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TECHNOLOGY TRANSFER MANAGEMENT AND KNOWLEDGE COMMERCIALIZATION STRATEGY – BEST PRACTICES OF PUBLIC UNIVERSITIES

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Abstract: Technology Transfer concerns the process for conceiving and implementing a new/novel application for an existing technology. It includes a range of formal and informal cooperation between technology developers and technology seekers. It is understood on different levels (e.g. technology policy, individual scientists). Technology transfer and industrial linkage can expand opportunities for education and it can lead to new sources of the research support. Analysis of the best practices on the technology transfer management including public universities have been presented in the paper.

Keywords: technology transfer, knowledge commercialization

1. INTRODUCTION

Research on the innovativeness of the economy is a frequently undertaken topic of theoretical and empirical scientific works in Poland and abroad. It is therefore not surprising that they have a wealth of literature on what innovation is, how it can be measured and how to support it. A very important, but still insufficiently documented trend of research on innovations in Poland is their practical dimension related to the commercialization of research results, implementation and technology transfer.

One of the classical definition of the innovation, that was proposed in the Oslo Manual, treats the implementation of innovation as an inherent part of the innovation process. It is defined in it as the implementation of a new or significantly improved product (product, service) or the process, a new marketing method or a new organizational method in economic practice, workplace organization or relations with the environment (Oslo Manual 2018).

However, research on innovations often ignores the threads related to their economic effect, which should be the commercialization of what has been improved. It is it that ultimately leads to a feedback loop in which the positive economic effects of expenditure on innovation in the form of an increase in corporate profits or economic growth on a national scale are the source from which further innovations in enterprises and the

entire economy can be financed, as well as an increase in the standard of living of the society.

The literature review related to problems of technology transfer was focused on issues connected with functions of the technology transfer as well as on obtaining licenses and patents (Bradley et al. 2013). There is an extensive technology transfer literature that focuses on the international technology transfer, chiefly from more developed to less developed nations (Bozeman, 2000) and it is not addressed here. The aims of the international literature tend to be quite different than any domestic literature and the policy drivers are very different ones. Though the published literature on federal laboratory technology transfer has not grown much since 2000, the broader technology transfer literature has been expanding rapidly, especially in the domain of university-based technology transfer. Similarly, there have been many studies of the government laboratory and research center technology transfer published, but government laboratories of other nations, especially European nations (Bozeman 2013).

While the technology transfer literature includes a great many conceptual papers and single case study papers, the current analysis focuses chiefly on empirical research, including qualitative research. The robust literature on international and cross-national literature, likewise, receives little attention because the concerns of that literature tend to be quite different, focusing on donor and recipient nations or developing nations and trade policies (Reddy and Zhao, 1990; Wahab, et. al. 2012). In order to meet the identified imperfections and taking into account the research cited in different studies, the following definitions of these terms should be adopted:

- commercialization is a profit-driven process in which the effects of research and development activities become, or are intended to become, the subject of market trading;
- implementation of the research results is their application in socio-economic practice, including, in particular, placing on the market in the form of specific products or services;
- technology transfer is the flow of elements of a technique or related knowledge for the purpose of exploitation or development that takes place between at least two entities.

Comparing the meaning scopes of the above terms, it should be noted that the term commercialization may cover entire process: from noticing new market opportunities, through shaping research ideas, carrying out these studies, creating new products and introducing them to the market and selling them. In this sense, it is the broadest concept in terms of meaning. In the above perspective, technology transfer seems to be the narrowest term related to the flow of technology or related knowledge between various entities. Technology transfer in this context can be both an element of implementation (commercial and non-commercial) and commercialization.

At the same time, it should be pointed out that the implementation and transfer of technologies may go beyond economic activity and may be associated with the desire to create benefits for society resulting from changes in the institutional environment resulting from social, scientific, educational, cultural and political activities.

Technology Transfer Effectiveness Criteria have been presented in Table 1 (Bozeman 2013).

Table 1. Technology Transfer Effectiveness Criteria

Effectiveness Criterion	Key Question	Theory Base	Major Advantage and Disadvantage
"Out-the-Door"	Was technology transferred?	A theoretical or classical organization theory	Advantage: Does not hold transfer agent accountable for factors that may be beyond control. Disadvantage: Focuses on activity rather than outcome
Market Impact	Did the transferred technology have an impact on the firm's sales or profitability?	Microeconomics of the firm	Advantage: Focuses on a key feature of technology transfer. Disadvantage: Ignores important public sector and nonprofit transfer; must accommodate market failure issues.
Economic Development	Did technology transfer efforts lead to regional economic development?	Regional science and public finance theory.	Advantage: Appropriate to public sponsorship, focuses on results to taxpayer. Disadvantage: Evaluation almost always requires unrealistic assumptions.
Political	Did the technology agent or recipient benefit politically from participation in technology transfer?	Political exchange theory, bureaucratic politics models	Advantage: Realistic. Disadvantage: Does not yield to systematic evaluation.
Opportunity Cost	What was the impact of technology transfer on alternative uses of the resources?	Political economy, cost-benefit analysis, public choice	Advantage: Takes into account especially alternative uses for scientific and technical resources. Disadvantage: Difficult to measure.
Scientific and Technical Human Capital	Did technology transfer activity lead to an increment in capacity to perform and use research?	Social capital theory (sociology, political science), human capital theory (economics)	Advantage: Treats technology transfer and technical activity as an overhead investment. Disadvantage: Not easy to equate inputs and outputs.
Public Value	Did technology transfer enhance collective good and broad, societally shared values?	Public interest theory, public value theory	Advantage: Excellent and easily sanctioned criteria for public policy. Disadvantage: Extremely difficult to measure systematically

Source: Bozeman 2013.

WIPO describes technology transfer as a transfer of new technologies from universities and research institutions to parties capable of commercialization or in the sense of transfer of technologies across international borders, generally from developed to developing countries. Generally Technology Transfer consists of knowledge or IP rights that are (Muredzi 2015):

- licensed in the form of intellectual property,
- the subject of formal consulting or training agreements,
- communicated in the work place or research settings
- diffused by publication or other means.

Technology transfer and commercialization (TTC) occur via, both, formal and informal channels. Formal channels include training and education, hiring students and researchers from universities and PROs, sharing of equipment and instruments, technology services and consultancy, sponsored research and R&D collaboration, and other mechanisms. Informal channels include the transfer of knowledge through publications, conferences, and informal exchanges between scientists. Technology transfer and commercialization do not evolve naturally and linearly from research and the discovery of scientific solutions (Innovation Policy Platform 2021).

According to WIPO policy Technology Transfer Goals are goals of Technology Transfer Compliment University Missions as follows: disseminate knowledge, encourage innovation and creative work, enhance the experience of students, improve the health/economy of the community and public. Best practices on the technology transfer have been presented in Figure 1.

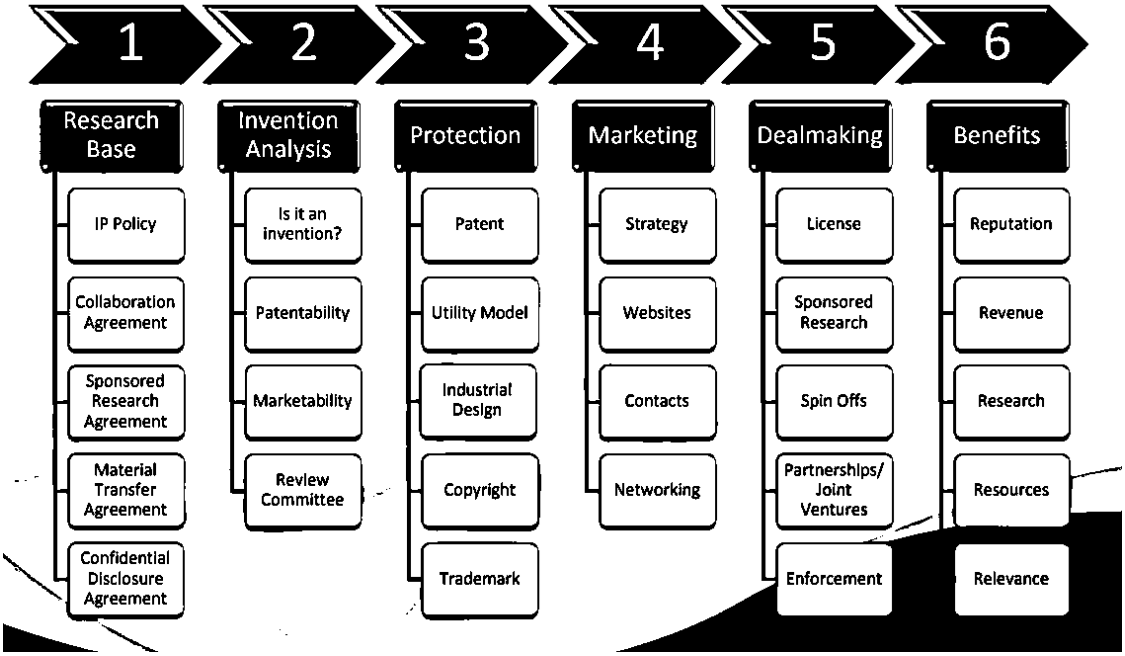

Figure 1. Technology Transfer Office Overview Incorporating Best Practices.

According to WIPO, the transformation of technologies from research results originating in academic institutions has been the source of inventions, products, and companies for as long as there has been university research and entrepreneurs. The focus of the university to support new startups and the commercialization of technologies will often determine the pathway of commercialization. Universities are able to provide resources,

acknowledgment, and academic reward or commercialization may be considered to be counter stance to the academic focus of the institution (WIPO 2002).
WIPO University Initiative addresses critical issues and assists universities in the establishment of IP awareness, including comprehensive IP policies, IP and technology management infrastructure for universities; development of human capital skilled in IP and technology management; promotion of effective use of IP, in particular, patents, utility models and trademarks; and creation of national, regional, and global university IP groups so that universities can enjoy the full benefit of the IP system (WIPO 2002).
Universities play important role in the technology transfer management processes since they are primary and rising sources of new knowledge and technologies. Statistics of WIPO confirmed that the compound annual growth rate was about 13% for all patent applications, 35% come from university applications. According to WIPO, almost a third of R&D in developed countries is undertaken in the public sector which includes universities. In developing countries this trend is even more marked with the majority of new technology development being carried out in public universities and R&D institutions.
Commercialization of the knowledge at universities is related to the transformation of technologies that come from the research results obtained at academic institutions. Many studies have identified the aspects that impact commercialization of technological knowledge (Hoye and Pries, 2009; Rasmussen, 2008; Swamidass and Vulasa, 2009).

2. METHOGOLOGY OF RESEARCH

Measurement of the commercialization, technology transfer and implementation is the part of the statistics on the science and technology, but it is still a side trend to the measurement of research and development and innovation. There is still no uniform, internationally recognized set of rules for collecting data in the field of the research commercialization, implementation or technology transfer.
The current state of the European Research Area (ERA) and the progress made on ERA implementation in 2016-2018 are presented in the 2018 ERA Progress Report that measures the research progress at country level using the ERA monitoring mechanism (a set of 24 core indicators jointly defined by Member States, research stakeholders and the Commission that includes eight headline indicators). Findings throughout this report refer to the Science-Metrix Report ‘Data gathering and information for 2018 ERA monitoring’, which also includes definitions of the headline indicators.
The European Research Area (ERA) Progress Report 2016-2018 relates to the implementation of the ERA Roadmap 2015-2020. The National Action Plans for the implementation of research related activities in line with the ERA Roadmap show the ambition to make further progress on the ERA. The aim and promise of the ERA is to better align national and European research and innovation programs, achieve critical mass and real added value at European level. As new challenges arise, European and national authorities must increasingly adapt their political response to seize new opportunities and remove old obstacles. Progress towards achieving ERA objectives is measured against a core set of 24 indicators covering all six ERA priorities. The results of the research show that the pace of implementation of activities in this space is falling and large disproportions between countries persist. For most of the priorities, there is not only much room for further improvement (European Commission 2019).
The European Research Area (ERA) implementation is focused on 6 priorities (European Commission 2019):

1. More effective national research systems.
2. Optimal transnational cooperation and competition, including ‘jointly addressing grand challenges’ and ‘research infrastructures’.
3. An open labour market for researchers.
4. Gender equality and gender mainstreaming in research.
5. Optimal circulation, access to and transfer of scientific knowledge, including ‘knowledge circulation’ and ‘open access’.
6. International cooperation.

Universities have different priorities with regard to their strategies on the technology transfer management according (Figure 2).

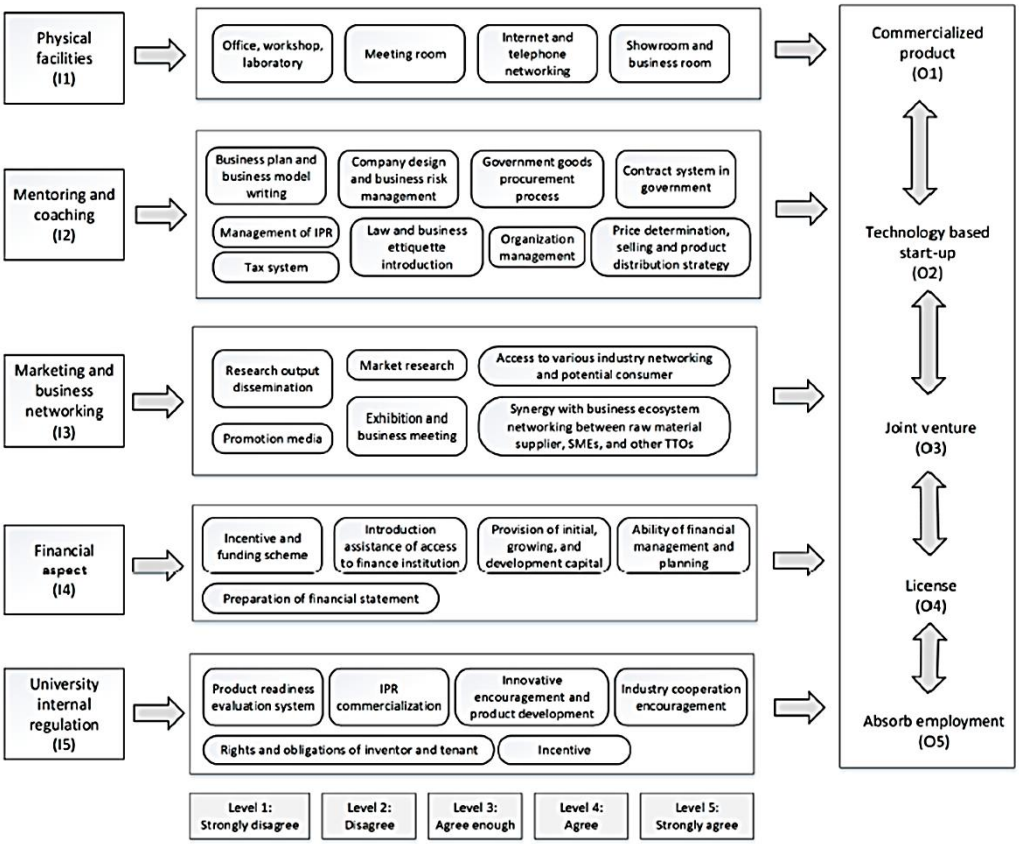

Figure 2. University strategies on technology transfer management.

A great number of public universities have created commercialization programs or extended joint programs to incorporate education in business and research:

- The Boston University School of Management Institute for Technology Entrepreneurship & Commercialization has established academic programs, collaborative projects, events, and services, to build management skills for translating ideas into marketable products and services (Boston University 2014),
- USC Graduate Certificate in Technology Commercialization (University of Southern California) designed to let students experience the entire spectrum of the commercialization process – invention, product development, technical and market feasibility analysis, intellectual property acquisition, business planning and venture funding (University of Southern California 2014),

- Online and on site educational programs such as the Master of Science in Technology Commercialization, McCombs School of Business-Graduate at The University of Texas at Austin (University of Texas 2014).
- National University of Singapore Enterprise Group (NUS Enterprise) including the NUS Industry Liaison Office (NUS ILO) and the NUS Entrepreneurship Centre (NEC). NEC promotes and supports entrepreneurial startups by NUS investigators and their collaborators and conducts research on policy and technology venturing. Their activities are organized in 4 key areas: Experiential Education, Entrepreneurship Development, NUS Enterprise Incubator and Entrepreneurship & Innovation Research (NUS Entrepreneurship Centre 2014),

Universities also support business development by projects through the university's office of technology transfer as well as internships with early stage companies. Different roles of universities in the technology transfer management is presented in table 2.

Table 2. Summary: Roles, determinants and engagement modes of universities

Model	*Main Role of universities*	*Main Unit of analysis*	*Directionality of engagement*	*Dominant methodology*	*Key factors influencing impact*	
Knowledge 'factory'	Producer of scientific knowledge	Innovation outputs	Unidirectional (implicit)	Industrial surveys Citation count Production function analysis	Research intensity/inputs Geographical proximity Industry sector	Mansfield (1991); Beise and Stahl (1999 Jaffe (1989); Feldman and Florida); Anselin (1997); Anselin (2000) Anselin (2000); Jaffe (1989); Feldman and Florida (1994) ;Cockburn and Henderson (2001)
Relational university	Exchange of knowledge	Linkages	Bi-directional (implicit)	Industrial surveys Case studies	Size of firm R&D intensity Age of firms Openness of firms Technical field / Industrial sector Scientists' research excellence/ experience	Schartinger (2002); Cohen et al (2002); Fontana et al (2006) Schartinger (2002) Fontana et al (2006) Laursen and Salter (2004); Cohen et al (2002) Laursen and Salter (2004); Fontana et al (2006) Meyer-Kramer and Schmoch (1998); Cohen et al (2002); D'Este and Patel (2007) D'Este and Patel (2007)
Entrepreneurial university	Active commercialisation role	Intermediaries (ILOs/TTOs)	Bi-directional (explicit)	Surveys of university TT managers	Organisational structures/forms Managerial practices Faculty behaviour/ incentives	Bercovitz et al (2001); Gill et al (2003); Siegel et al (2003), Markmann et al, 2005 Siegel et al (2003); Jain and George (2007); Belenzon and Shankerman (2007) Siegel et al (2003); Lach and Shankerman (2003);
Systemic university	Boundary-spanning role	Systems/ networks	Triple-helix (univ, ind and government)	National and regional innovation surveys Case studies	Regional system configuration Regional policy Institutional capacity of universities	Koschatzky and Sternberg (2000); Todtling and Trippl, 2005; Braczyk et al, 1998 Kitagawa (2004); Coenen (2007) Etzkowitz and Leydesdorff (1997); Etzkowitz (2000)

Source: Uyarra 2008.

In Poland, there are no separate studies on the commercialization, implementation and transfer of technology, and the manner and type of data collected gives an imprecise picture of these phenomena. There is a visible dispersion and lack of data integration. The system of collecting them is primarily used for the purposes of those units, which include the Central Statistical Office (GUS), the Information Processing Centre - National Research Institute (OPI-BIP), the Association of Organizers of Innovation and Entrepreneurship Centres in Poland (SOOIPP) and the National Centre Research and Development. The POL-On database, run by OPI-PIB, contains information on the implementation of the results of scientific research or development works, information on revenues from the commercialization of scientific research results or development works of scientific units. SOOIPP mainly collects information from business environment institutions that provide innovation and entrepreneurship support services. On the other hand, the National Centre for Research and Development uses the "implementation report" tool. It is directed to the beneficiaries of programs which include

the obligation to implement or commercialize the results generated under the co-financed project.

The analysis of the approaches used by various institutions, both Polish and foreign, shows that some of the measures used are similar, and some occur only individually. It is influenced by the specificity of the institution's operation and the related purpose for which the data is collected, the specificity of the environment in which they operate, and the availability of the indicated data or the possibility (and cost) of their collection. The similarities mainly concern measures related to intellectual property, cooperation between the science and business sectors, the creation of new enterprises and the generated income. Less frequently used, but interesting areas include those related to the team of the commercialization unit, repeatability and continuity of cooperation, competences and transfer of skills.

3. RESEARCH RESULTS AND DISCUSSION

The 2016 ERA Progress Report showed that substantial progress had been made on ERA implementation over the last decade. At EU level, all headline indicators improved, although there were still large disparities between Member States in both performance levels and growth rates.

Analysis of research trends in applications for co-financing submitted to the NCBR under the SG OP in 2016-2019 (National Centre for Research and Development 2020) confirms that technology transfer centres most willingly collaborated with universities (i.e. universities, polytechnics, colleges, etc.). The main area of cooperation was partnership in projects (93.8%), followed by cooperation with experts and specialists (87.5%) and knowledge of technology and research results (87.5%). Cooperation in the field of experts and specialists is the dominant area of cooperation in terms of all groups of entities. Partnership in projects for CTT is the motive for cooperation with R&D units (50%), local government (50%) and OI (43.8%).

The analysis of the number of applications from individual thematic classifications indicates which industries in Poland are making efforts to generate innovation with the support of public funds from European funds, and also see the need for investment in research and development. Over 30% of the applications for funding submitted to the NCRD concern research issues related to electronics and IT. A similar number of applications (27%) covers the area of transport and mechanical engineering. On the other hand, the fewest applications cover research problems in the field of social and economic sciences, as well as agricultural sciences and environmental protection. Over 30% of the applications for funding submitted to the NCRD concern research issues related to electronics and IT. A similar number of applications (27%) covers the area of transport and mechanical engineering. On the other hand, the fewest applications cover research problems in the field of social and economic sciences, as well as agricultural sciences and environmental protection. It should be emphasized that most applications for funding are interdisciplinary. In each of the distinguished areas, a significant influence of IT techniques is visible, which is a natural phenomenon in the era of progressing automation of processes. Additionally, in areas such as materials engineering, energy, medicine / pharmacy, there will always be projects strongly related to chemistry.

On the basis of the research carried out by PARP in 2014, several areas of cooperation were identified that were very important for the functioning of the CTT (scores on a 0-5 scale). The cooperation with universities had the greatest impact on the operation of centres in Poland due to: access of experts and specialists (3.8), access to infrastructure (3.6), acquiring knowledge in the field of technology and research results (3.6), as well as partnership in projects (2.9).

4. CONCLUSION

Countries achieving a high level of development are characterized by the best economic base, which ensures adequate availability of financing sources supporting the supply of research and development works and commercialization of scientific results. These countries also have a great ability to create demand for the results of such activity on the part of enterprises capable of commercializing R & D & I works, as well as on the side of the public sector, which often creates such demand itself, e.g. through orders directed to enterprises. Such phenomena are noticed in Germany and the USA.

Some countries, in particular the United States, have a unique demand for innovation in the areas of technology ahead of existing trends through the development of space programs and military technology development programs. Countries with a high level of development are also characterized by the best developed systems of institutions supporting the process of commercialization of R&D works. As a result, they have many years of experience and the resulting organizational knowledge, which allows them to constantly improve their support tools.

Poland is characterized by a weaker own economic base, shorter experience and less accumulated organizational knowledge, as well as a lower number of domestic competitive enterprises able to commercialize the results of R & D & I works and a lower national ability to mobilize own funds that can be spent on financing commercialization projects R & D + I. As a result, the commercialization policy in Poland should focus on the development of national knowledge resources and the institutions that create it. It should also stimulate, first of all, the development of domestic enterprises, including their ability to commercialize the results of R & D & I works produced in national research centres. It should also use the experience and best practices applied by highly developed countries, including the analysed economies in this study.

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