Future of Work and Digital Management Journal

Article type:
Original Research

Article history:
Received 20 August 2025
Revised 19 November 2025
Accepted 22 November 2025
Published online 01 January 2026

# An Indigenous Grounded Theory Model for Technology Commercialization in Technology-Based and Knowledge-Based Firms

Sayyed Yaser . Moeinoddini Chadeghani [1], Hassan . Ghorbani Dinani [2*], Seid Mohammad Reza. Mirahmadi [3]

1 Ph.D. Student in Business Management, Department of Management, Mo.C., Islamic Azad University, Isfahan, Iran.
2 Department of Management, Mo.C., Islamic Azad University, Isfahan, Iran
3 Department of Management, Dol.C., Islamic Azad University, Isfahan, Iran

Corresponding author email address:
hasssngh@iau.ac.ir

How to cite this article:
Moeinoddini Chadeghani , S.Y., Ghorbani Dinani, H. & Mirahmadi, S.M.R. (2026). An Indigenous Grounded Theory Model for Technology Commercialization in Technology-Based and Knowledge-Based Firms. *Future of Work and Digital Management Journal,* *4*(1), 1-14. https://doi.org/10.61838/fwdmj.182



## ABSTRACT

This study aims to design an indigenous and comprehensive model for technology commercialization in Iranian technology-based and knowledge-based firms using a grounded theory approach. This qualitative research employed grounded theory using an interpretive paradigm and inductive reasoning. Data were gathered through semi-structured interviews with 13 experts selected through purposive and snowball sampling until theoretical saturation was achieved. Interview durations ranged from 25 to 60 minutes. Data analysis followed Strauss and Corbin's open, axial, and selective coding procedures. Through line-by-line coding, 38 initial categories emerged and were systematically grouped into six main components: causal conditions, the core phenomenon, contextual conditions, intervening conditions, strategies, and consequences. The analysis was conducted concurrently with data collection to ensure theoretical sensitivity, iterative refinement, and the emergence of a coherent paradigmatic model. The analysis revealed that technology commercialization is influenced by key causal factors such as market needs identification, technological innovation, and market foresight. Contextual conditions including the technology ecosystem, regulatory frameworks, cultural and social dynamics, and financial capabilities significantly shape commercialization readiness. Intervening conditions—particularly international sanctions, regulatory instability, and financial shortages—were found to either facilitate or hinder commercialization trajectories. Effective commercialization strategies were identified, such as marketing, branding, networking, collaboration with universities, standardization, export planning, the use of emerging technologies, and feasibility analysis. These strategies collectively lead to desirable outcomes including profitability, market expansion, customer satisfaction, sustainable production, and competitive advantage. The study presents a comprehensive grounded theory model that explains how technological, institutional, market-based, and strategic factors interact to shape technology commercialization in knowledge-based firms. The model highlights the need for ecosystem strengthening, regulatory stability, and capability-building to enable successful commercialization outcomes in emerging economies.

**Keywords:** Technology commercialization; knowledge-based firms; grounded theory; innovation ecosystem; strategic management

## Introduction

Technology commercialization has increasingly become one of the most essential drivers of national competitiveness, economic growth, and innovation ecosystems in both developed and developing countries. As emerging technologies advance at an unprecedented pace, transforming scientific knowledge into commercial products and services has become a strategic priority for research universities, technology-based firms, and national innovation systems [1]. The commercialization process is widely recognized not merely as a linear transfer of technology from laboratory to market but as a multidimensional, dynamic, and interactive system shaped by organizational structures, institutional conditions, market

dynamics, and policy interventions [2]. In this context, universities and research institutions play a pivotal role in fostering knowledge creation and enabling commercialization pathways, especially through university–industry collaboration frameworks that accelerate technology transfer and support entrepreneurial activities [3].

Recent empirical studies show that the commercialization of emerging technologies is affected by technological maturity, organizational readiness, environmental uncertainty, and institutional arrangements [4]. Moreover, the increasing complexity of technologies—ranging from biotechnology to digital platforms and renewable energy systems—necessitates robust commercialization strategies that balance technological capability with market demand [5]. This complexity underscores the importance of innovation intermediaries and ecosystem actors that facilitate knowledge exchange, reduce uncertainty, and support startups in achieving product innovativeness [6]. At the same time, sustainability considerations, such as the environmental performance of emerging technologies, shape commercialization viability in modern markets [7].

Global evidence highlights that commercialization success is heavily influenced by institutional quality, ecosystem maturity, and strategic flexibility, particularly for firms operating in volatile, competitive, or resource-constrained environments [8]. The outsourcing of university commercialization activities to sophisticated technology transfer offices (TTOs) has also demonstrated significant performance improvements, especially in countries with established research infrastructures [9]. In parallel, methodological advances—such as fuzzy logic and multi-criteria decision-making approaches—have enhanced the ability of researchers and policymakers to evaluate commercialization performance and prioritize critical success factors [10].

From a broader perspective, the emergence of the global knowledge economy has reshaped how nations view the role of universities and research institutions in technology-driven economic development. System dynamics research underscores that technology commercialization is part of a larger socio-technical system influenced by feedback loops and dynamic interactions among market forces, technological capability, and institutional pressures [11]. These system-level perspectives are particularly important in developing countries where resource limitations, environmental uncertainty, and policy inconsistencies pose barriers to efficient commercialization [12].

The existing literature further highlights that forecasting and long-term planning play a pivotal role in commercialization, especially in environments where technologies evolve rapidly [13]. For countries dealing with institutional transitions and evolving innovation systems, policy models and ecosystem-level frameworks are essential to guide commercialization pathways across different sectors [14]. Recent research also shows that long-term forecasting accuracy can significantly enhance commercialization strategies by anticipating market trends, competitive pressures, and technological risks [15]. Furthermore, intellectual property (IP) management has become a critical dimension of commercialization success, especially for small knowledge-based firms navigating patenting strategies and global competitive pressures [16]. As patenting trends reveal, university TTOs in technologically advanced nations such as the US and China have developed sophisticated tools for accelerating technology transfer and commercialization outcomes [17, 18].

In addition to institutional and policy factors, technological capability is a major determinant of commercialization performance. Studies indicate that asymmetric technological capabilities across firms can drive differences in supply chain innovation and commercialization potential [19]. Policy instruments and policy mixes can also support universities in bringing emerging technologies to market, especially when combined with ecosystem-based strategies that address firm-level and industry-level challenges [20]. Moreover, strategic flexibility and alliances have been shown to significantly enhance

commercialization outcomes in technology-based entrepreneurship contexts [21]. These findings align with conceptual frameworks suggesting that open innovation capacity plays a crucial role in enabling universities and firms to absorb external knowledge and accelerate the commercialization process [22].

However, commercialization efforts in developing countries often face structural, financial, and institutional constraints. Research shows that bioenergy commercialization, for instance, remains hindered by technology dissemination challenges, financial barriers, and institutional weaknesses in many developing regions [23]. These challenges extend to small and medium-sized enterprises (SMEs) that struggle to develop technological capabilities, thereby limiting their commercialization performance despite possessing high innovation potential [24]. Prior studies also note that forecasting models, market analysis, and strategic decision-making tools are essential to mitigate commercialization risks and enhance product readiness levels [25]. Furthermore, in context-specific environments such as Iran, open technology commercialization models have been proposed to address ecosystem deficiencies, institutional gaps, and industry-specific needs [26-29].

In addition, earlier studies emphasize that commercialization performance is directly linked to the creation of sustainable competitive advantage, particularly for knowledge-based firms operating in volatile and competitive markets [30]. Strategic barriers and drivers—such as market readiness, institutional support, and technological capability—have historically shaped commercialization outcomes across defense, energy, ICT, and biotechnology sectors [31, 32]. While international evidence demonstrates the importance of university support systems, incubators, venture financing, and innovation partnerships [33], more recent studies highlight the need to design context-sensitive commercialization models tailored to national innovation system characteristics [34].

Despite extensive literature on commercialization frameworks, several gaps remain—particularly regarding the development of indigenous commercialization models for countries with unique structural, institutional, and market conditions. In Iran, knowledge-based firms play a critical role in national economic diversification and technological self-sufficiency. However, these firms face persistent challenges including institutional instability, limited financing mechanisms, market uncertainty, technology diffusion barriers, and limited integration with global value chains. Existing models developed in Western or East Asian contexts cannot be fully transplanted without considering local ecosystem dynamics, regulatory structures, cultural factors, and the constraints imposed by international sanctions. Therefore, formulating an indigenous, grounded, and context-sensitive commercialization model is essential for strengthening Iran's capability to transform technological innovations into competitive market offerings.

Accordingly, the aim of this study is to design an indigenous and comprehensive model for technology commercialization in Iranian technology-based and knowledge-based firms using grounded theory.

## Methodology

Given the exploratory nature of the models and frameworks in the present study, the research method is qualitative with an inductive approach. Additionally, based on its purpose, the study is applied, and in terms of research philosophy, it is interpretive. The qualitative method employed is grounded theory, as this approach is the most suitable for data collection considering the research title and stated objectives. This method has a predictive orientation. In other words, grounded theory is used in studies where precise information and specific statistics on the issue under investigation are lacking; therefore, a group of experts in the research domain is consulted to reach consensus and final conclusions. This method

includes multiple stages, and the validity of the final results depends entirely on the degree of expertise and mastery of the participants regarding the research topic.

Grounded theory is a qualitative research method used to develop theory about the phenomenon under study. This approach is applied when the existing research literature on the topic lacks sufficient depth, and the aim is to propose a new theory that has not yet been addressed in scholarly communities. The primary method of data collection in grounded theory is interviewing. Through the analysis and coding of interview texts, a paradigmatic model is developed. In grounded theory, a theory is generated inductively from a set of data, such that it explains a process, action, or interaction at a broad conceptual level. In this paper, an effort is made to elaborate on the foundational principles of the grounded theory method.

Accordingly, in this study, to identify the requirements for technology commercialization, semi-structured interviews were conducted with knowledgeable individuals, including university professors. By asking various questions, the researchers sought to deeply assess their perceptions, attitudes, and beliefs regarding the research subject. Using purposive sampling, interviews were conducted with 13 experts in the field of technology and technology commercialization, as well as managers of knowledge-based firms, to discuss new product development, its necessities, and its requirements. The synthesis of these interviews resulted in a compiled list of dimensions related to technology commercialization in technology-based and knowledge-based companies.

Regarding the validity and reliability of the interviews, it is stated that the most common definition of validity is whether the instrument measures what it is intended to measure. This question emphasizes the extent to which the measurement tool assesses the intended characteristic. Validity refers to the purpose for which the test is designed. The most important types of validity include content validity and face validity. In this study, the validity of the derived codes was confirmed by several interviewees (participants).

On the other hand, trustworthiness or reliability is one of the technical characteristics of measurement tools. Reliability is strengthened when the researcher uses high-quality audio recording equipment and, through transcribing the recordings, produces detailed field notes. The recorded audio must be transcribed in a manner that captures pauses and subtle verbal interactions, which are often crucial.

## Findings and Results

To analyze the interview data using the grounded theory method, the first step is open coding. In this stage, the data are examined line by line, phrase by phrase, or paragraph by paragraph, and each unit of analysis is assigned a concept or code. These codes must fully capture the underlying meaning of the data and saturate their conceptual space.

Grounded theory is one of the most important qualitative research approaches that, through an inductive process, enables the development of theory based on empirical data. This method allows the researcher to identify patterns and general characteristics of the phenomenon under study by analyzing the data and subsequently proposing a coherent theory. Strauss and Corbin (1998), in their book *Basics of Qualitative Research*, introduced three types of coding: open coding, axial coding, and selective coding, all of which were used in the present study for data analysis.

To develop an indigenous model of technology commercialization with a focus on technology-based and knowledge-based firms, a qualitative research method and semi-structured interviews were used. This method enables an in-depth examination of experts' perspectives and experiences and assists in discovering the hidden concepts and patterns within the phenomenon

under investigation. In this study, face-to-face interviews were conducted with 13 experts in the field of technology commercialization. Each interview lasted between 25 and 60 minutes, and the questions were designed in an open-ended format to allow participants to express their views freely. In some cases, interviews were repeated or supplementary questions were asked to enrich the data and validate the initial findings.

For selecting participants, purposive sampling and snowball sampling techniques were used. These methods enabled the researcher to gradually access individuals with sufficient knowledge and experience in technology commercialization through initial recommendations from participants. Snowball sampling is particularly effective in specialized subjects where accessing the target population is challenging. In this study, this method facilitated the identification of experts and specialists with relevant expertise.

Qualitative data analysis began simultaneously with data collection. This approach—known as concurrent analysis—allowed the researcher to achieve a deeper understanding of the data, conduct more accurate coding, and adjust the research direction if necessary. The participants in this study were selected from experts in the field of livestock equipment, who, due to their extensive knowledge and experience, provided valuable insights. The purposive selection of these individuals was based on their specialization in the study domain.

In the open coding stage, initial themes were identified and categorized through a careful review of interview transcripts. These codes, directly extracted from the text, represent the concepts, ideas, and key expressions present in the participants' responses.

To extract codes using the grounded theory method, interview statements were first broken down into initial concepts (open codes), which were subsequently grouped into broader conceptual categories (axial codes). A sample table of open and axial codes extracted from the interviews is presented below:

**Table 1**

*Open and Axial Codes*

| Axial Code | Open Code |
|---|---|
| Market Analysis | Identifying market needs |
| | Competitor assessment |
| | Market foresight |
| Technology Development | Technology localization |
| | Technological innovation |
| | Technology upgrading |
| Project Management | Project management tools |
| | Strategic decision-making |
| Human Resources | Team building |
| | Specialized human resources |
| Financial Resources | Investment attraction |
| | Profitability |
| Technology Ecosystem | Collaboration with universities |
| | Networking |
| | Institutional support |
| Marketing and Sales | Branding |
| | Advertising |
| | Distribution channels |
| Legal Challenges | Regulatory instability |
| | Licensing and customs |
| Sanctions | International sanctions |
| Open Innovation | Open innovation |
| Standardization | Product standardization |
| Export | Export markets |
| | Export strategies |

| | |
|---|---|
| Emerging Technologies | Artificial intelligence |
| | Internet of Things |
| Sustainability | Sustainable technologies |
| Customer Experience | Customer satisfaction |
| | After-sales services |
| Research and Development | R&D expenditures |
| | R&D units |
| Competition | Competitive advantage |
| | Unfair competition |
| Communications | Customer relations |
| | Social networks |
| Culture-building | Culture-building |
| Technology Assessment | Feasibility analysis |

In the grounded theory method, to categorize the initial codes into open and axial codes, the initial codes must first be grouped based on shared and related concepts. The initial codes extracted from the detailed analysis of interview data represent the specific and granular concepts present in participants' responses. These codes are then organized into broader conceptual categories, known as axial codes. Axial codes present more general and comprehensive concepts that reveal the relationships among the initial codes and provide the foundation for developing the theoretical model.

Selective coding is a key and final stage in qualitative data analysis using the grounded theory method. The purpose of this stage is to develop a coherent and comprehensive theoretical model capable of explaining the complexities of the phenomenon under study. After open and axial coding, the researcher is faced with a large set of coded data that requires careful integration and organization. In this stage, axial codes are reviewed, and through identifying their relationships, a coherent theoretical narrative is developed that fully and systematically explains the studied phenomenon.

In the present study, with the aim of presenting a comprehensive model for technology commercialization, the data obtained from the interviews and documents were categorized into 38 initial categories. Then, based on the grounded theory framework, these categories were organized into six main groups: causal conditions, the core phenomenon, contextual conditions, intervening conditions, strategies, and consequences. As shown in Figure 1, the paradigmatic model demonstrates that the core phenomenon (i.e., technology commercialization) is influenced by various factors. Causal conditions act as the primary drivers of this phenomenon, while contextual and intervening conditions influence how it is formed and realized. The identified strategies serve as tools for managing and directing this process, and finally, the consequences reflect the outcomes of technology commercialization.

**Core Phenomenon: Technology Commercialization**

The core phenomenon of this study is "technology commercialization" in technology-based and knowledge-based companies, referring to the process of transforming developed technologies into marketable products or services. This phenomenon includes stages such as market needs assessment, product development, marketing, and sales, with the goal of creating economic value from innovative technologies. Based on the data, technology commercialization in these companies is not limited to product development but also requires extensive interactions with stakeholders (customers, government agencies, universities) and aligning technology with market needs. For example, labels such as "product commercialization" and "commercializable technology offerings" reflect the interviewees' emphasis on this process as the central focus of their activities.

This phenomenon occurs within Iran's technology ecosystem, where knowledge-based companies face challenges such as financial constraints, sanctions, and legal complexities. As a dynamic process, technology commercialization requires

coordination among technical aspects (e.g., technology development), managerial aspects (e.g., strategic decision-making), and marketing activities (e.g., branding). Success in this process depends on a company's ability to identify market opportunities, attract resources, and create competitive advantage, which is reflected in labels such as "market creation" and "competitive advantage."

**Causal Conditions**

Causal conditions include factors that initiate or stimulate technology commercialization in knowledge-based companies. These factors include identifying market needs, technological innovation, market foresight, customer experience and demands, and high technological capability. For example, identifying market needs (labels such as "identifying market needs" and "domestic market demand") directs companies toward developing products that meet real demand. Technological innovation and market foresight (labels such as "new innovations" and "market foresight") also act as drivers encouraging companies to develop new technologies or improve existing ones to compete in domestic and global markets.

These causal conditions emerge from companies' interactions with customers, analysis of global trends, and internal technical capabilities. For instance, the label "customer experience and demands" illustrates how customer feedback can generate ideas for product development. Similarly, high technological capability (label "high technological capability") enables companies to produce technologies with strong commercial potential. Together, these factors provide the motivation and direction needed to initiate the commercialization process and play a key role in determining the technology development pathway.

**Contextual Conditions**

Contextual conditions refer to the environmental settings in which technology commercialization occurs and include the technology ecosystem, government regulations, social factors, cultural factors, and financial/equipment capabilities. The technology ecosystem (labels such as "collaboration with universities" and "location in a technology park") serves as a key setting that provides access to scientific resources, institutional networking, and institutional support. Government laws and regulations (label "government laws and regulations") also define a framework that may facilitate (e.g., tax exemptions) or restrict (e.g., bureaucratic processes) commercialization efforts.

Social and cultural factors (labels such as "social factors" and "culture-building") influence societal acceptance of technology. For example, Western-consumerist culture or distrust of domestic products (label "Western-oriented culture") may hinder adoption of knowledge-based products. Financial and equipment capabilities (label "financial capability") also serve as essential infrastructure determining companies' ability to invest in research, development, and production. These contextual factors create the environment in which the commercialization process is either facilitated or challenged.

**Intervening Conditions**

Intervening conditions are factors that either facilitate or hinder the technology commercialization process. These include international sanctions, regulatory instability, lack of financial resources, unhealthy competition, and weak customer knowledge. International sanctions (label "sanctions") in particular create significant limitations on access to global markets, procurement of raw materials, and international collaborations. Regulatory instability (label "regulatory instability") also creates uncertainty in long-term planning, impeding company progress. Lack of financial resources (label "insufficient credit") is one of the major challenges that restricts product development and marketing.

Unhealthy competition (label “unhealthy competition”) and weak customer knowledge (label “weak customer understanding of product value”) act as internal and external barriers to commercialization. For example, unhealthy competition—such as imitation or rent-seeking—can weaken companies’ competitive advantage. Weak customer knowledge also calls for greater efforts in culture-building and customer education. These intervening conditions are dynamic variables whose impact may vary based on environmental circumstances and require strategic management.

**Strategies**

Strategies refer to the actions taken by knowledge-based companies to manage technology commercialization and overcome challenges. These include marketing and sales, branding, networking, university collaborations, product standardization, export strategy formulation, the use of emerging technologies, and feasibility analysis. Marketing and sales (labels such as “advertising” and “distribution channels”) help companies introduce their products and increase market share. Branding (label “branding”) and product standardization (label “compliance with global standards”) are essential for building trust and enhancing competitiveness in the market.

Networking (label “communication networks”) and collaboration with universities (label “collaboration with universities”) allow access to scientific resources and commercial partners. Export strategy formulation (label “export strategy formulation”) and the use of emerging technologies such as artificial intelligence (label “use of artificial intelligence”) help companies strengthen their position in global markets. Feasibility analysis (label “economic and technical feasibility”) serves as a prerequisite strategy to prevent investment in technologies with low commercial potential. These strategies, when employed in an integrated and coordinated manner, strengthen the success of technology commercialization.

**Consequences**

Consequences represent the outcomes of implementing strategies and the overall technology commercialization process. These include profitability, market expansion, customer satisfaction, creation of competitive advantage, sustainable production, and market leadership. Profitability (label “profitability level”) serves as a key indicator of economic success and provides the resources needed for further development. Market expansion (label “export markets”) strengthens a company’s position through penetration into domestic and international markets. Customer satisfaction (label “customer satisfaction level”) and competitive advantage (label “creation of competitive advantage”) contribute to long-term sustainability in the market.

Sustainable production (label “sustainable production”) and market leadership (label “market pioneering”) are additional positive outcomes indicating a company’s ability to consistently respond to market needs and maintain a competitive position. However, potential negative outcomes—such as product stagnation in the market (label “product stagnation”)—may occur if challenges are not properly managed. These consequences provide feedback to the commercialization process and can be used to enhance future strategies.

**Figure 1**

*Proposed model for technology commercialization with a focus on technology-based and knowledge-based companies*


## Discussion and Conclusion

The purpose of this study was to develop an indigenous grounded theory model of technology commercialization in technology-based and knowledge-based firms. The findings revealed a multifaceted paradigm consisting of causal conditions, contextual conditions, intervening conditions, strategies, and consequences. The discussion interprets these findings in light of the existing body of knowledge and demonstrates how the present results align with or extend previous studies. The central phenomenon—technology commercialization—was shown to be a dynamic, iterative, and ecosystem-dependent process shaped by technological capabilities, institutional environments, market readiness, and strategic organizational practices.

The identification of market needs, technological innovation, market foresight, and customer-driven insights as causal factors aligns with prior research suggesting that technology commercialization is initiated when firms effectively match technological functionality with real market demands [1]. Studies within university–industry collaboration frameworks similarly emphasize that commercialization success begins with accurate market sensing and innovation alignment,

consistent with the emphasis on foresight capabilities found in system dynamics research [2]. Moreover, the recognition of technology maturity as a driver of commercialization reiterates findings in Indonesian university models, which highlighted the need for readiness at the early stages of commercialization [3]. As noted in recent analyses of emerging technologies, readiness involves not only technological feasibility but also strategic anticipation of market evolution [4].

The results emphasize technological capability and innovation as essential stimuli driving commercialization. This is consistent with earlier literature demonstrating that strong technological capability increases firms' ability to pursue process innovations within supply chains [5]. Innovation intermediaries, as conceptualized in recent configurational studies, play an enabling role by helping startups and knowledge-based firms overcome technological uncertainty and enhance their product innovativeness [6]. Additionally, sustainability-oriented commercialization models—most notably in energy storage technologies—highlight technological capability as a foundation of commercialization viability [7]. This intersection of innovation, capability, and commercialization was also observed in the present study, particularly in the emphasis on advanced technology readiness and customer-driven adaptation.

A key contribution of this study is the role of contextual conditions—such as technology ecosystems, institutional regulations, cultural factors, and financial capacity. Prior research confirms that commercialization outcomes are strongly shaped by the surrounding ecosystem. For instance, studies on strategic flexibility and alliances demonstrate how ecosystem relationships strengthen entrepreneurial commercialization outcomes in technology sectors [8]. Similarly, research on outsourcing university commercialization activities in Australia underscores the importance of ecosystem sophistication and well-developed technology transfer structures [9]. The significance of financial capability and institutional support discovered in the present study mirrors earlier findings regarding fuzzy analytical models for evaluating resource allocation in decision-making environments [10].

The model's emphasis on regulatory frameworks and governmental policies as contextual drivers also aligns with system-level research. System dynamics studies confirm that institutional environments powerfully shape the speed and effectiveness of knowledge transfer and commercialization [11]. In Iran and similar innovation systems, institutional complexity, policy fluctuations, and bureaucratic obstacles have long been documented as structural barriers to commercialization efforts [12]. Furthermore, general system dynamics literature notes that contextual conditions must be considered in commercialization modeling, particularly in countries where policy uncertainty affects strategic decision-making [13]. These insights support the present study's findings regarding the centrality of contextual and regulatory conditions for technology transfer and commercialization.

The study also identified intervening conditions, which include sanctions, regulatory instability, financial shortages, unhealthy competition, and limited customer awareness. These findings are consistent with studies examining commercialization in emerging economies and biotechnology industries, which frequently highlight unstable regulatory systems and weak financial infrastructures as major inhibitors [14]. Long-term forecasting research further emphasizes that uncertainty—whether economic, institutional, or technological—undermines commercialization decisions, a finding strongly reflected in pandemic-related forecasting studies [15]. For small knowledge-based firms, IP management challenges and institutional constraints directly affect commercialization viability, with research showing that small firms must navigate complex regulatory and market challenges to protect their intellectual property [16]. Comparative studies of US and Chinese

TTOs likewise reveal that supportive institutional structures mitigate such challenges and enable more effective technology transfer and commercialization [17, 18].

The strategies identified in this study—marketing, branding, networking, university collaboration, product standardization, export strategy formulation, emerging technologies, and feasibility analysis—are strongly supported by prior research. Several studies highlight the importance of policy instruments, strategic communication, and market-oriented initiatives for commercialization. For example, analyses of university policy mixes demonstrate that mixed policy instruments enhance commercialization when aligned with strategic initiatives and market-based incentives [20]. Strategies rooted in strategic flexibility and alliances, as seen in entrepreneurial commercialization models, further explain how firms can leverage relational networks to navigate uncertainties [21]. Open innovation capacity, which the present study identifies through networking and collaboration with universities, is similarly emphasized as a key facilitator of commercialization in academic innovation systems [22].

Moreover, the role of standardized products and global compliance reflects past findings showing that cross-national technology products require strong regulatory alignment and quality assurance mechanisms—particularly in bioenergy and biotechnology industries operating in developing countries [23]. The influence of technological capability on commercialization performance among SMEs further reinforces the importance of emerging technologies and technological readiness, consistent with prior analyses of SME technology capability models [24]. This integration of branding, marketing, and technological readiness is also echoed in forecasting and new product development literature, which emphasizes the need for robust market analysis and product readiness forecasting [25].

The consequences identified in the study—profitability, market development, customer satisfaction, competitive advantage, sustainable production, and market leadership—are highly consistent with existing commercialization outcome frameworks. In studies of Iranian knowledge-based companies, commercialization performance has been shown to directly shape competitive advantage and long-term sustainability [30]. Drivers and inhibitors identified in earlier research on technology commercialization also validate the dual nature of consequences, where successful commercialization yields economic benefits while failure leads to market stagnation [31]. Additionally, foundational studies on university startup performance demonstrate that effective commercialization outcomes are closely tied to institutional support, intellectual property management, and resource mobilization [32, 33]. The current study's findings reinforce these long-standing theoretical perspectives by mapping commercialization outcomes onto ecosystem, capability, and regulatory dimensions.

The present findings also align strongly with prior Iranian studies emphasizing indigenous commercialization models adapted to national ecosystem constraints. Iranian research has historically stressed the need for customized frameworks that account for cultural factors, regulatory challenges, financial limitations, and technology diffusion barriers [26-29]. More recent Iranian research similarly highlights the need to integrate innovation capability, commercialization readiness, and ecosystem maturity into a holistic framework for knowledge-based firms [35]. The meta-synthesis of pharmaceutical and biological product commercialization models also emphasizes the importance of designing context-specific commercialization frameworks tailored to sectoral needs [34]. These findings closely mirror the contextualized and indigenous orientation of the present model.

In summary, the discussion confirms that the grounded theory model developed in this study is strongly connected to international and national literature on technology commercialization. The alignment with past studies across multiple

methodological and contextual settings demonstrates the robustness of the model and its suitability for addressing commercialization challenges in developing economies, particularly Iran. The integration of technological, market, institutional, and strategic dimensions provides a comprehensive understanding of commercialization processes and contributes meaningfully to the field.

This study, like most qualitative grounded theory research, is limited by its sample size and dependence on expert perspectives. Although theoretical saturation was achieved, the inclusion of participants from other industries or regions might have yielded additional insights. The context-specific nature of commercialization challenges in Iran, especially under international sanctions, may also limit the generalizability of the findings to other national ecosystems. Furthermore, the reliance on interview data may introduce subjective biases, despite rigorous coding and cross-validation procedures.

Future research should employ mixed-methods designs to validate and operationalize the constructs identified in this study. Quantitative studies could develop measurement scales for the causal, contextual, and intervening factors in the model. Comparative cross-country studies would also be valuable for understanding how national innovation systems and institutional environments shape commercialization pathways. In addition, further research could explore commercialization dynamics in specific high-tech sectors such as biotechnology, AI, clean energy, and advanced materials.

Practitioners should focus on strengthening ecosystem collaboration, improving regulatory stability, and enhancing access to financial resources. Emphasis should be placed on developing strategic foresight capabilities, building technological readiness, and investing in branding and global standardization. Policy-makers should prioritize supporting knowledge-based firms through targeted incentives, innovation-friendly regulations, and investment in research infrastructures.

## Acknowledgments

We would like to express our appreciation and gratitude to all those who cooperated in carrying out this study.

## Authors' Contributions

All authors equally contributed to this study.

## Declaration of Interest

The authors of this article declared no conflict of interest.

## Ethical Considerations

The study protocol adhered to the principles outlined in the Helsinki Declaration, which provides guidelines for ethical research involving human participants. Written consent was obtained from all participants in the study.

## Transparency of Data

In accordance with the principles of transparency and open research, we declare that all data and materials used in this study are available upon request.

## Funding

This research was carried out independently with personal funding and without the financial support of any governmental or private institution or organization.

## References

[1] G. Tolin and A. Piccaluga, "Commercializing technology from university-industry collaborations: A configurational perspective on organizational factors," *Journal of Business Research*, vol. 188, p. 115105, 2025, doi: 10.1016/j.jbusres.2024.115105.

[2] D. Pujotomo, A. Ma'aram, M. Ikmal Isyraf, S. A. Helmi Syed Hassan, and W. Sutopo, "The scenario of accelerating technology commercialization at research university, a system dynamics approach," *Journal of Open Innovation: Technology, Market, and Complexity*, vol. 11, no. 1, p. 100497, 2025, doi: 10.1016/j.joitmc.2025.100497.

[3] U. N. Dzakiy, Y. Matsuura, T. M. Simatupang, and E. A. Prasetio, "Practical model of technology commercialisation at an indonesian university: a case study from institute teknologi bandung," *J. Open Innov.: Technol., Mark., Complex.*, vol. 10, no. 3, p. 100341, 2024, doi: 10.1016/j.joitmc.2024.100341.

[4] M. Amini, S. M. Farahi, and A. M. Mesbahinia, "Investigating the Commercialization Process of Emerging Technologies and Factors Affecting It," 2024.

[5] L. Wang, J. Lu Jin, and K. Z. Zhou, "Technological capability strength/asymmetry and supply chain process innovation: The contingent roles of institutional environments," *Research Policy*, vol. 52, no. 4, p. 104724, 2023, doi: 10.1016/j.respol.2023.104724.

[6] M. Stahl, H. Zarco-Jasso, and F. Miralles, "How can innovation intermediaries enable product innovativeness in startups? a configurational approach," *J. Open Innov.: Technol., Mark., Complex.*, vol. 9, no. 1, p. 100007, 2023, doi: 10.1016/j.joitmc.2023.02.004.

[7] X. Shu *et al.*, "Sustainability Assessment of Energy Storage Technologies Based on Commercialization Viability: MCDM Model," *Sustainability*, vol. 15, no. 6, p. 4707, 2023, doi: 10.3390/su15064707.

[8] A. Olawore, K. Y. Wong, A. Ma'aram, and W. Sutopo, "Prioritization of technology commercialization success factors using fuzzy best worst method," *J. Open Innov.: Technol., Mark., Complex.*, vol. 9, no. 3, p. 100096, 2023, doi: 10.1016/j.joitmc.2023.100096.

[9] A. Nugent and H. F. Chan, "Outsourcing university research commercialization to a sophisticated technology transfer office: Evidence from Australian universities," *Technovation*, vol. 125, p. 102762, 2023, doi: 10.1016/j.technovation.2023.102762.

[10] N. Goldani and M. Kazemi, "A fuzzy best-worst method based fuzzy interval scale," in *Decision Making in Social Sciences: A Fuzzy Logic Approach*, 2023, pp. 59-73.

[11] Q. Zhou, X. Deng, B. G. Hwang, and M. Yu, "System dynamics approach of knowledge transfer from projects to the project-based organization," *Int. J. Manag. Proj. Bus.*, 2022, doi: 10.1108/IJMPB-06-2021-0142.

[12] J. Yazdi Moghadam, "Presenting a Model for Evaluating Technology Commercialization Success," *Industrial Technology Development Quarterly*, vol. 20, no. 50, pp. 1-19, 2022.

[13] M. Tursun and I. Aksu, "System dynamics approach and its usage in social sciences," *Pamukkale Univ. J. Soc. Sci. Inst.*, 2022, doi: 10.30794/pausbed.1107306.

[14] S. Tawate, R. Gupta, and K. Jain, "Development of a Technology Commercialization Model for Indian Biotechnology Firms," *IEEE Trans. Eng. Manag.*, vol. 69, no. 5, pp. 1878-1890, 2022, doi: 10.1109/TEM.2019.2939417.

[15] H. Rahmandad, R. Xu, and N. Ghaffarzadegan, "Enhancing long-term forecasting: Learning from COVID-19 models," *PLOS Comput. Biol.*, vol. 18, no. 5, p. e1010100, 2022, doi: 10.1371/journal.pcbi.1010100.

[16] C. S. Hayter and A. N. Link, "From discovery to commercialization: Accretive intellectual property strategies among small, knowledge-based firms," *Small Business Economics*, vol. 58, pp. 1367-1377, 2022, doi: 10.1007/s11187-021-00446-z.

[17] M. A. Fassi, "A Review of Patenting Trends and Technology Commercialization Practices in University Technology Transfer Offices in the United States and China," *World Patent Information*, vol. 68, p. 102097, 2022, doi: 10.1016/j.wpi.2022.102097.

[18] M. Abdul Fasi, "An Overview on patenting trends and technology commercialization practices in the university Technology Transfer Offices in USA and China," *World Patent Information*, vol. 68, p. 102097, 2022, doi: 10.1016/j.wpi.2022.102097.

[19] W. Wang, G. Lyu, W. Cui, and Y. Li, "Strategic technology commercialization in the supply chain under network effects," *International Journal of Production Economics*, vol. 231, p. 107895, 2021, doi: 10.1016/j.ijpe.2020.107895.

[20] Q. Gan, J. Hong, and B. Hou, "Assessing the different types of policy instruments and policy mix for commercialisation of university technologies," *Technology Analysis & Strategic Management*, vol. 33, no. 5, pp. 554-567, 2021, doi: 10.1080/09537325.2020.1831468.

[21] A. K. Chebo and Y. F. Wubatie, "Commercialisation of technology through technology entrepreneurship: The role of strategic flexibility and strategic alliance," *Technology Analysis & Strategic Management*, vol. 33, no. 4, pp. 414-425, 2021, doi: 10.1080/09537325.2020.1817367.

[22] M. Baron, "Open Innovation Capacity of Polish Universities," *Journal of the Knowledge Economy*, vol. 12, no. 1, pp. 73-95, 2021, doi: 10.1007/s13132-017-0515-8.

[23] A. Bakhtiar, A. Aslani, and S. M. Hosseini, "Challenges of Dissemination and Commercialization of Bioenergy in Developing Countries," 2020, doi: 10.1016/j.renene.2019.06.126.

[24] H. Kim, S. Y. Park, and W. I. Joh, "A study on technology development performance and technology commercialization performance according to the technology development capability of smes focusing on a comparative analysis of technology business groups," *Journal of Open Innovation: Technology, Market, and Complexity*, vol. 5, no. 3, p. 65, 2019, doi: 10.3390/joitmc5030065.

[25] M. Mas-Machuca, M. Sainz, and C. Martinez-Costa, "A review of forecasting models for new products," *Intangible Capital*, vol. 10, no. 1, pp. 1-25, 2014, doi: 10.3926/ic.482.

[26] Z. Sahami, "Investigating the Effect of Insurance Coverage for Knowledge-Based Companies' Products in the Supply Chain on Company-Supplier Relationships," 2013.

[27] N. Jamalizadeh and H. Ranjbar, "Identifying and Prioritizing the Components of Nanotechnology Commercialization in a Petrochemical Company Using the Fuzzy Analytic Hierarchy Process," 2013.

[28] J. Haghighat Monfared, "An Indigenous Model for the Commercialization of Complex Technologies Based on Partnership in the Information and Communication Technology Sector," *Iranian Journal of Information Technology and Communication*, vol. 15, no. 55, pp. 9-34, 2013.

[29] M. Darjazini, S. M. Mahmoudi, M. Mohammadi, and M. Shahbazi, "Presenting an Open Technology Commercialization Model for Small and Innovative Companies Active in the Urban Sector," *Iranian Journal of Urban Economics and Management*, vol. 10, no. 41, pp. 85-110, 2013.

[30] K. Shahroudi, M. Shadpour, and M. H. Pourshal, "Evaluating the Impact of Technology Commercialization Performance on Creating Sustainable Competitive Advantage for Knowledge-Based Companies with Emphasis on the Moderating Role of Environmental Factors," 2012.

[31] A. Zolfaghari, H. Zandhesami, M. Akbari, and H. Amin Esmaeili, "Drivers and Inhibitors of Technology Commercialization," *Quarterly Journal of Innovation Management in Defense Organizations*, vol. 3, no. 3, pp. 77-104, 2010.

[32] S. Anbaraki and S. Pouroshasb, "Investigation of Infrastructures and Commonly Used Models in Technology Commercialization and Development," 2010.

[33] D. Di Gregorio and S. Shane, "Why do some universities generate more start-ups than others?," *Research policy*, vol. 32, no. 2, pp. 209-227, 2003, doi: 10.1016/S0048-7333(02)00097-5.

[34] M. Kaoui, H. Sadeghi, and M. Azizi, "Designing a model for the technology commercialization process with a focus on the pharmaceutical and biological products industry using a meta-synthesis approach," 1401.

[35] S. H. Mirghafouri, A. Marvati Sharifabadi, and A. A. Zahedi, "Designing an integrated model for developing the level of innovation and commercialization of Iranian knowledge-based companies," *Innovation and Creativity in Humanities*, vol. 7, no. 4, pp. 107-142, 2018.