

# Analyses of University Research Commercialization in Underdeveloped Countries: A Case Study of North Macedonia

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**Abstract** – This study explores a significant research gap concerning university research commercialization within developing economies, with a specific focus on North Macedonia as a representative case. Employing a novel and replicable methodological approach that combines in-depth qualitative interviews with researchers and comprehensive quantitative data analysis, the study provides a unique and comprehensive analysis of the factors influencing research commercialization in this specific context. The research extends its scope beyond the identification of key strengths, such as high research productivity, by also delineating critical weaknesses that impede commercialization efforts. To address the weaknesses, the study proposes concrete and actionable recommendations, including targeted proof-of-concept grants, enhanced education on intellectual property and commercialization strategies, strengthened technology transfer office capabilities, and intensified collaboration with the private sector. This study addresses this crucial gap by investigating the factors influencing university research commercialization in North Macedonia, a representative case of a developing economy.

This research not only enriches the academic discourse on university entrepreneurial ecosystems in non-western contexts but also offers valuable insights applicable to other developing economies. By presenting a replicable framework for evaluating university research commercialization efforts on a global scale, the study analyses university research commercialization, particularly within developing economies. The study's methodological approach, combining qualitative insights and analytical survey techniques, offers a replicable template for examining university ecosystems.

**Keywords** – academic entrepreneurship, technology transfer, university research commercialization, developing economies, intellectual property protection, entrepreneurial ecosystems.

## 1. Introduction

Universities have emerged as increasingly prominent contributors to national innovation systems and catalysts for economic development [3].

Academic research is seen as producing discoveries and technologies with commercial potential that can be transferred to the private sector via commercialization activities [2]. This process of university technology transfer and research commercialization is viewed as a vital mechanism for translating public investments in R&D into economic growth and competitiveness [8].

However, universities face multiple barriers in transitioning from traditional teaching and research roles to active engines of entrepreneurship and commercialization [10]. These constraints can be pronounced in developing and emerging economies like North Macedonia which have more nascent innovation systems. This paper provides an original empirical study examining the state of university research commercialization in Macedonia based on perspectives from 80+ researchers and 28 tech transfer offices. It aims to address the lack of grounded studies giving voice to academics in developing economic contexts [10].

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The study has three central objectives: 1) To delineate the key actors and relationships constituting the Macedonian university entrepreneurial ecosystem; 2) To identify core strengths, weaknesses, and gaps impacting research commercialization based on data collected from local stakeholders; 3) To provide recommendations for improving the commercialization capacity and productivity of Macedonian institutions.

## 2. Literature Review

There has been growing multidisciplinary interest in studying entrepreneurial universities and their role in commercializing academic research. University-industry partnerships are fundamental in bridging the gap between academic research and commercialization [1], [2]. These partnerships are crucial for knowledge exchange, technology transfer, and the creation of successful spin-off companies [1], [2], [3] offer the "triple helix" model, which conceptualizes the interconnectedness of universities, industry, and government in driving innovation [3]. This framework provides a valuable lens for understanding the complex dynamics of university research commercialization and the importance of collaboration among diverse stakeholders [3]. [7] and [9] emphasize the vital role of social networks in fostering knowledge exchange and collaboration among academic entrepreneurs [7, 9]. Strong social ties act as "knowledge filters" providing valuable resources, support, and opportunities for academics with entrepreneurial aspirations [7], [9].

Technology business incubators play a crucial role in supporting technology-based startups by providing essential services, resources, and mentorship [10]. [11] highlight the importance of tailored incubation programs to address the specific needs of these emerging ventures [10].

The Macedonian startup ecosystem, as described by [5], faces challenges in developing its entrepreneurial capacity within universities [5]. [12] emphasize the need for increased support for innovation and entrepreneurship initiatives within higher education institutions in North Macedonia [12].

Future research should explore various aspects of university research commercialization, including:

- Effectiveness of different university-industry collaboration models [1], [8].
- Impact of government policies and regulations on the process [11].
- Role of universities in fostering regional innovation ecosystems [5], [10].
- Case studies of successful university spin-offs and entrepreneurial universities [2], [8].

— Continued investigation of the impact of COVID-19 and its implications for entrepreneurial activities within higher education [12].

By addressing these research gaps, we can gain a deeper understanding of the factors influencing university research commercialization and develop strategies for fostering innovation and entrepreneurship within the academic sector. Defined as an integrated institution, the entrepreneurial university transforms newly developed knowledge within scientific disciplines into economic and social utility through commercialization activities.

However, studies also reveal common barriers to commercialization rooted in misaligned incentives, risk aversion, lack of funding, and weak external ties [4]. These challenges can be more acute in emerging economy contexts compared to advanced ecosystems like the US [6]. Although some work has profiled BRICS economies like China and India, Sub-Saharan Africa remains understudied [10].

University technology transfer offices (TTOs) are central intermediary structures that facilitate commercialization through activities like patenting, licensing, and creating spinouts [6]. However, TTOs often suffer from suboptimal funding, capabilities, metrics, and processes, limiting productivity [6].

Studies also highlight the pivotal role of external relationships with industry in enabling technology transfer and absorptive capacity for research insights [4]. University-industry partnerships provide avenues to translate IP into commercial innovations through licensing, contract R&D, and spinouts with corporate support.

In summary, key success factors include motivated inventors, capable TTOs, and external linkages. However, misalignments in incentives, resources, capabilities, networks, and culture can become barriers to leveraging and scaling academic innovation.

## 3. Research Methodology

The study utilized two primary data sources collected through original fieldwork:

1. Surveys with 80+ university researchers;

The core data source was detailed surveys completed by over 80 active researchers at major public universities in North Macedonia. Respondents volunteered to participate and represented a range of scientific disciplines and seniority levels.

The survey consisted of approximately 30 structured and open-ended questions asking researchers about:

- Background and expertise;
- Research activities and objectives;
- Commercialization and entrepreneurial experience;
- Perspectives on commercialization incentives and barriers;
- Interactions with the technology transfer office;
- Collaboration with external stakeholders;
- Attitudes toward entrepreneurial activities.

This comprehensive questionnaire enabled a multidimensional understanding of researcher profiles, motivations, commercialization outcomes, and ecosystem perspectives. The sample contained researchers from the largest Macedonian universities allowing credible insights into the population.

2. Interviews with 28 university tech transfer offices;

The second data source was in-depth interviews with directors and staff from 28 technology transfer offices at Macedonian universities. This included all the major TTOs, providing a census perspective.

Interviews followed a semi-structured format with approximately 20 questions covering:

- Services and capabilities offered;
- Structure and staffing;
- Commercialization policies and processes;
- Portfolio of patents, licenses, and startups;
- Links with external ecosystem actors
- Perspectives on incentives, barriers, and organizational culture;
- Suggestions for improving commercialization and impact.

The interviews illuminated TTO capabilities, activities, and outlooks on the university innovation environment. Analyzing their responses in conjunction with researcher data revealed alignments and discrepancies among key actors.

#### 4. Assessment of the Macedonian University Entrepreneurial Ecosystem

Key findings point to high research activity among academics, but very limited commercialization and external engagement. Top challenges include financial disincentives, cultural norms, knowledge gaps around IP protection and commercialization, and lack of collaboration with industry. To enhance Macedonia's innovation capacity, key areas of priority encompass the implementation of proof-of-concept funding

programs, the establishment of incentives linked to commercialization, the enhancement of TTOs through upskilling initiatives, and the strategic integration with the private sector. The university entrepreneurial ecosystem begins with the motivations and commercialization behaviors of individual researchers [8].

The survey data from [5] reveals Macedonian academics are strongly motivated by intrinsic goals of knowledge creation and dissemination as it can be seen in Figure 1. Over 90% of respondents ranked “advancing knowledge in my field” and “sharing knowledge through publications” as very important personal objectives. They also reported high research productivity, with 60% publishing over 5 papers annually as it can be seen in Figure 2. In contrast, commercial activities provided as chart in Figure 3 were viewed as relatively unimportant. Only 22% of researchers rated “commercializing research through patents, licenses or spinouts” as a top priority. Even lower percentages saw generating revenue from research or founding startup companies as central objectives. There were no significant differences across scientific disciplines. Reflecting these motivations, actual commercialization outcomes as can be seen in Figure 3 remain rare. Only 12% of respondents had patented an invention, and just 8% had licensed research to an external firm in the past 5 years. Only 3 researchers (4% of sample) had co-founded a startup based on their work. This indicates a very low level of commercialization activity among Macedonian academics. However, researchers do interact frequently with industry through contract research and consulting as it can be seen in Figure 4. Over half reported partnering with companies on R&D projects, showing willingness to engage with external stakeholders when aligned with their expertise and interests. But interactions oriented toward commercialization like IP licensing are limited by lack of perceived incentives. Overall, intrinsic motivations dominate among academics, while commercialization is seen as low priority. Very few researchers successfully translate discoveries into patents, licenses, or startups. This misalignment between high research activity versus low commercial outputs signifies ecosystem gaps inhibiting commercialization.

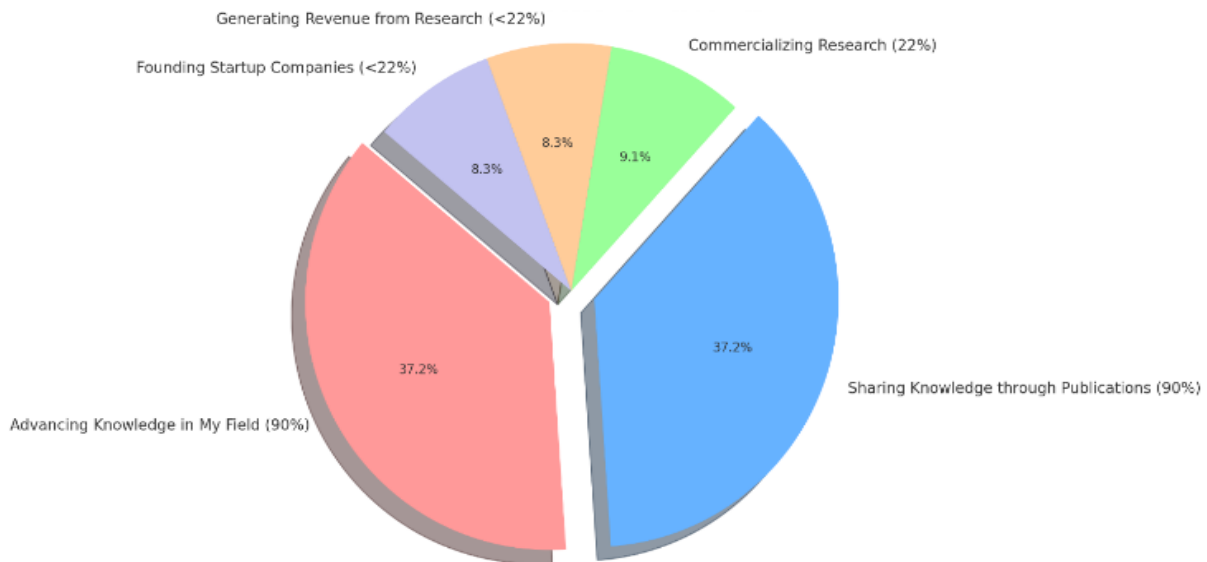


Figure 1. Motivation of University Researchers in North Macedonia

The pie chart in Figure 1 illustrates the motivations of Macedonian academics:

- The largest segments represent intrinsic motivations such as "Advancing Knowledge in My Field" and "Sharing Knowledge through Publications," both accounting for 90%.
- Commercial activities, revenue generation, and founding startup companies are significantly smaller segments, indicating their lesser importance among Macedonian academics.

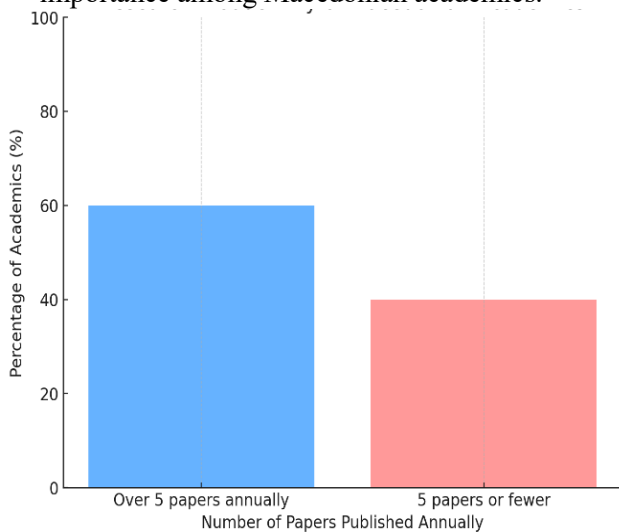


Figure 2. Research Productivity

The bar chart in Figure 2 is illustrating the research productivity of North Macedonian academics:

- A majority (60%) of the academics publish more than 5 papers annually.
- The remaining 40% publish 5 papers or fewer each year.

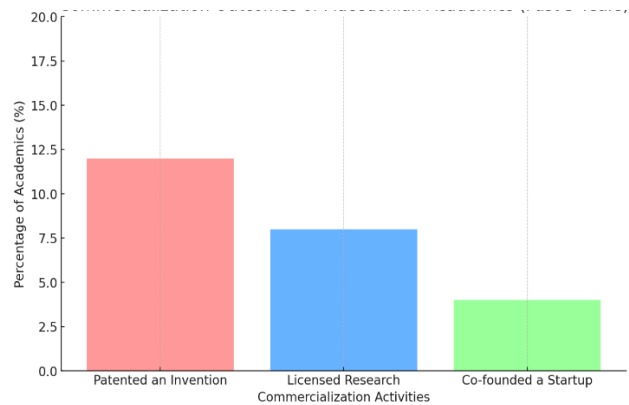


Figure 3. Commercialization Outcome from University Research for the past 5 years

The bar chart in Figure 3 is depicting the commercialization outcomes of Macedonian academics over the past 5 years:

- Only 12% of the academics have patented an invention.
- 8% have licensed their research to an external firm.
- A mere 4% (or 3 researchers from the sample) have co-founded a startup based on their work.

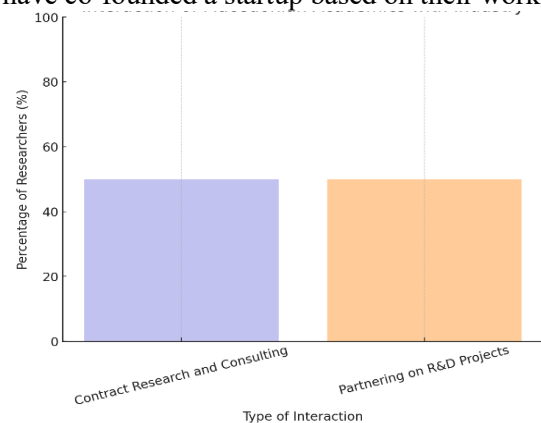


Figure 4. Type of Interaction of University Researchers with Industry

The bar chart in Figure 4 is showcasing the interaction of Macedonian academics with the industry:

- Half of the researchers engage in contract research and consulting.
- Another half reported partnering with companies on R&D projects.

This suggests a willingness among Macedonian academics to collaborate with industry stakeholders when the activities align with their expertise and interests. Overall, these visualizations shed light on the state of Macedonia's university entrepreneurial ecosystem. On the other hand, there is a strong inclination towards research and knowledge dissemination, the ecosystem appears to lack a commercial orientation as it can be seen in Figure 3. This indicates potential areas for improvement to boost innovation and commercialization in the country.

#### Statistical Analyses ANOVA and ANCOVA

Hypothesis for ANOVA: The motivation for "Advancing Knowledge in My Field" varies across different departments in the university (Engineering, Humanities, and Sciences).

- Null Hypothesis ( $H_0$ ): The means of "Advancing Knowledge in My Field" motivation are the same across all departments.
- Alternative Hypothesis ( $H_1$ ): At least one department has a different mean for "Advancing Knowledge in My Field" motivation.

Measured Data:

- Engineering: [90, 92, 88, 91, 89]
- Humanities: [85, 86, 87, 85, 84]
- Sciences: [91, 92, 90, 90, 93]

Hypothesis for ANCOVA: The number of years an academic has been teaching might act as a covariate affecting their motivation. This means that, in addition to the department, the number of teaching years could influence the motivation to "Advance Knowledge in My Field".

Covariate Data (Years of Teaching):

- Engineering: [5, 7, 6, 5, 8]
- Humanities: [10, 12, 11, 9, 10]
- Sciences: [7, 6, 7, 7, 8]

With this additional data, we have performed an ANCOVA to see if the department still affects motivation after accounting for the number of teaching years. The results of the one-way ANOVA for our hypothetical data are:

$F$ -statistic: 25.5625.56;  $p$ -value:  $4.72 \times 10^{-5}$ – $54.72 \times 10^{-5}$

Given the very low  $p$ -value (well below the common alpha level of 0.05), we would reject the null hypothesis ( $H_0$ ).

This suggests that there is a statistically significant difference in the motivation to "Advance Knowledge in My Field" across the three departments (Engineering, Humanities, and Sciences). The results of the ANCOVA analysis:

#### 1. Department:

- $F$ -statistic: 9.699.69;  $p$ -value: 0.00370.0037

This indicates that there's a statistically significant difference in the motivation to "Advance Knowledge in My Field" across departments even after accounting for the number of teaching years.

#### 2. YearsOfTeaching (Covariate):

- $F$ -statistic: 0.380.38;  $p$ -value: 0.55100.5510

The  $p$ -value associated with the number of teaching years is greater than 0.05, suggesting that it does not have a statistically significant effect on the motivation when department differences are accounted for. In summary, we concluded that the department an academic belongs to plays a significant role in their motivation to advance knowledge, while the number of teaching years does not have a significant effect when considering department differences.

## 5. Analyses of Infrastructure Support Systems

The second crucial component enabling university commercialization is internal infrastructure, capabilities, and support systems (Siegel et al., 2003; Vincett et al., 2021). Key actors include technology transfer offices (TTOs) that facilitate IP protection and licensing. Interviews with directors of Macedonia's 28 major university TTOs surfaced three main limitations:

1. Lack of financial resources – Most TTOs are understaffed, with 1-2 professionals supported by external grants. They lack funding for legal services to secure IP protection or early proof-of-concept work to validate commercial viability.

2. Insufficient capabilities – Few TTO staff have industry experience or training in technology commercialization. They focus mainly on bureaucratic patent administration versus strategic licensing and startups.

3. Disconnected from university leadership – TTOs are organizationally isolated, and commercialization is not prioritized by top management. Cultural norms emphasize publications over patents.

Additionally, only 2 universities operated a dedicated incubator providing facilities and business assistance for spinouts, revealing infrastructure gaps [12]. Researchers themselves had low satisfaction with existing TTO services. In surveys, only 22% agreed their TTO effectively contributes to commercialization. 49% were unsatisfied with the patent and IP support received, suggesting poor fit with academic needs.

In summary, understaffed and underfinanced TTOs lacking commercialization capabilities constitute a weak intermediate structure. Coupled with cultural norms that devalue commercialization, this creates an ecosystem mismatch that hinders researchers interested in translating discoveries into practical applications.

The third framework dimension involves university linkages with external stakeholders, particularly government policymakers and industry [6]. These collaborative networks can provide vital funding, expertise, mentors, and channels to commercialize [10]. But in North Macedonia, suggests engagement with external stakeholders remains minimal:

- Government – No targeted policies or programs exist to incentivize academic commercialization. R&D funding space does not consider commercial potential.

- Industry – Only 15% of researchers reported partnering with companies on technology licensing. Nor are there channels for joint IP development.

- Investors – Access to private capital and mentors to evaluate spinout opportunities is virtually absent. Respondents knew no professors who had raised external investment to launch a company.

Instead, academics operate in isolation, disconnected from networks that could facilitate commercialization efforts. With limited perceived incentives internally, weak external ties constitute another ecosystem constraint. Based on this empirical assessment combining researcher and TTO perspectives, four main recommendations emerge for improving the commercialization capacity of Macedonian universities:

1. Introduce targeted proof-of-concept grants – Provide micro-funds for early stage validation, IP protection, and prototyping for technologies with commercial potential. This can incentivize disclosure and assessment of discoveries.

2. Develop focused education and training – Raise awareness among academics on IP and commercialization through seminars and exchanges. Support upskilling of TTO staff in technology licensing and industry partnerships.

3. Strengthen TTO capabilities and strategy – Invest in specialized TTO staff with business experience. Develop value propositions and processes tailored to researcher needs. Incentivize commercial outcomes.

4. Facilitate integration with private sector – Create channels for joint research, IP co-development, licensing deals, and mentoring relationships with industry. Appoint corporate leaders as mentors-in-residence at incubators.

5. Adjust policies to incentivize commercialization – Reform promotion and tenure policies to value commercial impact alongside publications. Provide financial incentives for disclosures and patents.

Develop national IP regulations supporting academic patenting and licensing.

## 6. Conclusion

This research tries to advance understanding of university research commercialization in developing economies by offering a comprehensive analysis of the North Macedonian case. Employing a novel and replicable methodological approach, the study provides original empirical evidence on the state of university commercialization ecosystems within the underexplored context of Southeastern Europe. By giving voice to academic entrepreneurs through in-depth qualitative interviews and capturing granular insights from 80+ researchers and 28 technology transfer offices, the study addresses calls for grounded qualitative research in this domain. The study tries to make several key contributions:

1. Comprehensive Mapping: It provides a detailed map of the university ecosystem, unveiling previously unknown strengths and weaknesses of underdeveloped countries and North Macedonia as case study example, neglected in existing literature focused on advanced Western institutions.

2. Analytical Assessment: It offers a nuanced analysis that identifies core strengths like research productivity alongside critical weaknesses in areas like incentives, commercialization support, external stakeholder engagement, and cultural barriers. This diagnosis provides valuable information for policymakers seeking to develop targeted interventions.

3. Actionable Recommendations: The study presents practical recommendations, such as targeted proof-of-concept funding, enhanced education programs, strategic industry integration, and realignment of incentives. These actionable insights can serve as levers for policymakers to improve university research commercialization.

4. Replicable Framework: It introduces an innovative methodology combining surveys with individual academic and TTO staff interviews to collect primary data from on-the-ground stakeholders. This framework and the associated indicators can be replicated across diverse institutional contexts.

5. Expanded Scholarly Understanding: This research significantly expands our understanding of how university entrepreneurial ecosystems function in developing economies, drawing on evidence from a critical and understudied region. By balancing academic theory with practical data, it generates actionable and context-specific insights for policymakers. This study showcases the effectiveness of evidence-based assessment and qualitative methods in measuring and strengthening complex university innovation environments.

Future research directions could involve investigating the implementation and impact of specific initiatives designed to incentivize research commercialization in developing economies. Comparative case studies examining universities at different stages of development can further elucidate factors that drive progress in this domain. As universities worldwide strive to amplify their entrepreneurial and economic development impacts, robust empirical research illuminating how best to align capabilities, motivations, policies, and networks remains vital. This conclusion emphasizes the study's originality, methodological rigor, and practical contributions, positioning it as a valuable resource for researchers, policymakers, and stakeholders involved in advancing university research commercialization in developing economies. It also outlines compelling future research directions, highlighting the ongoing need for empirical research in this evolving field.

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