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Designing a Value Creation Model in the Commercialization Process of Agricultural Research Results in Iran: A Mixed-Methods Approach

Roya Ahmadyousefi[1], Homayoun Farhadian[1], Shahla Choobchian[1]*, and Hossein Shabanali Fami[2]

ABSTRACT

Commercializing innovative ideas and transforming agricultural research results into economic value constitute a comprehensive, system-oriented, and customer-centered approach that fosters the practical utilization of agricultural education and research. Despite increasing global attention to research commercialization, the issue has not received adequate focus within Iran's agricultural domain, where persistent challenges hamper the achievement of commercialization objectives. This study was conducted to design a value-creation model for the commercialization of agricultural research outputs in Iran. The research adopts a descriptive–analytical design and employs a mixed-methods approach that incorporates qualitative and quantitative phases. In the qualitative phase, thirty-one experts were selected through purposive sampling using the snowball sampling technique. Data were collected via semi-structured interviews and analyzed using a grounded theory approach; For quantitative evaluation, structural equation modeling (SEM) was applied using Smart PLS4 software. All path coefficients were positive and statistically significant, confirming the robustness of the proposed model. The findings suggest that value creation in the commercialization process of agricultural research in Iran is shaped by specific conditions grouped into three major categories: causal conditions (emergence of innovative ideas, institutional framework, and economic incentives), contextual conditions (communication and structural infrastructure), and intervening conditions (key stakeholders). Strategic components include interaction and communication management, business project administration, and the monitoring and evaluation of commercialization processes. The resulting outcomes encompass social, economic, political, and environmental dimensions, highlighting the multifaceted impact of effective commercialization on sustainable agricultural development. Overall, the results confirm that the proposed value-creation model provides a coherent and empirically supported framework

[1] Department of Agricultural Extension and Education, Faculty of Agriculture, Tarbiat Modares University, Tehran, Islamic Republic of Iran.
[2] Department of Agricultural Management and Development, Faculty of Agriculture, University of Tehran, Islamic Republic of Iran.
*Corresponding author; e-mail: shchoobchian@modares.ac.ir

for strengthening the commercialization of agricultural research in Iran. Accordingly, its implementation can help bridge the gap between research production and practical application, leading to more sustainable and economically impactful agricultural development.

Keywords: Agricultural research commercialization, Grounded theory, Innovation systems, Stakeholder engagement.

INTRODUCTION

Today, innovation in Iran's agricultural sector is more essential than ever, as water, land, and forests are under increasing pressure to meet production demands, whereas climate change and evolving weather patterns continue to exert adverse effects on agriculture. Accordingly, agricultural development has become one of the foremost priorities of a country's national development programs. In modern approaches to agricultural development, knowledge and technology play a vital role in achieving sustainable agricultural growth, and the commercialization of innovative knowledge-based ideas has emerged as an imperative and indispensable process (Farsani et al., 2024). Commercialization can be defined as the process of bringing an idea or innovation to the market, one that involves a thorough analysis of market needs, conducting the necessary research and experiments, prototype development, standardization of the product development process, and managerial coordination to ensure its successful introduction to potential customers or markets (Biranvand et al., 2021). In Iran, commercialization is the most crucial missing link in the chain from research to production. Identifying effective pathways for transferring research outcomes, particularly in the agricultural sector, which is the focus of this study, is crucial for bridging the gap between research and industry domains (Dehdashti et al., 2019). As Ganz and Stern (cited in Mirghafouri et al., 2019) have noted, greater attention to commercialization and the selection of appropriate models and strategies are vital, since the ability to transform market-oriented research ideas into well-structured techno-economic technologies can turn a developing country that exports raw materials into an advanced nation that exports technical and economic knowledge. Therefore, the commercialization of research findings, especially in agriculture, is one of Iran's key needs for improving its economic cycle (Keikhay Farzaneh et al., 2019). To this end, the establishment of knowledge-based companies within science and technology parks (STPs) was among the first serious initiatives aimed at transforming innovations into practical technologies in Iran. However, numerous pieces of evidence indicate that although a large number of research projects in Iran have been technically efficient, only a small fraction have achieved success in commercialization. Consequently, despite growing pressures on water and land resources, the impacts of climate change, limited innovation in Iranian agriculture, and the urgent need to commercialize research outcomes, the transfer of knowledge to the industrial sector through technology parks has not achieved significant success. Despite Iran's abundance of research centers and its substantial potential to harness this latent resource for national development, it appears that although the importance of knowledge in innovation and industrial revitalization has increased, the process of transferring knowledge from research institutions to industry continues to progress at a very slow pace. Therefore, a clear and coherent policy framework is required to overcome commercialization barriers and strengthen systematic linkages among universities, STPs, and industry. Such a framework can facilitate the translation of scientific knowledge into practical agricultural innovations. Such a framework would enable effective planning at the individual, organizational, and national levels to create the necessary conditions for commercializing research findings in the agricultural sector. To achieve this goal, it is necessary for various stakeholder groups within agricultural research centers and STPs often managed independently to collaborate under a shared framework of principles and regulations to provide services cohesively and to play complementary and well-defined roles.

In innovation and research commercialization literature, value is commonly conceptualized as the set of tangible and intangible benefits generated through the transformation of knowledge, technologies, and research outputs into outcomes that address the needs of multiple stakeholders (Perkmann et al., 2013). Beyond economic returns, such value encompasses social, environmental, and institutional dimensions, reflecting the multi-dimensional nature of contemporary innovation systems (Etzkowitz & Zhou, 2017). Accordingly, value creation refers to a dynamic and interactive process through which these benefits are generated, amplified, and delivered via structured collaboration among universities, industry, and government actors within broader innovation ecosystems (Audretsch, 2014). In the context of agricultural research commercialization, value creation occurs when scientific outputs are effectively translated into applied innovations that enhance productivity, sustainability, market efficiency, and societal welfare (Klerkx et al., 2019; Klingenberg et al., 2022).

Accordingly, this study aims to develop a value-creation model for the commercialization of agricultural research. By proposing a comprehensive guiding framework that serves as a roadmap and balanced action plan, this research seeks to align diverse stakeholders within Iran's agricultural research institutions toward a unified structure that facilitates the effective planning and implementation of agricultural research commercialization projects. In this study, we seek to design a value-creation model in the process of commercializing agricultural research results in Iran using the Structural Equation Modeling (SEM) approach. To better position the present study within the existing body of knowledge, the following section reviews relevant literature and identifies key gaps.

Research background

Previous studies have extensively examined the commercialization of scientific and agricultural research outputs from institutional, organizational, and innovation-system perspectives. Existing literature generally emphasizes that successful commercialization depends on the interaction among institutional support mechanisms, stakeholder collaboration, innovation infrastructures, market access, and policy environments. However, despite increasing scholarly attention to commercialization processes, important theoretical and empirical gaps remain regarding the mechanisms through which value is created throughout the commercialization of agricultural research outputs. To provide a systematic overview of the existing literature and identify the research gap addressed by the present study, a comparative review of representative studies is presented in Table 1.

Table 1. Comparative Review of Previous Studies on Agricultural Research Commercialization.

Study	Research Focus	Main Findings	Research Limitations/Gaps
Mirghafouri et al. (2019)	Innovation and commercialization in knowledge-based firms	Market access and innovation capability were recognized as central commercialization drivers	Focused mainly on knowledge-based firms rather than agricultural research systems
Sharifi et al. (2020)	Alternative commercialization mechanisms in agriculture	Joint ventures, patenting, IP transfer, and university-based firms were identified as key mechanisms	Limited attention to stakeholder interactions and commercialization dynamics
Biranvand et al. (2021)	Factors affecting commercialization of academic research	Organizational and structural factors were identified as the most influential determinants	Lack of integrated process-oriented commercialization framework
Feo et al. (2022)	Agricultural innovation systems	Multi-actor collaboration and stakeholder integration were essential for agricultural innovation	Limited focus on commercialization value creation
Klingenberg et al. (2022)	Value creation in agricultural value chains	Value creation emerges through complex actor interactions and governance arrangements	Did not provide a commercialization-specific conceptual model
Pujotomo et al. (2023)	University–industry collaboration and technology commercialization	Institutional support, IP management, and collaborative networks significantly influence commercialization success	Insufficient attention to agricultural research systems
Tereshchenko et al. (2024)	University–industry cooperation and innovation transfer	Organizational capabilities and trust-building mechanisms facilitate commercialization	Lack of integrated SEM-based commercialization framework
Mahmoodi et al. (2024)	Challenges and strategies of agricultural research commercialization in Iran	Weak governmental support, insufficient commercialization policies, poor university–industry interaction, and educational limitations were identified as major barriers	Focused primarily on barriers rather than value-creation mechanisms
Sun and Ma (2025)	Stakeholder co-creation in agricultural innovation systems	Collaborative service platforms enhance sustainable value generation	Limited empirical modeling of commercialization processes

As summarized in Table 1, the existing literature demonstrates that commercialization is a multidimensional and interactive process shaped by institutional structures, stakeholder relationships, market mechanisms, and innovation capacities. Nevertheless, several important gaps remain insufficiently addressed. First, most previous studies have primarily concentrated on identifying barriers, enabling factors, or commercialization strategies independently, while limited attention has been devoted to explaining how value is created throughout the commercialization process. Second, many studies have focused either on higher education institutions or knowledge-based firms in general, whereas agricultural research commercialization has received comparatively limited scholarly attention despite its strategic importance for sustainable agricultural development. Third, prior research has generally examined isolated dimensions such as institutional support, market access, innovation capability, or stakeholder collaboration without integrating these components into a comprehensive and process-oriented conceptual framework.

Accordingly, there remains a significant theoretical and empirical gap regarding the development of an integrated value-creation model capable of explaining the dynamic relationships among causal conditions, contextual factors, stakeholder interactions, commercialization strategies, and multidimensional outcomes within agricultural research commercialization systems. The present study addresses this gap by developing and empirically validating a comprehensive value-creation model for the commercialization of agricultural research results in Iran. Beyond its national context, the proposed framework may also provide valuable implications for other developing countries with similar institutional and structural conditions seeking to strengthen agricultural innovation systems and research commercialization capacities.

METHODOLOGY

This study aimed to develop a value-creation model for the commercialization of agricultural research outcomes in Iran. To achieve this objective, a sequential exploratory mixed-methods design was adopted, integrating qualitative and quantitative approaches. The qualitative phase was conducted to identify the key dimensions and components of value creation, whereas the quantitative phase was undertaken to validate the proposed conceptual model using structural equation modeling (SEM). The overall research design is illustrated in Figure 1.

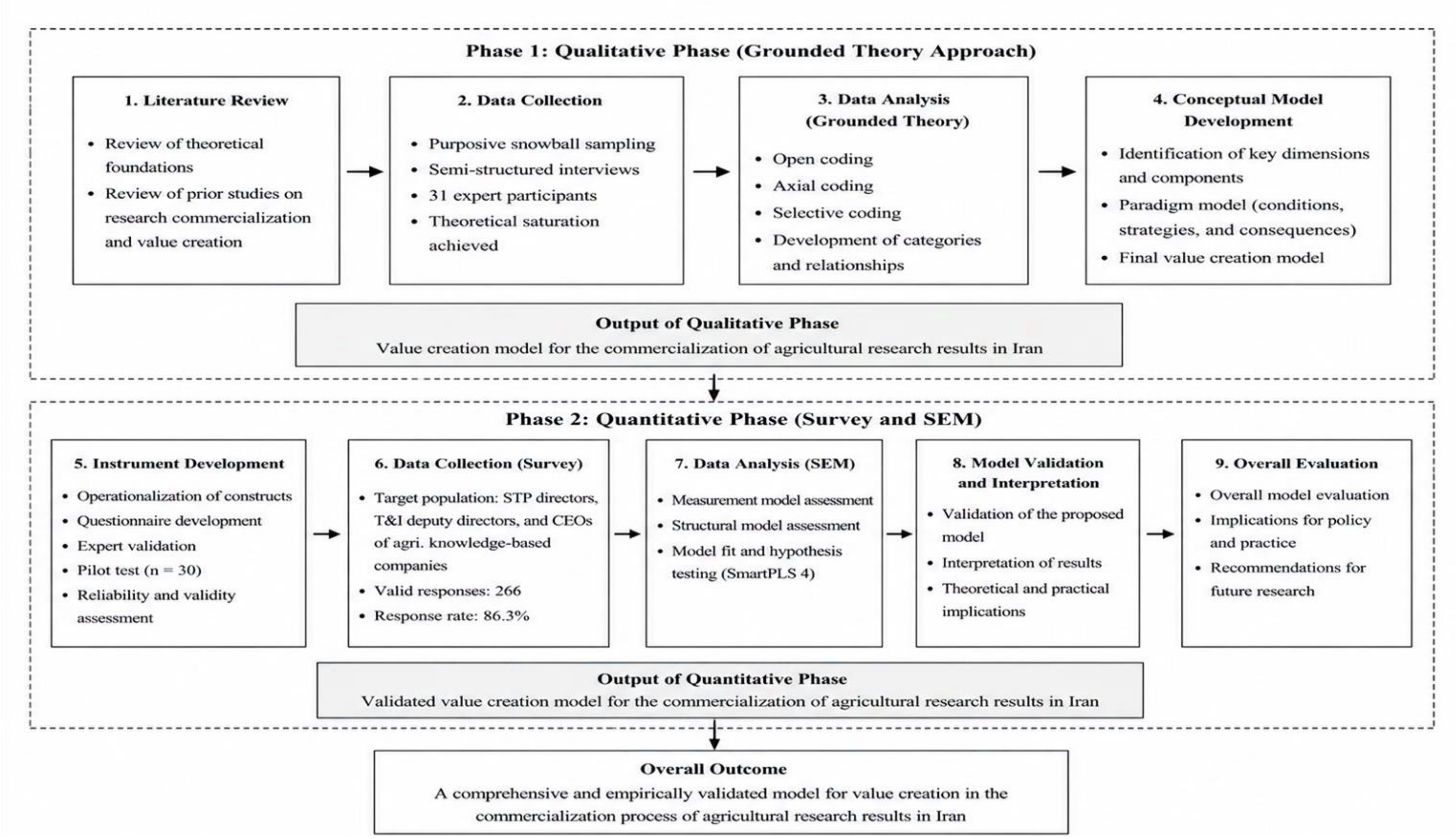

Fig 1. Overall research design of the study.

Qualitative Phase

A purposive snowball sampling strategy was employed to recruit participants for the qualitative phase of the study. Selection was guided by predefined inclusion criteria to ensure the relevance and richness of the data. Eligible individuals were required to possess substantial expertise in one or more of the following areas: agricultural research, agricultural innovation, STPs, knowledge-based companies, research management, or agricultural commercialization. In addition, they were required to have at least five years of professional experience and direct involvement in research commercialization, technology transfer, innovation management, or related policy-making processes. Individuals without demonstrable experience in agricultural research commercialization were excluded. Participants' expertise was verified through their professional positions, academic qualifications, publication records, and recommendations obtained during the snowball sampling process. Data were collected through individual face-to-face semi-structured interviews with subject-matter specialists and university faculty members. Theoretical saturation was achieved after the twenty-seventh interview, when no new concepts, categories, or relationships emerged. To confirm the stability and completeness of the developing theoretical framework, four additional interviews were conducted. As these interviews yielded no substantially new insights, saturation was considered fully achieved. Consequently, the qualitative phase included 31 experts. The demographic characteristics of the participants are summarized in Table 2. As shown, most participants were between 41 and 60 years of age, and the majority held doctoral degrees, reflecting a high level of academic and professional expertise. Most participants had 5–10 years of professional experience, followed by those with more than 10 years of experience, indicating substantial practical involvement in agricultural research commercialization and innovation activities.

Table 2. Demographic Characteristics of Qualitative Participants.

Variable	Category	Frequency	Percentage (%)
Age	30–40	2	6.45
	41–50	15	48.39
	51–60	14	45.16
Education	Master's	4	12.90
	PhD	26	83.87
	Postdoc	1	3.23
Experience	<5 years	5	16.13
	5–10 years	16	51.61
	>10 years	10	32.26
Total	-	31	100

The interview protocol explored six broad themes: (1) the underlying causes of the limited commercialization of agricultural research outcomes in Iran; (2) strategies for overcoming commercialization barriers; (3) factors influencing value creation throughout the commercialization process; (4) the meaning and sources of value in agricultural research commercialization; (5) the mechanisms through which value is created; and (6) the stakeholders who create, receive, and capture value.

To capture diverse perspectives, participants were recruited from five stakeholder groups: (1) managers and deputy directors of STPs; (2) researchers working within STPs; (3) managers and specialists from agricultural research centers; (4) university administrators and research managers; and (5) faculty members actively involved in executive and commercialization activities within STPs.

Trustworthiness and Data Analysis

The trustworthiness of the qualitative findings was ensured by applying the criteria proposed by Lincoln and Guba (1985), namely credibility, transferability, dependability, and confirmability. Credibility was strengthened through prolonged engagement with participants and member checking, whereby preliminary interpretations and findings were returned to selected participants for verification and feedback. Transferability was enhanced by providing a comprehensive description of the research context, participant selection procedures, data collection process, and analytical approach, enabling readers to assess the applicability of the findings to comparable contexts. Dependability was established through systematic documentation of all stages of the research process, including data collection, coding procedures, category development, and analytical decisions, thereby creating a transparent audit trail. Confirmability was reinforced through both internal review by the research team and external evaluation by experts in agricultural commercialization and innovation, whose comments and recommendations were incorporated into the final analytical framework. Qualitative data were analyzed using the coding procedures of grounded theory. The analytical process consisted of three sequential stages: open coding, axial coding, and selective coding. During open coding, interview transcripts were examined line by line to identify initial concepts and assign conceptual labels. In the axial coding stage, related concepts were grouped into higher-order categories by identifying relationships among categories and their subcategories. Finally, selective coding was employed to integrate the core categories into a coherent theoretical framework, resulting in the development of the proposed value-creation model for the commercialization of agricultural research in Iran.

Quantitative Phase

The second phase of the study employed a quantitative research design to evaluate and validate the conceptual model developed during the qualitative phase. Findings from the grounded theory analysis served as the basis for designing the research instrument and operationalizing the constructs incorporated into the structural model. The researcher-developed questionnaire consisted of two sections. The first section collected respondents' demographic information, including gender, age, educational attainment, and professional experience in research commercialization. The second section comprised 86 measurement items representing the value-creation constructs identified during the qualitative phase. The questionnaire was evaluated for both face validity and content validity by an expert panel comprising faculty members from the Department of Agricultural Extension and Education at Tarbiat Modares University and the University of Tehran. Their recommendations were incorporated into the final version of the instrument to improve its clarity, relevance, and content coverage. A pilot study involving 30 respondents from the target population was conducted to assess the reliability of the questionnaire. These responses were excluded from the final statistical analysis. Internal consistency was evaluated using Cronbach's alpha coefficient, and all statistical analyses related to the pilot study were performed using SPSS version 27. The reliability assessment results are presented in Table 3. All Cronbach's alpha coefficients exceeded the recommended threshold of 0.70, demonstrating satisfactory internal consistency for each construct. Specifically, the reliability coefficients ranged from 0.76 to 0.80 across the five dimensions of the proposed model, indicating excellent reliability of the measurement instrument.

Table 3. Reliability assessment of research instruments using Cronbach's alpha method

	Factors that create value in the commercialization process of agricultural research results	Number of items	Cronbach's alpha	Interpretation
1	Causal Conditions with 6 Components	30	0.80	Good
2	Contextual Conditions with 2 Components	8	0.76	acceptable
3	Intervening Conditions with 1 Components	6	0.77	acceptable
4	Strategies with 3 Components	21	0.80	Good
5	Consequences with 5 Components	21	0.80	Good

Source: Research findings

Following the pilot study, the final questionnaire was administered using a cross-sectional survey design. Data were collected through both face-to-face administration and electronic distribution of the researcher-developed questionnaire. The target population consisted of three principal stakeholder groups involved in agricultural research commercialization in Iran: (1) directors STPs, (2) deputy directors for technology and innovation within STPs, and (3) Chief executive officers (CEOs)of agricultural knowledge-based companies. According to official statistics obtained from the Statistical Center of Iran, the Vice Presidency for Science, Technology and Knowledge-Based Economy, and the Deputy for Development of Knowledge-Based Companies, Iran had 51 active STPs and 503 registered agricultural knowledge-based companies in 2025. Based on this population and Morgan's sample size table (2003), the required sample size was determined as presented in Table 4.

Table 4. Statistical Population and Sample Size for the quantitative part of the Research.

	Heads of STPs	Deputy Directors for Technology and Innovation of STPs	Chief Executive Officers of Agricultural Knowledge-Based Companies	Total
Statistical Population	51	51	503	605
Statistical Sample	45	45	218	308
Number of Incomplete Questionnaires	18	14	10	42
Total completed questionnaires	27	31	208	266
Percent	10.2	11.7	78.1	100

Source: Research findings

Overall, 266 completed questionnaires were returned, corresponding to a response rate of 86.3%, which indicates a high level of participant engagement and provides a robust basis for subsequent statistical analyses. The demographic characteristics of the respondents are summarized in Table 5. The sample was predominantly male (89.5%), with more than half of the respondents aged between 41 and 50 years. Nearly all participants held postgraduate qualifications, with master's and doctoral degrees accounting for approximately 99% of the sample. In terms of organizational position, CEOs of agricultural knowledge-based companies represented the largest respondent group (78.2%), followed by deputy directors for technology and innovation (11.7%) and directors of STPs (10.1%). Regarding professional experience, the majority of respondents (82.3%) had fewer than five years of experience, while smaller proportions reported longer professional experience.

Table 5. Demographic characteristics of the survey respondents (n = 266).

Variable	Category	n	%
Gender	Male	238	89.5
	Female	28	10.5
Age (years)	30–40	93	35.0
	41–50	138	51.9
	51–60	35	13.1
Education	Master's degree	133	50.0
	PhD	131	49.2
	Postdoctoral	2	0.8
Organizational position	CEO (knowledge-based companies)	208	78.2
	Deputy Director (technology & innovation)	31	11.7
	Head of science & technology park	27	10.1
Work experience (years)	<5	219	82.3
	6–10	40	15.0
	11–15	6	2.3
	16–20	1	0.4

Source: Research findings.

RESULTS

Results from the qualitative method

After the interviews were conducted and the saturation point was achieved, the data derived from the interviews were analyzed as follows: Initially, the interview transcripts were repeatedly reviewed so that the researcher could gain a relative mastery of all the interviews and become thoroughly familiar with the underlying concepts and meanings embedded within the texts. Subsequently, through a manual review of the interviews, the initial codes were identified. This process involved underlining words and phrases that the researcher recognized as relevant codes. The coding continued systematically to ensure that any codes overlooked during earlier stages were detected. Next, similar codes and concepts that referred to a particular domain or topic were placed into the same category. At this stage, the researcher iteratively grouped the codes that pointed to a common meaning and classified them into a single category. In the following phase, the researcher re-examined the various categories and, by defining and refining the shared nature within each category, determined an appropriate name for them, which was identified as the theme. In this step, eight principal categories emerged from the interview data analysis. In the Axial coding stage, the data derived from the interviewees were compared again, and the identified categories were organized into conditional, interactive, and consequential groups, as outlined in Table (6). In the selective coding stage, the interrelationships between the categories that were theoretically saturated and logically sequenced in the previous stages and extracted in the axial coding stage were identified, and the key factors for the commercialization of agricultural research results as value-creating, which were identified and explained using the extracted categories, were logically linked. The results of the data analysis clearly show that in the process of value-creating for the commercialization of agricultural research results, the key factors underlying this process include the emergence of innovative ideas, the institutional framework and economic incentives as causal conditions, communication and structural infrastructures as contextual conditions, and key stakeholders as intervening conditions. Interactions and communications, management of the commercialization initiative, and monitoring and evaluation of commercialization activities within the strategic framework affect this process. These categories may be influenced by the infrastructure and key stakeholders. Ultimately, the successful commercialization of agricultural research findings is expected to have positive social, political, economic, and environmental consequences, as well as increased stakeholder satisfaction. To support the credibility of the extracted categories, several direct quotations from participants are presented. For example, in relation to environmental consequences, one expert stated: “Without proper commercialization mechanisms, most agricultural research outputs remain unused and fail to contribute to environmental sustainability.” Another participant emphasized the importance of institutional support by noting: “STPs can play a key role in transforming research into practical solutions, but only if proper policies and incentives are in place.” These statements illustrate the underlying meaning of the identified categories and demonstrate how participants’ experiences informed the development of the final conceptual model. The detailed categories, subcategories, and dimensions underlying each component of Conditional, interactive, and consequential of the model are summarized in Table 6.

Table 6. Conditional, interactive, and consequential groups

Category type	Main Category	Sub-category	
Conditional	Infrastructures	Communicational	
		Structural (fundamental)	
	Institutional system and economic incentives	Institutional system	Policies and regulations
			Educational-research system
			Agricultural extension system
		Economic incentives	Motivating
			Marketing
			Holding events
			Financial support
	Formation of an innovative idea	Idea characteristics	
		Idea monitoring	
	Key stakeholders	Research sector	
		Science and technology park sector	
		Customers sector	
		Governmental sector	
		Private sector	
Interactive	Interaction and communications	Communications	
		Cooperation	
	Monitoring and evaluation of the commercialization process	Monitoring	
		Evaluation	
	Commercial project management	Management issues	Planning
			Organizing
			Developing trust and sympathy
		Resource issues	
		Process issues	
		Market and target community	
Consequential	Commercial effects and consequences	Social dimension	
		Economic dimension	
		Political dimensions	
		Environmental dimension	
		Satisfaction	

Source: Research findings

Based on the categories identified through open, axial, and selective coding, an integrated conceptual model of value creation in the commercialization of agricultural research results was developed. The model synthesizes the relationships among the causal conditions, contextual conditions, intervening conditions, value creation process, strategic actions, and expected consequences identified during the qualitative phase of the study. As illustrated in Figure 2, value creation in the commercialization process emerges through the interaction of institutional, infrastructural, economic, and stakeholder-related factors and is operationalized through a set of strategic actions that ultimately generate social, economic, political, and environmental outcomes. The model therefore provides a comprehensive representation of the mechanisms through which agricultural research outputs can be transformed into practical and sustainable value within the Iranian context.

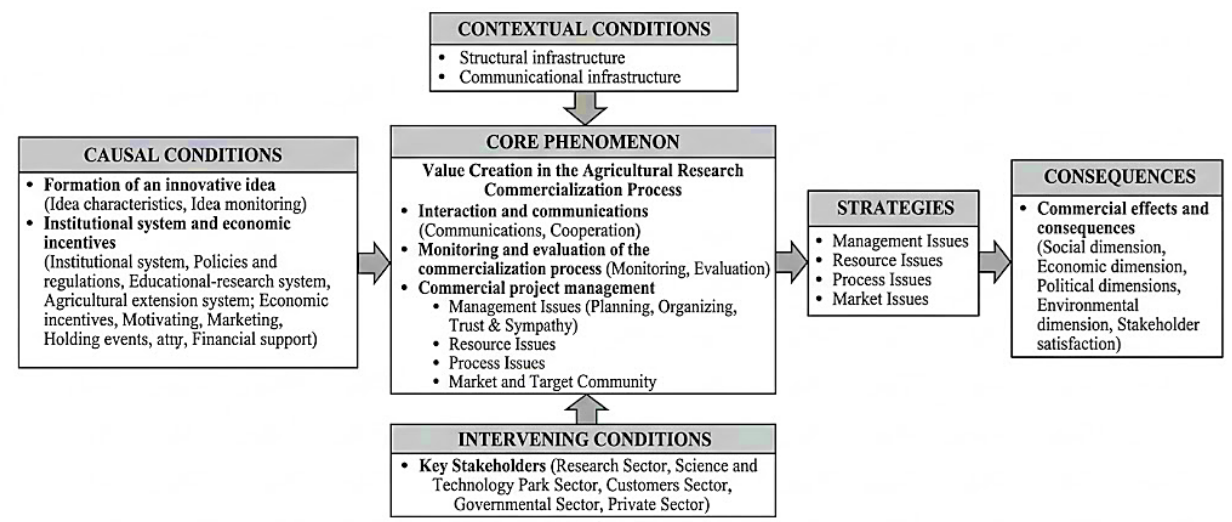

Fig 2. Final Value Creation Model for the Commercialization of Agricultural Research Results in Iran.

To ensure methodological consistency between the qualitative and quantitative phases, the categories identified through grounded theory analysis were systematically transformed into measurable constructs for the questionnaire development process. The operationalization procedure was based on the conceptual structure of the paradigm model and aimed to preserve the theoretical meaning of each category during quantitative validation. As shown in Table 7, the quantitative constructs were directly derived from the categories emerging from the qualitative phase. Therefore, the quantitative analysis did not seek to develop a new theoretical framework;

rather, it aimed to empirically evaluate the relationships proposed by the grounded theory model and assess the validity of the resulting value creation framework.

Table 7. Transformation of Grounded Theory Categories into Quantitative Constructs.

Grounded Theory Category	Key Concept	Quantitative Construct	Sample Measurement Item
Formation of an Innovative Idea	Idea generation and opportunity recognition	Innovation Capability	Agricultural research projects are developed based on innovative ideas and emerging opportunities.
Institutional System and Economic Incentives	Policy, regulations, financial support	Institutional and Economic Support	Existing institutional mechanisms effectively support commercialization activities.
Structural Infrastructure	Physical and organizational infrastructure	Structural Infrastructure	Adequate infrastructure exists for transferring research outputs to the market.
Communicational Infrastructure	Information exchange and networking	Communication Infrastructure	Effective communication channels facilitate collaboration among stakeholders.
Key Stakeholders	Government, private sector, STPs, customers	Stakeholder Engagement	Relevant stakeholders actively participate in commercialization activities.
Interaction and Communications	Cooperation and coordination	Collaborative Interaction	Effective collaboration exists among actors involved in the commercialization process.
Monitoring and Evaluation of Commercialization	Performance assessment	Commercialization Monitoring	Commercialization activities are regularly monitored and evaluated.
Commercial Project Management	Planning, organizing, trust building	Commercialization Management	Commercialization projects are managed through systematic planning and coordination.
Management, Resource, Process and Market Issues	Strategic actions	Commercialization Strategy	Appropriate strategies are implemented to address commercialization challenges.
Commercial Effects and Consequences	Economic, social, environmental outcomes	Value Creation Outcomes	Commercialization of agricultural research results generates sustainable value.

Results of the quantitative method

To evaluate the proposed conceptual model, Partial Least Squares Structural Equation Modeling (PLS-SEM) was performed using SmartPLS 4. Following the recommended analytical procedure, the evaluation was conducted in three stages: (1) assessment of the measurement model, (2) assessment of the structural model, and (3) evaluation of the overall model fit.

Measurement Model Assessment

Reliability

The reliability of the measurement model was assessed using Cronbach's alpha and composite reliability (CR). As presented in Table 8, all Cronbach's alpha values exceeded the recommended threshold of 0.70, ranging from 0.710 to 0.817, indicating satisfactory internal consistency across all constructs. Similarly, composite reliability values ranged from 0.815 to 0.901, exceeding the recommended minimum value of 0.70 and confirming the reliability of the measurement model.

Convergent Validity

Convergent validity was evaluated using the Average Variance Extracted (AVE). As shown in Table 8, the AVE values ranged from 0.513 to 0.820, all exceeding the recommended threshold of 0.50. These findings confirm that each construct explains more than half of the variance of its associated indicators, thereby demonstrating satisfactory convergent validity.

Table 8. Results of Model Reliability and Validity Assessment

Construct	**Cronbach's alpha**	**R^2**	**Composite reliability (rho-c)**	**Composite reliability (rho-a)**	**AVE**
Core phenomenon	0.710	0.317	0.815	0.757	0.529
Causal conditions	0.817	-	0.868	0.822	0.523
Contextual conditions	0.780	-	0.901	0.782	0.820
Intervening conditions	0.810	-	0.863	0.814	0.513
Strategies	0.728	0.442	0.846	0.734	0.647
Consequences	0.790	0.108	0.855	0.793	0.542
Source: Research findings					

Discriminant Validity

Discriminant validity was assessed using the Fornell–Larcker criterion. As reported in Table 9, the square root of the AVE for each construct (diagonal values) exceeded its correlations with all other constructs (off-diagonal values). This finding indicates that each construct shares greater variance with its own indicators than with other constructs, thereby confirming satisfactory discriminant validity.

Table 9. Matrix of Discriminant Validity Assessment Based on the Fornell-Larcker Criterion.

Construct	Value creation for the process of commercializing	Strategies	Contextual conditions	Causal conditions	Intervening conditions	Consequences
Value creation for the process of commercializing	0.727					
Strategies	0.627	0.804				
Contextual conditions	0.347	0.395	0.905			
Causal conditions	0.563	0.498	0.259	0.723		
Intervening conditions	0.310	0.305	0.116	0.202	0.716	
Consequences	0.413	0.329	0.270	0.326	0.188	0.736
Source: Research findings						

Structural Model of the Research

The structural model of the research was analyzed in terms of standardized coefficients and significance coefficients. The path coefficients and factor loadings for the research model are presented in Figure 3; these diagrams were derived from the output of the PLS Algorithm test. According to some researchers, a path coefficient greater than 0.1 is considered influential within the model (Hanafizadeh & Zare, 2012, p. 12). As shown in Figure (3), the factor loadings of all constructs are greater than 0.4 and are statistically significant. This demonstrates that the proposed model effectively explains the process of value creation in the commercialization of agricultural research results through the selected construct.

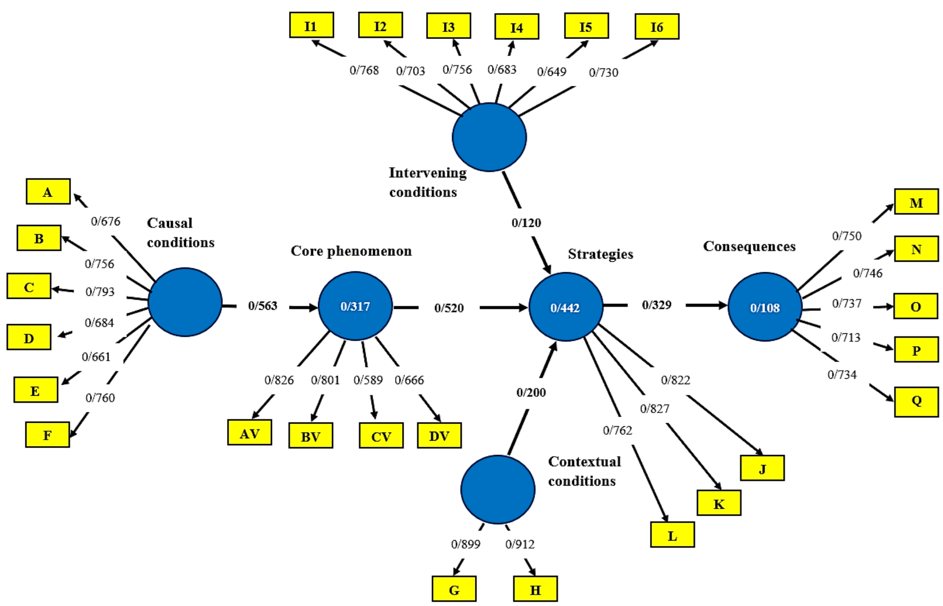

Fig 3. Structural Model with Standardized Coefficients.

Structural Model Assessment in Terms of Significance Coefficients (t-values)

To assess the significance of the structural paths, three indice, namely the path coefficient (β), t-value, and significance level (Sig), must be examined. The path coefficient represents the magnitude and direction of these effects. The t-value must fall outside the interval of –1.96 to +1.96, and the Sig value should be less than 0.05 or 0.10. Table (10) presents the path coefficients and their corresponding t-statistics at the 95% confidence level for the full model. By comparing the calculated t-values for each path, the confirmation or rejection of the proposed research hypotheses can be determined. Thus, if the t-statistic is greater than the absolute value of 1.96, the hypothesized relationship or effect is considered significant at the 95% confidence level (Davari and Rezazadeh, 2014:53). The results obtained from the path coefficients and t-values indicate that all factor loadings are statistically significant at the aforementioned confidence level, as shown in Figure (4). Effect of Causal Conditions on Value Creation in the Commercialization Process: The t-value is greater than 1.96 (t = 10.767), confirming significance at the 95% confidence level. The path coefficient is β = 0.563, meaning that for every one-unit change in the variable "Causal Conditions," the variable "Value Creation in the Commercialization Process" changes by 0.563 units.

Effect of Value Creation in the Commercialization Process on Strategies: The t-value is greater than 1.96 (t = 10.268), indicating confirmation at the 95% confidence level. The path coefficient is β = 0.520, meaning that for each one-unit change in the "Value Creation" variable, the "Strategies" variable changes by 0.520 units. Effect of Contextual Conditions on Strategies: The t-value exceeds 1.96 (t = 3.501), confirming significance at the 95% confidence level. The path coefficient is β = 0.200, showing that each one-unit change in the "Contextual Conditions" variable results in a 0.200-unit change in "Strategies. Effect of Intervening Conditions on Strategies: The t-value exceeds 1.96 (t = 2.617), confirming significance at the 95% confidence level. The path coefficient is β = 0.120, indicating that a one-unit change in the "Intervening Conditions" variable leads to a 0.120-unit change in "Strategies". Effect of Strategies on Consequences: The t-value exceeds 1.96 (t = 5.865), confirming significance at the 95% confidence level. The path coefficient is β = 0.329, meaning that for every one-unit change in "Strategies," the "Consequences" variable changes by 0.329 units.

Table 10. Path Coefficients and Corresponding t-statistic and Significance Values.

Path Origin	Path Destination	Path Coefficient (β)	t-value	Sig	Result
Causal Conditions	Value Creation	0.563	10.767	0.000	Significant
Value Creation	Strategies	0.520	10.268	0.000	Significant
Contextual Conditions	Strategies	0.200	3.501	0.000	Significant
Intervening Conditions	Strategies	0.120	2.617	0.000	Significant
Strategies	Consequences	0.329	5.865	0.000	Significant

Source: Research findings

The data presented in Table (10) indicate that, according to the respondents surveyed in this study, causal conditions exert the greatest influence on the process of value creation in the commercialization of agricultural research findings, whereas intervening conditions have the least impact.

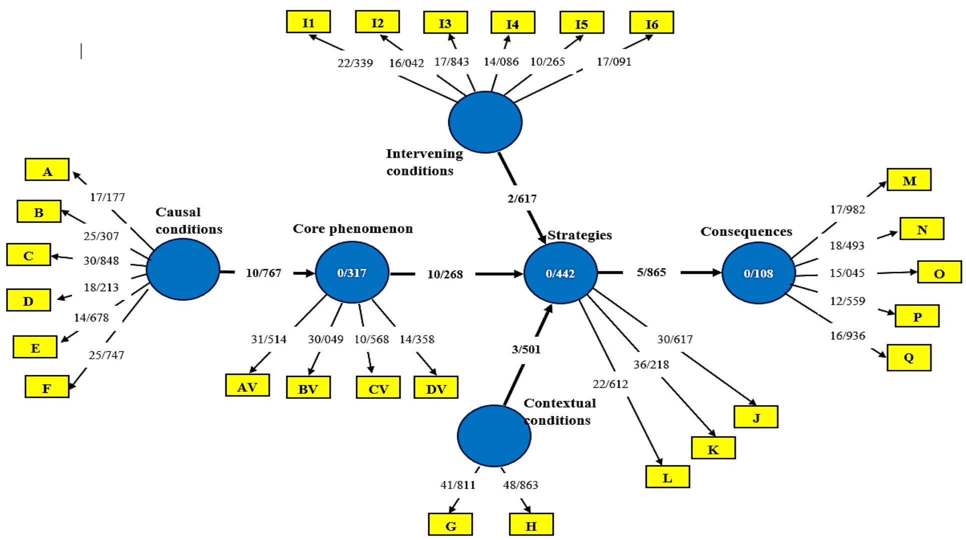

Fig 4. Structural Model with t-values.

Model Goodness of Fit (GOF) Assessment in PLS

The GOF index was used to confirm the quality of the research model. This index ranges between 0 and 1, where values closer to 1 indicate a higher model quality. The GOF is calculated as the geometric mean of the average communality (or Average Variance Extracted – AVE) and the average coefficient of determination (R^2), using the following formula (Davari & Rezazadeh, 2014: 53): $GOF = \sqrt{(\overline{communality} \cdot \overline{R^2})}$ or $GOF = \sqrt{(\overline{AVE} \cdot \overline{R^2})} = \sqrt{(0/595.0/289)} = 0/414$

The computed GOF value of 0.414 indicates an acceptable overall fit, and suggests that the structural and measurement models possess adequate quality and validity within the PLS framework. In addition to the Goodness-of-Fit (GOF) index, several complementary fit and predictive relevance indicators were assessed to provide a comprehensive evaluation of the PLS-SEM model. The Standardized Root Mean Square Residual (SRMR) was 0.071, which is below the recommended threshold of 0.08, indicating a satisfactory model fit. Furthermore, the Normed Fit Index (NFI) was 0.905, exceeding the recommended cut-off value of 0.90 and demonstrating an acceptable level of model fit. The predictive relevance of the model was evaluated using Stone–

Geisser's Q^2 coefficient obtained through the blindfolding procedure. The Q^2 value was 0.421, indicating strong predictive relevance for the endogenous constructs and confirming the model's capability to predict the observed data.

DISCUSSION AND CONCLUSIONS

The present study sought to develop and validate a value-creation model for the commercialization of agricultural research results in Iran. The findings demonstrate that commercialization is not merely a technological or market-oriented activity; rather, it is a complex value-creation process shaped by the interaction of institutional arrangements, infrastructural capacities, stakeholder engagement, and strategic management mechanisms. The proposed model indicates that value creation emerges through the dynamic relationships among causal conditions, contextual factors, intervening conditions, commercialization strategies, and multidimensional outcomes. One of the central findings of this study is the critical role of institutional systems, economic incentives, and communication infrastructures as fundamental drivers of commercialization. These findings are consistent with Biranvand et al. (2021), who identified organizational and structural factors as major determinants of research commercialization. The convergence of findings suggests that commercialization success depends not only on the quality of research outputs but also on the existence of supportive institutional environments capable of facilitating technology transfer, resource mobilization, and stakeholder coordination. However, unlike previous studies that primarily focused on identifying influential factors, the present research explains how these factors operate collectively within a value-creation process and influence commercialization outcomes through interconnected causal mechanisms. The findings further highlight the importance of policy frameworks, regulatory support, and agricultural extension systems in facilitating commercialization. This observation is consistent with Mahmoodi et al. (2024), who reported that weak governmental support, insufficient commercialization policies, and limited university–industry interaction constitute major barriers to agricultural research commercialization in Iran. The consistency between the two studies indicates that institutional and policy-related challenges remain persistent constraints within the agricultural innovation system. Nevertheless, the current study extends previous research by moving beyond the identification of barriers and demonstrating how institutional support mechanisms contribute to value creation when integrated with stakeholder participation, communication infrastructures, and commercialization strategies.

Another important finding concerns the central role of stakeholders in the commercialization process. The results indicate that research institutions, science and technology parks, governmental agencies, private-sector organizations, and end users collectively influence commercialization outcomes. This finding supports the multi-actor perspective proposed by Feo et al. (2022), who emphasized that innovation in agricultural systems emerges through interactions among multiple actors rather than through isolated organizational efforts. Similarly, the stakeholder-centered structure identified in the present study reinforces the argument that sustainable commercialization requires continuous collaboration, knowledge exchange, and coordination among diverse actors throughout the innovation lifecycle. The strategic dimensions identified in this research, particularly communication management, commercialization-oriented project management, and monitoring and evaluation mechanisms, also align with previous studies on university–industry collaboration and technology transfer. Pujotomo et al. (2023) emphasized the importance of institutional support, intellectual property management, and collaborative networks for successful commercialization, while Tereshchenko et al. (2024) highlighted organizational capabilities and trust-building mechanisms as critical success factors. The present findings support these arguments and further demonstrate that communication and collaboration are not merely facilitating factors but strategic mechanisms through which value is created, transferred, and sustained during commercialization processes.

The study also contributes to the emerging literature on value creation within agricultural innovation systems. Klingenberg et al. (2022) argued that value creation in agricultural systems results from complex interactions among actors, governance arrangements, and resource flows. Similarly, Sun and Ma (2025) emphasized the importance of stakeholder co-creation in generating sustainable value. The findings of the present study support these perspectives but extend them by providing an empirically validated framework that explains how value creation unfolds throughout the commercialization process. Rather than treating value creation as an outcome of innovation alone, the proposed model conceptualizes value creation as a multidimensional process linking institutional conditions, stakeholder interactions, commercialization strategies, and economic, social, political, and environmental outcomes. Taken together, these findings suggest that agricultural research commercialization should be viewed as an integrated innovation-system process rather than a linear technology-transfer activity. While previous studies have often examined institutional support, stakeholder engagement, innovation capabilities, or commercialization barriers separately, the present study combines these dimensions within a single explanatory framework. This integrated perspective represents the primary theoretical contribution of the research and helps explain how agricultural research outputs can be transformed into sustainable value under the institutional conditions of developing countries. In conclusion, the proposed value-creation model provides a comprehensive explanation of the mechanisms underlying agricultural research commercialization. The results demonstrate that successful commercialization depends on the interaction of institutional systems, economic incentives, infrastructures, stakeholder networks, and strategic management practices. By integrating these components into a coherent and empirically validated framework, this study contributes to both commercialization theory and agricultural innovation policy while offering practical guidance for improving the utilization and societal impact of agricultural research outputs.

POLICY RECOMMENDATIONS

To address the gap between policy formulation and practical implementation, the present study translates its findings into an operational framework for agricultural research commercialization. This framework emphasizes actionable policy instruments, institutional responsibilities, and measurable outcomes to ensure effective implementation. To enhance the practical applicability of the proposed policy measures, the recommendations are synthesized into an implementation-oriented framework. This framework specifies key actions, responsible institutions, implementation mechanisms, timelines, and performance indicators, as presented in Table 11. The matrix-based presentation enables a clearer translation of policy directions into operational steps for effective commercialization of agricultural research outputs.

534 **Table 11.** Implementation Matrix for Agricultural Research Commercialization Policies in Iran.

Policy Domain	Action (What to do)	Responsible Actors (Who)	Implementation Mechanism (How)	Timeframe	Key Performance Indicators (KPIs)
University-Level Commercialization	Establish Technology Transfer and Commercialization Offices (TTCOs) in agricultural faculties	Universities, Ministry of Science	Institutional restructuring; creation of dedicated TTCO units with commercialization mandate	Short-term (1–2 years)	Number of TTCOs established; number of commercialization-ready projects identified
University Incentive Reform	Integrate commercialization outputs into academic evaluation systems	University boards, accreditation bodies	Revision of promotion rules to include patents, licensing, startups, industry collaboration	Medium-term (2–3 years)	% of faculty with commercialization outputs; number of patents/startups
Academia–Industry Coordination	Establish joint advisory committees between universities and industry	Universities, agribusiness firms, STPs	Periodic stakeholder meetings for market alignment and project selection	Short-term	Number of joint projects; industry participation rate
Ministry-Level Support Units	Establish Agricultural Commercialization Support Units	Ministry of Agriculture	Creation of intermediary units for mentoring, validation, and business model development	Short-term	Number of supported projects; commercialization conversion rate
Extension System Reform	Transform extension agents into innovation brokers	Ministry of Agriculture, extension organization	Training programs and role redesign for demand-driven innovation transfer	Medium-term	Number of technologies adopted by farmers; farmer satisfaction index
Funding Mechanisms	Introduce seed funding, innovation vouchers, and commercialization grants	Vice Presidency for Science & Technology	Competitive funding schemes and risk-sharing financial instruments	Short-term	Number of funded projects; survival rate of funded startups
Regulatory & Monitoring System	Establish national commercialization evaluation system	National innovation authorities	Development of standardized KPI-based monitoring dashboard	Medium-term	Technology transfer rate; ROI of commercialization projects
Science & Technology Parks	Create specialized agri-tech incubation and acceleration centers	STPs, private sector	Development of incubation infrastructure and mentoring systems	Short-term	Number of startups incubated; graduation rate
Commercialization Roadmaps	Develop sector-specific commercialization pathways	STPs, research institutes	TRL-based structured roadmap design for agricultural technologies	Medium-term	Time-to-market reduction; commercialization success rate
National Coordination System	Establish National Agricultural Commercialization Coordination Council	Government, Ministry of Agriculture, Science & Tech authorities	Creation of semi-autonomous governance body for policy harmonization and oversight	Medium-term	Policy alignment index; reduction in duplication of programs

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