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Comparative analysis of technology transfer models of Hungary and Israel☆

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ABSTRACT

This study offers a comparative analysis of the technology transfer models in Hungary and Israel, focusing on the conversion of academic research into market-ready innovations. The research emphasizes traditional technology transfer mechanisms, particularly the roles of Technology Transfer Offices (TTOs) and Technology Transfer Companies (TTCs). To assess the effectiveness of these models, apart from the literature review and secondary data analysis, six in-depth semi-structured interviews were conducted with experts from Hungary and Israel. This qualitative approach provided insights into the dynamics that shape technology transfer practices, highlighting differences between the two countries' systems. Israel's technology transfer is marked by flexibility and proactive government policies. Israeli TTCs prioritize licensing over patenting, which allows for greater adaptability in commercialization. This model supports continuous innovation by enabling universities to reclaim and further develop innovations if startups fail. In contrast, Hungary's system, though evolving, tends to focus on patenting and direct commercialization, often missing opportunities for early-stage collaboration between academia and industry. The slower governmental response and weaker integration between universities and industry hinder the effectiveness of technology transfer in Hungary. The study suggests that Hungary could enhance its technology transfer framework by adopting more flexible commercialization strategies, fostering stronger university-industry collaborations, and improving governmental responsiveness. While Hungary's system differs from Israel's, elements of the Israeli model could be adapted to strengthen Hungary's technology transfer capabilities.

1. Introduction

The focus of this study is the process of technology transfer – the mechanism through which academic research is transformed into market-ready innovations. Technology transfer acts as a strong foundation for successful startup ecosystems (Good et al., 2019).

Israel is the leader in best practices - apart from the country's many successes - the country (9.558 million) has almost the same population as Hungary (9.643) (9643 million) (World Bank, 2022). However, Israel has 991 startups. Among those, there are more than a hundred unicorns (startup companies with a value of over $1 billion), and Hungary has 420 startups (Startupblink, 2024) with no Hungarian unicorns (Startup Genome, 2024). Israel's ability to have a high number of unicorns with a similar population size offers a valuable lesson for Hungary. Efficient technology transfer operations are just one of many factors behind Israel's remarkable success in this field.

The Global Innovation Index (GII) ranks the economies of the world based on their innovation competences. Hungary is the 35th of the 132 economies according to the GII, the country is more or less stagnating in this position since 2020. It shows a negative tendency if it is compared with the position of 2018, when Hungary was the 33rd (GII, 2022). It is also important to highlight that Hungary ranks the 35th when it comes to PCT patents by origin/bn PPP$ GDP (GII, 2022).

In contrast to this, Israel ranks the first when it comes to PCT patents by origin/bn PPP$ GDP (GII, 2022). Israel ranked the 14th of the Global Innovation Index among 132 economies in 2022 (GII, 2022). Israel's top technology institution, Technion University managed to gain 48 patent approvals in the United States in 2023, being the first in approved US patents among Israel and throughout Europe (Siegel-Itzkovich, 2024). Mobileye is one of the great examples of successful outcome of university research and technology transfer that is traded on the Nasdaq at a valuation of $33 billion. The company was founded in 1999 and one of the co-founders is a Math professor at Hebrew University, Amnon Shashua (Times of Israel, 2023). These are just a couple of many great achievements for Israel that show the success of university-based technology transfer. Israel serves with numerous best practices for creating

☆ Analysis of Hungarian Practices and Lessons from Israel's Technology Transfer Strategies

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efficient and useful technology transfer methods, that could change and reshape the future of innovation.

The article focuses on the processes that enable research to reach commercialization and explores how Technology Transfer Offices (TTOs) and Technology Transfer Companies (TTCs) facilitate the connection between universities and industry - see Figure 1. While there are many forms of knowledge and technology transfer, including collaborative research, research consortia, and industry-sponsored PhD programs, this study specifically focuses on traditional technology transfer.

1.1. Technology transfer efficiency for Hungary

According to the European Innovation Scoreboard – later referred to as EIS - (European Commission, Hollanders, 2023), Hungary is a moderate innovator, in 2023 it reached the 70.4 % of the EU average – countries who reached the 70 % of the EU average count as Moderate Innovators. The EIS also states that the difference in innovation performance between Hungary and the average performance of the European Union is becoming bigger (European Commission, Hollanders, 2023). There are numerous factors that influence a country's innovation performance, one of which is technology transfer and effective technology transfer can lead to profitable innovation outcomes. For Hungary, technology transfer remains an underutilized opportunity to capitalize on the high-quality research conducted by universities and drive industrial commercialization.

However, to establish an environment for efficient technology transfer in Hungary, a more integrated approach to industry-academia collaboration, along with strategic enhancements in governmental support and TTO capabilities, are essential. The Research, Development, and Innovation – later referred to as RDI - strategy of Hungary (2021–2030) is not without its limitations as well. One of the primary challenges is the actual implementation of these goals, which requires not only financial investment but also a cultural shift in the way research and industry work together. In addition, the absence of concrete examples and specific action plans in Hungary's RDI strategy (2021–2030) is a significant limitation. This lack of detail introduces ambiguity in how strategic goals should be interpreted and implemented across the stakeholders, this could lead to efforts that might reduce the overall effectiveness of the strategy. Moreover, without clear steps, measuring progress towards these goals becomes challenging. This gap also reduces stakeholder engagement; detailed plans and examples are crucial for fostering collaboration and ensuring alignment among researchers, industry partners, and policymakers. The absence of specifics makes prioritizing initiatives and efficiently allocating resources more difficult, potentially leading to not efficient use of the available financial and human capital. Addressing this limitation by developing documents that provide specific examples, highlighting action plans, and outline responsibilities would enhance the strategy's clarity, execution, and impact, would offer a clearer plan to achieve the desired outcomes (NKFIH, 2021).

To address these challenges effectively, incorporating frameworks like Business Model Dynamics (BMD) can provide a structured approach to adapting, innovating, and evolving strategies. Business model dynamics (BMD) offers a strategic lens for understanding how organizations respond to evolving external conditions, especially in technology transfer. This framework encompasses three main processes: Business Model Adaptation (BMA), Business Model Innovation (BMI), and Business Model Evolution (BME). BMA focuses on aligning an organization's existing model to new environmental factors, such as regulatory shifts or market demands, ensuring economic sustainability. In contrast, BMI involves creating novel value propositions, aiming to disrupt market conditions and establish competitive advantage. BME describes incremental, iterative changes in the business model to refine its alignment with strategic goals over time (Peñarroya-Farell and Miralles, 2021).

Integrating open innovation into BMD enhances the effectiveness of technology transfer by leveraging external knowledge flows and stakeholder collaborations. As highlighted in the article, open innovation facilitates distributed innovation processes, allowing firms to co-create and test new business models with diverse partners, including universities and industry stakeholders (Peñarroya-Farell and Miralles, 2021).

The National Research, Development and Innovation Office (NRDI) of Hungary is responsible for the country's research and innovation policies. The NRDI Office is responsible for providing grants and support for scientific research, thereby facilitating the commercialization of research outcomes. This includes managing Hungary's participation in international programs like the European Union's Horizon Europe, succeeding Horizon 2020, which supports collaborative projects across EU member states (NKFIH, 2020).

Hungarian universities and research institutions are increasingly

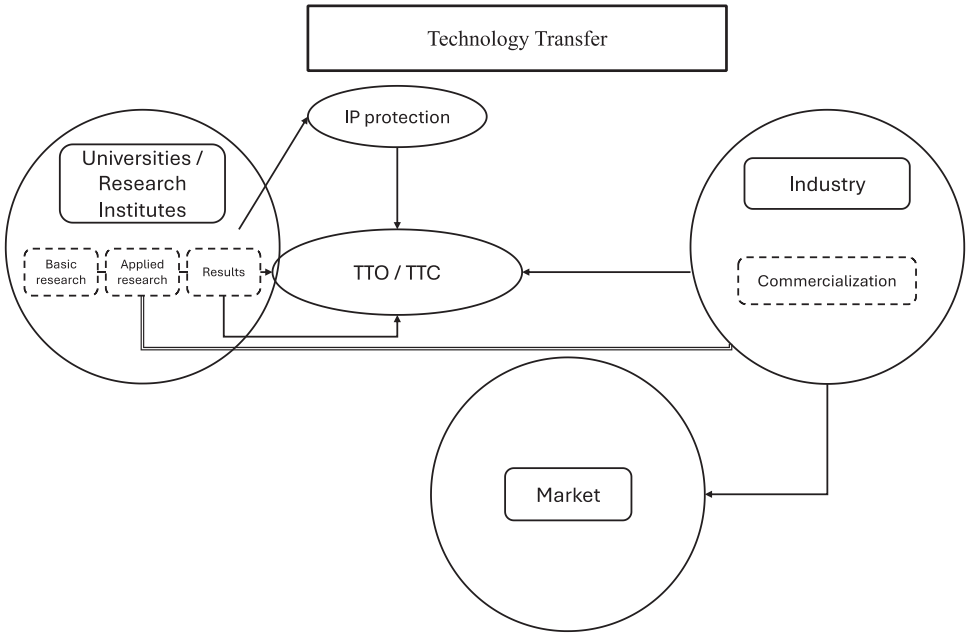

Fig. 1. Context of Technology Transfer. Source: Own work based on the research.

establishing Technology Transfer Offices (TTOs) to manage IP, support industry partnerships, and manage the commercialization of academic innovations. While these offices are integral to Hungary's technology transfer ecosystem, there is still room for improvement as some of the universities in Hungary do not have TTOs or their operation has yet to reach its full potential.

Hungary faces challenges in its technology transfer efforts. Ranking 36th in the Global Innovation Index 2024, the country lags in innovation capacity. Its gross R&D expenditure stands at 1.61 % of GDP, significantly lower than Israel's, limiting the resources available for fostering innovation. Patent activity is also not so significant, with PCT patent applications at 58.8 % of the EU average, signaling room for growth in intellectual property production. Additionally, weaker university-industry linkages, as indicated by Hungary's lower ranking in collaboration metrics, hinder the effective transfer of research outputs into practical applications (European Commission, Hollanders, 2023).

1.2. Israel's success in technology transfer

Israel's business industry significantly enhances its technology transfer ecosystem, supporting a dynamic collaboration between academia and the market. Businesses not only invest in research and development – later referred to as R&D - but also actively participate in incubators and accelerators, guiding academic research towards market needs (Israel Innovation Authority, 2023). Moreover, Israeli companies are partners in licensing and managing intellectual property (IP), turning academic research into products and services through strategic licensing agreements. This not only benefits the commercial sector but also provides royalties back to the academic institutions, supporting further research and development (Meseri and Maital, 2024). Through global networking, these businesses introduce Israeli technologies to international markets, highlighting the country's innovation on a global scale. The industry's openness to new technologies creates a stable demand for innovative solutions, particularly in sectors like cybersecurity, medtech, and agritech, driving continuous innovation and technology transfer (Israel Export Institute, n.d.). The industry takes part in policy advocacy, working alongside the government to support an environment suitable for innovation, entrepreneurship, and technology transfer (Israel Innovation Authority, 2023).

Israel maintains a highly effective technology transfer ecosystem, supported by significant innovation outputs and strategic investments. Ranking 7th globally in patent families per GDP (PPP), the country demonstrates its capacity to generate commercially viable intellectual property. Israel's commitment to research and development is evident, with 6 % of its GDP allocated to R&D—the highest globally. Strong collaboration between universities and industry, ranked 2nd worldwide, further reinforces Israel's ability to transfer knowledge and technologies from academia to the commercial sector. The success of this ecosystem is reflected in the high proportion of high-tech exports, which account for a substantial share of the nation's trade (WIPO, 2023).

1.3. Objective of the article and research questions

Learning from models like Israel's could provide valuable insights and help to improve the legal and regulatory framework for technology transfer and promote a culture of innovation within academic institutions. The objective of this article is to present successful strategies within the domain of technology transfer, drawing upon the example of Israel, and to conduct a thorough analysis of the areas requiring enhancement within Hungary's framework. Furthermore, it seeks to identify the factors from Israel's approach that could be effectively integrated into the Hungarian strategy for technology transfer.

This study seeks to address the following knowledge gaps: What are the primary challenges facing the technology transfer environment in Hungary? What factors contribute to the success of technology transfer in Israel? Which Israeli practices could be effectively implemented in Hungary to improve its technology transfer outcomes? This study aims to spot the areas for improvement in the Hungarian operation of Technology Transfer and provide strategic suggestions to improve it in Hungary.

The research and the first study of this topic was initially conducted for a paper at a Scientific Students' Associations Conference. Following its initial presentation, the research was expanded and further developed, diving deeper into the topic to provide more comprehensive insights and findings. The study got the nomination for best paper award and the further development for publication was recommended.

First, a comprehensive overview of the existing literature on theories related to technology transfer, including the phenomenon of the valley of death and the innovation ecosystem, such as the Triple Helix Model, will be provided, concluding with a presentation of the current technology transfer landscape in Hungary and Israel.

Second, the challenges within the Hungarian technology transfer landscape will be examined. This will be followed by a section on methodology, which details the profiles of the interviewees and the research method. The article will conclude with a presentation of the findings from these interviews, highlighting specific issues in the Hungarian system, describing the Israeli technology transfer environment and offering recommendations to improve Hungary's technology transfer framework.

2. Literature review

2.1. The history of technology transfer, the valley of death and the triple helix model

The history of technology transfer dates back to 1980 with the introduction of the Bayh-Dole Act1, which, according to the Drexel University (n.d.), "enables universities, nonprofit research institutions and small business to own, patent and commercialize inventions developed under federally funded research programs within their organizations." This Act established a uniform patent policy among funding agencies and provided the foundation for reliable technology transfer, encouraging universities to participate in this process (Drexel University, n.d.). Despite these advancements, many universities faced difficulties in marketing and market research, leaving them unable to complete the final step of successful technology transfer. This often led to projects ending up in the valley of death, a gap between academic research and commercialization.

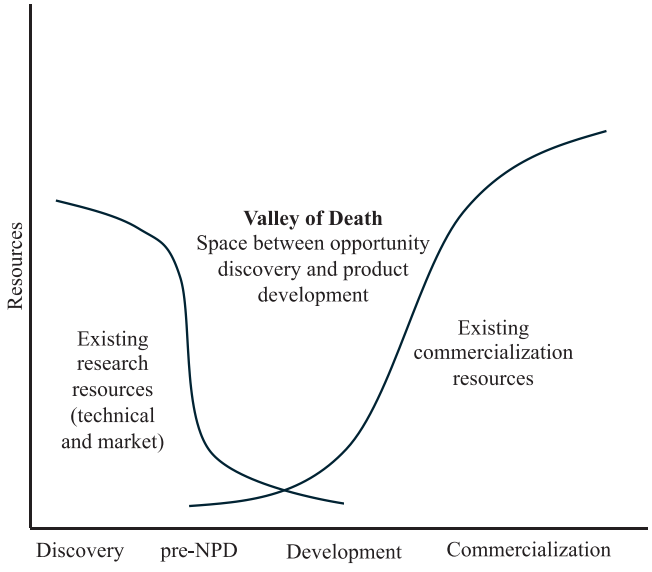

Fig. 2. Valley of Death (Markham, 2002).

The valley of death, as illustrated in Figure 2, arises from several factors. One common issue is the depletion of funds after initial research grants, leaving insufficient resources to advance projects to the commercialization stage (S.A. Gbadegeshin et al., 2022). In addition, inadequate skillsets, human resources, and infrastructure contribute to the failure of new businesses. While some scholars attribute this gap to a lack of collaboration between organizations, others argue that communication exists but is often fraught with challenges due to differing priorities between academia and industry. For instance, businesses prioritize profit-making, while researchers focus on innovation, patents, and publications (Pusateri et al., 2015). The root cause of many of these issues lies in inefficient cooperation, which could be mitigated through the Triple Helix model – visually presented in Figure 3. This framework emphasizes the importance of synergy among academia, industry, and government to combine their unique strengths and reduce the risks associated with research commercialization (Etzkowitz and Leydesdorff, 2000).

2.2. Innovation ecosystems contribution to technology transfer

Innovation ecosystem is the term that describes the actors, stakeholders and members of communities that are essential for innovation. An innovation ecosystem includes participants such as universities, government, corporations, startup accelerators, venture capitalists, investors, entrepreneurs, and the media. These ecosystems enable the creation of process by which the key players can develop solutions to solve problems as efficiently as possible (MassChallenge, 2018).

Rather by looking at the players of this ecosystem individually, to consider them as cooperative members of a team leads to the term of open innovation. Henry Chesbrough's (2003) definition of innovation is that open innovation is a model in which internal and external knowledge to the firm is leveraged to bring new products and services to the market.

Open innovation significantly enhances technology transfer processes from universities by leveraging both internal and external knowledge flows. This approach facilitates the development and commercialization of new technologies, driving research and development (R&D) projects and fostering close relationships between universities and regional innovation systems. Such interactions contribute positively to the performance of technology transfer, encouraging the commercialization of developments generated from academic research (Padilla et al., 2023).

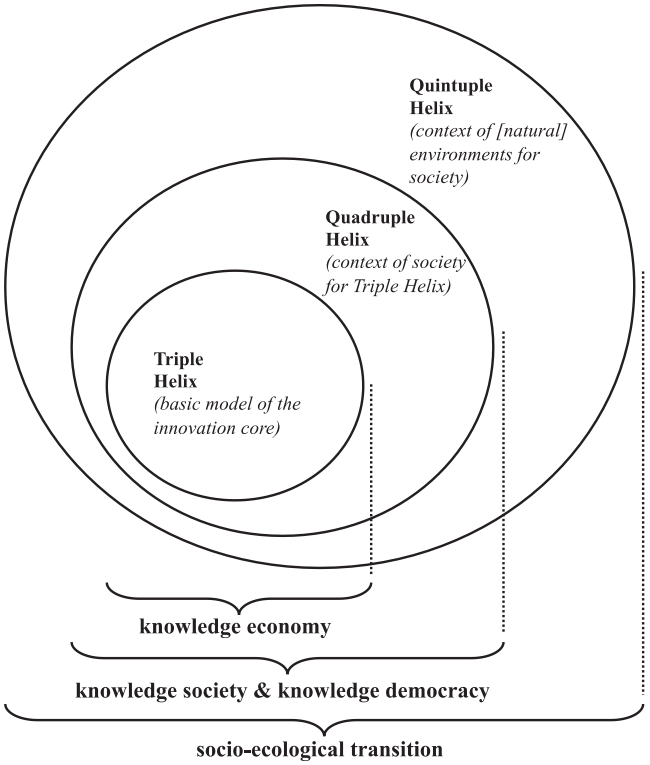

Fig. 3. Triple Helix Model and Beyond (Carayannis et al., 2012).

However, as highlighted by Audretsch and Belitski (2022), open innovation is not without its limitations. Transaction costs, such as coordination, knowledge transfer, and intellectual property management, pose significant challenges, particularly in sectors heavily reliant on research and development. These costs often deter firms from fully engaging in collaborative innovation, as knowledge-intensive sectors face higher risks of intellectual property outflows and imitation. Addressing these constraints through managerial strategies and targeted policies can help firms better navigate the complexities of open innovation while maximizing their innovation output (Audretsch and Belitski, 2022).

The geographical dimensions of open innovation further complicate the dynamics of collaboration. While local and regional partnerships offer reduced coordination costs and foster trust through spatial proximity, international collaborations often introduce regulatory, cultural, and cognitive barriers. As the article notes, firms in creative and knowledge-intensive sectors face heightened limits to open innovation when operating across national and international boundaries. These barriers are compounded by the need for formal mechanisms to protect intellectual property and adapt innovations to diverse markets. Yet, the strategic integration of localized networks with global knowledge flows presents an opportunity to balance the benefits and costs of collaboration. By strengthening absorptive capacity and leveraging digital infrastructure, firms can enhance their ability to integrate external knowledge, driving more sustainable and impactful innovation practices in technology transfer contexts (Audretsch and Belitski, 2022).

The concept of bounded rationality in open innovation dynamics offers an insightful perspective on the complexities of technology transfer. Economic agents, as Yun et al. (2022) explain, often operate with limited information, leading to decision-making processes that are inherently constrained. This is particularly relevant in technology transfer, where collaboration between academia and industry requires continuous adaptation and negotiation. The zigzag growth pattern identified in their study underscores the iterative nature of these interactions, where innovation agents depend on each other's actions to progress. Applying this framework to technology transfer provides a deeper understanding of how systemic inefficiencies can be addressed, enabling stakeholders to foster more effective partnerships and sustainable innovation outcomes (Yun et. al, 2022).

Managing openness in open innovation projects further strengthens the technology transfer process by leveraging diverse external partnerships. For instance, engaging a broad spectrum of collaborators—such as suppliers, industry players, and research institutions—facilitates access to complementary skills and insights that are often crucial for adapting technologies to market demands. In the context of technology transfer, balancing the breadth of partnerships with the depth of collaboration ensures that resources are allocated effectively and that partnerships are sustainable. Dynamic governance mechanisms, tailored to the complexity and stage of the transfer project, help mitigate risks while maintaining flexibility (Lappalainen et al., 2023).

Organizations acknowledged that research and development may not only come from inside of a corporation and the importance of collaboration with external stakeholders.

Collaboration, cooperation and the increasing competition between businesses are some of the main forces that form the landscape of innovation ecosystems and the synergy between the stakeholders. Both open innovation and technology transfer are based on the principle of mutual benefit. In open innovation, organizations benefit from external ideas, while contributors gain recognition or financial incentives. In

technology transfer, the organization transferring the technology benefits by potentially commercializing its intellectual property, and the recipient gains access to valuable technology (Dubouloz et al., 2020).

2.3. Technology transfer landscape in Hungary

2.3.1. History of technology transfer in Hungary

In Hungary, the collapse of innovation structures following the regime change required years of adjustment to establish a framework suited to the economy. Initially, the organizational and legal environment was inadequate for technology transfer, requiring measures such as creating legal and institutional frameworks, securing intellectual property rights, and integrating universities into the innovation chain. From 1992, the government enacted innovation laws and, in 2008, launched supporting programs that provided resources, infrastructure, and facilitated knowledge transfer from universities to market actors. These efforts also aimed to shift the mindset of research institutions toward market-oriented thinking (Béza, 2013).

2.3.2. RDI strategy of Hungary between 2021 and 2030

One of the primary objectives of Hungary's Research, Development, and Innovation (RDI) strategy for 2021–2030 is to incentivize knowledge and technology transfer. This strategy aims to enhance the nation's technological capabilities and foster a well-working ecosystem for knowledge exchange, particularly between the state and non-state sectors. The strategy emphasizes strengthening cooperation tools and financial mechanisms to address the "valley of death," a critical phase where many innovations fail due to insufficient funding.

To achieve effective technology transfer and collaboration, the RDI strategy proposes creating intermediary institutions that bridge the gap between researchers and industry. Building trust among RDI actors is prioritized through organized cooperative platforms that foster confidence. The strategy also underlines the importance of science and technology diplomats, who monitor international RDI practices and adapt successful models to the Hungarian context. Supporting sabbaticals and encouraging researchers to gain business experience further narrow the gap between academia and industry. Additionally, the strategy integrates global best practices through international programs like Horizon Europe and fosters strategic international partnerships, including the establishment of foreign research centers in Hungary and collaborations with neighboring countries (NKFIH, 2021).

2.4. Israel's technology transfer model: a blueprint for innovation and economic growth

Israel's technology transfer model represents a comprehensive approach to innovation and economic development, distinguished by its ability to efficiently convert academic research and ideas into market-ready technologies and successful enterprises. This model is underpinned by several core components that together create a fertile environment for innovation and entrepreneurship.

In Israel, there is an organization called Israel Innovation Authority (IIA), that serves as a cohesive force for the innovation ecosystem. It is an independent, publicly funded organization that among many of its important activities, IIA is a platform that fosters collaboration between the actors of the innovation ecosystem, for entrepreneurs, enterprises, venture capital, government, and academia. Applied research has received 77.4 million NIS amount of grant from the IIA in 2022 (Israel Innovation Authority, 2022).

The three main actors in the innovation ecosystem - as presented in the Triple Helix Model - are the government, industry and academia are the most dominant actors in Israel when it comes to technology transfer. The academia is represented by technology transfer companies (TTC) operating as a subsidiary of research universities that are responsible for the commercialization and marketing of the research outcomes produced by the researchers of the universities. The first TTC - which was the commercialization company of Weizmann Institute of Science – Yeda Research and Development Company Ltd. was established in 1959 and it is still the among most successful TTCs in not just Israel, but also internationally (WIPO, 2023).

At the center of the Israeli model is significant government support and a policy framework that not only invests heavily in research and development (R&D) but also encourages the commercialization of technology. Government initiatives, exemplified by the activities of the Israel Innovation Authority, offer critical financial backing for R&D projects and startups, mitigating the inherent risks of technology development. Additionally, favorable policies facilitate industry-academia collaboration and provide tax incentives for R&D investments, laying the groundwork for a dynamic innovation ecosystem (IIA, 2023).

The venture capital (VC) sector in Israel plays an indispensable role, offering the capital necessary to nurture innovative ideas into successful businesses. The abundance of VC firms, alongside angel investors and government funding programs, ensures accessible financing for startups at various development stages. This rich financial support not only aids in the commercialization of technology but also attracts international investment, reinforcing the model's efficacy (IIA, 2023).

Collaboration and networking form the social fabric of the Israeli model, promoting an ecosystem where entrepreneurs, researchers, investors, and governmental bodies share ideas and resources. This culture of cooperation is facilitated through networking events, incubators, and accelerators, which are instrumental in building connections across the innovation ecosystem (IIA, 2023).

Despite its successes, the Israeli technology transfer model confronts challenges such as market saturation in certain sectors and the need for ongoing adaptation to technological advancements. The model's sustainability hinges on its ability to evolve in response to these challenges, through policy adjustments, investment in new technologies, and efforts to integrate diverse populations into the innovation ecosystem.

In essence, Israel's model demonstrates how a synergistic policy environment, effective IP management, a stable financing infrastructure, and a collaborative culture can collectively spur innovation and economic growth. This model offers valuable insights for other nations aiming to enhance their innovation ecosystems, highlighting the importance of adaptability and inclusivity in sustaining technological and economic advancement.

3. Methodology

This research was conducted in accordance with the ethical standards of Corvinus University of Budapest and the regulations of Hungary. Formal approval from an ethics committee was not required, the study involved interviews with adult professionals.

All participants were fully informed about the study's purpose, procedures, and their rights, including the right to withdraw at any time without consequence.

Confidentiality and anonymity were ensured to participants and removing any identifying information from the data. Data were securely stored and handled in compliance with relevant data protection legislation.

After concluding the literature review captured in the section above, it was decided to follow a qualitative approach to conduct research into the approaches that can enhance collaborative dynamics between academia and industry.

The research was conducted to examine the efficacy of technology transfer models in Israel and Hungary to identify strategic approaches that can enhance the collaborative dynamics between academia and industry.

After careful consideration of the research objectives and the nature of the data required, it has been determined that a qualitative research approach will be employed to provide a deeper understanding of the underlying themes and insights relevant to this study. The data analysis

process was conducted manually by closely reviewing the transcribed interviews to identify recurring themes and patterns relevant to the research objectives. Key insights were organized into categories corresponding to the main challenges and opportunities identified in technology transfer practices, such as TTO/TTC operations, policy execution, and university-industry collaboration. The findings were synthesized into a matrix to provide a structured overview of the issues and actionable recommendations. This matrix is presented in the discussion sections to illustrate the key challenges and proposed improvements in technology transfer practices.

The depth and flexibility of qualitative research, also within interviews allow for exploring the breadth of experiences and insights that quantitative methods might not cover, especially in understanding the interpersonal and interorganizational dynamics that influence technology transfer policies and practices. It allows to present complex insights into the experiences and opinions of practitioners involved in the technology transfer processes in their respective countries and also to get an inside view of the perspective of a person who works with businesses who take part in technology transfer. When designing the questions, the focus was placed on exploring the factors that contribute to successful technology transfer projects and the incentives that facilitate collaboration between universities and industry.

Data was collected through six detailed, in-depth semi-structured interviews with experts in the technology transfer field – see interview questions in the *Appendix*. In-depth interviews help to find out detailed information about individuals' perspectives and experiences (Rutledge and Hogg, 2020). Six people have been interviewed, all of them are experts - given their experience - in the field of technology transfer and they have thorough knowledge with which they could provide many insightful information for this research – Table 1.

The first interviewee is a Hungarian chemical engineer, started her carrier as a researcher and has experience in R&D program design from the executive and the planning perspective, and worked in the private sector with Ernst & Young as an R&D expert. The second interviewee is an innovation consultant in Israel with a broad range of experience across research organizations, industry sectors, and governmental bodies managing national R&D programs. He also has experience with many other countries' technology transfer environments, he was working with Hungarian institutions as well and provided his knowledge and experience to develop the Hungarian innovation ecosystem. The other interviews were made with intellectual property experts, usually they are working from a low perspective (patent attorneys and patent agents.) The interviews were transcribed and analyzed using thematic analysis to identify, analyze, and report patterns within the data.

Table 1
Information about the interviewees.

	Gender	Age range	Area of expertise	Professional experience
Interviewee 1	Woman	40–50	chemical engineering, R&D program design, and innovation consultancy	research, executive R&D planning, leader of a TTO, and private-sector consultancy as an R&D expert with Ernst & Young
Interviewee 2	Men	40–50	innovation consultancy, national R&D program management, and technology transfer	Experience in research organizations, industry sectors, and government bodies in Israel and internationally, including contributions to the Hungarian innovation ecosystem
Interviewee 3	Men	40–50	Patent agent	Management member and patent agent at a patent agency
Interviewee 4	Men	45–55	Innovation expert and Economist	Management member at TTO and market researcher.
Interviewee 5	Men	45–55	Patent agent, Lawyer -International law	Management member at legal office, specialized to patent cases
Interviewee 6	Men	30–40	Patent agent	Patent agent at a patent agency, former R&D researcher at engineering field

Source: Own work based on the information about interviewees

While qualitative methods provide deep insight, the findings are not generalizable to all settings but are specific to the contexts from which the data were drawn. The sample size is also limited, focusing on three individuals, which might not capture all possible perspectives within the technology transfer environment.

In spite of the small sample size the findings cannot be generalized, the research findings derived from the interviews are sufficient for the scope of the study and it helped to get insights from people with relevant experience who presented all of the perspectives relevant for this study.

4. Research findings

In this section the interview answers will be discussed and analyzed. First, the findings of the Hungarian technology transfer operation are going to be presented and the areas that require improvement will be identified. Afterward, the Israeli perspective will be introduced while pointing out the key factors contributing to the successful operation of technology transfer.

4.1. Hungarian perspective

4.1.1. Operation of technology transfer offices in the Hungarian ecosystem

The insights presented in this section are primarily derived from the responses of Interviewee 1, a patent agent with extensive experience in Technology Transfer Offices (TTOs) in Hungary.

In Hungary, TTOs predominantly focus on projects submitted by researchers who believe their innovations are ready for patenting. According to Interviewee 1, these offices play a comprehensive role in supporting the patenting process. They conduct thorough investigations to assess the project's patentability, identify target industries, and locate potential commercial partners. Additionally, they perform competitor analyses, maintain communication with patent attorneys, and facilitate negotiations with companies interested in commercializing the invention. Throughout these processes, TTOs strive to ensure that all parties involved are satisfied with the negotiation outcomes.

Interviewee 1 highlighted that the primary role of TTOs has traditionally been reactive, facilitating processes initiated by researchers rather than actively engaging with researchers at earlier developmental stages. This lack of engagement often results in researchers lacking motivation to pursue patenting, commercialization, and technology transfer. However, it was noted that ongoing efforts are being made to redesign TTO operations, particularly at ELTE and potentially across other Hungarian universities with TTOs. The redesign involves hiring staff who actively collaborate with researchers to identify projects suitable for technology transfer, thereby shifting toward a more proactive approach. This transformation is intended to enhance the effectiveness of TTOs by integrating them earlier in the research process and ensuring promising innovations are identified and supported.

University TTOs play an important role in creating relationships between various stakeholders and in knowledge transfer activities (Grimaldi et al., 2020; Luo and Lee, 2015). While organizational performance in TTOs has often been attributed to "hard" factors such as staffing levels and experience, research suggests that "soft" factors, particularly employee empowerment and engagement, are also

significant (Cavallone and Palumbo, 2021). These soft Total Quality Management (TQM) practices create conditions for improved organizational performance, and managers should focus on promoting employee empowerment and engagement within TTOs (Cucino et al., 2022). TTO licensing, a key outcome of organizational performance, requires considerable effort from technology transfer professionals who must balance scientific and patent competencies with the ability to build trust with licensees (Ustundag et al., 2011). This focus on employee empowerment and specialized competencies aligns with the challenges highlighted by Interviewee 1, who emphasized the need for a more diverse and specialized team structure to overcome administrative burdens and inefficiencies within TTOs.

Several challenges faced by TTOs were also discussed by Interviewee 1. These include significant administrative burdens and a lack of diverse expertise among staff. For instance, the current structure often requires a single employee to possess expertise in patenting, software systems, and various fields of research—a combination that is both unrealistic and inefficient. To address this, the redesign aims to introduce a more diverse and specialized team, capable of effectively handling these varied responsibilities and improving the overall performance of TTOs.

Administrative inefficiencies were also emphasized by Interviewee 1, who pointed out the absence of software solutions to streamline administrative tasks. These tasks consume a disproportionate amount of time, detracting from more strategic activities such as identifying commercial partners and negotiating agreements. The implementation of dedicated software was suggested as a solution to enhance efficiency, allowing TTO staff to allocate more resources to high-value tasks while minimizing the risk of administrative errors.

4.1.2. Improvement of Hungarian technology transfer policy and government support

This section examines the policy framework of the Hungarian Technology Transfer ecosystem. While the findings are subjective to some extent and formal research in this area is scarce, the collective expertise of the participants lends significant value to the study. Although the research may not meet the criteria for a fully scientific investigation, it addresses a critical gap by exploring inefficiencies within Hungarian technology transfer activities and identifying potential areas for improvement.

Across several interviews, three key areas emerged as requiring significant improvement: (1) the execution of policies, (2) changes within the university ecosystem, and (3) the insufficient motivation and understanding of R&D and innovation among small and medium enterprises (SMEs). Despite innovation being a popular topic, multiple interviewees highlighted a gap in actual knowledge and application among many SMEs.

The interviewees collectively observed that, while Hungary has stable policy frameworks for technology transfer, their implementation often falls short, leading to outcomes that deviate significantly from policymakers' original intentions. A recurring theme was the need for experts within policy execution teams to ensure that policies are implemented effectively and that they deliver tangible benefits to the technology transfer process.

Insights from the interviews further emphasized that within universities, the incentivization of researchers and businesses to engage in technology transfer activities is often ineffective. This issue, as highlighted by multiple participants, stems partly from inadequate efforts in this area and is closely linked to poor policy execution. Specifically, interviewees noted a lack of effective Key Performance Indicators (KPIs) for universities and their Technology Transfer Offices (TTOs). Instead of driving meaningful outcomes, the current focus on meeting documentation requirements diminishes the potential impact of these metrics. This challenge is corroborated by the analysis conducted by the National Office of Intellectual Property (SZTNH, 2021), which outlines the difficulty of defining KPIs for TTOs.

Another frequently discussed issue was the administrative burdens faced by TTOs. Multiple participants suggested that software solutions could alleviate these burdens and make technology transfer projects more appealing to businesses and researchers. However, interviewees noted that organizations are often reluctant to adopt such solutions due to high costs and a perceived lack of necessity, leading to hesitancy in investing in organizational development.

Finally, limited motivation and resources among SMEs were identified as critical barriers to their participation in R&D activities. SMEs, despite being ideal candidates for engaging in technology transfer, often lack the incentive to redesign their operations. According to the European Innovation Scoreboard (2023), Hungarian SMEs perform below the EU average in both product innovation (68.8) and business process innovation (32.2). Interviewees attributed this to SMEs' risk-averse nature, smaller budgets, and primary focus on short-term cost savings, which deter investment in innovation.

4.1.3. Challenges of bridging the gap between research and business

The interviewee 1 highlights three main challenges in bridging the gap between academia and industry in Hungary. Firstly, the selection of research topics that align with industrial interests is essential; researchers must adopt a perspective that considers the potential industrial application. Secondly, as projects often lose focus once initial funding runs out, there is a challenge in continuing the research projects beyond the funding period. These insights emphasize the need for a more industry-oriented mindset in academic research and the importance of sustainable funding models to utilize research outcomes. The third challenge that was identified relates to investment funds. For those cases where there are no suitable grant opportunities, another approach could be to attract investors, especially for projects that could lead to the funding of spinoff companies or startups. However, many researchers do not accept investments, misunderstanding how investment works where investors ask for equity in return for funding, unlike grant funding which does not require equity stakes. There is a lack of trust towards investors, and the researchers feel as though giving up equity is unfair for them. This phenomenon shows a significant cultural and educational gap within the academic community regarding the commercialization process and the principles of business and investment in the innovation ecosystem. To complement this, based on my research, there are universities in Hungary - such as the University of Óbuda - where the university itself established a venture capital (Szeberényi, 2023), which could potentially enhance the receptiveness of the researchers to venture capital as a source of funding. However, the impact of such initiatives might not be immediately visible.

4.1.4. Incentives and programs for businesses to engage in technology transfer activities

The interviewee distinguished three different incentive mechanisms, direct and indirect incentives. Direct incentives, or supply-side measures, are R&D tenders that stimulate corporations and businesses to engage in technology transfer projects. Another direct incentive but they are demand-side incentives are public procurement projects and innovation partnerships. This is the less common incentive mechanism as there is lack of trust and expertise in procurement mechanisms. The utilization of this incentive mechanism is currently below its potential, and there is a clear need to boost the propensity to take advantage of it effectively. According to an innovation study conducted by Edquist and Zabala-Iturriagagoitia (2012) public procurement is currently not an efficient incentive instrument as it is focusing on the products to buy not on the functions it should fulfil. By focusing on functional requirements rather than pre-existing products, public procurement can drive innovation and competition, as it encourages suppliers to develop new solutions to meet these functional needs. Another analysis of innovation procurement practices highlights the need to change from traditional push and market-driven strategies to pull and demand-driven strategies. (INSPIRE Project, 2015). Thus, it is not only a problem in Hungary, but it affects the global innovation ecosystem as well.

Tax incentives and discounts are indirect tools that work as financial motivator for businesses, reducing fiscal burdens on companies engaging in R&D activities. In addition, it helps mitigating some of the risks of R&D activities by providing financial relief and Companies might be more inclined to partner with universities or research institutions for technology transfer if they know that their investments will be supported by tax incentives. As tax incentives make R&D more affordable, businesses are more likely to commit to long-term projects that could lead to substantial technological advancements and transfer opportunities.

The third; capital market tools, including venture capital and equity investment forms. These tools help companies develop and commercialize innovative technologies that might otherwise lack the necessary financial resources. This type of financing not only ease the initial investment burden but also considers the interests of investors and companies towards achieving marketable and scalable innovations, supporting stable environment for technology transfer.

Based on the research and interviews conducted, certain mechanisms within the Hungarian ecosystem, such as tax incentives and R&D tenders, effectively encourage the business sector to engage in R&D activities. However, improvements are needed in public procurement projects. Public procurement represents 15 % of total GDP (Edquist and Zabala-Iturriagagoitia (2012)), suggesting it has significant potential to become a more influential policy instrument in promoting these activities.

4.2. Israel's perspective

In the following, insights from the interview with Interviewee 2, an Israeli innovation expert, will be presented. In Israel, the government encourages the licensing of technologies rather than patenting. This approach focuses on either exclusive or non-exclusive licenses, instead of full patent rights. According to Interviewee 2, the preference for licensing over patenting primarily stems from reversibility; if a startup fails, the license can be revoked, and the technology reverts to the university, whereas a patent would transfer permanent ownership to the company. This policy is supported by the government with the understanding that universities are likely to attempt commercialization again, thereby increasing the chances of successful technology transfer.

4.2.1. Operation of Israeli technology transfer companies

In Israel, TTCs serve as crucial intermediaries in the technology transfer process. They are often described as translators between industry and academia. Interviewee 2 emphasized that the difference between these two sectors is so significant that TTCs must play a translation role. Their primary function is to facilitate the transition of academic discoveries into marketable innovations by supporting researchers through various stages of development and commercialization. TTCs also manage licensing processes, ensuring that new technologies efficiently transition from the lab to the marketplace.

A study conducted by Zhang and Zeng (2024) identifies three TTO governance structures: market-oriented, hierarchy-oriented, and hybrid. Using data from 157 Taiwanese universities between 2016 and 2018, the authors analyze the relationship between these structures and TTO performance, measured by the number of patents licensed and technology transfer revenue. The findings suggest that a market-oriented structure is positively associated with TTO performance, while a hierarchy-oriented structure has a negative impact (Zhang and Zeng, 2024). The study shows how different governance structures impact TTO performance, and Israel's TTCs provide a real-world example of how a market-oriented approach can drive success. By actively fostering relationships between academia and industry and prioritizing performance metrics, Israeli TTCs demonstrate the key factors that lead to stronger technology transfer outcomes.

The operation of TTCs in Israel is characterized by a proactive approach to fostering relationships between academia and industry. According to Tamar Raz of Hadasit, one of Israel's prominent TTCs, a significant aspect of their role involves translating academic research into a language comprehensible for industrial partners (Times of Israel, 2023). This translation process bridges the gap between theoretical academic research and practical industrial applications. Interviewee 2 also highlighted that TTCs in Israel are driven by performance metrics, striving to secure high-quality licensing deals. These metrics not only measure the quantity of deals but also their market impact, ensuring technologies have real-world applications.

Additionally, Interviewee 2 pointed out that Israeli TTCs benefit from an extensive network of industry contacts and partnerships that have been cultivated over many years. This network is essential for identifying the right commercial partners for new technologies. Through experience, TTCs have developed mechanisms that support and accelerate the technology transfer process. The effectiveness of Israeli TTCs is further enhanced by their strategic approach to innovation management, actively seeking out promising research with potential market applications. As noted by Leichman (2018), this proactive stance ensures that valuable innovations are developed into products and services rather than remaining confined to academic publications.

In summary, the operational model of TTCs in Israel is a well-functioning mechanism that focuses on maximizing the commercial potential of academic research. Through effective translation services, well-defined performance metrics, a strong network of industry relationships, and a proactive approach to innovation management, TTCs play a vital role in Israel's technology transfer ecosystem.

4.2.2. Role of the Israeli government and policies

The government plays a crucial role in the ecosystem of technology transfer, primarily through regulatory oversight and targeted financial support. According to Interviewee 2, this oversight ensures that all parties, especially businesses seeking government support, act responsibly and ethically. Financial incentives provided by the government direct research efforts toward areas of national and immediate importance, allowing for strategic alignment between academia and industry. Interviewee 2 emphasized that the government's ability to deploy funds rapidly in response to emerging challenges demonstrates its role as a strategic director of research.

In Israel, governance is not limited to fixed policies but includes dynamic decision-making, which allows the government to foster a responsive research environment. This agility avoids bureaucratic delays, ensuring timely responses to emerging challenges. Interviewee 2 also highlighted that the government strategically establishes specialized roles and centers in universities to facilitate effective technology transfers. If initial strategies fail, the government reevaluates and adjusts its approach, ensuring efficient resource utilization and continued innovation.

4.2.3. Incentives that encourage businesses to engage in technology transfer

Several programs incentivize businesses to collaborate with researchers in Israel. According to Interviewee 2, most of these programs are operated by the Israeli Innovation Authority (IIA), while others are run by the Ministry of Science, Technology, and Innovation. The interviewee noted that the IIA adopts a market-pull mechanism, focusing on industry needs, whereas the Ministry employs a technology-push approach, emphasizing academic priorities. Research suggests that market-pull strategies are more readily commercialized than technology-push strategies (Ameka, 2013), reinforcing the need for balanced integration.

Programs such as MAGNETON connect companies seeking specific technological solutions with researchers possessing the necessary expertise. Interviewee 2 described how programs like NOFAR support early-stage applied research, providing a pathway for projects that do not yet meet the criteria for more advanced programs like MAGNET. These initiatives bridge the gap between academic research and industry needs, promoting collaboration and innovation.

Additionally, Israel's tax policies, including reduced tax rates for technology companies and R&D tax credits (Israel Tax Authority, n.d.), were highlighted by Interviewee 2 as essential incentives. These measures attract investment in technology startups and encourage companies to engage in innovative activities.

4.2.4. *Key factors of effective technology transfer in Israel*

Interviewee 2 emphasized that close collaboration between researchers and industry professionals is significantly facilitated by the small size of the Israeli academic ecosystem. Many researchers work closely with former students now employed in industry, fostering mutual understanding and collaboration. This network ensures a continuous exchange of practical knowledge and innovation between academia and industry.

Financial dependencies further align academic research with industry needs. According to Interviewee 2, while academia provides basic salaries, additional funding for research often comes from industry partnerships. This dependency motivates researchers to produce industry-relevant outcomes, fostering stronger collaboration.

Finally, the symbiotic relationship between academia and industry is supported by structured government programs, as described by Interviewee 2, which reduce financial risks and encourage innovation. This interaction ensures that academic institutions provide cutting-edge research while businesses gain access to novel technologies and insights at reduced costs (Sheykin, 2023).

5. Discussion

The comparative analysis between Israel and Hungary is relevant due to the countries' similar population sizes but significantly different outcomes in technology transfer and innovation ecosystems. While both nations have established frameworks for research and development, Israel's proactive policies, government support, and strong university-industry collaborations have positioned it as a global leader in innovation and in technology transfer practices as well. In contrast, Hungary's developing ecosystem offers potential for improvement by adapting practices from Israel's success.

This research employs an exploratory approach, addressing gaps in the existing literature on technology transfer, particularly within the Hungarian and Israeli contexts. As an exploratory study, many of the findings presented in this research have not been extensively discussed in previous academic works. This lack of direct comparison highlights the novelty and significance of the study in shedding light on under-researched aspects of technology transfer practices and policies. While the findings align with broader theoretical frameworks, such as innovation systems theory and models of university-industry collaboration, they also reveal unique challenges and opportunities specific to the Hungarian and Israeli ecosystems. The absence of prior literature directly addressing some of these findings further enforces the need for further empirical investigation and theoretical development in this field. By contributing new insights, this study lays the groundwork for future research to build upon and validate these initial observations.

Open social innovation, as described by Murray et al. (2010), provides a valuable framework for addressing the challenges of technology transfer through collaboration and inclusivity. By involving diverse stakeholders — such as universities, industries, government, and civil society — this approach promotes the co-creation of solutions to complex societal challenges. For Hungary's technology transfer ecosystem, adopting open social innovation principles could strengthen collaboration between academia and industry by fostering greater trust and alignment of objectives. Similarly, Israel's success in building a dynamic innovation ecosystem highlights the importance of inclusive partnerships and adaptive policies in translating research into societal and economic benefits (Murray et al., 2010).

In conclusion, the Hungarian technology transfer ecosystem faces several challenges that affect its effectiveness, but strategic improvements can significantly enhance its functionality – the summary of challenges and recommended improvements are shown in Table 2 and Table 3.

It is important to make stronger and more successful university and corporate connection. As Stocker (2019) say managerial perceptions on civil service and education has significant positive association with firm-level competitiveness. And also, Stocker (2019) say that Hungarian International New Ventures grow faster, create more added value, pay higher wages and create higher return on investment than other new ventures. Thereby, it reflects that if the Hungarian Technology Transfer ecosystem can improve, every participant can benefit from it.

It is essential to address several key issues in the discussion section.

Firstly, Technology Transfer Offices (TTOs) currently operate reactively, mostly engaging with projects that are ready for patenting by researchers. This limits the scope of projects that receive support. A proactive redesign of TTO operations is essential, involving staff who actively identify and nurture early-stage projects. Introducing a team with diverse expertise and implementing specialized software would reduce administrative burdens and

allow staff to focus on strategic activities such as securing commercial partnerships.

Secondly, while Hungary has elaborate policy frameworks for technology transfer, the execution often fails, resulting in outcomes that are different from original intentions. Improving policy implementation with expert oversight and realigning university KPIs towards meaningful innovation outcomes could bridge this gap. Furthermore, integrating efficient administrative software could streamline processes, making technology transfer more attractive to researchers and businesses.

Thirdly, Small and Medium Enterprises (SMEs) display a lack of motivation to engage in R&D due to a focus on short-term cost savings. Enhancing incentives and educational outreach can illuminate the long-term benefits of innovation, potentially increasing SME participation in technology transfer. The average Hungarian company avoids R&D even though Troilo et. al. (2024) found a positive and significant relationship between the former and the probability of paying dividends, investing in research and development (R&D), and spending on capital expenditures (CAPEX).

Lastly, public procurement, representing a significant portion of GDP, is underutilized as an incentive for innovation due to mistrust and lack of expertise. Shifting from product to functional procurement and

Table 2
Challenges of Hungarian technology transfer and recommended improvements based on the interviews and research.

	Current Challenges	Recommended Improvements
TTO operations	Reactive engagement mostly with projects ready for patenting, limiting support scope.	Redesign TTO operations to be proactive; introduce diverse expertise and specialized software to reduce administrative burdens.
Policy execution	Policies are well-designed but poorly executed, leading to outcomes different from original intentions.	Enhance policy implementation with expert oversight; realign university KPIs towards meaningful innovation outcomes.
University-industry relationship	Insufficient collaboration and communication between universities and industries; low translation of research to market applications.	Strengthen collaborative platforms, establish regular industry-academia forums and partnership programs to enhance synergy and knowledge transfer.
Public Procurement	Underutilized as an innovation incentive due to mistrust and lack of expertise.	Shift from product to functional procurement; provide training to stakeholders to unlock its potential as a driver of innovation.

Source: Own work based on the research

Table 3
Challenges of Hungarian Technology Transfer and recommended improvements from Israeli examples.

	Challenges in Hungary	Recommended Improvements from Israeli Example
KPI and performance measurement of TTOs / TTCs	KPIs are not well defined, there is a focus on quantitative rather than qualitative metrics.	Well-defined KPIs with strictly measured resulting in effective operation of the TTCs
University-Industry Synergy	Limited interaction between academia and industry.	The collaboration between industry and academia starts early on in most researcher's career.
Incentives for Industry Collaboration	Insufficient incentives for SMEs to engage in R&D and technology transfer.	Implement targeted financial incentives and programs like Israel's MAGNETON to encourage industry-academia collaboration and leverage industry pull. Trusted system of personal incentives.
Policy execution	Even though there are stable policies, the execution often fails.	Experts are making sure that the policies are effectively implemented.

Source: Own work based on the research

training stakeholders could unlock its potential as a driver of innovation.

6. Conclusion

In the study, both the Israeli and Hungarian technology transfer operations, the innovation environment, and the collaborative willingness of universities and industry were examined. Based on interviews conducted with professionals from Israel and Hungary, areas for improvement in the Hungarian technology transfer environment were highlighted, and the main factors contributing to the success of Israel's technology transfer ecosystem were outlined. From the interviews, it can be concluded that Israel's dynamic technology transfer ecosystem underpins its success, while Hungary's system is still evolving and holds significant potential for growth. Even though, the differences between Hungary and Israel are significant and not every practice could be applied, there are several points from the Israeli example that the Hungarian technology transfer benefit from. A concise overview of how technology transfer functions in Israel and Hungary will be presented, actionable recommendations for enhancing Hungary's approach—based on in-depth interviews and research—will be provided, and the scope and limitations of this study, including areas for potential further research, will be discussed.

Israel's framework is known for facilitating seamless integration between academic research and industrial application, supported by agile government policies and effective TTCs. In Israel, the strategy to prioritize licensing over patenting allows for greater flexibility in commercialization. This flexibility is crucial because it permits the rescinding of licenses if startups fail, thereby reverting the innovations back to the universities. This approach contrasts sharply with the irrevocable nature of patents, which transfer unconditional ownership to corporations. Israeli TTCs enhance this dynamic by actively participating from the initial stages of academic research, helping to translate scientific discoveries into commercially viable products through strategic oversight and important industry relationships.

In Hungary, there are some issues that need to be addressed in order for the processes and the collaboration between industry and university to develop. Hungarian TTOs focuse on patenting and direct commercialization activities. This approach tends to overlook the potential of early-stage innovations and limits the scope for academic-industry collaborations during the formative phases of technology development. The Hungarian system also suffers from slower governmental responses and a less integrated relationship between academia and industry, which decreases the efficiency of the adaptation to market and technological advancements.

The operational frameworks in Israel and Hungary underscore significant disparities that influence their respective effectiveness in technology transfer. Israel's success is largely due to its government's proactive and flexible approach, which facilitates immediate and strategic responses to new technological challenges. This dynamic is supported by comprehensive policies that adapt swiftly to industry needs, allowing for continuous innovation and alignment with global technological trends.

In contrast, Hungary's system is characterized by bureaucratic operation that delays the response to technological opportunities and impedes the seamless flow of innovations from academia to industry. Israeli TTCs operate within a culture of innovation that nurtures strong networks among academics, industry professionals, and former students, creating a collaborative ecosystem for technology transfer. These networks support the commercialization process and enhance the collaborative attitude, making it easier for startups and established companies to innovate together with universities and academia.

Conversely, Hungarian TTOs lack this interconnected framework, resulting in isolated operations and limited industry interaction. Additionally, the Israeli incentive model, which combines direct and indirect strategies to stimulate both demand and supply sides of technology transfer, provides an example that Hungary could consider implementing. This comprehensive approach helps bridge the gap between academic research and market demands, fostering a vibrant environment conducive to innovation.

From the practices of the Israeli technology transfer ecosystem, Hungary could implement several strategic improvements. Governmental agility would allow faster strategic decisions in response to emerging technological trends and market needs. This could be achieved by simplifying the bureaucratic processes and enhancing the flexibility of funding mechanisms to support innovative projects.

Reforming Hungarian TTCs to engage more actively in the early stages of the innovation process would also be beneficial. This involves training TTC staff across various disciplines to ensure a broad understanding of both technological and market demands, which would enhance their ability to support academic innovations from beginning of the research to commercial realization. In addition, the adoption of advanced administrative technologies could significantly reduce the bureaucratic overhead, freeing up resources to focus on core activities such as strategic partnership development and complex negotiations.

Strengthening the ties between academia and industry through structured programs would encourage a continuous exchange of knowledge and resources. It is important to reform the attitude of researchers towards technology transfer, so they could see the benefits of commercialization of their research and be more open to the industry.

Moreover, refining the incentive structures to make them more comprehensive and accessible would stimulate both academic and industrial sectors to commit more fully to technology transfer activities. This includes enhancing the transparency and accessibility of grant programs and revising public procurement policies to incentivize innovation through practical and functional requirements.

6.1. Limitations

The study may not fully account for the cultural and institutional differences between Israel and Hungary. These differences can influence how policies and practices are implemented and received. For instance, the risk-taking entrepreneurial culture prevalent in Israel is less typical in Hungary, which could affect the implementation of certain strategies.

The study primarily relies on qualitative analyses through 6 in-depth interviews. Our goal was to interview highly credible and experienced professionals who have been actively involved in technology transfer for an extended period. We also aimed to include participants from diverse

roles, such as researchers, innovation consultants, patent agents, and TTO/TTC managers, to capture multiple perspectives on the technology transfer process. While this approach provided rich qualitative insights, the small sample size of six interviewees may not fully capture the breadth of experiences across both countries' technology transfer ecosystems. The limited number of participants restricts the generalizability of the findings, and future studies could benefit from a larger participant pool.

The findings and recommendations proposed based on the Israeli model may not be fully generalizable or applicable to the Hungarian context without significant adaptations. This limitation comes from different national priorities, economic conditions, and governmental policies that shape each country's technology transfer environment.

Another limitation is caused by the availability and recency of data. Technology transfer is a rapidly evolving field, and data or case studies that are even a few years old may not accurately reflect current conditions or emerging trends.

The financial strategies and models of funding that work in Israel might not be viable in Hungary due to different economic scales and capabilities. The economic feasibility of implementing certain Israeli practices in Hungary could be a significant limitation.

6.2. Recommendations

The study's comparison of technology transfer processes between Israel and Hungary offers valuable insights for various stakeholders.

Policymakers can use these findings to refine technology transfer policies, crafting incentives and regulatory environments that strengthen collaboration between academia and industry, ultimately boosting national innovation systems and economic strategies.

University administrators and TTOs can optimize research commercialization by adjusting partnership models, IP management, and industry engagement for greater efficiency.

Business leaders and entrepreneurs, especially in startups and tech sectors, can enhance their strategic planning by leveraging successful technology transfer models, fostering long-term collaborations that bring cutting-edge technologies into their operations.

Academics and researchers in innovation management can gain fresh perspectives on negotiation strategies and stakeholder dynamics through the comparative analysis.

By comparing the framework of Israel with the emerging ecosystem in Hungary, key areas for improvement and identified actionable strategies were mentioned that could significantly enhance Hungary's innovation ecosystem.

In the future, it is essential to focus on making improvements in the current functioning and building an environment where technology transfer can operate as a key component of Hungary's innovation landscape.

6.3. Suggestions for further research

Future research should explore the broader systemic factors that contribute to successful technology transfer ecosystems, examining areas such as policy governance, cultural attitudes towards innovation, and global best practices in academic-industry collaboration. For instance, studies could investigate how different governance models—such as centralized versus decentralized management of technology transfer—affect the speed and efficiency of commercialization processes. Additionally, research might focus on the role of national education systems in fostering innovation mindsets, such as integrating entrepreneurship training into STEM curricula to prepare researchers for technology commercialization. Further research could also analyze the socio-economic impacts of successful technology transfer, assessing how the establishment of regional innovation hubs or science parks stimulates local economies in less developed regions.

Finally, longitudinal research could track the evolution of Hungary's technology transfer ecosystem and similar emerging systems, providing insights into the long-term impacts of specific interventions and identifying areas requiring further refinement to drive innovation and competitiveness.

Ethics statement

This research was conducted in accordance with the ethical standards of Corvinus University of Budapest and the regulations of Hungary.

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CRediT authorship contribution statement

Korányi Rachel: Writing – review & editing, Writing – original draft, Visualization, Investigation, Conceptualization. **Dr. Fülöp Zoltán:** Writing – review & editing, Supervision, Resources, Methodology, Funding acquisition, Conceptualization.

Declaration of Generative AI and AI-assisted technologies in the writing process

During the preparation of this work the author(s) used DeepL in order to minimize grammar and linguistic mistakes. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendices

1. Interview questions – Israel

1. Could you provide an example of a successful technology transfer case you have experienced in Israel and describe the critical elements that led to its success?

2. What mechanisms are currently in place in Israel to encourage businesses to collaborate with academic institutions?

3. How does the Israeli innovation ecosystem facilitate the alignment of research projects with the interests and needs of the business sector?

4. In your opinion, what are the key factors that make technology transfer particularly effective in Israel?

5. Could you discuss the role of government policies in supporting technology transfer in Israel?

6. How do Technology Transfer companies in Israel encourage researchers to pursue projects with strong commercial potentials?

7. What best practices from Israel's approach to technology transfer could be applied to Hungary to strengthen the connection between research and market application?

2. Interview questions – Hungary

1. Can you share a successful example of technology transfer you have been involved with in Hungary? What were the key factors that contributed to its success?

2. From your experience, what are the main challenges in bridging the gap between academia and industry in Hungary, and how can these be addressed?

3. What role do Technology Transfer Offices (TTOs) play in the Hungarian ecosystem? Could you describe how they operate within the institution you worked in?

4. Are there specific sectors or industries in Hungary where you see a stronger alignment or more successful collaboration between academia and business?

5. What incentives or programs are currently in place to encourage businesses in Hungary to engage with academic research and innovation?

6. In your view, how could Hungary improve its framework or policies to better facilitate technology transfer and stimulate innovation?

7. What actions or initiatives have been most effective in encouraging researchers to focus on areas of research that align with industry needs and have commercial potential?

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