**University infrastructure and organizational strategies to strengthen the innovation performance of the agro biotechnological research**

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**Abstract**

The world’s food demand will increase massively over the next two decades. As research has to provide an efficient answer to this problem, this evolution will challenge the traditional role of the university. In order to positively impact the business environment, universities and research institutes are considered to open the knowledge market to industry and to deliver desirable outputs. This paper aims to contribute to the understanding of the appropriate policies and structures that agricultural universities have to address in order to participate in both generating top-quality scientific knowledge and accelerating the translation of agro biotechnology knowledge into innovation and commercial products. To analyze the financial allocation along the innovation value chain, we have performed an analysis using the linear model of the innovation process. At both the national and UASVM level, the first stage of the value chain is predominantly targeted comparing with the early technology and product development stage.

**Keywords**: innovation, technology transfer offices (TTOs); university–industry relations

**Introduction**

Over the past century, agricultural research has recorded an extraordinary global achievement in increasing agricultural productivity, transforming agriculture and contributing to the development of the entire society. Large yield-increasing innovations have been achieved by a good access to the new and advanced technologies provided, typically freely disseminated, by the public sector and non-profit institutions, including universities. (Wright [1]). World food demand will increase massively over the next two decades. Research has to offer an efficient answer, and this evolution challenges the traditional role of the university (Geiger [2]; Bok [3]) towards entrepreneurial activities (Lerner [4]).

A key issue in Europe’s economic strategy to respond to global challenges is the “European Paradox”. The Innovation Union, a Europe 2020 Flagship Initiative, aims at ensuring that innovative ideas are translated into new goods and services that create growth and jobs, pointing out that the instruments to support the commercialization of innovative ideas should accompany research efforts: innovation/knowledge clusters, knowledge transfer platforms, and voucher systems. Across the national economies, the need for more emphasis to be placed on transferring knowledge generated within the universities has been acknowledged and the entrepreneurial culture has been identified as a key element for successful universities’ transfer structures (Clark [5]).

In order to positively impact the business environment, universities and research institutes are considered to open the knowledge markets to industry and to deliver desirable outputs. In the standard model of research benefits, research impacts the supply curve to shift down and out against a stationary demand curve, giving rise to an increased quantity produced and consumed, and a lower price (Alston, Norton, and Pardey [6]). The consumer
and producer benefits are assessed using the Marshall model of research-induced changes, with the assumption that the research results are freely disseminated (Alston [7]). Over the last three decades, the framework of innovations, their financing, commercialization, adoption and diffusion have been influenced by stronger intellectual property protection regulations (Alston [7]).

The recent evaluation of the Romanian RDI system performed by the World Bank (World Bank, May 2011) points out that "Romania's RDI sector is in a silent crisis, with seriously negative implications for the country’s longer term competitiveness and growth prospects. Research, development and innovation are not recognized as a linked system to promote private sector innovation and economic growth”. Licensing and spinoffs tend to happen accidentally while technology transfer offices have unclear mandates and are poorly equipped for the commercialization task. Some of the recommendations highlighted in the report are to: accelerate the process of transmitting R&D; attentively consider the commercialization of public funded research; set up appropriate intellectual property legislation; provide technical and financial assistance to start up firms applying innovations.

The growing imperative to participate in the overall efficiency and performance improvement of national and EU innovation system and to shape academic research into commercialisable programmes has generated the creation of Technology Transfer Offices (TTOs) within universities. They are expected to encourage more applied research while assisting researchers to understand the complexities of patenting, licensing and royalty negotiations. The compromise between providing incentives for the production of new ideas and information and ensuring that spillovers from that research flow to others is likely to lead to different methods of organizing research efforts in different spheres, depending on the relative importance of the intellectual property systems versus the benefits of full and costless knowledge diffusion (Hall [8]).

The organizational characteristics of the universities, the presence of comprehensive systems to the identification, protection and commercialization of the university intellectual property play a significant role in the entrepreneurial behavior of the academics (Shea [9]).

This paper proposes to contribute to the understanding of the appropriate policies and structures that agricultural universities have to set in order to participate in both generating top quality scientific knowledge and accelerating the translation of agro biotechnology knowledge into innovation and commercial products.

Materials and Methods

The main question that guided our exploratory analysis was how Romanian agronomic universities answered and contributed to the overall efficiency and performance improvement of national and EU innovation systems, and what kind of technological transfer they can use in order to transfer the agro biotechnological technology to the economy? In order to address these research questions, we structured the paper as follows: a). a first section focusing on understanding the process of technology transfer by examining the mechanisms commonly used and incentives to exploit these mechanisms; b). section 2 presents a comparative analyse of the Romanian relative innovation performance with that of the EU countries; The data for the study were obtained from the Eurostat database and were statistically processed and interpreted; We then applied the linear model of the innovation process in order to analyze the financial allocation along the innovation value chain at the national level, and compared it with the specific situation of one Romanian agronomic university, the University of Agronomic Sciences and Veterinary Medicine of Bucharest; We concluded our study and have provided a basis for considering the design of the effective university infrastructure and
strategies to maximize the exploitation of research results in this rapidly innovating industry and implications for future research.

Results and Discussion

Process of technology transfer in universities

The increasing interest of transferring university-generated knowledge into new goods and services has created new opportunities and challenges for research cooperation between the public and private sectors, and has provided incentives for researchers to focus on the recognition and exploitation of these commercial opportunities (Maredia [10]).

There are several studies analyzing the national innovation environment that impacts the commercialization of the university technology (Goldfarb and Henrekson [11]). University technology transfer potential structures, their organizational, managerial and legal perspective, as well as factors that could increase the knowledge transfer have been the object of several studies (Duderstadt [12]; Jensen and Thursby [13]; Sohn and Lee [14]). Debackere and Veugelers [15] consider that, in order to stimulate a climate of entrepreneurship, universities should employ: incentive structures to reward the academic entrepreneurial efforts; decentralized operating structures to provide larger autonomy to research teams; and a centralized experienced technology transfer staff able to manage the contracting and training issues associated with the technology transfer process. Siegel et al. [16] emphasize the findings concerning the organizational and managerial factors to be considered by the university in order to increase the knowledge transfer into innovation and products: staffing practices in the technology transfer office, reward systems for the technology transfer, flexible university policies to facilitate the university technology transfer, allotting additional resources to the technology transfer unit and working to improve the cultural and informational environment that stimulates the technology transfer process. Shea [9] points out his findings concerning the factors that could encourage the academic entrepreneurship: (1) the need for the development of a commercially supportive culture emergent within universities in order to enable a flourishing academic entrepreneurship; (2) the need for active partnership with and financial support for industry and government funding agencies; (3) the recruitment and development of science and engineering academic stars, and (4) the development of a commercial infrastructure to enable the valorization of academic research.

Universities are therefore more and more stimulated to create technological transfer offices, to promote patenting and licensing, to support the emerging of spinoff companies, in order to increase the knowledge transfer. There is great variation among universities in the commercialization of the new academic discoveries (Nelson [17]). Several categories of transfer process have been described in the literature: between the university and an established firm, between the university and a recently created new venture, transfer resulting in the creation of a new company by the university, or a technology developed by a private firm that aims to assist the university in areas where expertise is required (Harmon, [18]). Moreover, cases could be added according to the prior relationship of these several categories of companies with the university. As the authors stated, in the overwhelming majority of cases, some forms of relationship – ranging from long term friendship to cooperation – existed between the university and the private firm prior to the transfer.

A number of scholars have pointed out deficiencies of these challenges considering that the universities increased their overall patenting with an apparent decrease in patent quality, suggesting the harvesting of the lower quality outputs resulting from their research (Henderson, Jaffe and Trajtenberg [19]).

One of the main economic challenges of the universities’ protection system and
knowledge transfer seems to be how to maintain a balance between the two objectives: ensuring social benefits of knowledge and providing incentives to the private producer (Foray [20]). There are opinions that scientists should completely disclose all their new discoveries to the scientific community, not to impede knowledge dissemination and the collective progress of industries (Argyres & Liebeskind [21]), considering that treating knowledge as a private good may render much of it inaccessible and thus constrain discovery and innovation in time (Slaughter and Rhoades [22]). There are also opinions arguing that the university can best serve public interest by protecting and restricting the use of knowledge (Maredia [10]).

There are also opinions emphasizing that the two goals are not reciprocally exclusive, scientists involved in university-industry collaborations tending to produce both more private and more public goods than other academic researchers (Blumenthal and Campbell [23]; Lee and Bozeman [24]). Sunding and Zilberman [25] consider there may be some complementarities between the two tasks allocation, as an increase in public sector research leading to patentable discoveries may result in the private sector spending on commercialization research, on the condition of appropriate IP rights. In this sense, while universities emphasize discovery and basic research, the private sector research efforts are dedicated to the commercialization and refinement of innovations. On the other hand, Goldfarb and Henrekson [11] consider that there is little reason to believe that the goal of producing useful inputs into the research of other academics is congruent with the goal of producing commercially valuable knowledge.

In this context, it is considered appropriate to formulate a knowledge transfer policy in a manner that considers the multitude of social, ethical and market concerns influencing the dynamics of biotechnological research, development and commercialization (Gold [26]). In this framework, the University of Glasgow’s new knowledge transfer model called Easy Access intellectual property, focusing on maximizing the dissemination of knowledge rather than on optimizing the income, can be considered a completely new approach to the academic technology transfer (Wündisch [27]). This model considers that the intellectual property regime is designed to maximize the social benefits of innovation towards society. According to the author, this new approach is only applied to the intellectual property which university is not able to commercialize in a profitable way, which means that universities must not lose sight of licensing or transferring results on a royalty basis. This brings us closer to the ideas promoted by Chesbrough [28] concerning the concept of open innovation. As Chesbrough concludes, “open innovation is a paradigm that assumes that firms can and should use external and internal ideas, internal and external path to market”. In the open innovation model, the role of R&D is extended far beyond the boundaries of the firm, integrating external ideas and knowledge with ideas developed within the organisation. Many industries, including biotechnology, are currently transitioning from closed to open innovation, “exploring ways in which external technologies can fill gaps in their current business and looking at how their internal technologies can spawn seeds of new business outside the current organisation.”

In order to increase the understanding of future potential configurations of the universities’ IP and knowledge transfer strategies, we can also add the EC commitment (Innovation Union, SEC (2010) 1161) to promote open access to the results of publicly funded research, and to support the development of smart research information services that are fully searchable and allow the results of the research projects to be easily accessed.

Therefore, alternative institutional actions that could maximize the public-welfare orientation of university research are expected to emerge (Kenney and Patton [29]), raising the question of the most appropriate transfer mechanisms of research results from universities to businesses.
Romanian relative innovation performance

Romania’s innovation performance is well below the EU-27, despite its improved performance in recent years, according to The European Innovation Scoreboard (EIS) 2011. With a value of the Summary Innovation Index of 0.263 out of 1, compared to an average of 0.539 for EU27, Romania ranks fourth to last among the EU-27 countries. In 2011, very low values were recorded for the intellectual properties indicators (e.g. EPO patents, community trademarks and design), compared to the EU-27 average: a value of 0.067 accounting only for about 12% of the EU 27 average.

Romanian patenting is not a prevailing activity either within the country or even abroad, the pattern applications to the EPO remaining insignificant at the European level (0.7%). Patenting activity, an indicator of Romania’s innovative performance, is below that of countries with similar levels of development. In 2011, Romania had 0.15 patent applications per billion GDP (PPP), which accounted for only about 3.9% of the EU 27 average (3.78). The situation is much worth if we consider the patents applications in societal challenges (health technology and climate change mitigation, etc.), the Romanian contribution accounting for only about 1.5% of the EU27 average.

Fig. 2. PCT patent applications per billion GDP (in PPP€).
Source: Innovation union scoreboard, 2011

At the national level, the number of applications for protection titles decreased by 30% during 2006-2010, negatively impacted by the declining number of applications for trademark and design registration. Patent applications, while experiencing an increase in the analyzed period, had a low share in the total number of applications, accounting for only 1418 applications (CBI) in 2010 (according to the Patent Law no. 64/1991).

Fig.3. National applications for protection titles (no)
Source: State Office for Inventions and Trademarks, 2010 annual Report
In 2010, the number of applicants as legal entities started to increase, unlike the previous years when the number of natural persons was predominant. The pattern applications originating from universities and research institutes increased from 17% in 2006 to 45% in 2010.

![Fig. 4. Patent applications arranged by categories of applicants (%). Source: State Office For Inventions And Trademarks, 2010 annual Report](image)

While the total number of EPO patent applications remains almost the same in the analyzed period (although with some fluctuations), biotechnology patent applications decreased to about 50% at the end of the analyzed period.

**Table 1.** Patent applications to the EPO by priority year at the national level (number)

<table>
<thead>
<tr>
<th>GEO/TIME</th>
<th>2005</th>
<th>2007</th>
<th>2010</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Total</td>
<td>dc biotech</td>
<td>Total</td>
</tr>
<tr>
<td>EU27</td>
<td>56.788</td>
<td>2.830</td>
<td>57.376</td>
</tr>
<tr>
<td>Germany</td>
<td>23.914</td>
<td>834</td>
<td>23.993</td>
</tr>
<tr>
<td>France</td>
<td>8.366</td>
<td>371</td>
<td>8.540</td>
</tr>
<tr>
<td>Italy</td>
<td>4.894</td>
<td>173</td>
<td>4.851</td>
</tr>
<tr>
<td>Hungary</td>
<td>135</td>
<td>6</td>
<td>189</td>
</tr>
<tr>
<td>Netherlands</td>
<td>3.490</td>
<td>250</td>
<td>3.263</td>
</tr>
<tr>
<td>Poland</td>
<td>128</td>
<td>7</td>
<td>202</td>
</tr>
<tr>
<td>Romania</td>
<td>29</td>
<td>1</td>
<td>33</td>
</tr>
<tr>
<td>Total world</td>
<td>134.114</td>
<td>8.168</td>
<td>128.516</td>
</tr>
</tbody>
</table>

Source: Eurostat (* 2009)

**Table 2.** Patent applications to the EPO: business sector and higher education institutions of total patent applications (%)

<table>
<thead>
<tr>
<th>GEO/TIME</th>
<th>2001</th>
<th>2005</th>
<th>2007</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>d.c. Business</td>
<td>d.c. higher education</td>
<td>d.c. Business</td>
</tr>
<tr>
<td>EU27</td>
<td>88.1</td>
<td>1.5</td>
<td>87.2</td>
</tr>
<tr>
<td>Germany</td>
<td>90.2</td>
<td>0.4</td>
<td>90.4</td>
</tr>
<tr>
<td>France</td>
<td>84.2</td>
<td>1.2</td>
<td>83.2</td>
</tr>
<tr>
<td>Italy</td>
<td>86.7</td>
<td>1.1</td>
<td>85.1</td>
</tr>
<tr>
<td>Hungary</td>
<td>73.8</td>
<td>0.2</td>
<td>77.0</td>
</tr>
<tr>
<td>Netherlands</td>
<td>94.2</td>
<td>1.0</td>
<td>88.4</td>
</tr>
<tr>
<td>Poland</td>
<td>51.7</td>
<td>0.3</td>
<td>65.8</td>
</tr>
<tr>
<td>Romania</td>
<td>30.8</td>
<td>6.4</td>
<td>51.5</td>
</tr>
</tbody>
</table>

Source: Eurostat, (* 2009)
Although university-patenting activity has increased dramatically, universities still account for less than 2.4% of patents granted at the EU level, a value above the EU average in Romania (Table 2).

The amount of venture capital indicates the relative dynamism of new business creation which, in the fields using risky technologies, is often the only available means of financing the business. The accessibility of venture capital widely differs in Europe. Only five countries (UK, Sweden, Netherland France and Germany) out of 27 account for 75% of the newly created companies by venture capital investment at the EU level. Romania is almost nonexistent in this ranking, which indicates the absence of innovation investors who could help to move ideas into the market (Table 3).

**Table 3. Venture Capital Investment at Start-up stage source: (Number of companies)**

<table>
<thead>
<tr>
<th>GEO/TIME</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU27</td>
<td>1.544</td>
<td>1.841</td>
<td>1.777</td>
<td>1.748</td>
<td>1.652</td>
</tr>
<tr>
<td>Germany</td>
<td>362</td>
<td>424</td>
<td>457</td>
<td>471</td>
<td>451</td>
</tr>
<tr>
<td>Ireland</td>
<td>45</td>
<td>53</td>
<td>49</td>
<td>40</td>
<td>61</td>
</tr>
<tr>
<td>France</td>
<td>153</td>
<td>224</td>
<td>241</td>
<td>221</td>
<td>197</td>
</tr>
<tr>
<td>Italy</td>
<td>12</td>
<td>9</td>
<td>17</td>
<td>40</td>
<td>32</td>
</tr>
<tr>
<td>Hungary</td>
<td>6</td>
<td>4</td>
<td>2</td>
<td>7</td>
<td>18</td>
</tr>
<tr>
<td>Netherlands</td>
<td>134</td>
<td>94</td>
<td>136</td>
<td>135</td>
<td>132</td>
</tr>
<tr>
<td>Poland</td>
<td>7</td>
<td>21</td>
<td>1</td>
<td>6</td>
<td>11</td>
</tr>
<tr>
<td>Romania</td>
<td>0</td>
<td>5</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

Source: calculations based on Eurostat data.

Comparable results are obtained when analyzing the financial allocation along the innovation value chain. We compare the financing on the innovation value chain stages, at the national (by the National Authority for Scientific Research - NASR) and the UASVM level, applying the linear model of the innovation process. According to it, innovation starts with basic research, is followed by applied research and development, and ends with production and diffusion (Godin [26]).

**Table 4. Financial allocation along the innovation value chain at (%)**

<table>
<thead>
<tr>
<th></th>
<th>Basic Research/</th>
<th>Applied Research</th>
<th>Innovation Development</th>
<th>Innovation production and diffusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>National R&amp;D Financing</td>
<td>69</td>
<td>29</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>UASVM’ R&amp;D Financing</td>
<td>87.4</td>
<td>12.6</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Source: own calculation based on 2012 World Bank Report and UASVM statistical data.

The financing programs considered at each stage of the innovation chain are:

a). *Basic research stage:* Nucleus program, Human Resources, Capacities and Ideas (within NPII); Sectorial Operational Program—Increase of Economic Competitiveness (SOP–IEC) 2.1.2. Foreign experts; SOP–IEC 2.2.1. Infrastructure; SOP–IEC 2.2.3. SOP–IEC GRID GEANTS; SOP–IEC 2.2.4. Administrative capacity;

b). *Applied Research stage:* Partnerships and Innovation under NPII; SOP –Partnership 2.1.1.; and agricultural sectorial and World Bank programs for the UASVM case;

c). *Innovation Development, Innovation production and diffusion stages:* SOP-Private infrastructure 2.3.2.; SOP Innovation 2.3.3.; SOP starts up-spin off.
As our results indicate, the first stage of the value chain, the funding of basic research is predominantly targeted in both situations, i.e. the national and UASVM level. The Early Stage Technology and Product development, the so-called “valley of death”, is scarcely funded.

Conclusions

Several efforts have been made recently to promote patenting and licensing, the emergence of spin-off companies, the expansion of joint or contract research, for the academic research results to be transferred and to have a positive impact on the economic development. Taking into account the commercialization pressures on universities, sufficient commitment is needed to invest in basic scientific research programs. Thus, a virtuous circle could be promoted for the expansion of commercial technologies.

The creation of Technology Transfer Offices (TTOs) within universities and public research institutes is actively promoted in many countries. With their dedicated role to stimulate the exploitation of the research results, we expect the diversification of different transferring mechanisms to be used in various settings. These structures prove their usefulness and timeliness, supporting academic researchers to understand the complexities of patenting, licensing, and royalty negotiations, while seeking to maximize the dissemination of knowledge. In the current environment of increased complexity of research transfer mechanisms, a major issue for the universities is to attract skilled TTO staff with competences beyond legal experience in protecting IP and able to integrate external ideas and knowledge with ideas developed within the organisation.

World food demand will increase massively over the next two decades. Research has to efficiently answer by delivering public goods in the field of food and biomaterial supply, environmental preservation, mitigation and adaptation to climate change. Maximizing the knowledge transfer will require a wise judgment of the values and skills that the university needs to hold, and an increasing role of the professionals working in administrative support for new economic activities.

References

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