Innovation and Technology Transfer in Romanian Horticulture

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An analysis of the research, innovation and technology transfer environment carried out by the European Commission ranks Romania in one of the last places in Europe, mentioning the lack of investments in research, especially at the level of modern infrastructure and equipment, among the most important reasons. On the other hand, Romanian universities must face the competition at the international and the European level, in order to face the technical and socio-economic challenges both at the societal level, and with respect to the inherent technological evolutions.

Keywords: growth ; innovation ; economic development ; technology transfer

1. Innovation and Technology Transfer Worldwide

Innovation is defined in the literature as an idea, a concept, a process for designing, operationalizing, and experimenting with a new product model, new processes, or new functional structures for industrial application [1]. Innovation is the ability to take new ideas and translate them into commercial outcomes by new processes, products, or services [2][3]. “Innovation is the multi-stage process whereby organizations transform ideas into new/improved products, services or processes, in order to advance, compete and differentiate themselves successfully in their marketplace” [4].

Therefore, innovation, compared to invention, does not necessarily concern an absolute novelty, but makes the scope and speed of implementation more accessible [5][6]. From a very general point of view, innovation can be understood as a process from the generation of an idea to its commercialization—bringing the idea or invention to the market as a new product, process or service through the phases of idea generation, research and development, product development, marketing, and selling a new product or service. The idea becomes an invention, when it is converted into a tangible new artifact. Inventions are necessary seeds for innovations, but the inventions do not inevitably lead to the innovation. Innovation is mostly regarded as the commercial and practical application of ideas or inventions [7], while other authors [8] consider that “technological innovation and high-quality economic development are inevitable requirements of sustainable development, and the digital economy has gradually become a new engine to enhance technological innovation and the high-quality development”.

Technological transfer (TT) is seen either as a sub-process of innovation or as a step to complement the concept of innovation. Organizations dealing with TT are an interface between interested social groups: bidders of research results and potential applicants as well as beneficiaries. As the Bayh–Dole Act puts it, “the mission of university technology transfer offices (TTOs) is to transfer research results to commercial application for public use and benefit” [9], meaning the process of developing practical applications for the results of scientific research. This usually involves the identification of research, typically by dedicated TTOs in universities, governmental organizations, and companies, which have potential commercial interest and the design of strategies for how to exploit it in mind. Such strategies can include the creation of licensing agreements or joint ventures, partnerships, or spin-out companies to develop a new technology and bring it to market [10][11].

TT can be a significant source of revenues for the university and provide industry with important new technologies, and is seen as playing an increasingly significant role in stimulating economic development [12][13]. Successful TT does not end when the technology is handed over to industry, but rather it requires utilization of the technology in new products, processes, or innovative organizational changes [14][15]. Additionally, firms are concerned with the time to market because the benefits from innovation may depend on how quickly a new product can be developed [12]. Therefore, specialized faculty knowledge and involvement is necessary for firms to be willing to license and develop technologies in early stages [16][17].

To formulate an alternative view of TT, it is useful to identify the various factors that contribute to the TT process. Heinzl et al. [14] recognize factors that can influence university TT performance: funding structures, research activities, the university's legal environment, and the institutional setting. This process typically includes sifting for gold (identifying new technology) and knowing what to do with it when you find it, i.e., strategies for protection through patents and copyrights, the development of commercialization strategies such as technology development, marketing, and licensing to existing private companies, or the creation of new start-up companies based on the technology [4].

From a Higher Education perspective, spin-offs are defined as companies set up to exploit IP (intellectual property) that has originated from within the higher education institute. From a business perspective, a spin-off occurs when a division of a company or an organization becomes an independent business. The newly formed company usually obtains the assets, IP, technology, and/or existing products from the parent organization. A start-up company is a newly formed company that has a limited operating history. These companies, generally newly created, are in a phase of development and research for markets. Start-up companies can have a high element of risk associated with their development, but this can be balanced by their high potential rate of growth and scalability [10]. Spin-off and start-up companies provide academic entrepreneurs with an alternative pathway for disseminating and commercializing research, often when they are unable to license their technology to large companies or an external entrepreneur [18][19]. Sometimes a spin-off or start-up is the only option for developing a technology, and without the creation of a new entity that technology might never become commercially viable [20][21]. Furthermore, spin-offs and start-ups appropriate the value of their innovation and can provide opportunities for additional funding mechanisms to further their research agenda [22][23].

Spin-off creation benefits from support structures such as incubators or science/research parks within or close to the university [14][24]. Not all universities have a research park, but for those that do, university spin-offs are more likely to originate in science/research parks that are closest to the university, as well as in technology-focused science/research parks such as those centered on biotechnology [25]. The potential rewards from spin-offs and start-ups create incentives for universities to engage in entrepreneurial activities [26].

2. Innovation and Technology Transfer in Romania

The European Commission, through the European Innovation Scoreboard, provides a comparative analysis of innovation performance in European countries and regional neighbors. It also evaluates relative strengths and weaknesses of national innovation systems and helps countries identify areas they need to address.

Studying the scoreboard of European innovation 2021 [27] in detail, it can be seen in **Table 1** below that the strongest dimensions of Romanian innovation are digitalization and the impact of sales. Broadband penetration has risen above the EU average, as have exports of high-tech goods and venture capital. Recent increases in performance are seen in international scientific co-publications, most cited publications, number of foreign PhD students, and innovative SMEs collaborating with others. Innovators, firm investments, and human resources are the weakest dimensions of innovation. The lowest scores of indicators in Romania are in terms of lifelong learning, SMEs with product or process innovations, SMEs with marketing or organizational innovations, and innovative SMEs in the interior. For all four indicators, performance is the lowest in 2018 in all countries, leading to a relative score of 0.

Table 1. Romania 2014–2021, performance relative to EU 2014.

Romania	Relative to EU 2021 in	Performance Relative to EU 2014 in	
	2021	2014	2021
Summary Innovation Index	31.2	31.0	35.1
Human resources	13.2	39.6	14.0
New doctorate graduates	22.1	77.0	19.6
Population with tertiary education	10.9	13.2	14.0
Lifelong learning	4.0	5.6	4.4
Attractive research systems	35.0	22.3	39.4
International scientific co-publications	36.1	30.0	47.4
Most cited publications	40.5	19.8	39.8

Romania	Relative to EU 2021 in	Performance Relative to EU 2014 in	
Foreign doctorate students	24.0	17.7	28.5
Digitalization	61.8	57.4	85.5
Broadband penetration	100.0	104.9	151.7
People with above-basic overall digital skills	4.5	0.0	5.6
Finance and support	28.7	24.7	34.2
R&D expenditure in the public sector	3.6	21.1	3.5
Venture capital expenditures	72.6	28.3	122.0
Firm investments	7.2	17.1	8.7
R&D expenditure in the business sector	16.3	11.0	18.1
Non-R&D innovation expenditures	0.0	40.4	0.0
Innovation expenditures per employee	6.3	4.7	8.4
Use of information technologies	26.1	11.1	30.2
Enterprises providing ICT training	6.7	0.0	6.7
Employed ICT specialists	42.9	23.8	57.1
Innovators	3.8	9.7	5.2
Product innovators (SMEs)	7.8	0.0	11.0
Business process innovators (SMEs)	0.0	18.2	0.0
Linkages	16.0	15.1	21.5
Innovative SMEs collaborating with others	13.4	0.0	19.7
Public–private co-publications	20.8	19.9	24.5
Job-to-job mobility of HRST	0.0	10.3	0.0
Intellectual assets	32.8	22.0	28.4
PCT patent applications	6.3	4.7	5.5
Trademark applications	56.9	47.0	59.8
Design applications	26.1	12.6	17.9
Employment impacts	10.3	4.4	10.5
Employment in knowledge-intensive activities	23.2	10.7	25.3
Employment in innovative enterprises	0.0	0.0	0.0
Sales impacts	79.9	55.9	81.4
Medium- and high-tech product exports	100.8	92.1	110.4
Knowledge-intensive services exports	61.3	46.7	64.9
Sales of innovative products	72.4	19.4	63.0
Environmental sustainability	38.2	61.4	39.8
Resource productivity	10.6	7.7	15.7
Air emissions by fine particulate matter	66.4	59.9	70.6
Environment-related technologies	19.5	95.3	14.7

Source: European Innovation Scoreboard 2021 [27]. **Legend**: The colors show normalized performance in 2021 relative to that of the EU in 2021. Dark green: above 125%; light green: between 100% and 125%; yellow: between 70% and 100%;

orange: below 70%. Normalized performance uses the data after a possible imputation of missing data and transformation of the data.

Further, in **Table 2** below, structural differences with the EU are presented, including, compared to the EIS 2020, new information on different types of (innovative) enterprises (innovation profiles) and environmental indicators: GDP (gross domestic product) per capita, the employment share in services, and top R&D (research and development) spending enterprises per 10 million population are well below the EU average, while the average annual GDP growth, enterprise births, and total entrepreneurial activity are well above the EU average. However, many of the economic indicators in Romania tend to be closely above or beneath the EU value.

Table 2. Structural differences between Romania and the European Union.

Performance and Structure of the Economy	RO	EU
GDP per capita (PPS)	20,400	30,800
Average annual GDP growth (%)	0.4	−2.5
Employment share manufacturing (NACE C) (%)	18.8	16.5
of which high and medium high-tech (%)	33.9	37.9
Employment share services (NACE G-N) (%)	32.4	41.2
of which knowledge-intensive services (%)	26.8	35.1
Turnover share SMEs (%)	42.0	36.5
Turnover share large enterprises (%)	42.7	45.7
Foreign-controlled enterprises—share of value added (%)	15.9	11.8
Business and Entrepreneurship		
Enterprise births (10+ employees) (%)	2.2	1.0
Total entrepreneurial activity (TEA) (%)	10.8	6.7
FDI net inflows (% GDP)	2.9	2.0
Top R&D spending enterprises per 10 million population	0.0	16.2
Buyer sophistication (1 to 7 best)	2.8	3.7
Innovation Profiles		
In-house product innovators with market novelties	2.4	10.7
In-house product innovators without market novelties	5.0	12.3
In-house business process innovators	3.5	11.0
Innovators that do not develop innovations themselves	3.4	11.6
Innovation: active non-innovators	0.2	3.3
Non-innovators with potential to innovate	29.4	19.9
Non-innovators without disposition to innovate	2.8	3.7
Governance and Policy Framework		
Ease of starting a business (0 to 100 best)	73.0	76.5
Basic-school entrepreneurial education and training (1 to 5 best)	2.4	2.0
Govt. procurement of advanced tech products (1 to 7 best)	2.5	3.5
Rule of law (−2.5 to 2.5 best)	0.4	1.1
Climate Change Indicators		
Circular material use rate	1.6	11.7
Greenhouse gas emissions intensity of energy consumption	86.3	86.6

Performance and Structure of the Economy	RO	EU
Eco-innovation index	**57.0**	**100.0**
Demography		
Population size (millions)	**19.4**	**446.7**
Average annual population growth (%)	**−0.5**	**0.1**
Population density (inhabitants/km^2)	**83.7**	**108.8**

Source: European Innovation Scoreboard 2021 [27].

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