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THE ROLE OF NATIONAL TECHNOLOGY TRANSFER FRAMEWORK IN COMMERCIALIZATION OF UNIVERSITIES' RESEARCH RESULTS: CASE STUDY CROATIA

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ABSTRACT

Technology transfer is a process of commercial utilization of scientific research results created by universities and research institutions out to the industry where these results are transformed into new products and services. The process of technology transfer is one of the fundamental processes that have a positive impact on the economic performance of any country. It is a complex process that requires an appropriate framework for technology transfer at the national level to enable its successful implementation. Technology transfer offices are important intermediaries in managing the technology transfer process between academia and industry promoting innovation and economic development. This paper aims to provide a theoretical overview of the relevant factors that need to be considered and implemented in building an adequate, strong and effective national technology transfer system in Croatia that enables universities and research institutions to engage in technology transfer and in this way contribute to economic development. The analysis of the Croatian framework conditions for technology transfer is based on four relevant prerequisites for a successful technology transfer process: available infrastructure and key actors (i.e., main stakeholders), policy and legislative framework, funding opportunities, and relevant skills. The results of the analysis serve as a basis for concrete recommendations for improving the Croatian framework conditions for technology transfer.

Keywords: *technology transfer, commercialization, universities, technology transfer offices, economic development*

1. INTRODUCTION

Many universities today have incorporated the so-called "third mission" (i.e., technology transfer) into their institutional policies and strategies to contribute to social and economic development by bridging the gap between academia and industry within the national innovation system (Compagnucci and Spigarelli, 2024). Technology transfer is a process of

commercializing scientific research results created by research institutions (i.e., universities) for industry in order to transform the research results into viable new products and services. Since technology transfer improves the national competitiveness of a particular country, it is the focus of interest of many researchers, technology transfer experts and the government (Grimaldi et al., 2011, Muscio 2010).

The importance and promotion of knowledge and technology transfer through the establishment of specialized units, the knowledge and technology transfer units, has been the focus of national governments in many countries and has been emphasized by many researchers (Aragones-Beltranetal et al., 2017; Dzakiy et al., 2024; Debackere, 2012; Fernandez-Alles et al., 2019; Geuna and Muscio, 2009; and Kochenova et al., 2016). Knowledge and technology transfer offices play an important role in facilitating and managing the knowledge and technology transfer process. Nowadays, almost all universities and scientific research institutions have established their respective technology transfer offices to make the technology and knowledge transfer process more efficient (Karanikic and Bezic, 2021). The knowledge and technology transfer offices manage the entire process of knowledge and technology transfer, which includes, among others, the management of joint research projects, protection of intellectual property rights (IPRs), licensing of IPRs, research contracts, establishment of academic spin-off companies, and provision of services to support academic entrepreneurship (de Falani Bezerra and Torkomian, 2024).

Technology transfer is a complex and risky process that requires significant financial resources and adequate human resources (Bradley et al., 2013). As the Organization for Economic Cooperation and Development (OECD) (2003) points out, well-trained human resources in knowledge and technology transfer are essential for an efficient technology transfer process. The operationalization and functions of TT units are heterogeneous and therefore require TT staff to have a variety of skills to manage multiple actions (Cunningham et al., 2020) such as a comprehensive understanding of the national innovation ecosystem in which universities operate, stakeholder engagement and network building, identification of market and business opportunities, legal expertise in intellectual property protection, and experience in spin-off creation.

In the knowledge economy, public institutions such as universities and research organizations are considered sources of knowledge creation and exploitation and, in this sense, key actors that promote innovative activities and contribute to economic development and growth. As sources of knowledge creation and exploitation, universities are shaped by relevant TT policy and legislation (O'Kane et al., 2015), directly funded by public resources to implement a mix of innovation and entrepreneurial activities, or indirectly supported through partnership with industry (Muscio et al., 2013). Public funding can be used to support and strengthen national technology transfer systems (Geoghegan and Pontikakis, 2008), and these policy interventions can have a positive impact on science-industry collaboration and encourage interaction between the public and private sectors (Cunningham and Link, 2014).

Although many developing countries have established their knowledge and technology transfer offices and created their technology transfer frameworks, they are still relatively inefficient in implementing technology transfer. The focus of developing countries remains on transforming from resource-based to knowledge-based economies by building their specific national innovation systems (NIS). In a given country, the NIS represents a system of institutions in both the public and private sectors in which these institutions initiate, modify and disseminate new technologies through the implementation of their activities, with universities and research institutions being important actors with a specific role within the NIS (Etzkowitz and Leydesdirff, 2000, Ranga and Etzkowitz, 2013; Brescia et al. 2016). As national government policies and public funding influence the behavior of technology transfer in a given country (Hsu et al., 2015) and policy makers create policies and laws to enhance collaboration between academia and industry (Audretsch, 2014; Lehmann and Menter, 2016) it is important to create and develop an appropriate and favorable technology transfer system within the national innovation system that enables universities and scientific research institutions to engage in knowledge and technology transfer more efficiently.

This paper provides a theoretical overview of the relevant factors for an effective technology transfer system. This will help universities and scientific research institutions in Croatia to improve their technology transfer activities and performance. The research question in this paper is: What is the role of a national technology transfer framework for effective university technology transfer in Croatia? The research results will serve as a basis for recommendations to improve the Croatian technology transfer framework.

This paper is structured as follows. The introductory part presents and explains the research topic. The second part provides an overview of the existing literature related to the defined research question. The third part of the paper analyzes the relevant factors for an effective technology transfer system. The fourth part discusses the research findings in relation to the relevant factors for an effective technology transfer system in Croatia and possible practical implications for Croatian universities. The fifth and final part of the paper summarizes the research findings and suggests elements for future research.

2. THEORETICAL OVERVIEW

Technology transfer offices at universities and research institutions facilitate the implementation and management of the entire technology transfer process and can have different organizational forms and structures depending on the various factors (Brescia et al., 2016). An efficient technology transfer system and the management and implementation of the technology transfer process require the introduction of appropriate strategies and tools. Lehmann and Menter (2017) argue that it is crucial that policy makers introduce appropriately designed programs, strategies and policy instruments to support the effective long-term technology transfer process. The successful process of technology transfer requires strong collaboration between all relevant stakeholders, the existence of appropriate infrastructure, policy and legislative frameworks, and adequate funding (Karanikic, 2022).

National governments continuously seek and promote technology transfer activities in line with the "third mission" of universities for sustainable economic development. Technology transfer activities have increased in many countries due to public policy measures support to promote knowledge and technology transfer at universities and public research institutions (Feldman et al., 2002). Government interventions to support the commercialization activities of universities include the enforcement of regulations and legislative acts related to the ownership and exploitation of intellectual property (Baldini, 2006; Geuna and Rossi, 2011; Lissoni et al., 2013) and the establishment of publicly funded structures and programs (Rasmussen, 2008; Rasmussen and Rice, 2012; Wright et al., 2006).

The effectiveness of countries' national innovation systems is strongly influenced and depends on the interactions between the different actors (e.g., government, companies, universities, etc.). Their different objectives and priorities can jeopardize the long-term performance of technology transfer. The government can create incentives for collaboration and knowledge and technology transfer between these actors at all stages of the innovation process (Salmenkiata and Salo, 2002), including the introduction of collaborative programs between academia and industry in research and development. Another challenge is the communication between all actors involved, where the government has to intervene because academics do not understand the business culture and the requirements of commercialization and industry has insufficient command of the academic language. The government can intervene as a third party in the process by providing specialized facilities and advisory support to assist the interaction between the different actors within the knowledge and technology transfer process (Feldman et al., 2002). Another challenge that requires government intervention is the knowledge gap created by the lack of management skills and competencies required for knowledge and technology transfer among researchers, entrepreneurs, and technology transfer staff. The introduction of government policies to build the capacity of technology transfer personnel in universities in all aspects of the technology transfer process is critical.

Public policy reforms define rules and boundaries for the implementation of technology transfer activities between universities and the private sector in a given country. The direct financial support measures close the funding gap for knowledge transfer from universities to industry through subsidies, commercialization grants, proof-of-concept funds, pre-seed and seed funds, and government grants that provide funding programs for the establishment of TTOs, science parks, and incubators (Kochenkova et al., 2016).

The main catalyst for the commercialization of university research results and university-industry collaboration has been changes in national legislation (Geuna and Rossi, 2011). Two types of policy initiatives had a positive impact on the transfer of knowledge and technology from universities to industry: the changes in intellectual property ownership rights in favor of universities and specific regulations that encourage university-industry collaboration usually through tax deduction schemes (Kochenkova et al., 2016).

In addition to an appropriate legislative environment for knowledge and technology transfer, national governments are developing and implementing various public policy measures to

provide funding to universities and scientific research institutions for commercialization activities. There are various publicly funded programmes for knowledge and technology transfer implemented in many countries, such as proof-of-concept funds and funding for the establishment and development of technology transfer units and infrastructures (Kochenkova et al., 2016). Another important measure to promote university knowledge and technology transfer is public support measures for research and technology partnerships between universities and industry (Bozeman and Gaughan, 2007) through special technology transfer programmes.

The national technology transfer framework affects the implementation and management of university knowledge and technology transfer processes. The national context for technology transfer shapes the university technology transfer ecosystem. The commercialization of scientific research results is a challenging task for any university and depends on a well-established university technology transfer system (Karanikic et al., 2019) and is a prerequisite for the successful implementation of the university technology transfer process (Karanikic et al., 2021).

In their report, Bole et al. (2024) provided a comprehensive overview of technology transfer and intellectual property protection systems in Croatia in recent years. Their main findings suggest that while Croatia has achieved a significant improvement in innovation performance, the R&I system continues to show a low level of collaboration between academia and industry. They identified several main causes that have influenced the low TT performance such as the lack of continuity in funding programmes for technology transfer and cooperation between academia and industry, the low attention and irregular financial support given to TT professionals over the years, which has led to brain-drain of qualified TT personnel, the independence of university constituents (i.e., faculties) at the largest Croatian universities, and the lack of continuity in TT policies.

3. ANALYSIS OF RELEVANT FACTORS FOR THE TECHNOLOGY TRANSFER SYSTEM IN CROATIA

The Croatian framework for technology transfer is analyzed and discussed through a conducted desk research of publicly accessible sources. Four relevant prerequisites for a successful technology transfer process are taken as a basis: available infrastructure and main actors, policy and legislative framework, funding possibilities and relevant skills.

3. 1 Relevant actors and infrastructure for technology transfer in Croatia

Key actors in technology transfer in Croatia include higher education institutions, scientific research institutions, technology transfer units, private sector companies, start-up and spin-off companies, various intermediaries (e.g., science parks, incubators, accelerators), public and private funds, and relevant government agencies. The role of universities and scientific research institutions is to use the existing research infrastructure and available public and/or private funding to generate new knowledge that can be commercialized with the support

of dedicated TT units and intermediaries. The main actors related to the technology transfer system in Croatia are listed in Table 1.

Table 1. Relevant actors for technology transfer in Croatia

Stakeholder	Description
Ministry of Science, Education and Youth (MSEY)	The main institution responsible for the Croatian higher education and research system, and technological development.
Ministry of Economy (ME)	Implementation of specific programs relevant for R&D and technology transfer activities.
State Intellectual Property Office (SIPO)	Conducts activities in the field of intellectual property protection and supports professional and legislative activities related to intellectual property.
The Croatian Agency for SMEs, Innovation and Investments (HAMAG-BICRO)	The government agency that implements and manages various relevant TT programs.
Universities and scientific research institutions (i.e., institutes)	Higher education and scientific research institutions that carry out teaching and R&D activities.
Knowledge and technology transfer units at universities and PROs	Implementation, management and monitoring of knowledge and technology transfer activities at universities and public research institutions.
Science and technology parks, centers of competence, centers of scientific excellence, incubators and accelerators, investment funds, etc.	Innovative support institutions that assist in the implementation of knowledge and technology transfer.

Source: Author, based on the conducted desk research

The *Ministry of Science, Education and Youth (MSEY)* is the overarching institution responsible for the development of the Croatian higher education and research system and technological development. The MSEY prepares and implements relevant policy documents in the areas of higher education, research, knowledge and technology transfer, and scientific research funding. The Ministry of Economy (ME) implements various programs related to R&D and technology transfer and supports investments in entrepreneurial projects including collaborative R&D projects according to S3 priorities.

The *State Intellectual Property Office (SIPO)* is the administrative authority of the Republic of Croatia responsible for the protection of intellectual property rights. SIPO contributes significantly to the development of the Croatian TT system in several ways. This is done through its public information center (Incentiv) which provides free professional support and assistance in the protection and management of intellectual property rights at the national and international level by SIPO staff, as well as through the SIPO IP Academy which conducts training programs in the field of protection and exploitation of intellectual property rights.

The *Croatian Agency for SMEs, Innovation and Investments (HAMAG-BICRO)* is a state agency under the Ministry of Economy and is responsible for the development of SMEs, investments and the promotion of innovation. It supports business development, international cooperation, and internationalization of Croatian SMEs through various programs, grants, and financial instruments. Regarding the technology transfer framework, HAMAG-BICRO is responsible for the implementation and management of specific programs developed and designed by the MSEY, i.e., the Proof-of-Concept Program and the Technology Transfer Support Programs.

There are 10 public universities and 25 public scientific institutes in Croatia. While the universities teach and conduct research, the public scientific institutes conduct exclusively scientific research and represent the backbone of the Croatian research system. The largest public universities in Croatia are the University of Zagreb, the University of Split, the University of Rijeka, and the University of Osijek. The largest public scientific research institute is the Ruđer Bošković Institute.

The *knowledge and technology transfer units at universities and public research institutions* are responsible for the implementation and management of knowledge and technology transfer activities. The largest universities in Croatia have their own TT offices which are responsible for the management and implementation of TT activities. The same applies to the largest scientific research institute, the Ruđer Bošković Institute, which has its own TT unit. In addition, several faculties are very active in the cooperation between science and industry and have their own TT units such as the Faculty of Mechanical Engineering and Naval Architecture of the University of Zagreb with its Centre for Technology Transfer, and the Nikola Tesla Innovation Centre of the Faculty of Electrical Engineering and Computer Science of the University of Zagreb.

At the University of Zagreb, the oldest and largest university in Croatia, the Centre for Research, Development and Technology Transfer (CRDTT) with three departments for technology transfer, business development and EU projects is responsible for the management of technology transfer activities. The central office for cooperation between science and industry at the University of Split is its Technology Transfer Office (UNIST TTO) which reports to the Department of Science and Innovation. At the University of Rijeka, the central point in the field of innovation and knowledge transfer is the Department for Innovation and Knowledge Valorisation which reports to the University Centre for Research and Innovation. In addition, the Science and Technology Part of the University of Rijeka (Step Ri) was established in 2008 by the University of Rijeka as a limited liability company to facilitate interaction between science and industry and to support knowledge-based entrepreneurship by providing facilities and services for university scientists, students, and entrepreneurs. The University of Osijek manages its knowledge and technology transfer activities through TERA Tehnopolis Ltd., which was established in 2002 as a limited liability company resulting from cooperation between the University of Osijek, the City of Osijek, and the Osijek-Baranja County. The technology transfer office within Tera Tehnopolis Ltd. commercialises the intellectual property of the University of Osijek and strengthens the cooperation between science and industry.

Croatia does not yet have a formal TTO association or formal cooperation between the representatives of the technology transfer offices. However, there is informal cooperation between the technology transfer offices, which occasionally meet and discuss relevant aspects and issues related to knowledge and technology transfer activities at institutional and national level (Bole et. al., 2024).

3. 2 Legal and regulatory framework for technology transfer in Croatia

The legislative and regulatory framework plays an important role in supporting the development of each country's R&I and technology transfer system. The current legislative and regulatory framework for technology transfer in Croatia is summarized in Table 2.

Table 2. Legal and regulatory framework for technology transfer in Croatia

	Description
Smart Specialization Strategy (S3) until 2029	An overarching public policy document for investment in research, development and innovation in the Republic of Croatia which aims to improve the overall Croatian innovation efficiency and capacities in order to strengthen competitiveness and promote industrial digital and green transformation through three specific objectives: Improving scientific excellence, bridging the gap between the research and business sectors, and increasing innovation efficiency.
Intellectual property laws	Intellectual property laws in Croatia are fully harmonized with EU legislation and relevant international agreements and treaties.
National Development Strategy of the Republic of Croatia until 2030 (NDS 2030)	The Strategy links innovation policies and economic development.
The Labor Law	An important law related to the ownership of intellectual property rights in universities and their constituents (e.g., faculties) and PROs.
National Recovery and Resilience Plan 2021-2026 (NRRP 2021-2026) and supporting legislative acts	The focus of the NRRP 2021-2026 is on competitive, business-oriented R&I programs. Supporting acts include the Act on the Croatian Science Foundation, the Act on Higher Education and Scientific Activity, the Act on the Improvement of Entrepreneurial Infrastructure, and the Act on State Aid for Research and Development Projects.
National Guidelines for Technology Transfer	Provide a framework for the effective use of publicly funded research results through appropriate IPR management and entrepreneurial culture and related skills development in public scientific organizations.
Guidelines for technology transfer/IP guidelines and policies at universities/PROs	The largest universities in Croatia have their own regulations and guidelines for the management, protection, and commercialization of intellectual property.

Source: Author, based on the conducted desk research

The *Smart Specialization Strategy (S3) until 2029* improves the efficiency of the Croatian national innovation system and focuses on cooperation between science and industry. The new S3 is aligned with the national development strategy of the Republic of Croatia until 2030. It places a strong emphasis on creating higher value from the results of science-industry collaboration and redefines the governance system for the implementation and promotion of knowledge and technology transfer. The new S3 considers the NRRP Plan 2021-2026 as a relevant source of funding for science-industry cooperation.

The *State Intellectual Property Office's* responsibility is to coordinate the Croatian intellectual property system and granting intellectual property rights. Croatia is a signatory to all relevant international agreements and treaties related to intellectual property and a member of the European Patent Organization.

The direction relevant to technology transfer in the *National Development Strategy of the Republic of Croatia until 2030 (NDS 2030)* is Direction 1 Sustainable Economy and Society. It states that Croatia's economic growth and development will be based on increasing productivity in the public and private sectors, the creation and use of knowledge, and the promotion of investments, innovations and new technologies in order to achieve a technologically dynamic and export-oriented economy.

The *Labor Law* represents an important law when considering the issues related to the ownership of intellectual property at universities and public institutions. The largest universities in Croatia are non-integrated universities and their constituents (i.e., faculties) are separate legal entities with their own regulations that affect the ownership of intellectual property rights. The Labor Law states that any intellectual property created by the employee (e.g., invention) belongs to the employer. Some universities and faculties have developed internal regulations on TT and intellectual property issues and govern the mutual relationship between employee (i.e., researcher) and employer (i.e., faculty) with respect to intellectual property ownership and commercialization.

Under the *National Recovery and Resilience Plan 2021-2026 (NRRP 2021-2026)* Croatia focuses on supporting measures for the research, development, and innovation framework, including technology transfer. The objective of Component 3 Education, Science and Research, which is relevant for technology transfer is to improve the quality of education and scientific excellence and to promote technology transfer between academia and industry. The NRRP 2021-2026 highlights certain challenges related to research and development such as the ineffectiveness of R&I-related policies and the lack of publicly funded research outputs. In addition, the NRRP 2021-2026 takes into account the stronger role of the National Innovation Council as the main coordinating body of the entire National Innovation System and in the new S3 governance.

The *National Guidelines for Knowledge and Technology Transfer* were adopted in December 2022 and provide a framework and recommendations for TT units and research managers for the efficient management of knowledge and technology transfer activities and the commercialization of scientific research results at universities and scientific research institutes. They provide and describe a set of standard activities throughout the lifecycle

of the knowledge and technology transfer process, from idea generation to IP portfolio management and commercialization. The aim of the guidelines is to promote the efficient use of publicly funded research results through appropriate IPR management, commercialization, the development of relevant skills, and an entrepreneurial culture at universities and scientific research institutions, with the ultimate goal of improved collaboration between academia and industry. In addition, the guidelines define certain criteria that must be met for both academic and research organizations and their respective TT units to be eligible for public funding. These include an established TT unit, defined methods and protocols for the knowledge and technology transfer process available to all parties involved in the process, developed knowledge and technology transfer strategies and policies at institutional level, communication channels with a TT unit, etc.

The largest universities in Croatia have developed and adopted their own regulations and guidelines for the protection, management and commercialization of intellectual property. The University of Zagreb has the most detailed guidelines and rules on technology transfer, which were adopted in September 2022. The University of Split developed and adopted the Rules for the operationalization of its respective Technology Transfer Office in March 2022 and the Regulation on Intellectual Property in April 2022 which state that the entire technology transfer process should be implemented and managed by the University's Technology Transfer Office and the Intellectual Property Committee as an advisory body to the Rector for the protection and commercialization of the University's intellectual property. In 2010, the University of Rijeka developed and adopted the Regulation on Intellectual Property Management which regulates the procedures and mutual relations between the University and its constituents (i.e., faculties) and individual researchers in connection with the disclosure, evaluation, protection and commercialization of intellectual property created at the University or its constituent. The Intellectual Property Management Policy provides intellectual property management guidelines for all academic and administrative staff and students of the University to disclose, identify, protect, and commercialize intellectual property created at the University. The University of Osijek developed and adopted its Rules on Technology Transfer in July 2013 and regulates the establishment of a committee for the evaluation of research results, classification and selection of suitable commercialization projects (Bole et al., 2024). The common point of all the above regulations is that the decision on intellectual property protection and commercialization is in the hands of the faculties and their respective deans. This represents an optimal solution considering that the largest universities are not integrated (i.e., the faculties are separate legal entities) and considering the intellectual property rights issues under the Labor Law.

3. 3 Funding possibilities related to the technology transfer in Croatia

In Croatia, most of the R&I funding is provided by the Ministry of Science, Education and Youth (MSEY) through public funding of universities and public scientific research institutions which mainly covers the salaries of academic staff and researchers. The MSEY is very proactive in providing support to TT activities at Croatian research institutions and manages two

dedicated funding programs for TT: a Technology transfer support program, and a Support program for technology transfer offices. In addition, MSEY manages two other programs relevant to TT: the Proof-of-Concept Support Program and the Start-up/Spin-off Companies for Young Researchers Program.

The *Technology Transfer Support Program* supports research institutions in the implementation of technology transfer projects. The program supports the implementation of research and development activities for the development or further improvement of the developed solutions and technical validation prior to the commercialization phase as well as business validation. The program aims to increase the number of technology transfer processes in research organizations in Croatia. The Support program for technology transfer offices supports the activities of units that perform the tasks of the technology transfer office in the implementation of technology transfer projects. The program aims to increase the number of technology transfer processes in Croatian research organizations. The program supports the implementation of business validation activities of the developed solutions before the commercialization phase.

The *Proof-of-Concept Support Program* aims to increase the readiness of companies and scientific organizations for the development of new products and processes through improved R&D and innovation capacities. The program provides funding to micro, small, and medium-sized enterprises, and research institutions to co-finance pre-commercial activities in the initial phase of developing new products, services, and technological processes in order to identify the commercialization potential and guide their further development.

The aim of the *Young Researchers Start-up/Spin-off Enterprise Program* is to encourage young researchers employed at research institutions to set up their own start-up/spin-off company based on research and development activities and the commercialization of their research results.

The *Croatian Science Foundation (CSF)* is the central organization for funding science in all scientific fields in the Republic of Croatia. To fulfill its purpose, the Foundation provides financial resources for basic research (from the state budget) and applied research (with the help of the NRRP) in the early stages of technology readiness and scientific research that is of strategic interest to the Republic of Croatia, as well as for the development of the careers of researchers at the doctoral and postdoctoral level.

The *National Recovery and Resilience Plan 2021-2026 (NRRP 2021-2026)* focuses on the measures to support the framework for R&I which also includes technology transfer. Component 3 is relevant to technology transfer and includes various investments in research and innovation capacity, particularly from the private sector. Under the NRRP there is a funding program for targeted scientific research under the MSEY for which the Croatian Science Foundation (SCF) is responsible. The program aims to increase the number of newly developed technologies, products, and processes by conducting applied joint research between companies and research institutions and promoting their long-term cooperation. Another important source of funding for TT is the Vesna DeepTech VC Fund, which was established in 2024 with the

support of the Croatian Bank for Reconstruction and Development (HBOR) and the Slovenian Development and Export Bank (SID), in cooperation with the European Investment Fund (EIF). The Fund with a budget of 49 million Eur will invest in technology transfer, intellectual property protection, and commercialization of research projects at universities and scientific research institutions in Slovenia and Croatia. The fund will focus on the "proof-of-concept" phase. The fund will play an important role in supporting and creating a consistent framework for technology transfer with TT units at universities and scientific research institutions responsible for the implementation and management of the technology transfer process.

3. 4 Human resources and relevant skills related to technology transfer in Croatia

Qualified and competent human resources for technology transfer are a prerequisite for the successful implementation of knowledge and technology transfer activities at universities and scientific research institutions. TTOs in Croatia are understaffed with an average of 1 or 2 employees.

There is an obvious shortage of TT staff with the appropriate skills at universities and scientific research institutions in Croatia due to a lack of dedicated and continuous funding for TT with most TT units having on average only one or two competent staff to manage TT activities. Most of the existing TT staff develop their skills through learning-by-doing as there is no specialized training for them. However, TT staff in Croatia have at least a basic knowledge of the TT process and commercialization as well as a higher level of knowledge of IPR protection and management (Bole et al., 2024).

4. DISCUSSION

The governance and regulatory environment in which TT actors operate is an important prerequisite for their integration into the TT system at national and institutional level. The legislative and regulatory framework includes policies and regulations related to research and development (R&D), intellectual property rights (IPR), technology transfer and incentives for innovation.

There are many challenges in the field of technology transfer in Croatia, including insufficient collaboration between academia and industry, the lack of relevant technology transfer and entrepreneurial skills among researchers, and limited funding opportunities for early-stage commercialization. However, there are some ways to improve the TT framework such as the existence of TT units at universities and public research institutions, increased international collaboration with other universities and public research institutions, and continuous awareness-raising activities and events to promote collaborations and partnerships between academia and industry.

The TT environment in Croatia has undergone significant development over the last 15 years. While TT initiatives and the development of TT infrastructure have been in place for many

years, recent efforts have focused on improving the legal framework, TT funding, and the promotion of cooperation networks necessary for successful TT.

Universities and other research institutions in Croatia have included the "third mission" (i.e., technology transfer) in their institutional strategies. Most universities in Croatia have established dedicated units for TT which are mostly organizational units (e.g., centers) responsible for the implementation of TT activities. Most universities in Croatia have protocols and guidelines for facilitating and managing the TT process. In addition, some universities have appointed vice-rectors who are responsible for overseeing TT activities at their respective institutions.

There are several challenges that TT units at Croatian universities face in the implementation process. The first challenge is at the institutional level as the universities' management does not fully understand the TT process and is reluctant to engage in TT activities. Another challenge is at the national level as the analysis conducted shows that Croatia should focus on a top-down approach to technology transfer as there is a lack of coordination and adequate communication between relevant TT stakeholders. For the creation of a successful and sustainable technology transfer system, good communication between all relevant actors within the national innovation system is crucial.

The success of TT units at universities will largely depend on the national context and framework for TT, with clear performance indicators defined to guide and push universities to engage more in knowledge and technology transfer. Universities' management must recognize the importance and benefits of knowledge and technology transfer and create the institutional framework for TT that ensures a positive environment and secure the main preconditions for knowledge and technology transfer. In addition, universities' management should prioritize knowledge and technology transfer and incorporate it into their strategies and policies with concrete performance indicators that will enable the continuous monitoring of TT implementation based on key performance indicators. TT performance indicators at university level should be aligned with TT performance indicators at national level. This will enable universities to continuously adapt and improve their TT activities.

5. CONCLUSION

Universities today are under increasing pressure to deliver impact that contributes to socio-economic development. The implementation of the Third Mission and the successful commercialization of universities' research outputs depend largely on the adequate TT frameworks. The national TT frameworks guide the implementation of TT activities at universities.

The main features identified through the conducted desk research and the study results regarding the TT system in Croatia indicate that there is still room for improvement. Although there were some initiatives in the past that provided funding to support TT activities at research institutions, TTOs faced a lack of staff with appropriate TT skills, non-continuous funding of TTOs in terms of available funding programs for TT that would lead to commercially

viable projects. There were only a few successful projects from universities and public research institutions where TTOs have contributed significantly to their commercialization.

The introduction of the National Recovery and Resilience Plan 2021-2026, the Smart Specialization Strategy until 2029, and the National Guidelines for Technology Transfer (National TT Guidelines), combined with a strong national commitment to technology transfer, represent an important step towards creating the conditions for establishing a structured and functioning system for technology transfer in Croatia, securing stable funding for technology transfer and thus encouraging higher education institutions and public research institutions to engage strongly in technology transfer.

An important aspect that needs to be improved in the context of the TT system in Croatia is the increase of R&D investments, especially in the business sector. In addition, it is also important to increase investment in basic research as it is the basis for high-quality applied research that leads to new knowledge and innovation. From the universities' point of view, it is important to invest in the human resources working in TT and in the infrastructural capacities of universities to ensure the necessary scientific capacities to be internationally competitive and have commercial potential.

Establishing the National TT Network in Croatia and supporting its operationalization and activities will help universities to share their best practices and expertise, as well as to use the shared expertise and resources in the implementation of knowledge and technology transfer activities at universities.

This research has certain limitations. The analysis of the Croatian technology transfer framework was conducted by researching publicly available sources and is based on four relevant prerequisites for a successful technology transfer process which are placed in the overall context. For this reason, only general and limited conclusions could be drawn on the current state of the Croatian TT context and framework. For a more comprehensive understanding of the existing national TT framework an assessment of the TT framework at universities is needed. Future research should therefore include an in-depth analysis and assessment of the TT context and framework, as well as the work of TT units at Croatian universities "per se" based on the same four premises and place them in the context of the national TT framework. The results could potentially be used to improve the existing national TT framework based on specific case studies and the particular context and environment in which these universities and their TT units operate.

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ULOGA NACIONALNOG OKVIRA ZA TRANSFER TEHNOLOGIJE U KOMERCIJALIZACIJI REZULTATA ISTRAŽIVANJA NA SVEUČILIŠTIMA: STUDIJA SLUČAJA HRVATSKA

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SAŽETAK

Transfer tehnologije je proces komercijalnog iskorištavanja rezultata znanstvenih istraživanja stvorenih na sveučilištima i znanstvenoistraživačkim organizacijama prema industriji gdje se ti rezultati utjelovljuju u nove proizvode i usluge. Proces transfera tehnologije jedan je od temeljnih procesa koji ima pozitivan učinak na ekonomske performanse svake zemlje. To je složen proces koji zahtijeva odgovarajući okvir za transfer tehnologije na nacionalnoj razini kako bi se omogućila njegova uspješna provedba. Uredi za transfer tehnologije imaju značajnu ulogu u upravljanju procesom transfera tehnologije između znanstvenoistraživačkih organizacija i industrije te poticanju inovacija i gospodarskog razvoja. Cilj ovog rada je pružiti teorijski pregled relevantnih čimbenika koje je potrebno razmotriti i osigurati u kreiranju odgovarajućeg, snažnog i učinkovitog nacionalnog sustava transfera tehnologije u Republici Hrvatskoj koji će omogućiti sveučilištima i znanstvenoistraživačkim institucijama da se učinkovitije uključe u transfer tehnologije i na taj način posljedično doprinesu gospodarskom razvoju. Analiza nacionalnog okvira za transfer tehnologije u Republici Hrvatskoj provedena je temeljem četiri relevantna preduvjeta za uspješan proces transfera tehnologije: dostupna infrastruktura i relevantni dionici, regulative i zakonodavni okvir, mogućnosti financiranja i relevantna znanja i vještine. Rezultati provedene analize predstavljaju osnovu za konkretne preporuke za unapređenje nacionalnog okvira za transfer tehnologije u Republici Hrvatskoj.

Ključne riječi: *transfer tehnologije, komercijalizacija, uredi za transfer tehnologije, gospodarski razvoj*