CORVINUS UNIVERSITY of BUDAPEST

Doctoral School of Economics, Business and Informatics

Ph.D. Thesis

Booklet

Xin Huang

Technology Transfer in Higher education

Supervisor: Dr. András Gábor CSc.

Budapest 2024

I. Research Background and Justification for the Selection of the Topic

The Role of Higher Education Institutions in Technology Transfer

Higher education institutions (HEIs) play a crucial role in advancing knowledge and fostering innovation through technology transfer (TT). Acting as bridges between academia and industry, HEIs contribute to the commercialization of research findings, addressing societal challenges, and driving economic growth. However, despite their importance, current TT practices often fail to meet the increasingly complex demands of a rapidly evolving technological landscape.

Challenges in Current Technology Transfer Practices

The modern TT environment is shaped by rapid technological advancements, globalization, and shifting societal needs. These dynamics expose critical shortcomings in traditional TT models:

1. **Limited Adaptability**: Traditional TT models struggle to respond to dynamic technological and market trends.
2. **Weak Ecosystem Engagement**: Insufficient collaboration between HEIs and external stakeholders such as industry, government, and civil society.
3. **Fragmented Internal Processes**: Inefficient coordination within HEIs hampers effective TT implementation.

As shown in **Table 1**, while existing TT frameworks such as the Triple Helix Model have established the foundational role of university-industry-government collaboration, they often neglect broader societal and environmental dimensions critical for addressing today's challenges.

Framework	Strengths	Limitations
Linear Model	Simplifies the TT process, easy to implement.	Ignores feedback loops, lacks ecosystem considerations.
Triple Helix Model	Highlights collaboration among university, industry, and government.	Limited focus on adaptability and broader societal factors.

Quadruple Helix Model	Incorporates civil society and culture into the innovation system.	Increased complexity; requires strong stakeholder alignment.
Quintuple Helix Model	Integrates environmental and sustainability considerations into innovation.	Challenging to operationalize in HEIs; requires extensive coordination.

Table 1: Comparative Analysis of Technology Transfer Frameworks

Relevance of the Study

This dissertation addresses these challenges by focusing on the development of innovative and sustainable TT models that cater to the unique capabilities and contexts of HEIs. Specifically, the research highlights three critical dimensions for improving TT practices:

1. **Research and Development (R&D)**: Strengthening internal capabilities to foster research output and innovation.
2. **Ecosystem Engagement**: Establishing robust collaborations with industry, government, and civil society to co-create value.
3. **Adaptability**: Equipping HEIs with tools and strategies to remain agile and responsive to external changes.

Justification for the Topic

The critical role of TT in solving global challenges underscores the need for enhanced frameworks. By developing models that incorporate inclusivity, sustainability, and adaptability, this research aims to provide actionable insights for HEIs, policymakers, and stakeholders. The study builds upon existing TT theories such as the Triple, Quadruple, and Quintuple Helix Models (Etzkowitz & Leydesdorff, 2000; Carayannis & Campbell, 2020) and advances them to address the evolving needs of HEIs in diverse contexts.

As illustrated in **Figure 1**, the integration of adaptability and sustainability into TT practices is vital for creating innovation ecosystems that are resilient and impactful.

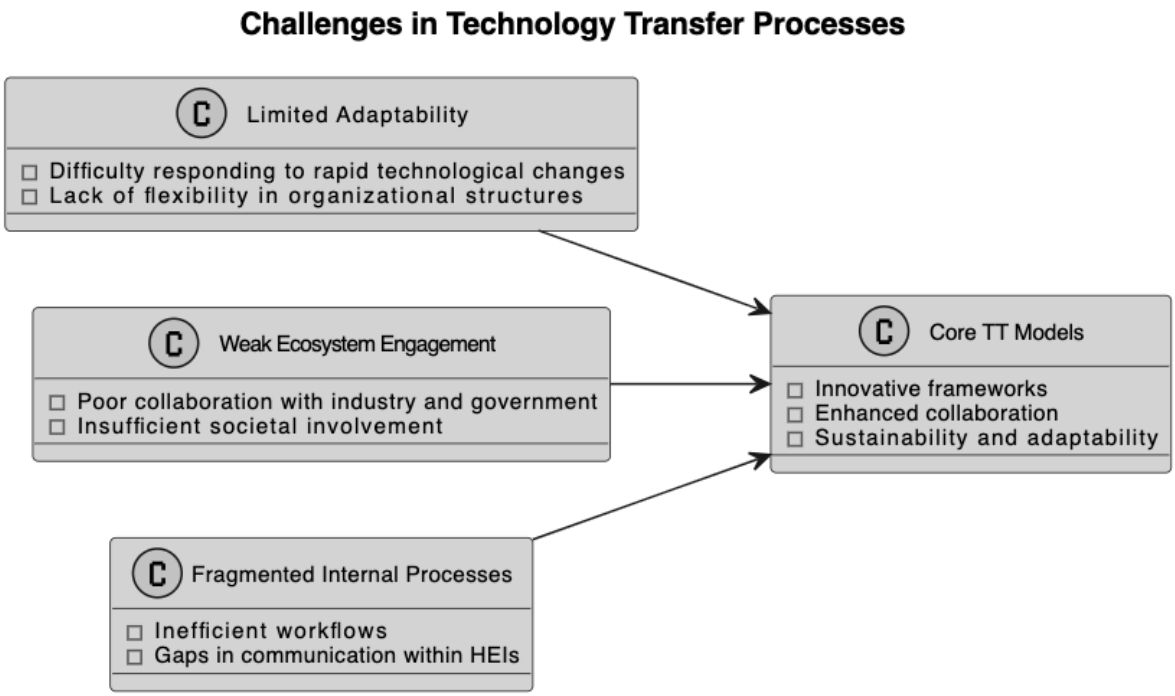

Figure 1: Challenges and Dimensions of Effective Technology Transfer

II. The Methods Used

The research adopts a comprehensive, multi-methodological approach to address the complexities of technology transfer (TT) within higher education institutions (HEIs). By integrating theoretical exploration, empirical investigation, and process optimization, the study aims to develop robust and adaptable TT models suitable for diverse institutional contexts. The multi-method approach is designed to ensure that the models are both theoretically sound and practically effective.

Literature Review

The study begins with an extensive literature review, synthesizing both academic and industry perspectives to establish a solid theoretical foundation and identify existing gaps in current TT practices. This review serves several key purposes:

- **Identifying Theoretical Gaps**: The review critically examines the limitations of existing TT frameworks, such as the Linear Model, the Triple Helix, and the Quadruple Helix models. These traditional models, although foundational, often fail to account for the increasingly dynamic and complex nature of TT activities in contemporary HEIs.

For instance, the analysis identifies that the Triple Helix model—which emphasizes interactions between universities, industry, and government—lacks sufficient consideration for societal and environmental dynamics. The literature also highlights that the Quintuple Helix model, which adds an environmental sustainability layer, still requires a more practical pathway for integrating these elements into everyday university activities.

- **Understanding Best Practices**: The review also explores successful TT practices implemented by HEIs globally, emphasizing the importance of scalability and adaptability in different institutional settings. It focuses on the diverse strategies adopted by HEIs to foster successful TT, including mechanisms for IP management, entrepreneurship, and collaborative partnerships with industry（Chesbrough, 2006).
- **Synthesizing Insights**: Widely recognized models, such as the Triple Helix, Quadruple Helix, and Quintuple Helix, were critically analyzed to understand their practical applications and limitations. The Triple Helix model, for example, underscores collaboration among universities, industry, and government as a critical driver of innovation, while the Quadruple Helix introduces civil society as an important factor in the innovation process. The Quintuple Helix further extends this by integrating environmental considerations, emphasizing the need for sustainable innovation ecosystems. These models provide a conceptual basis for developing TT strategies tailored to the evolving roles of HEIs in society (Ranga & Etzkowitz. 2015).

Empirical Investigation

The empirical phase of the research is built on data collected from the TETRIS [1]project, which involved 14 universities from Europe and Latin America, representing a range of institutional profiles. The empirical investigation employed both quantitative and qualitative methods to explore TT practices and challenges, providing a comprehensive understanding of TT processes within diverse institutional contexts.

- **Quantitative Surveys**: Surveys were administered to collect data on key TT indicators, such as intellectual property (IP) management, contract research, spin-off creation, and engagement with external ecosystems. Data collection focused on metrics like the

[1] TETRIS - TECHNOLOGY TRANSFER INNOVATION SCHEMES IN LATIN AMERICA (618597-EPP-1-2020 -1-PT-EPPKA2-CBHE-JP)

number of patents filed, the frequency of industry collaborations, and the revenue generated through licensing activities. This quantitative data allowed for an assessment of the strengths and weaknesses of different HEIs in terms of their TT capabilities, highlighting significant disparities between institutions with advanced TT frameworks and those still in the developmental phase (OECD,2015).

- **Qualitative Focus Groups**: To complement the survey data, qualitative focus groups were conducted with various stakeholders, including researchers, university administrators, and industry partners. These discussions provided valuable context-specific insights into the challenges and barriers faced in TT processes. Barriers identified included regulatory hurdles, cultural resistance to commercialization, and funding gaps. By engaging directly with those involved in TT, the focus groups offered a nuanced understanding of the institutional and systemic factors that impact TT success.

The findings from these empirical investigations revealed considerable variations in TT effectiveness across institutions. High-performing HEIs demonstrated extensive patenting activity, robust spin-off support, and well-developed industry partnerships, while medium- and low-performing institutions faced challenges related to limited ecosystem engagement and weaker research commercialization strategies.

Business Process Modeling (BPM)

Business Process Modeling (BPM) was employed to bridge theoretical insights and practical applications, facilitating the design and refinement of TT workflows. The use of BPM allowed for a systematic representation, analysis, and optimization of TT processes within the participating HEIs.

- **Mapping Existing Workflows**: The initial phase involved mapping the existing TT workflows at participating universities to identify inefficiencies and bottlenecks. These included prolonged patent approval times, fragmented communication channels, and lack of interdepartmental coordination, which hindered effective TT. This mapping provided a detailed overview of the operational challenges and served as a foundation for subsequent optimization efforts.
- **Designing Optimized Workflows**: Building on stakeholder feedback, optimized TT workflows were designed to streamline processes, reduce delays, and enhance

coordination. For example, specific measures were introduced to shorten the patent filing process, establish regular stakeholder forums to facilitate industry collaboration, and enhance incubation support for spin-offs. By involving stakeholders in the design phase, the optimized workflows were tailored to meet the unique needs of the institutions and their respective ecosystems.

- **Iterative Validation**: The proposed models underwent iterative validation through simulations and stakeholder reviews. These iterative cycles ensured that the models were feasible and effective in addressing the identified inefficiencies. The validation process included testing the workflows in controlled settings and gathering feedback from TT professionals to refine the models further. The optimized workflows showed significant improvements, such as reducing patent filing times from 12–18 months to 6–9 months and enhancing the frequency and quality of industry interactions.

Dynamic Workshops

Dynamic workshops were conducted to facilitate real-time input from a diverse range of stakeholders, fostering collaboration and enhancing the development of TT models. These workshops played a pivotal role in ensuring that the TT models were contextually relevant and practically applicable.

Focus Areas of Workshops:

1. **IP Protection and Valorization**: The workshops addressed strategies for effective IP protection, including best practices for patent filing and licensing, as well as methods to maximize the commercial potential of research outputs. Participants discussed common challenges in IP management, such as navigating complex regulatory landscapes and managing stakeholder expectations.
2. **Research and Innovation Management**: The focus here was on improving research project management and resource allocation, aligning research priorities with industry needs, and fostering collaboration across institutional boundaries. The discussions emphasized the importance of clear communication channels and targeted support mechanisms to enhance research impact.
3. **Ecosystem Engagement and Entrepreneurship**: Workshops also explored initiatives to strengthen industry partnerships and foster entrepreneurship among students and faculty. Strategies discussed included establishing innovation hubs, providing

mentorship programs for startups, and enhancing access to funding opportunities to support entrepreneurial ventures.

Analytical Tools

To ensure a robust and comprehensive analysis of the collected data, the study employed both quantitative and qualitative analytical tools:

- **Quantitative Tools**: The research utilized Excel for statistical analysis of survey data, including descriptive statistics and regression analysis to identify patterns and relationships among TT indicators. Additionally, R Studio was used for data visualization and advanced analytics, such as cluster analysis, which grouped universities by their TT performance levels, providing insights into institutional strengths and weaknesses.
- **Qualitative Tools**: Thematic analysis was applied to the focus group discussions to identify recurring themes, such as the barriers to ecosystem engagement and the institutional factors influencing TT success. Content analysis was also conducted on the workshop outputs to extract actionable recommendations for TT model development, allowing the research to provide tailored suggestions for institutional improvements.

In conclude, the multi-methodological approach employed in this study ensures that the developed TT models are both theoretically grounded and empirically validated. By combining an extensive literature review, empirical investigation through the TETRIS project, BPM for process optimization, dynamic workshops for stakeholder engagement, and advanced analytical tools, the research provides a comprehensive framework for understanding and enhancing TT practices in HEIs. This approach not only bridges theoretical and practical domains but also equips institutions with adaptable strategies that can respond effectively to the evolving demands of technology transfer, fostering innovation and societal impact.

III. Scientific Results of the Dissertation

The dissertation presents significant findings that contribute to the field of technology transfer (TT) in higher education institutions (HEIs). These results highlight the diverse capabilities, challenges, and opportunities within the TT ecosystem, providing both practical and theoretical

insights for improving TT processes in varying institutional contexts. The scientific results are categorized into the development of TT models, institutional performance analysis, process optimization, strategic recommendations, and contributions to academic literature, each enriched by empirical data and visual representations derived from the research.

Development of Technology Transfer Models

The research proposes three distinct models for improving TT practices in HEIs, each tailored to specific institutional contexts, capabilities, and strategic orientations. These models are designed to help institutions navigate the complexities of TT by aligning internal resources, external partnerships, and adaptive capacities. Figure 2 for a roadmap outlining different institutional models.

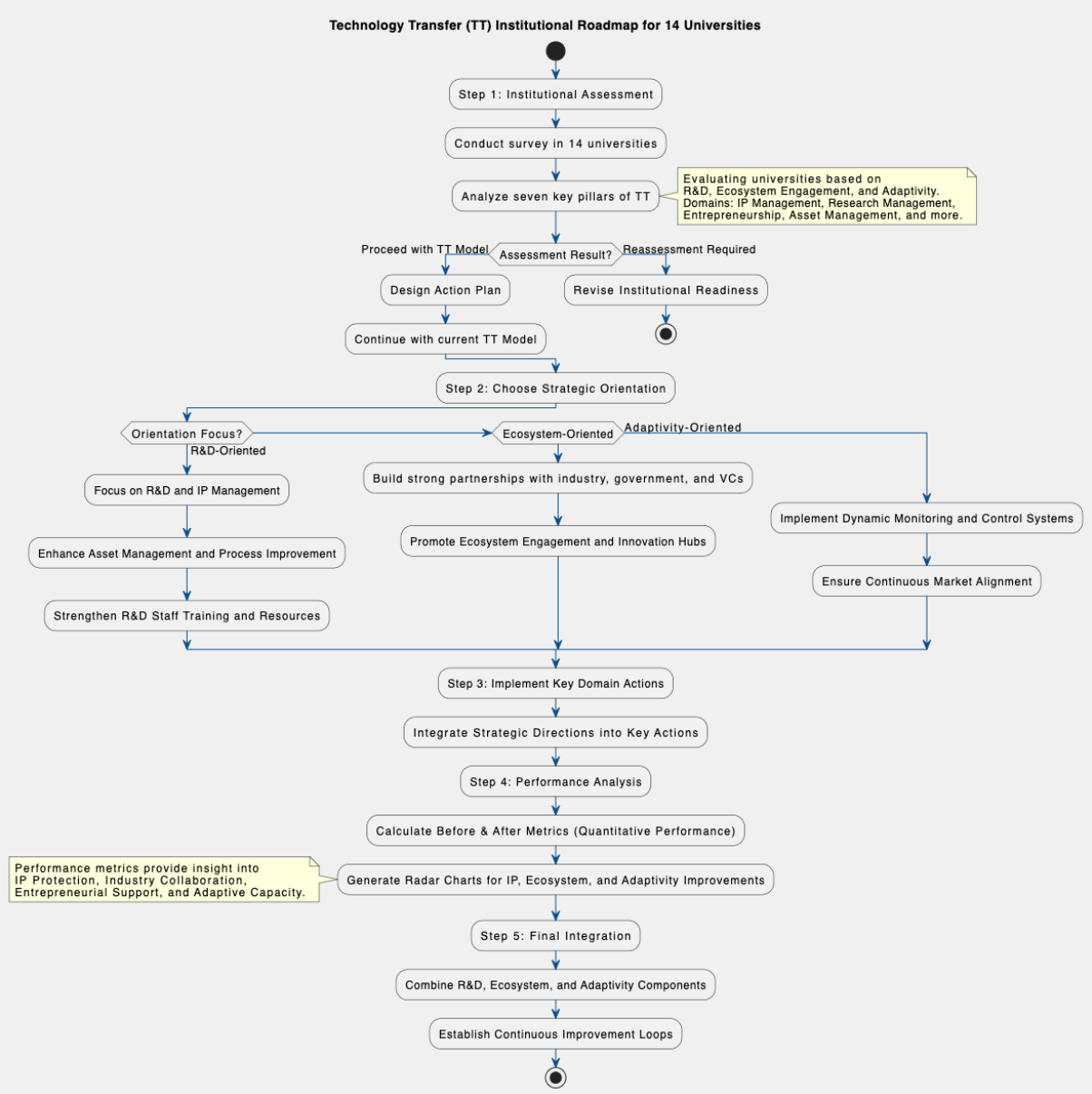

Figure 2: Technology Transfer Institutional Roadmap for 14 Institutions

- **R&D-Oriented Model**: This model emphasizes strengthening internal research capabilities, effective intellectual property (IP) management, and the establishment of spin-offs. It is particularly suited to research-intensive universities that focus on maximizing the commercialization potential of their research outputs. The model also prioritizes internal process efficiency, with specific attention to IP valorization strategies and innovation management. Figure 3 for a detailed breakdown of the components and workflow designed to enhance research capacity, IP protection, and commercialization pathways.

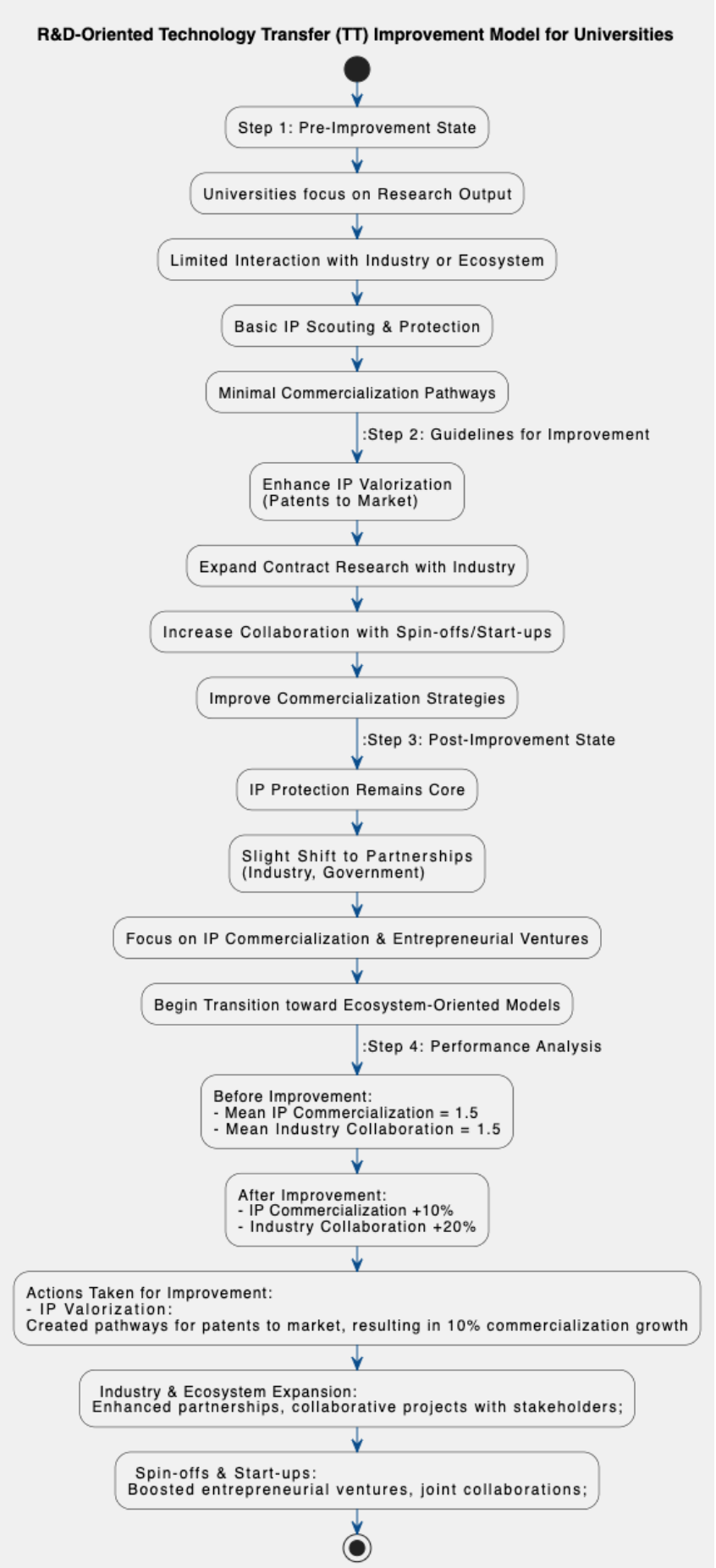
R&D-Oriented Technology Transfer (TT) Improvement Model for Universities
Step 1: Pre-Improvement State
Universities focus on Research Output
Limited Interaction with Industry or Ecosystem
Basic IP Scouting & Protection
Minimal Commercialization Pathways
:Step 2: Guidelines for Improvement
Enhance IP Valorization (Patents to Market)
Expand Contract Research with Industry
Increase Collaboration with Spin-offs/Start-ups
Improve Commercialization Strategies
:Step 3: Post-Improvement State
IP Protection Remains Core
Slight Shift to Partnerships (Industry, Government)
Focus on IP Commercialization & Entrepreneurial Ventures
Begin Transition toward Ecosystem-Oriented Models
:Step 4: Performance Analysis
Before Improvement:
- Mean IP Commercialization = 1.5
- Mean Industry Collaboration = 1.5
After Improvement:
- IP Commercialization +10%
- Industry Collaboration +20%
Actions Taken for Improvement:
- IP Valorization:
Created pathways for patents to market, resulting in 10% commercialization growth
Industry & Ecosystem Expansion:
Enhanced partnerships, collaborative projects with stakeholders;
Spin-offs & Start-ups:
Boosted entrepreneurial ventures, joint collaborations;

Figure 3: R&D-Oriented Technology Transfer Improvement Model

Ecosystem-Oriented Model: This model focuses on building robust partnerships with industry, government, and civil society, creating an environment conducive to collaborative innovation. It emphasizes the establishment of entrepreneurial ecosystems that foster new ventures and spin-offs. Universities employing this model aim to leverage external resources and stakeholder networks to co-create value and promote open innovation. Figure 4 for a depiction of the institutional links with ecosystem partners, including government agencies, industry, and non-academic stakeholders, showcasing how universities position themselves within broader innovation ecosystems.

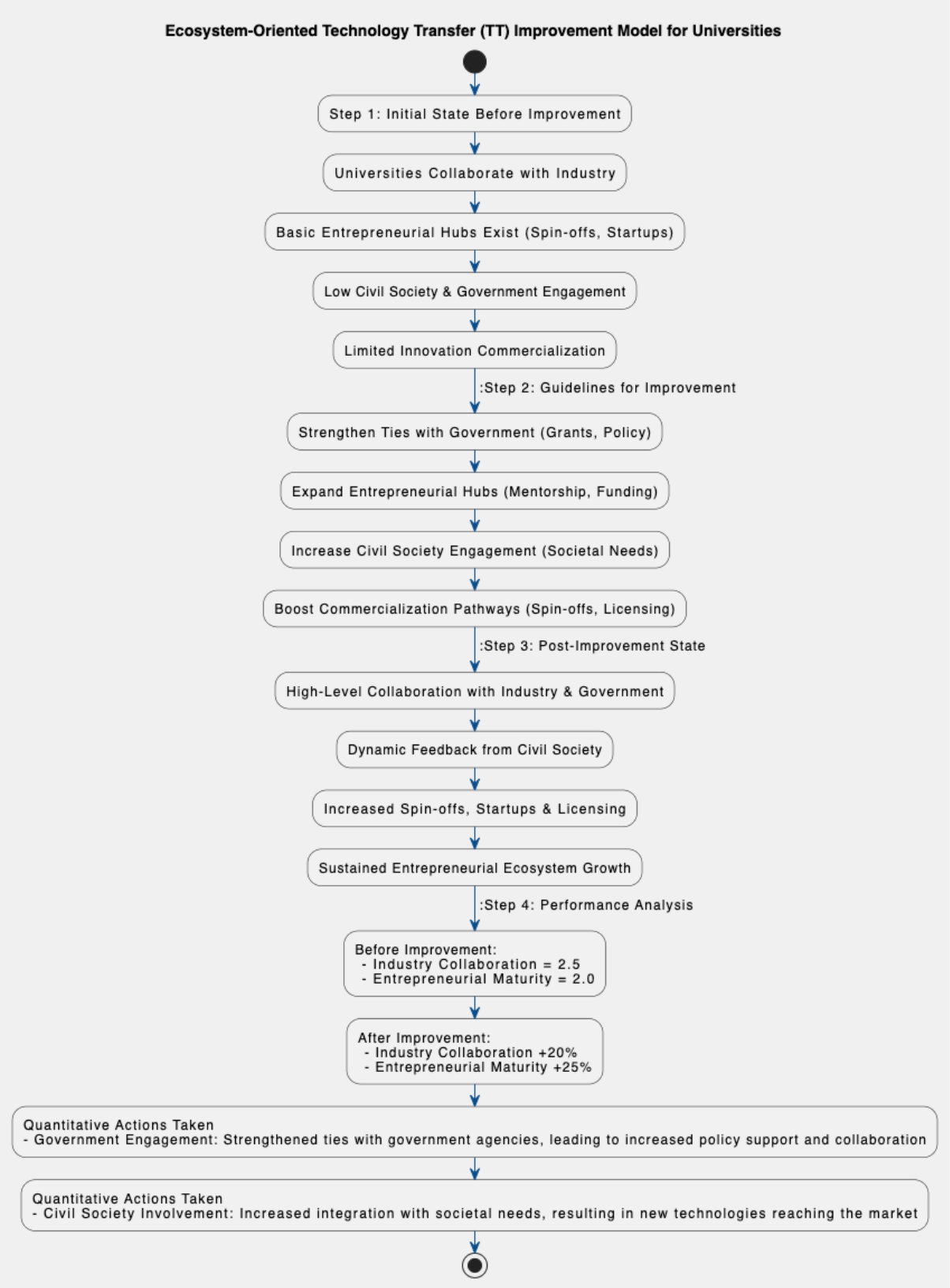

Figure 4: Ecosystem-Oriented Technology Transfer Improvement Model

- **Adaptivity-Oriented Model**: Designed for institutions seeking to maintain flexibility and responsiveness to external changes, this model integrates sustainability considerations and real-time monitoring systems. It focuses on adaptability by emphasizing continuous learning, feedback loops, and environmental sustainability. The model supports HEIs in dynamically adjusting their TT strategies to meet changing market and societal needs. Figure 5 for an illustration of the mechanisms involved in integrating real-time monitoring, sustainability practices, and adaptive strategies.

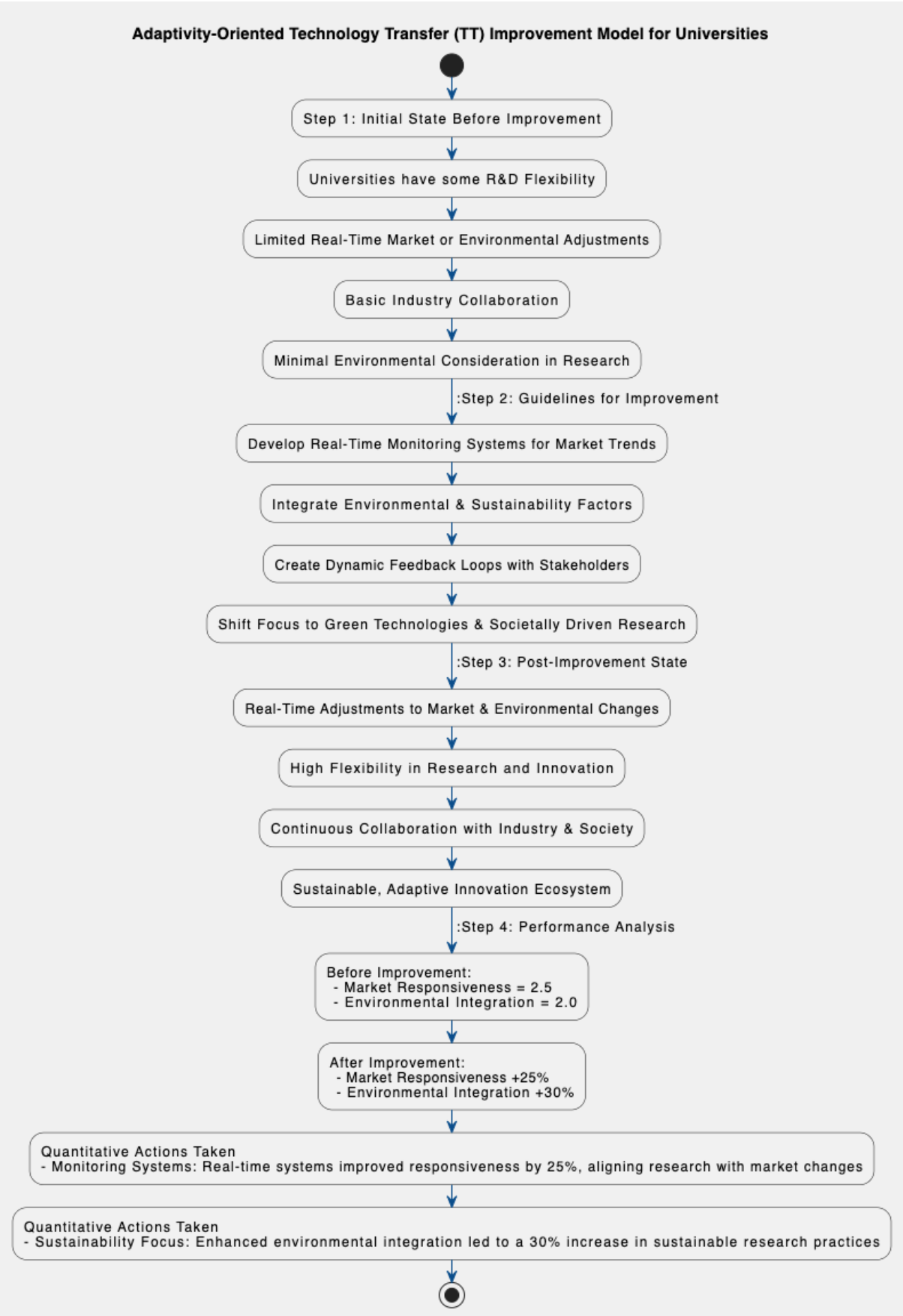

Figure 5: Adaptivity-Oriented Technology Transfer Improvement Model

Institutional Performance Analysis

The dissertation utilizes empirical data from the TETRIS project to assess the TT performance of 14 universities across Europe and Latin America, each with varying levels of TT maturity and ecosystem engagement.

- **High-Performing HEIs**: The analysis shows that institutions with advanced TT capabilities excel in intellectual property commercialization and effective ecosystem engagement. These institutions typically have well-established TT offices, a clear innovation strategy, and extensive industry partnerships, resulting in a high number of patents filed and spin-offs created.
- **Medium-Performing HEIs**: Medium-performing institutions exhibit a strong research output but face challenges in translating these outputs into marketable innovations. They often lack the depth of ecosystem connections and support systems needed for effective commercialization, despite having potential in terms of research activities and capacity.
- **Low-Performing HEIs**: Institutions in this category struggle with foundational TT processes, including research management and the acquisition of adequate funding. These HEIs require foundational support, particularly in building institutional infrastructure and enhancing capacity for IP management and industry collaboration.

Process Optimization

The study identifies several critical inefficiencies in existing TT workflows and proposes optimized solutions aimed at enhancing overall performance.

- **Streamlining IP Management**: The research highlights the need to reduce administrative bottlenecks in IP management processes. By adopting digital tools and streamlined approval workflows, HEIs can significantly reduce the time required for patent filing and IP protection.
- **Enhancing Communication and Collaboration**: A significant finding is the importance of enhancing communication between academia and industry partners. Establishing regular stakeholder forums and leveraging digital communication platforms are recommended to foster more effective knowledge transfer and engagement.

- **Implementing Digital Tools**: The use of digital tools for monitoring and evaluating TT activities was identified as a key area for improvement. These tools enable real-time data collection and analysis, providing valuable insights for optimizing TT practices.

Policy and Strategic Recommendations

Based on the empirical findings, the dissertation provides actionable recommendations for HEIs, policymakers, and industry stakeholders to improve TT outcomes and foster a supportive innovation environment.

- **For HEIs**: Institutions should invest in capacity-building programs that enhance TT competencies, foster a culture of innovation, and align research priorities with market demands. Additionally, HEIs should implement training programs for researchers and establish clear IP management policies to support commercialization efforts.
- **For Policymakers**: The research suggests that policymakers need to develop supportive policies that incentivize TT activities, including providing grants for collaborative research and reducing regulatory barriers. Policies that foster university-industry linkages and provide financial incentives for start-ups and spin-offs are crucial for enhancing TT efficiency.
- **For Industry Stakeholders**: Strengthening networks between academia, industry, and government is essential for facilitating effective knowledge transfer. Industry partners are encouraged to actively engage in collaborative projects, provide funding for university-led research, and participate in joint ventures that drive innovation.

Contribution to Academic Literature

The dissertation makes several significant contributions to the academic literature on technology transfer in higher education:

- **Expanding Theoretical Understanding**: It expands the theoretical understanding of TT dynamics within HEIs by integrating concepts from the Triple, Quadruple, and Quintuple Helix models into a cohesive framework. This interdisciplinary approach offers a nuanced view of how universities can effectively engage with multiple stakeholders to foster innovation.

- **Providing Empirical Evidence**: The study provides empirical evidence on the effectiveness of tailored TT models, demonstrating that context-specific approaches are more effective than generic models. The empirical insights derived from the TETRIS project serve as a valuable reference for other HEIs seeking to evaluate and improve their TT practices.
- **Introducing a Scalable Framework**: By developing a scalable framework that can be adapted to different institutional contexts, the research contributes to the development of practical tools for enhancing TT processes across diverse HEIs. This framework provides a basis for future research and implementation, offering a structured approach for improving TT practices at multiple levels.

These scientific results offer both practical guidance and theoretical advancements for enhancing the efficiency and effectiveness of TT in higher education, ultimately supporting universities in their mission to drive innovation and contribute to societal and economic development.

IV. Main References

The dissertation draws on a comprehensive range of academic and practical resources to ensure a robust theoretical foundation and relevance to the field of technology transfer (TT). Key references include:

1. Etzkowitz, H. and Leydesdorff, L. (2000). The dynamics of innovation: from National Systems and “Mode 2” to a Triple Helix of university–industry–government relations. Research Policy, 29(2), pp.109-123..
2. Carayannis, E.G. and Campbell, D.F. (2020). Mode 3 knowledge production in quadruple helix innovation systems: Quintuple Helix and social ecology. In Encyclopedia of Creativity, Invention, Innovation and Entrepreneurship (pp. 1668-1676). Cham: Springer International Publishing .
3. Chesbrough, H. (2006). Open business models: How to thrive in the new innovation landscape. Harvard Business Press .
4. OECD. (2015). Frascati Manual 2015: Guidelines for Collecting and Reporting Data on Research and Experimental Development. OECD .

5. Ranga, M. and Etzkowitz, H. (2015). Triple Helix systems: an analytical framework for innovation policy and practice in the Knowledge Society. In Entrepreneurship and Knowledge Exchange (pp. 117-158)

V. List of Own (or Co-authored) Publications on the Topic

The findings and contributions of this dissertation are supported by several peer-reviewed publications authored or co-authored by Xin Huang:

1. **Huang, X., & Gábor, A. (2024)**: Developing effective R&D models in higher education: Criteria and structured approaches. *Vezetéstudomány Budapest Management Review*, 55(11), 53–68.DOI: https://doi.org/10.14267/VEZTUD.2024.11.05
2. **Xin Huang, & Gábor András. (2023)**: Competitiveness of higher education in a changing environment from a technology transfer point of view. *Verejná Správa a Spoločnosť*, 24/2023(1).DOI: https://doi.org/10.33542/VSS2023-1-7
3. **Xin, Huang. (2022)**: Online Learning in the COVID-19 Pandemic: Catastrophe or Opportunity? *SEFBIS Journal*. DOI: http://doi.org/10.14267/SEFBIS.2022.02
4. **Xin, Huang. (2022)**: Innovation Technology Transfer: Higher Education Institution in European and Latin American Countries. *Proceedings of the 17th Biannual CER Comparative European Research Conference*.
5. **Xin, Huang. (2022)**: Technology Transfer in Higher Education. *Proceedings of the 18th Biannual CER Comparative European Research Conference*.
6. **Xin, Huang. (2022)**: Technology transfer office: Efficiency in a changing environment. *Critical Rethinking of Public Administration: Book of Abstracts*.