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Academic knowledge commercialization in Romania - a discriminant analysis

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Abstract

In the modern knowledge economy, Higher Education Institutions are being required to operate more entrepreneurially, commercializing the results of their research and spinning out new, knowledge-based enterprises. However, the possibility to engage in entrepreneurial behaviours varies substantially between regions and countries. As a post-communist country, Romania faces numerous constraints in this respect. According to Erawatch Country Report (2010), technology transfer activities from universities to business firms are relatively limited, due to a low demand from industry and also relatively weak offer from universities, but many universities are currently actively involved in strengthening their technology transfer capacity.

This paper explores different patterns of academic knowledge commercialization in 90 Romanian universities, using the data collected by the Romanian Ministry of Education, Research, Youth and Sports in 2011. In this purpose, we have used the discriminant analysis, due to its advantages in both synthesizing a set of variables and expressing the relationships between them.

The discriminant variable by which we divided the universities in groups was the commercial (licensing) income generated by the 90 Romanian universities in 2010. The statistical observation has been carried out on a set of eight variables that were previously standardised using the Z-score technique and tested for normal distributions and homogeneity of variances. The test F for Wilks's Lambda was significant at 0.05 for four of our variables (FTE research staff, research expenditure, patent applications at EPO and new products) and had a Sig. smaller or equal to 0.1 for another four variables (patent applications in Romania, R&D grants with domestic private funding, number of partnerships with private companies and sponsorships).

The first discriminate function accounting for 55,8 of between group variability revealed four significant predictors, of which research expenditure (,811^{*}) was by far the strongest one. The other four predictors were grouped under the second canonical discriminate function. The cross validated classification showed that 58,9% of original grouped cases were correctly classified. Finally, we have grouped the universities by their region of origin and placed them in a 2x2 matrix that reflects their position in relation to the two discriminant functions. Policy implications aimed at improving academic knowledge commercialization at each region's level are further advanced.

Keywords: academic entrepreneurship, knowledge commercialization, discriminant analysis, regional patterns

JEL codes: I2, O3, R58

1. Introduction. The entrepreneurial paradigm today

At the policy level, the commercialization of university research has been viewed as a key driver of national competitiveness and been consequently supported by a range of initiatives to promote the links between universities and industry. This transformation involved the setting up of administrative offices and structures such as Technology Transfer Offices (TTOs) and business incubators, increased financial resources devoted to technology transfer and the promotion of different mix of activities more focused towards spin-offs and the marketing of licenses. The effects of legal changes such as the Bayh-Dole Act in the US, led to a sharp increase in technology transfer activity, as measured by patenting applications and licensing income. However, according to Mowery and Sampat (2005), efforts to emulate the Bayh-Dole Act elsewhere in the OECD countries are likely to have modest success at best without greater attention to the underlying structural differences among the higher education systems of these nations.

Etzkowitz (1983) has coined the phrase “entrepreneurial university” to describe the more active role that universities have in promoting direct transfer of academic research. These changes are bringing about an “academic revolution” in which commercial outputs become the norm rather than an optional side activity (Etzkowitz, 2003). Existing work investigating the features of the entrepreneurial university has primary focused on academic researchers’ engagement in patenting, licensing and academic entrepreneurship (Phan and Siegel, 2006, Rothaermel et al., 2007). According to Siegel et al. (2004), to foster a climate of entrepreneurship, university administrators should focus on organizational and management factors such as: systems for university – industry technology transfer, staffing practices in the TTO, flexible university policies to facilitate technology transfer, additional resources for technology transfer and working to eliminate cultural and informational barriers that impede the process. Debackere and Veugelers (2005) support this view and postulate that universities should employ incentive structures to reward academic entrepreneurial endeavors, decentralized operations and a centralized staff of experienced technology transfer personnel to manage the contract and training issues associated with the technology transfer process. In their turn, Phan and Siegel (2006) suggest that institutions that emphasized the entrepreneurial dimensions of technology transfer must address skill deficiencies in technology transfer offices, reward systems that are inconsistent with

enhanced entrepreneurial activity and the lack of training for faculty members, post-doc graduates in starting new ventures or interacting with entrepreneurs.

Many concerns have been raised about the expectations of universities over the benefits of commercialization activities, given the fact that only a modest number of universities generate substantial revenues (Geuna and Nesta, 2006), with the cost of running a technology transfer office generally out-weighting their revenues. Concerns have been also raised in the US over the potential impact of the Bayh Dole on academic freedom, teaching quality, the balance of fundamental against more application – oriented research and not least its effectiveness to stimulate higher level of university – industry interactions (Mowery et al. 2001). Critics have also underlined the potentially detrimental effects of entrepreneurial science on the long-term production of scientific knowledge. In their view, entrepreneurial activities have the potential to affect the university system's mission and its traditional focus on academic governance of faculty (Slaughter and Leslie, 1997, Blumenthal et al. 1996, Behrens and Gray 2001 etc.). Geuna and Nesta (2006) fear that an increase in university patenting exacerbates the differences across universities in terms of financial resources and research outcome and could lead to a substitution effect between patenting and publishing. Moreover, universities are not the most entrepreneurial of institutions because of numerous constraints to it, in particular the hierarchical structure, the conservatism of the corporate culture, the lack of entrepreneurial talent etc. (Kirby, 2006).

Despite these critics, there are also some arguments for the complementarity between entrepreneurial orientation of a university and its traditional mission. Agrawal and Henderson (2002) show that patenting seems not substituting for more fundamental research; Van Looy et al. (2004) provides some evidence that engaging in entrepreneurship coincides with increased publication output, without affecting the nature of publications involved. D'Este and Patel (2007) observe a positive relation between having been involved in research services and having a joint patent with universities. In their turn, Di Gregorio and Shane (2003) and O'Shea et al. (2005) did observe a positive relation between scientific productivity and spin-off activities. Thus, by actively engaging in technology development, universities are demonstrating **ambidexterity** in their ability to produce both scientific knowledge and technological outputs (Ambos et al., 2008).

At a macro level, entrepreneurial activities are undertaken with the objective of improving regional or national economic performance as well as the university's financial advantage and that of its faculty. The possibility of playing such a role does, however, vary by region and country, reflecting differences in the way both the industry and academia have developed over this past century, and in this sense it would be wrong to presume a single European model.

This paper explores different patterns of academic knowledge commercialization in Romania, a post-communist country whose performances in R&D and technology/ transfer are generally weak and lag well behind other European countries. In 2011, following the first National Assessment Exercise for the Classification and Ranking of Romanian universities and Study programs, data from 90 Romanian universities were made publicly available by the Romanian Ministry of Education, Research, Youth and Sports. Based on specific data reflecting universities' knowledge commercialization performances, we have conducted a discriminant analysis, in order to identify those indicators that discriminate between individual universities, but also between groups of universities at each of the eight development regions.

2. Introducing the context: Romania's RDI profile

There is a widespread opinion among analysts that in the transition period, the Central and East European (CEE) countries have failed to capitalize on their science-base, despite potential large R&D assets in terms of the R&D labour force and policy initiatives aimed at commercialization of R&D assets or enhancement of science-industry linkages (Radosevic, 2011). According to Formica et al. (2008), the lack of knowledge flows between universities and enterprises in CEE countries has at least two explanations: on the one hand, there is a low innovation literacy of business, which cannot formulate its own ideas or find sophisticated partners and is not open to cooperation; on the other hand, one has to recognize the unsatisfactory business literacy level of academic society, with its accompanying inability and unwillingness to offer cooperation. The result is not only small industry investment in R&D, but also far more destructive lack of outcome: neither universities nor enterprises make much of a contribution to knowledge, technology-intensive industries and products, the GDP and the national budget.

Data from the survey carried out for the *Global Competitiveness Report 2011-2012* (Schwab K., 2011) provides information on the potential for the research base to co-operate with industry. In this respect, Estonia and the Czech Republic are the most competitive countries in Central and Eastern Europe, ranking 33rd and 38th, respectively, especially due to their excellent education and highly efficient and well-developed goods, labour, and financial markets. On the contrary Romania lags well behind (115th/ 142), especially due to the poor quality of research institutions (91st) and the weak innovation capacity (95th).

The Romanian R&D system went across a very difficult period after 1989: as noted by the National RDI Strategy 2007-2013, the underinvestment and delayed restructuring only permitted a connection to the global trends in science and technology in isolated cases and the still fragile enterprise sector in Romania could not exert a real innovation demand. Even if in the last decade the R&D intensity (measured by gross domestic expenditure on R&D - GERD) increased from 0,37 in 2000 to 0,47 in 2009, Romania scores one of the lowest R&D intensities in the EU, whose average GERD was of 2,01 in 2009 (Eurostat statistics). In 2010, the effects of economic crisis continued to be felt, so that the public expenditure increased only by 8,6% relative to 2009, getting closer values of 2008 (Erawatch, 2010).

Besides underinvestment, an important challenge for the RDI system is the overall fragmentation, reflected by the large number of research performers, combined with a lack of critical mass of the quality of research results (INNO Policy Trendchart: Romania, 2009). There are 264 public R&D institutions in Romania and approximately 2000 organizations with R&D activities, of which about 850 in the private sector. The RDI system is organized on several levels which are relatively stable, but its large size and multi-level distribution often create significant incoherencies in policy making and implementation (Erawatch, 2010). As a result, R&D performances are critically weak: the rate of overall number of co-publications between Romanian researchers and colleagues from other European countries is one of the lowest in Europe (118 as compared to 491 at the EU level), while there are only 6,2% of the scientific publications within the 10% most cited publications worldwide (as compared to 11,6% at the EU level). At the same time, patenting activities are modest: Romania's State Office for Inventions and Trademarks statistics show a relatively constant number of patent applications filed by

Romanian applicants during 2003-2009 around 45-50 applications/million inhabitant (Erawatch, 2010).

Given these weaknesses in the R&D capacity, Romania's innovation performances are similarly poor. According to the Innovation Union Scoreboard 2010, Romania's innovation performance is well below the EU-27 average, ranking forth to last among the EU-27 countries. In this respect, the main innovation challenges are to increase the innovative potential of enterprises, particularly SMEs, to improve technology transfer and business support infrastructure (business incubators, technology transfer offices, S&T parks etc.) and to improve partnerships among industry, university and R&D institutions.

In this RDI landscape, Romanian universities are expected to support the socio-economic development and to meet their third mission requirements. However, Romanian universities have been traditionally focused on the *teaching* mission, but after the Government Decision 1418/2006 they were forced to assume a *research* mission, as a condition for accreditation. The *third mission of universities - contribution to the local or regional wealth and economic development* - is in a very incipient stage, with only a few universities consolidating their technology transfer and commercialization infrastructure and personnel (mostly the leading academic centres in Bucharest, Timisoara, Iasi, Brasov, etc.) (Erawatch, 2010). As a result, higher education institutions are mostly education providers, as their research activities account for only a small share of activities and are not performed on a systematic basis. Concepts like 'entrepreneurial university' or 'university-industry consortia' have only recently emerged in the public debate and some support measures have been adopted, but their impact is still minor (INNO-Policy Trendchart, 2009). At the regional level, as confirmed by the analyses that backed the Regional Innovation Strategies (RIS), universities and industry experience significant gaps in their cooperation that are mainly sourced by the lack of resources for R&D, an unclear or inappropriate offer of R&D providers, poor managerial skills of researchers, a lack of awareness regarding the benefits of research and innovation and, more important, the lack of an innovation culture among SMEs (Serbanica, 2011). From this perspective, it becomes very interesting to explore the patterns of academic knowledge commercialization in Romania and to compare universities' current performances on available indicators.

3. Methodology

To explore different patterns of academic knowledge commercialization in Romania, we have used the discriminant analysis, due to its advantages in both synthesizing a set of variables and expressing the relationships between them. According to Klecka (1980), this statistical technique allows a researcher to study the difference between two or more groups of objects with respect to several variables simultaneously, determining whether meaningful differences exist between the groups and identifying the discriminating power of each variable.

The data for analysis were made publicly available by the Romanian Ministry of Education, Research, Youth and Sports in 2011, following the first National Assessment Exercise for the Classification and Ranking of Romanian universities and Study programs. 13 indicators were first selected for our study, as they corresponded to international acknowledged knowledge transfer metrics (Holi et al., 2008, EC, 2009), namely: 1) FTE research staff (Research_staff), 2) Staff in Knowledge Transfer Offices (KTO_staff), 3) Number of Knowledge Transfer Offices (No_KTOs), 4) Number of partnerships with private institutions (No_partnerships), 5) Research expenditure, 6) R&D grants with domestic private funding (Income_RO), 7) R&D grants with European private funding (Income_EU), 8) Income from industry contract research (Contract_research), 9) Sponsorships, 10) Number of patent applications in Romania (Patents_RO), 11) Number of patent applications at EPO (Patents_EU), 12) New products and services to industry (New_products) and 13) Number of spin-offs (Spin_offs).

As suggested in the literature, for producing comparable indicators, the great challenge is to find a relevant denominator to scale or to normalize the data from institutions that vary enormously in size. When using university – to – industry knowledge transfer metrics, there are two potential options to reduce the bias related to the size of the university, namely to normalize the variables relative to the number of FTE staff in each university or to the amount of research expenditures. However, research expenditure is not perfect as a normalizing variable, as it is affected by how expenditures are defined (EC, 2009). Given these considerations, we have included the normalized score relative to the number of FTE staff in each university. Therefore, using the Schweinle formula (2.5 standard deviation from mean), we identified the univariate outliers and transformed their values to the next highest non-outlier number. Finally, we standardized all the

variables with the Z-score technique and thus met the major assumptions of discriminant analysis: each predictor variable was normally distributed (Burns and Burns, 2008).

The discriminant variable by which we divided the universities in groups was the commercial (licensing) income generated by the 90 Romanian universities in 2010. This variable takes three values: 1 for no income, 2 for average income (0 – 1000 RON/ FTE staff, approx. 250 €/ FTE staff) and 3 for high income (> 1000 RON/ FTE staff), framing thus three approximately equal groups (1=30, 2=31, 3=29). However, the test F for Wilks’s Lambda was significant for only eight variables, with Sig. smaller than 0.05 for four of them (research_staff, research_expenditure, patents_EU and new_products) and with Sig. smaller or equal to 0.1 for another four variables (patents_RO, income_RO, no_partnerships and sponsorships) – *Table no. 1*. The remaining indicators were not good discriminators, so we removed them from further analysis.

Table no. 1

Tests of Equality of Group Means					
	Wilks' Lambda	F	df1	df2	Sig.
Zscore: Research_staff	,881	5,860	2	87	,004
Zscore: KTO_staff	,988	,540	2	87	,585
Zscore: No_KTOs	,997	,129	2	87	,880
Zscore: No_partnerships	,948	2,366	2	87	,100
Zscore: Research_expenditure	,834	8,673	2	87	,000
Zscore: Income_RO	,948	2,366	2	87	,100
Zscore: Income_EU	,960	1,803	2	87	,171
Zscore: Contract_research	,996	,193	2	87	,825
Zscore: Sponsorships	,941	2,746	2	87	,070
Zscore: Patents_RO	,937	2,946	2	87	,058
Zscore: Patents_EU	,933	3,133	2	87	,049
Zscore: New_products	,888	5,459	2	87	,006
Zscore: Spin_offs	,986	,610	2	87	,546

4. Results

As resulted from our SPSS 17 computation, the highest eigenvalue corresponds to the first discriminant function (,298) that accounts in a ratio of 55,8% for the dispersion of the group means, as compared to the second function that accounts for 44,2% of dispersion (*Table no. 2*). At the same time, Wilks' lambda indicates that both discriminant functions are significant (,001 and ,014) – *Table no. 3*.

Table no. 2

Eigenvalues				
Function	Eigenvalue	% of Variance	Cumulative %	Canonical Correlation
1	,298 ^a	55,8	55,8	,479
2	,236 ^a	44,2	100,0	,437

a. First 2 canonical discriminant functions were used in the analysis.

Table no. 3

Wilks' Lambda				
Test of Function(s)	Wilks' Lambda	Chi-square	df	Sig.
1 through 2	,623	39,458	16	,001
2	,809	17,673	7	,014

Table no. 4 provides an index of the importance of each predictor: research expenditure (,557) was the strongest predictor, while patents at EPO (,529) was the next in importance as predictor.

Table no. 4

	Standardized Canonical Discriminant Function Coefficients	
	Function	
	1	2
Zscore: Research_staff	,467	-,155
Zscore: No_partnerships	-,056	,521

Zscore:	,557	-,041
Research_expenditure		
Zscore: Income_RO	,034	,465
Zscore: Sponsorships	,276	-,013
Zscore: Patents_RO	,336	-,378
Zscore: Patents_EU	-,108	,529
Zscore: New_products	-,082	,447

The structure matrix table shows the correlations of each predictor variable and the discriminant function. The values of the structure coefficients obtained are presented in *Table no. 5*, and they are to be interpreted like factor loadings in factor analysis (Burns and Burns, 2008).

Table no. 5

Structure Matrix		
	Function	
	1	2
Zscore:	,811*	,118
Research_expenditure		
Zscore: Research_staff	,662*	,134
Zscore: Patents_RO	,476*	-,029
Zscore: Sponsorships	,460*	-,005
Zscore: New_products	,354	,612*
Zscore: Patents_EU	,110	,539*
Zscore: Income_RO	,062	,475*
Zscore: No_partnerships	,147	,451*

*. Largest absolute correlation between each variable and any discriminant function

For the first discriminant function, it can be seen that correlation coefficients have significant values for the first four variables. For the second discriminant function, the next four variables are most strongly correlated. As three out of four significant variables in the first function are related to financial and human resources for research and the fourth one (patents_RO) is also

strongly tied to research potential, we named the function “**Research resources and capabilities**”. New products, patents at EPO and R&D income from grants with domestic private funding have the largest loadings in the second discriminate function, together with the number of partnerships with private institutions, so we decided to name it “**Transfer and network capabilities**”.

When analyzing the discriminant functions at group centroids (*Table no. 6*), we can easily observe that the second group (the one that have reported average income from commercialization) is the nearest to the centroid for the first discriminant function (-,126), while the group that has reported high commercial income is the nearest to the centroid for the second function.

Table no. 6

Functions at Group Centroids

VAR00	Function	
	1	2
012		
1,00	-,576	-,439
2,00	-,126	,649
3,00	,731	-,239

Unstandardized canonical
discriminant functions evaluated
at group means

At the same time, from *Table no. 7* we can observe that research expenditure is the strongest discriminant variable in both the group that has reported no commercial income (-,328) and the group that has reported high income (,451), evidently, in different directions. As regarding the second group, patents at EPO have the most discriminant power.

Table no. 7

Classification Function Coefficients

	Commercial income		
	1,00	2,00	3,00
Zscore: Research_staff	-,212	-,168	,399
Zscore: No_partnerships	-,199	,350	-,168

Zscore:			
Research_expenditure			
Zscore: Income_RO			
Zscore: Sponsorships			
Zscore: Patents_RO			
Zscore: Patents_EU			
Zscore: New_products			
(Constant)			

Fisher's linear discriminant functions

Finally, the cross validated classification showed that 58,9% of original grouped cases were correctly classified. If for the first group the prediction was more accurate (73,3%), for the second and the third group it was partially true, indicating that the frontier between universities with medium and high commercial income is not clearly distinguishable.

Table no. 8

Classification Results^a

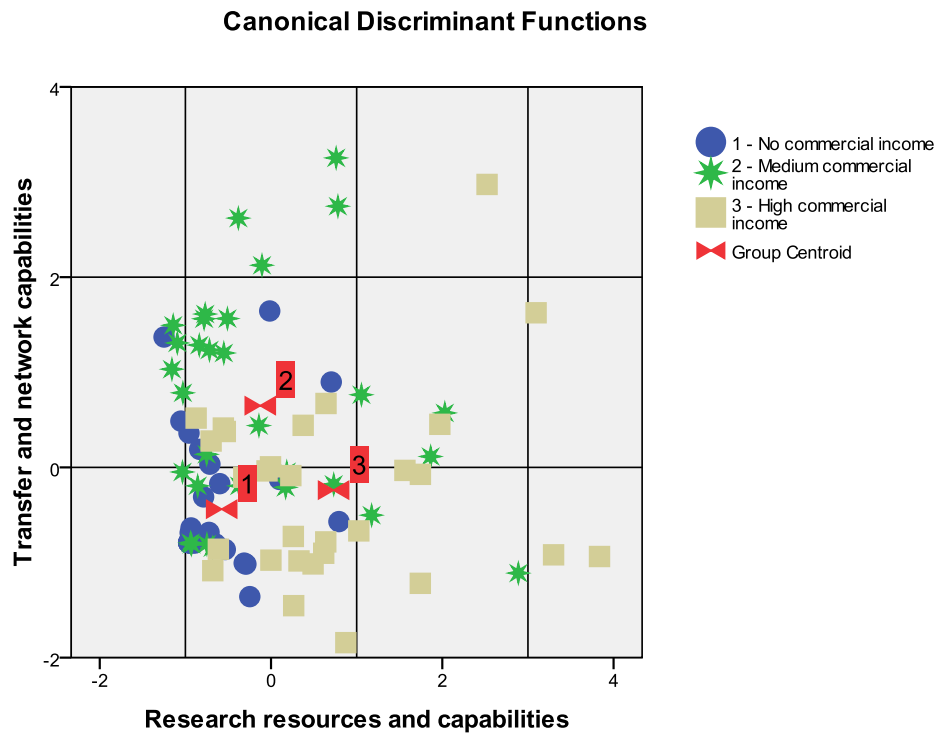
		Groups	Predicted Group Membership			Total
			1,00	2,00	3,00	
Original	Count	1,00	22	5	3	30
		2,00	8	15	8	31
		3,00	5	8	16	29
	%	1,00	73,3	16,7	10,0	100,0
		2,00	25,8	48,4	25,8	100,0
		3,00	17,2	27,6	55,2	100,0

a. 58,9% of original grouped cases correctly classified.

5. Discussions and conclusions

A closer look to the position of the 90 Romanian universities in respect to research resources and capabilities and transfer and network capabilities can give important hints about their profiles in commercial activities (*Figure no. 1*). On the one hand, most of the universities in the third group (that have reported high commercial income) are better positioned as regarding their research resources and capabilities. As shown in the *Table no. 7*, their research expenditure and staff, as well as their sponsorship revenues are important discriminators between the groups. At the same time, universities from this group take the lead for patent applications in Romania and this explains their high commercial income. On the other hand, universities in the second group are better positioned in relation to transfer and network capabilities and they take the lead for patents at EPO, new products and services, R&D grants with domestic private funding and the number of partnerships with private institutions. As regarding the third group, its centroid is positioned unfavourably to both research and transfer capabilities, with the lowest score being registered for research expenditure.

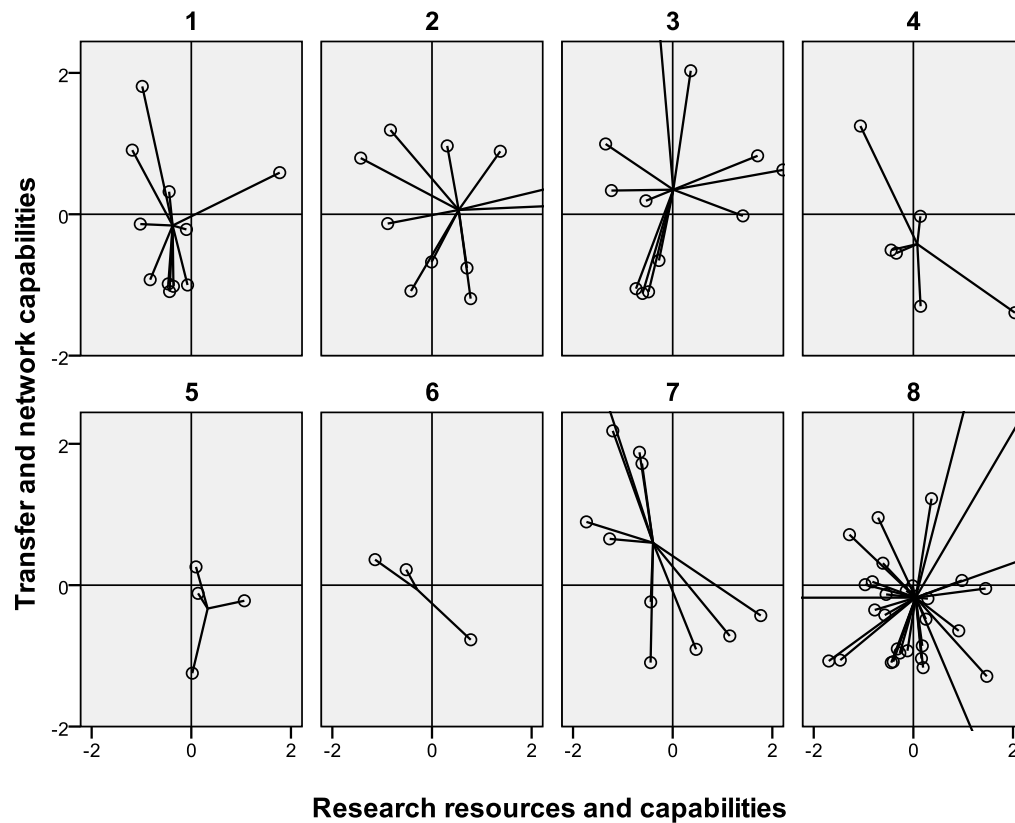
Figure no. 1



Finally, we have grouped the universities by their region of origin and placed them in a 2x2 matrix that reflects their position in relation to the two discriminant functions.

Figure no. 2

Regional academic knowledge commercialization profiles



1 = Centre, 2 = North-East, 3 = North West, 4 = South East, 5 = South, 6 = South West, 7 = West, 8 = Bucharest Ilfov

Figure no. 2 reveals the unbalanced distribution of universities across regions in Romania and gives some important insights for policy-making. As it can be observed, universities in the capital region – Bucharest Ilfov have the most heterogeneous composition and that is the reason why the group centroid is positioned at the intersection of the axes, even if there are some institutions that score very high on both discriminant functions. For research resources and capabilities, universities in group 2 – the North East region – take the lead and they differentiate themselves in the national landscape by the high number of patent applications (187 in 2007, according to

Eurostat statistics). For transfer and network capabilities, the North West and West regions are the leaders, justifying their “leading knowledge regions” status (Rogin, 2006). The other four regions – Centre, South East, South and South West – lag behind in both research and transfer capabilities.

As resulted from our study, universities that generate high income from commercial activities benefit from the most important research resources, but tend to use them especially for patent applications at the Romanian State Office for Inventions and Trademarks. To raise their R&D profiles, universities should be encouraged to target the EPO level and to market their research results through new products and services. At the same time, universities with average income from commercial activities should be supported to employ additional research staff, as they lag behind this indicator. Second, to leverage regional differences, increased attention should be paid to lagging behind regions – South, South East and South West – and also to the Centre (industrial) region, as they generally miss a solid R&D base. The main structure for knowledge and technology transfer in Romania – ReNiTT (network of institutions specialized in technology transfer and innovation) – should therefore intensify its activities in these regions, by providing additional assistance, especially to innovative SMEs. Finally, even if our study revealed the existence of some performers in academic knowledge commercialization, it should be noted that the general landscape is far from being the best one. To increase knowledge circulation, policy-makers should continue to stimulate the third mission of all universities, providing higher support for R&D and complementary measures to stimulate academic entrepreneurship, for example the creation of spin-offs, which is in its very incipient stage.

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