these?

The institutions themselves, having have created considerable portfolios of patents that are mostly unexploited, should consider more radical approaches in creating revenues from them. One possibility could be to transfer their rights in bulk, non-exclusive, licenses or options to one or more professional and properly accredited technology brokers for a small fixed fee per patent and a larger share of the income generated if the patent finds its way to the market.

b. How to improve knowledge exchange between academia/research and the industry for mutual benefit? We have seen that so far, the degree of engagement between academia and industry is rather low and all types of research agreements are the dominant channel for technology transfer. Therefore, Managing Authorities should seek to maximise the opportunities for such interactions, mainly in terms of collaborative or contract applied research projects focused on real industry needs. Such projects would harness the inventiveness and knowledge of HEI/PRO researchers for the benefit of the industry and moreover could create new jobs for young researchers to address brain-drain. More valuable and revenue-generating joint patents between HEI/PROs and the industry could also be an outcome of such schemes.

Managing Authorities should also pay special attention in stimulating first-time interactions of firms with HEI/PROs. A well-designed innovation voucher scheme would be the proper instrument here, especially if connected to a competitive approach to solve the firm-reported innovation needs (e.g., by using a platform to match supply and demand). If successful, such short-term, voucher-supported interactions would lead to more long-term ones.

In the framework of OP Human Capital, intersectoral mobility schemes ranging from rather simple to set up summer internships for undergraduate students to a Romanian version of Knowledge Transfer Partnerships and Industrial Master or PhD degrees would help formalize and maintain knowledge spillovers.

The diffusion of innovations and of relevant-to-the industry knowledge produced outside of the region can also be considered to educate by example regional enterprises in low-tech sectors such as agriculture, construction, transportation and tourism. Low-cost demonstration projects focusing on

demonstrating and communicating the benefits of adoption might probably be the most appropriate instrument here, giving a new engagement opportunity to the second-tier HEIs in the region.

Finally, the all regional stakeholders should put their efforts in maintaining the momentum created during the development of the regional smart specialisation strategy and especially the entrepreneurial development process and preserve the social capital and the informal networks that were created during the process.

c. How can the government stimulate technology transfer performance? During 2007 and 2008, the Government-designed accreditation methodology of universities as research units imposed three main indicators (ISI ranked articles, patents and contracts with industry). In addition, the funding methodology of universities introduced patents as one of the main indicators in evaluating (and financing) universities in terms of research. This approach has created some unintended consequences, namely a huge surge in unexploited patents, which, we can assume, was not the target of government policy. Since two of the three evaluation indicators have to do with technology transfer, the author would suggest to reconsider them and start using, after proper notice to the institutions, three alternative indicators:

(a) The total value of all new agreements with enterprises within a year (collaborative and contract research and consulting agreements);

(b) the total income from the same types of agreements per year, and

(c) the total income from licensing, spin-off profits or equity sales.

These three proposed indicators capture the *outcomes* of the technology transfer process and not the lead indicators and therefore are more efficient in motivating and rewarding technology transfer performance. Moreover, since technology transfer is by law part of the mission of higher education, it should be monitored more carefully and the results should be made publicly available. Fiche B2 of the ARACIS database contains a section (B313) entitled "Research Valorisation" that reports data on number of research contracts with various companies in the country and number of patents under protection or intellectual property rights. Clearly, these two are not adequate to monitor technology transfer. If adopted, the set of indicators provided in [3] would be far better and also provide the basis for benchmarking country-level data with international ones. They could be also considered for inclusion as a template in the annual activity reports produced by HEI/PROs. Transparent public ranking of performance always works, and if set-up correctly, it can drive much-needed change.

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